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Key Trends That Will Shape Army Installations of Tomorrow

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Preface

Given growing external pressures on Army installations, the U.S. Army asked RAND Arroyo Center to examine how external trends might affect Army installations out to the year 2025. The Army's Office of Assistant Chief of Staff for Installation Management (OACSIM) will use the study results to develop a strategic concept to shape the future of installations out to the year 2025, and to foster exploration and innovation that improves Soldier and Family Readiness at Army installations. This study analyzed a range of trends that are likely to impact installations from now out to 2025, including the areas of building design, climate change, energy, information technologies, loss of biodiversity, societal trends, sustainable agriculture, sustainable communities, transportation, urbanization and sprawling communities, and water scarcity.

This research was sponsored by OACSIM and was conducted in RAND Arroyo Center's Military Logistics Program. RAND Arroyo Center, part of the RAND Corporation, is a federally funded research and development center sponsored by the United States Army.

This report should be of interest to Army and Department of Defense staff involved in installation planning and management, including issues of environment, infrastructure investments, community, and quality of life. It should also be of interest to other federal agencies, state and local governments, nongovernmental organizations, and businesses that interact with Army installations, and to those that have more general interests in the relevant trend categories that we examine in this report.

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Summary

Background

For decades, Army installations tended to be isolated, which meant that they could train and carry out other activities largely unimpeded. Today, however, Army installations find themselves having to deal with an increasing number of external pressures. Expanding development is causing more and more houses to be built ever closer to installations, leading to concerns among residents about noise and safety, which in turn threaten to curtail training. The same development is making installations part of the remaining habitat for endangered plant and animal species, which puts increasing pressure on the installation to preserve species and habitat. Where once water was plentiful, it is now less so and even scarce in some areas. Thus, installations come under increasing pressure, either to share resources or to reduce consumption. Installations also find themselves asked to use less electricity, build more energy efficient structures, adopt new information and other technologies, cope with trends affecting society at large (such as the rising use of online social networks as part of Americans' sense of community), and find ways to reduce traffic congestion. And all of this occurs at a time when resources are likely to be less plentiful than in the recent past.

Purpose and Approach of the Research

None of these trends has escaped the notice of Army leaders. In response, the Office of the Assistant Chief of Staff for Installation Management (OACSIM), which conducts strategic planning to help shape the Army's installations, asked RAND Arroyo Center analysts to help assess how future trends external to installations, including technologies, policies, infrastructure changes, and other factors, could influence installations out to 2025. More specifically, the project objective was to examine trends external to Army installations that may affect its ability to provide quality installation services and infrastructure and that the Army should take into account in strategic planning. A second objective was to specify near-term and longer actions that the Army should take to address these trends.

The broad approach our Arroyo research team took was to review the relevant literature from academia, nongovernmental organizations (NGOs), industry, military and intelligence agencies, other federal agencies, and even state and local governments. We began by looking at a wide range of future trend studies and at literature in specific areas that would likely

impact installation infrastructure, services, and operations, such as information, buildings, energy, environmental and transportation technologies, policy, and management. The results of the literature review were bolstered by interviews with relevant experts.

The next step took a systems analysis approach to assessing the potential effects of trends on Army installations. This systems analysis consisted of four main steps:

- Identify and understand key relevant current trends and projections that appear to be most relevant for Army installations.
- Examine the causes of the trends and likely changes over time as well as the policies and activities that could change the trends and their effects.
- Examine the key interrelationships of these trends with other trends and installation processes and functions.
- Assess the significance of any relevant potential effects of the trends on Army installations.

Based on this analysis, we focused on trends that appeared to have the potentially largest impact, whether negative or positive, on Army installations' ability to provide quality services and infrastructure. These impacts could include significantly limiting or enhancing installation operations, incurring significant costs or saving the Army money, helping to meet or hurting the ability to meet future regulations and requirements, and helping to improve or potentially hurting Soldier and Family quality of life.

Given this analysis, we determined that the trends listed in Table S.1 were the ones most relevant for Army installations. Note that these trends are not presented in any particular order.

Conclusions and Recommendations

We developed some general and cross-cutting conclusions and recommendations as well as those that are specific to each trend area.

Overarching Conclusions and Recommendations

In examining external trends to Army installations out to the year 2025, we found that such trends are likely to impact installations in many different ways and in many different areas. Trends have the potential to cause harm to such installation operations as testing, training, and constructing activities; to cost or save the Army significant amounts in the future; to hurt or improve Soldier and Family quality of life; to improve installation operations; to help meet future installation requirements; and to improve or hurt environmental conditions.

Table S.1
Trend Areas Examined as Most Relevant for Army Installations

Trends	Illustrative Characteristics
Loss of biodiversity	Trends of biodiversity loss throughout the world and their effect on Army installations.
Urbanization, increased development, and sprawling communities	Growth in cities throughout the world and the U.S., and increasing sprawling communities in the United States, including in rural areas.
Climate change	Potential implications of climate change, including changes in snowfall and rainfall patterns.
Water scarcity	Global and U.S. trends in scarcity, implications of long-term drought, and water conservation measures.
Sustainable communities	Growth management, traditional neighborhood development/new urbanism, eco-industrial parks, and waste management.
Sustainable transportation	Compact land use and less personal vehicle travel, personal mobility options, and transportation system planning.
Sustainable agriculture	Community-supported agriculture, organic farming, and community gardening because of obesity, weight, nutrition, and health concerns.
Sustainable buildings	Increasingly greener building codes and voluntary standards, and evolving best practices for building management.
Energy	Growth in renewable energy technology implementation, and increasing requirements and investments in energy efficiency.
Information technologies	Online communities, pervasive computing, and robotics.
Societal	Trends in the ways people live and their relationships with each other and the world around them, including changes in U.S. society, trends and implications for youth, and use of the Internet.

The Army also has the ability, with strategic actions, to mitigate potentially negative consequences on its installations from the trends and to take advantage of their potentially beneficial opportunities. It is important that the Army consider and implement the types of actions identified in this study both in the near term and in its strategic planning to help save costs, to preserve installation operational flexibility, improve Soldier and Family quality of life, and to help meet installation requirements. Given the uncertainty with so many of these trends and knowing that they will evolve over time, the Army should continue to examine them, as well as others as they become relevant, and assess their implications for Army installations and actions. Our study provides a methodology and process that the Army can use for continuing assessment. This process includes key questions to ask and answer about the trends and sources to use to help answer them.

We also identify an issue that cuts across many different trend areas: that of community relationships becoming more important to Army installations. Community relationships include the local community, broader regional communities, and networks of communities with a shared interest, such as supporting Army Soldiers and Families or collaborating in regional ecosystem management. First, we noticed that communities are likely to be more interested in installation operations than in the past, and this is likely to continue into the future. Because of increased community interests in installations, Army installations will need to spend more time on community relationships. Second, community relationships are becoming more important for addressing external trends' influences and likely impact on installations, from the need to work with communities to prevent encroachment from sprawling home developments near an installation, to working together on Soldier and Family quality of life issues, to regional collaborative ecosystem management to prevent biodiversity loss. The need to consider the local, regional, and networks of communities with common interests and to collaborate with them will become more and more important to installations in the future.

Trend Area Conclusions and Recommendations

To help identify priority actions for the Army installation community today, we created different categories of actions based on the likely effect the trends will have on the Army. Specifically, the trends in this study fall into the following six categories:

1. Treat strategically now to avoid future harm to military operations.
2. Treat strategically now to avoid high future costs.
3. Treat strategically now to improve capability to meet future regulations and installation requirements.
4. Treat sooner because of the opportunity to get some benefits. Benefits can include meeting future requirements, saving money, and improving Soldier and Family quality of life.
5. Trend requires additional research or studies to better understand its impact on the Army and Army installations.
6. Trend requires tracking but not immediate action.

However, some trends cut across categories. It is important to note that the categories generalize based on likely main effects and that each area is complex. For the more complete and detailed situation of each trend, the reader should read the individual chapter on that trend. Table S.2 shows which trends fall in each general category. A red cell means the trend

Table S.2
Trends Examined and Their Potential Impact

	Trend Category					
Trend Area	**1: Avoid Future Harm to Operations**	**2: Avoid High Future Costs**	**3: Meet Future Require-ments**	**4: Opportunity for Benefits**	**5: Additional Study**	**6: Tracking but No Action**
Loss of biodiversity						
Urbanization, increased development, and sprawling communities						
Sustainable buildings						
Energy						
Sustainable transportation						
Water scarcity						
Sustainable communities						
Societal trends						
Sustainable agriculture						
Online communities						
Climate change						
Robotics						
Pervasive computing						

Red = high priority/impact. Gray = important but requires less urgency of action.

is likely to have a more significant influence in that area and will likely require higher-priority actions. For example, the trend area "sustainable buildings" is likely to imply significantly higher potential future costs if not considered soon; the trend area is likely to have some effect on meeting future regulations and requirements, but this is not ranked as significant in terms of near-term actions.

The research resulted in a substantial number of findings and recommendations. Here, we provide the main ones for the areas marked in red in Table S.2 as having significant influence and requiring a higher priority. It is important to note that other areas examined indicated by gray cells are important to Army installations as well, but they did not currently appear to require as much urgency of action given current trends and Army actions. For example, trends in online communities are significant to Army installations of the future, and addressing them sooner with our suggested recommendations will potentially provide benefits to Soldier and Family quality of life, but given what the Army is already doing and how the trends are evolving, not taking action soon will likely not incur significant harm or costs for Army installations.

Biodiversity Loss

Biodiversity loss is a significant trend throughout the world and the United States. This trend will probably continue and perhaps even accelerate, which is likely to result in more threatened and endangered species and pressures from federal, state, and local governments to protect them. This trend would probably lead to more restrictions on Army installation operations such as training, testing, and construction.

The Army should take strategic actions now to mitigate future effects of biodiversity loss, such as participating in collaborative ecosystem management. Army installation ecosystem management programs should continue and be strengthened. Additionally, the Army should take a lead role in collaborating with federal, state, and local governments; private companies and individuals; and NGOs to prevent biodiversity loss. The Army should continue to fund Army Compatible Use Buffering (ACUB) activities and identify which installations' ecosystems are most at risk and ensure that installations are collaborating with other organizations to preserve ecosystems. Senior Army and Department of Defense (DoD) leaders should meet with senior levels of Department of Interior and the U.S. Department of Agriculture to ensure they are adequately funding, managing, and protecting biodiversity in ecosystems where there are military installations and fully participating in relevant regional collaborations to protect biodiversity.

Urbanization, Increased Development, and Sprawling Communities

Sprawl and other land development pressures near installations are likely to continue. Such pressures cause encroachment on military installations, which can create a range of problems including more threatened or endangered species; wetlands, water, and air quality problems; competition for airspace and radio frequency spectrum; and more noise, smoke, and other complaints from the community about Army testing, training, and other installation operations.

The Army needs to address encroachment strategically and aggressively now. If not addressed soon, encroachment will likely cost the Army significantly more in the future to deal with it. The Assistant Chief of Staff for Installation Management (ACSIM) and the HQDA G-3 should take a lead role establishing a high-level organizational element that is responsible for integrating efforts across different parts of the Army, including training, testing, environmental, and community outreach organizations. The Army should develop an integrated, comprehensive, and strategic encroachment action plan that includes diverse effective ways to address different encroachment factors and that includes all relevant parts of the Army. Again, ACSIM should lead such an activity. The Army should implement more buffering and other mitigation activities, including dedicated funding for ACUB, and should also identify now the installations most at risk for biodiversity loss and species issues to help focus resources.

Sustainable Buildings

A number of trends will shape future buildings. State and local building codes, voluntary standards, and labeling programs will set increasingly higher performance goals, and best practices for building management, including building commissioning, life-cycle analysis, and proper operations and maintenance (O&M), will become more important. Federal legislation, Executive Orders, and DoD policies will likely continue to increase building sustainability requirements, as will state and local governments adopting more sustainable building policies. Finally, green procurement, life-cycle analysis, and designing buildings for reducing waste and deconstruction will receive more emphasis.

We make four recommendations for the Army regarding sustainable buildings to help save the Army money, to help meet future requirements, and to improve building operations and environmental quality. First, the Army should make it policy to strive to design buildings to exceed Leadership in Energy and Environmental Design (LEED)[1] Silver standards and give attention to regional and local priorities.[2] Properly investing now in energy and water efficiency improvements will provide years and even decades of savings. Second, the Army needs to ensure it is getting the cost savings from higher-performance buildings by requiring third-party certification for LEED building performance (both new construction and existing buildings) and improve building operations and maintenance practices. The Army

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[1] LEED is a well-known green building standards approach, but it is not without controversy. Some in the architectural community claim that LEED allows developers to reap the public relations benefits of building "green" without ensuring sustainability. For example, see Abby Leonard, "Architect Frank Gehry Talks LEED and the Future of Green Building," PBS, June 14, 2010.

[2] The NDAA of 2011 (Section 2830) prohibited the use of funds to be used for the LEED Gold and Platinum certification. Waivers are allowed if the Secretary of Defense submits notification that includes a cost-benefit analysis of the decision and demonstrates payback for the energy improvements or sustainable design features. Where possible the Army should do such analyses and submit such notification. So even though it is difficult to do right now given the NDAA of 2011 legislation, the Army should strive to have a policy to design buildings to exceed LEED Silver given appropriate implementation and cost-benefit analyses.

needs to ensure that its policy that new buildings will have third-party certification starting in FY13 occurs, and that such certification also applies to existing building renovations. The Army should also increase the use of continuous building commissioning to ensure that the benefits from capital investments are realized. Third, the Army needs to ensure that life-cycle analysis is used to minimize total costs. Fourth, the Army should place more emphasis on green procurement and designing buildings for reducing waste and deconstruction. We also have several specific recommendations for ACSIM and Installation Management Command (IMCOM) and other Commands that maintain buildings. They should assess the progress, barriers, and needed improvements in Army sustainable building implementation, green procurements in buildings, and designing buildings for reducing waste and deconstruction. They should also assist installations by helping to identify and evaluate the effectiveness of the many options for improving building performance and lowering costs. They should also support installation demonstrations of new technologies and evaluate their performance, such as green roofs. Lastly, they should facilitate installation investment in technologies that are demonstrated to be successful.

Energy

The demand for and the price of energy will continue to rise. Traditional energy sources will provide most U.S. energy, but the use of renewable energy and biofuels will grow. Renewable power generation capacity and use of natural gas are growing and expected to continue to do so. As this use and capacity of renewable energy technologies grow, they will become more cost competitive. Further, energy use and management will become smarter, more efficient, and more reliable. Lastly, federal, DoD, and Army policies are increasing requirements for energy efficiency and renewable energy, which places more pressures on Army installations to invest in energy efficiency and renewable energy technologies.

The Army should accelerate its efforts to improve energy efficiency and lay the foundation to implement more rigorous standards to save money over the long term. Installations will need to improve the energy efficiency of their buildings because of likely stricter OSD, Army, and even state requirements. For new construction, the Army should set a goal to be at least 65 percent more efficient than the ASHRAE 90.1-2004 standard. ACSIM should do a cost-benefit analysis to show the savings of such a standard over time to help its justification and implementation. Also, the Army should have a headquarters organization with the expertise to help installations with technical, financial, legal, and contracting issues regarding large-scale energy efficiency and renewable energy investments. Additionally, ACSIM and IMCOM and other Commands should help installations by supporting demonstrations of new energy technologies and evaluating their performance. They should also help installations collaborate more with utilities and industry to develop renewable and other energy resources or infrastructure and help installations identify low-cost opportunities to procure renewable power for sources inside and outside installations. Finally, ACSIM and IMCOM and other Commands should help installations promote competitive hiring and salaries for full-time energy managers and staff at installations.

Sustainable Transportation

Emphasis is increasing on compact land use and less personal vehicle travel. Additionally, more transportation system planning and operations improvements are being developed and implemented. Third, increasingly many and increasingly diverse personal mobility options, such as car sharing, are being implemented. Finally, more electric and other alternative energy vehicles are being developed and put into service.

ACSIM/IMCOM should encourage installations in master and transportation planning to do more compact land use and traditional neighborhood development practices and promote policies that decrease personal vehicle travel. Large installations should have free or low-cost and convenient post buses. More efforts should be made to partner with local governments and communities on providing transit. Designing bike lanes and bike racks for bike parking in key cantonment areas is another important activity. ACSIM/IMCOM should encourage installations to do more transportation system planning and operations improvements to ensure efficient flow and management of traffic and other transportation infrastructure. IMCOM should help installations implement more low-cost or even free car sharing pilot demonstrations, especially at large posts that have population growth and transportation problems. IMCOM should also explore doing a free or fee-based shared bicycle system or even a multi-modal system installation pilot that involves bicycles and cars. Finally, the Army should ensure the effective and efficient use of electric vehicles by comparing the costs and benefits of different alternative vehicle types and uses and planning for the electric charging infrastructure.

Such strategic installation transportation planning and investments now can help save costs; save valuable installation land space; improve installation quality of life; reduce traffic congestion, reduce air pollution and other environmental problems; help preserve installation operational flexibility from air quality and other regulations; and help meet future federal, OSD, and Army energy requirements.

Water Scarcity

Water has become increasingly scarce globally and in the United States, and this trend will likely continue. Army installations will need to cooperate more with local communities to manage scarce water resources and develop more aggressive water conservation methods and policies. The Army should place more emphasis, analysis, and visibility on water concerns now; the Net Zero Water Installation activities are a good start. Additional beneficial steps to implement include an analysis using installation and regional water case studies to examine likely installation implications and needs. ACSIM/IMCOM in collaboration with the Deputy Assistant Secretary of the Army for Environment, Safety and Occupational Health (DASA(ESOH)) within the Assistant Secretary of the Army for Installations, Energy and Environment (ASA(IE&E)) should develop an integrated strategic action plan that integrates future trends and scenarios and focuses on specific actions to deal with regional differences and needs. Lastly, individual installation sustainability and strategic plans should place more emphasis on long-term strategic approaches to water issues.

Conclusion

Many trends external to Army installations have the potential ability to help or hurt installations of the future. By examining such trends now and acting to address their implications for installations of the future, the Army can better take advantage of the beneficial ones and mitigate the impacts of the harmful ones to preserve installation operational flexibility and provide quality installation services and infrastructure. Such actions will ultimately save the Army money and improve installation operations and Soldier and Family quality of life.

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Acronyms

AAFES	Army and Air Force Exchange Service
ACC	Army Capstone Concept
ACS	Army Community Service
ACUB	Army Compatible Use Buffer
ADHD	Attention Deficit Hyperactivity Disorder
ASA(IE&E)	Assistant Secretary of the Army (Installations, Energy and Environment)
ASB	Army Science Board
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
BART	Bay Area Rapid Transit
BLM	Bureau of Land Management
BMI	Body Mass Index
BRAC	Base Realignment and Closure
CBO	Congressional Budget Office
CERL	Construction Engineering Research Laboratory (USACE)
CNT	Centers for Neighborhood Technology
CNU	Congress for the New Urbanism
CONUS	Continental United States
CSA	Community Supported Agriculture
CSP	Central Shortgrass Prairie
DASA(ESOH)	Deputy Assistant Secretary of the Army (Environment, Safety and Occupational Health)
DEERS	Defense Enrollment Eligibility Reporting System
DoD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DOT	Department of Transportation
EO	Executive Order
EPA	Environmental Protection Agency
ERDC	Engineer Research and Development Center (USACE)
ESTCP	Environmental Security Technology Certification Program
EU	European Union

F&WS	Fish and Wildlife Service
FAO	Food and Agriculture Organization
FIC	Farmland Information Center
FRG	Family Readiness Group
FS	Forest Service
FY	Fiscal Year
GAO	Government Accountability Office (formerly General Accounting Office)
GCEP	Global Climate and Energy Project
GDP	Gross Domestic Product
Generation M	Generation Media
GIF	Green Investment Fund
HETs	High Efficiency Toilets
HQDA	Headquarters, Department of the Army
HUD	Housing and Urban Development
IISD	International Institute for Sustainable Development
IMCOM	Installation Management Command
IPCC	International Panel on Climate Change
IUCN	International Union for Conservation of Nation
JBLM	Joint Base Lewis-McChord
KIPC	Keystone Industrial Port Complex
LEED	Leadership in Energy and Environmental Design
MEDCOM	United States Army Medical Command
MILCON	Military Construction
NCA	National Climate Assessment
NCAT	National Center for Appropriate Technology
NDAA	National Defense Authorization Act
NIC	National Intelligence Council
NGOs	Nongovernmental Organizations
NRCS	Natural Resources Conservation Service
O&M	Operations and Maintenance
OACSIM	Office of the Assistant Chief of Staff for Installation Management
OCONUS	Outside the Continental United States
OECD	Organization for Economic Co-operation and Development
OFPA	Organic Foods Production Act
OSD	Office of the Secretary of Defense

PIU	Problematic Internet Use
QDR	Quadrennial Defense Review
R&D	Research and Development
SCS	Soil Conservation Service
SERDP	Strategic Environmental Research and Development Program
SOV	Single Occupancy Vehicle
T&ES	Threatened and Endangered Species
TNC	The Nature Conservancy
TND	Traditional Neighborhood Development
TPL	The Trust for Public Land
TRADOC	Army Training and Doctrine Command
UN	United Nations
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
USACE	U.S. Army Corps of Engineers
USDA	United States Department of Agriculture
USGCRP	United States Global Change Research Program
WWF	World Wildlife Fund

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CHAPTER ONE
Introduction

Background

The Army's installations play a crucial role in preparing units to carry out their missions both at home and worldwide and in sustaining the readiness of individual Soldiers and their Families. The Office of the Assistant Chief of Staff for Installation Management (OACSIM) conducts strategic planning to help shape the Army's installations of the future. In such planning, it seeks to understand the issues and trends that installations will have to cope with so as to better plan, manage, and budget for installations of the future. OACSIM recognizes that many societal trends, policies, technology developments, and other sources of influence external to installations could affect future installations, in terms of both what they are able to do and what they need to be able to do. OACSIM asked RAND Arroyo Center analysts to help assess the literature about future trends, technologies, and other factors that could influence installations of the future.

Purpose

To respond to OACSIM's request, RAND Arroyo Center established two objectives for its study. The first was to identify trends external to Army installations that may affect their ability to provide quality installation services and infrastructure and that the Army should take into account in its strategic planning. Such trends could include everything from technology trends to social, economic, policy, and even physical trends, like changes in land use patterns. The period of focus was 2025. The second objective was to specify what near- and long-term actions the Army should take to address these trends. A lesser included goal was to provide the Army with a catalogue of sources that could assist installation personnel in their own analyses of trends over time, recognizing that trends will change and need to be continually monitored and assessed.

How RAND Went About the Study

RAND Arroyo Center researchers faced three challenges in carrying out the study. First, numerous uncertainties cloud the future, and these uncertainties are compounded by the complex interrelationships of the trends. We cannot predict precisely how technology will develop and how society will change, and moreover these changes are likely to interact with other trends, such as those in the environment and how land is developed and used, in complicated ways. The second challenge is to divine how those trends fit into or affect national, Department of Defense (DoD), and Army policy and, equally important, the environment in which the Army will be using its operational forces. The final challenge was to identify a process that the Army can use to continue to reassess the trends identified in this study and their effects on installations of the future. Such a process needs to include policies and activities that the Army can undertake to help influence the direction and course of a trend, to help change the effect of a trend on Army installations when it is likely to be negative, and to help take advantage of a trend that can be beneficial to Army installations and their military operations, including supporting Soldiers and Families.

The broad approach our research team took was to review the relevant literature from academia, nongovernmental organizations (NGOs), industry, military and intelligence agencies, other federal agencies, and even state and local governments. We began by looking at a wide range of future trend studies, such as the National Intelligence Council's *Global Trends 2025* report, and looking at literature in specific areas that would likely impact installation infrastructure, services, and operations, such as information, buildings, energy, environmental and transportation technologies, and policy and management trends. Three categories of relevant literature were found to be most useful. First, we examined studies and expert projections that directly projected trends out to 2025. Second, to help project and understand likely future trends, we used research that examined and assessed historical patterns and current trends, along with their causes. Third, we used detailed studies for a limited area that gave historical trends or future projections for a local region or area that could then potentially be used to extrapolate for other parts of the United States or the world.

The results of the literature review were bolstered by interviews with various experts in fields such as technology, trends, and strategic installations. Such interviews help us identify trend areas to focus on, especially given the timeline for our study. In one case, they led us to include an area we had not originally considered as relevant to Army installations, sustainable agriculture. In briefly discussing the study with Army installation sustainability experts at the Army Sustainability In-Progress Review held at Fort Bragg on January 12–14, 2010, as well as other Army staff from IMCOM and MEDCOM, we decided to add sustainable agriculture to our study.

Another valuable source of information was participation in the Army Science Board FY09 Summer Study on Installations 2025. These efforts also helped lead to the identification of key trends and their sources.

The next step was a systems analysis approach to assessing the potential effect of trends on Army installations. This systems analysis consisted of four main steps: (1) identify and understand key relevant current trends and projections that appeared to be most relevant for Army installations; (2) examine the causes of the trends and likely changes over time as well as the policies and activities that could change the trends and their effects; (3) examine the key interrelationships of these trends with other trends and installation processes and functions; and (4) assess the significance of any relevant potential effects of the trends on Army installations.

A key challenge for our research was to sort among the many possible trends to identify those of the most relevance to Army installations. For completeness sake, we looked at a range of trends including physical trends, such as changes in land use patterns and biodiversity lost; social and economic trends, such as increasing obesity patterns in youth and the health of the national and world economies; policy trends, such as changes in environmental regulations and energy consumption reduction policies; and technology trends, such as changes in information and renewable energy technologies.

To help winnow through the many possible trends, we identified several criteria. A very important one was to identify any trends that could pose future harm to military operations at installations. A second was to discover trends that could portend high future costs for Army installations. A third was trends that the Army might take advantage of to improve its capability to comply with possible future regulations or requirements at installations. Fourth, we also identified trends that the Army might want to invest in sooner rather than later because of the potential opportunity to get some installation benefits from such investments. Such benefits could include improving Soldier and Family quality of life, improving installation operations or environmental quality, or saving money over the long term. Fifth, we identified some trend areas that require further research or studies to better understand the impact on Army installations. Finally, our research team sought to discover trends that might not require immediate action but that the Army should continue to track. In some cases, we identified some useful lower-priority activities that the Army might want to pursue sooner rather than later because of potential long-term benefits.

Main Trends Identified as Relevant for Army Installations

Guided by these criteria, our research team identified the trends listed in Table 1.1 as the most relevant for Army installations. These are the main trends discussed in the rest of this report. Note that they are not presented in any particular order.

Table 1.1
Trend Areas Examined as Most Relevant for Army Installations

Trends	Illustrative Characteristics
Loss of biodiversity	Trends of biodiversity loss throughout the world and their effect on Army installations.
Urbanization, increased development, and sprawling communities	Growth in cities throughout the world and the U.S., and increasing sprawling communities in the United States, including in rural areas.
Climate change	Implications of climate change, including changes in snowfall and rainfall patterns
Water scarcity	Global and U.S. trends in scarcity, implications of long-term drought, and water conservation measures.
Sustainable communities	Growth management, traditional neighborhood development/new urbanism, eco-industrial parks, and waste management.
Sustainable transportation	Compact land use and less personal vehicle travel, personal mobility options, and transportation system planning.
Sustainable agriculture	Community supported agriculture, organic farming, and community gardening because of obesity, weight, nutrition, and health concerns.
Sustainable buildings	Increasingly greener building codes and voluntary standards, and evolving best practices for building management.
Energy	Growth in renewable energy technology implementation, and increasing requirements and investments in energy efficiency.
Information technologies	Online communities, pervasive computing, and robotics.
Societal	Trends in the ways people live and their relationships with each other and the world around them, including general changes in U.S. society, trends and implications for youth, and use of the Internet

Many more trends were examined than what appear in this table. It is important to remember that this study focused on trends that impact Army installations. Many other trend areas that we started to examine, such as nano-technologies and information technology advances in education, do have implications for the Army as a whole and potentially for limited parts of installations, but they were not as directly relevant to installation operations and/or were already being addressed by other parts of the Army that have more direct responsibility over them. These areas are not discussed in this document because they are areas that ACSIM and the rest of the installation management community do not need to follow as closely because they have a small role at installations and do not meet the impact criteria discussed earlier and will be integrated into installation operations based on the lead of other Army organizations.

Important areas examined, but not in this table, were political, economic, and demographic trends for the world and the United States. We found that such trends provide useful background information and help set the context for installations, and some of them are alluded to in the trends discussions. For instance, the world population will continue to rise, placing pressure on resources and potentially contributing to instability and conflict. Economic pressures, at least in the near term, will continue to mean that future Army budgets will be limited, and cost-efficient installations will become more important. These trends are discussed in more detail in Appendix A.

It is important to note that we examined both worldwide and U.S. trends, but focused more on U.S. trends.

For each trend selected for further analysis, we attempted to answer the following seven questions:

- What is the likely trend given current conditions?
- What evidence indicates that the trend will continue?
- What sources exist for tracking the trend?
- What could change the course of the trend?
- How does it relate to other trends?
- What are the potential effects on Army installations, both positive and negative?
- What is the Army context regarding the trend?
- Given this analysis, what actions, if any, should the Army be taking regarding the trend?

The answers to these questions are discussed for each trend area identified above in Table 1.1. We grouped trend areas into logical categories for presentation based on potential reader audiences. We also recognize that readers may not want to read this entire document, but just the trend areas most interesting to them. Most of the chapters can stand alone, so the reader may skip around as he or she chooses. However, some key terms or organizations may have been defined in earlier chapters. The trend areas and chapters are not presented in any priority order.

For ease of reading, we have tried wherever possible to be consistent in the structure of each trend area discussion. We begin by discussing useful background information, such as defining key concepts and terms related to the trend area, then we discuss the international and the U.S. trends for that area, followed by what could change the course of the trend and interrelationships with other trend areas. Next we discuss implications of the trend for Army installations. This section begins, where needed, with background information about what the Army is already doing related to the trend area to help set the context, and then ends with recommendations for Army actions given the trends and Army context. Lastly, in each trend area we give a range of useful sources. These sources are given because this type of assessment needs to be an ongoing process. No one can predict the future, and such trends will need to be continually reviewed by the Army. These sources provide a useful reference guide for the Army installation community to use to continue to examine how these trends are evolving and likely to impact installations.

The societal trends chapter is a little different given the wide range of uncertainty associated with them, so it does not quite follow this same structure.

Organization of This Document

This document is organized into seven chapters. Chapter Two examines land development and environmental trends including loss of biodiversity, increased development, urbanization, sprawl, climate change, and water scarcity. Chapter Three examines trends related to sustainability including sustainable communities, sustainable transportation, and sustainable agriculture. Chapter Four examines sustainable building and energy trends. Chapter Five examines information technology trends. Chapter Six examines societal trends that may impact Army installations, including decreased physical activity and increased use of media among youth. Chapter Seven presents our conclusions and main recommendations. Each of the trend chapters is complete and self-contained, and can be productively read individually. We recommend that readers selectively read the trend chapters most germane to their interests and responsibilities and the conclusions and main recommendations chapter.

Appendix A examines current and future political, economic, and demographic trends. Appendix B provides background on a RAND study of Soldier and Family problems and installation support needs.

CHAPTER TWO

Land Development and Environmental Trends

This chapter discusses some key land development and environmental trends and why they are important to Army installations. Issues discussed in this chapter include:

- Loss of biodiversity
- Urbanization, sprawling communities, and increased development
- Climate change
- Water scarcity

These issues were grouped together in this chapter because of the interrelationships among them. However, they also relate to other topic areas in other parts of this report, such as energy and sustainable communities. Other environmental issues are also discussed in other chapters, such as Chapter Three, which focuses on sustainable communities, agriculture, and transportation, and Chapter Four, which discusses buildings and energy. For example, solid waste issues are discussed under sustainable communities, and green buildings are discussed in the buildings and energy chapter.

Loss of Biodiversity

In this section we discuss ongoing trends of biodiversity loss throughout the world and their impact on Army installations. We begin by providing some background information on what biodiversity is and why it is important.

Background: Defining Biodiversity and Understanding Its Importance

One of the most significant environmental drivers currently and over the next few decades is biodiversity, and the high rate at which it is being lost. In its simplest form, biodiversity can be defined as biological variety. It refers to the number and diversity of species, the genetic material of those species, and the natural communities, ecosystems,[3] and landscapes in which

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[3] An ecosystem is a group of different plant, animal, and microbe species interacting with each other and their environment, which includes precipitation, temperature, amount of moisture, and other chemical and physical factors to which organisms are exposed (Bernard J. Nebel and Richard T. Wright, *Environmental Science: The Way the World Works*, Englewood Cliffs, New Jersey: Prentice Hall, 1993).

those species live.[4] Biodiversity loss is a key trend because as biodiversity is lost, more species become threatened and endangered.[5] As more species become threatened or endangered, more pressure is placed on the military to protect such species and their habitats.

Scientific evidence shows the importance of biodiversity trends to future environmental health and to the military. Biodiversity is important to maintain healthy and diverse natural resources and systems that humans depend upon. Arguments for preserving biodiversity include economic, environmental, genetic, aesthetic, and moral. Some environmental benefits of biodiversity include: healthier ecosystems, resistance to invasive species, regulation of the climate, contributions to organic waste disposal, soil formation and retention, biological nitrogen fixation, biological pest control, plant pollination, and bioremediation of chemical pollution. Some economic benefits of biodiversity include: increased crop yields, biotechnology, ecotourism, crop and livestock genetics, and increased supplies of food, animals, and pharmaceuticals from the wild.[6] A conservative estimate of the annual economic and environmental benefits of biodiversity in the United States is $319 billion; worldwide, it is $2,928 billion.[7] Other estimates of the worldwide economic benefits of biodiversity range as high as $33,000 billion per year.[8]

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[4] For illustrative examples about the biodiversity, ecosystems, and landscapes on and around Army installations, see the appendices on Fort Carson and Fort Stewart in Beth Lachman et al., *The Thin Green Line: An Assessment of DoD's Readiness and Environmental Protection Initiative to Buffer Installation Encroachment,* Santa Monica, CA: RAND, 2007, MG-612-OSD.

[5]The federal Endangered Species Act (ESA) is the law that protects species and can restrict federal activities that impact them. The ESA's purposes "are to provide a means whereby ecosystems upon which endangered species and threatened species depend may be conserved, [and] to provide a program for the conservation of such endangered and threatened species" (16 U.S.C. Section 1531(b) or Farley and Belfit, 2001). To accomplish this objective, the U.S. Fish and Wildlife Service (USFWS) establishes a list of species in danger of extinction, identifies the habitat needed for conservation, and develops plans to recover the species, and listed species are protected from being "taken" without express authorization of the USFWS.

[6] David Pimentel et al., "Economic and Environmental Benefits of Biodiversity," *BioScience*, Vol. 47, No. 11, December, 1997.

[7] These estimates are from Pimentel et al., 1997, which provides a quantitative assessment of biodiversity benefits.

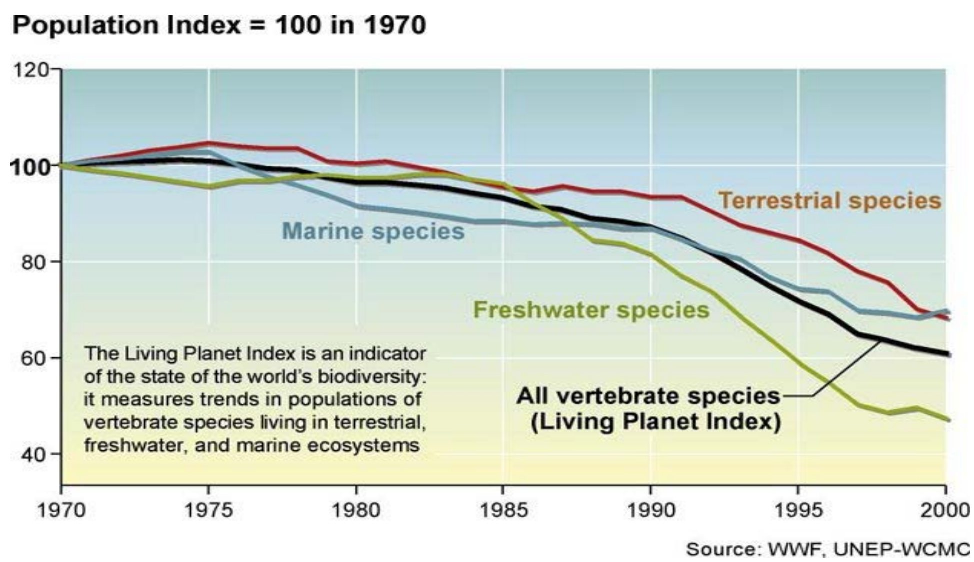
[8] R. Costanza et al., "The Value of the World's Ecosystem Services and Natural Capital," *Nature*, Vol. 387, 1997. For other approaches to arguing and quantifying the importance and benefits of biodiversity, see Gretchen C. Daily et al., "Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems," *Issues in Ecology*, Number 2, Ecological Society of America, 1997; Bruce Stein, Lynn S. Kutner, and Jonathan S. Adams (eds.), *Precious Heritage: The Status of Biodiversity in the United States*, Oxford: Oxford University Press, 2000,

Key Biodiversity Trends

Global Trends

Increased human activities and rapidly growing global populations threaten the earth's biodiversity. Across the world, biodiversity has been declining at significant rates (see Figure 2.1 below). A UN-backed study recently found that global environmental damage caused by human activity in 2008 alone totaled $6.6 trillion, equivalent to 11 percent of global gross domestic product.[9] The most comprehensive assessment ever done of the world's vertebrates - mammals, birds, amphibians, reptiles and fishes—has found that one-fifth of all birds, fish and animals are threatened with extinction.[10] In addition, the study found that on average, 50 species of mammal, bird and amphibian move closer to extinction each year due to the impacts of agricultural expansion, logging, over-exploitation and invasive alien species.[11]

Figure 2.1
Past Trends in Biodiversity Loss: The Living Planet Index, 1970–2000



SOURCE: UNEP Millennium Ecosystem Assessment, 2005.

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and Robert Leo Smith and Thomas M. Smith, *Ecology & Field Biology*, Sixth Edition, New York: Benjamin Cummings, 2001, pp. VII A-D.

[9] Chisa Fujioka, "World Needs Urgent Action to Stop Species Loss: UN," Reuters, October 18, 2010.

[10] International Union for Conservation of Nature, "Nature's Backbone at Risk," October 26, 2010.

[11] International Union for Conservation of Nature, 2010.

Worldwide, tens of thousands of species are becoming extinct every year,[12] and extinction rates are estimated to be 1,000 to 10,000 times higher than natural extinction rates.[13] For instance, the population of wild vertebrate species fell by an average of nearly one-third (31 percent) globally between 1970 and 2006, with the decline especially severe in the tropics (59 percent) and in freshwater ecosystems (41 percent).[14] Among extant species, 20 percent of all species that have been assessed are believed to be threatened with extinction in the near future.[15] For instance, the World Wildlife Fund (WWF) has estimated that there are as few as 3,200 tigers currently surviving in the wild and that the tiger may become extinct by 2022.[16]

Worldwide loss of biodiversity is likely to continue and may accelerate in the future. In 2005, the Millennium Ecosystem Assessment indicated that factors such as habitat change, climate change, and a growing population and consumption will continue to cause losses in biodiversity at the present pace or even faster.[17]

U.S. Trends

The United States has also experienced biodiversity loss. Assessments of 20,900 species indicate that one-third of the native U.S. flora and fauna is considered to be of concern (see Figure 2.2).

In addition, the proportion of species at risk varies from one group of plants and animals to another, from a high of 69 percent to a low of 14 percent (see Figure 2.3). Freshwater-dependent animals (such as mussels, crayfishes, stoneflies, amphibians, and fishes) are clearly the most vulnerable groups as measured by proportion at risk. For instance, the U.S. Environmental Protection Agency has found that watersheds covering almost one-quarter of the area of the lower 48 states have lost at least one-tenth of the native freshwater fish species known to have been present at some time prior to 1970.[18]

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[12] Smith and Smith, 2001, p. VII-A.

[13] Steven Kellert and Edward O. Wilson (eds.), *The Biophilia Hypothesis*, Washington, D.C.: Island Press, 1993; Jonathan Baillie, Craig Hilton-Taylor, and Simon N. Stuart (eds.), *A Global Species Assessment*, Cambridge, UK: IUCN, 2004.

[14] *Global Biodiversity Outlook 3*, Montreal: Secreatariat of the Convention on Biological Diversity, 2010, p. 24.

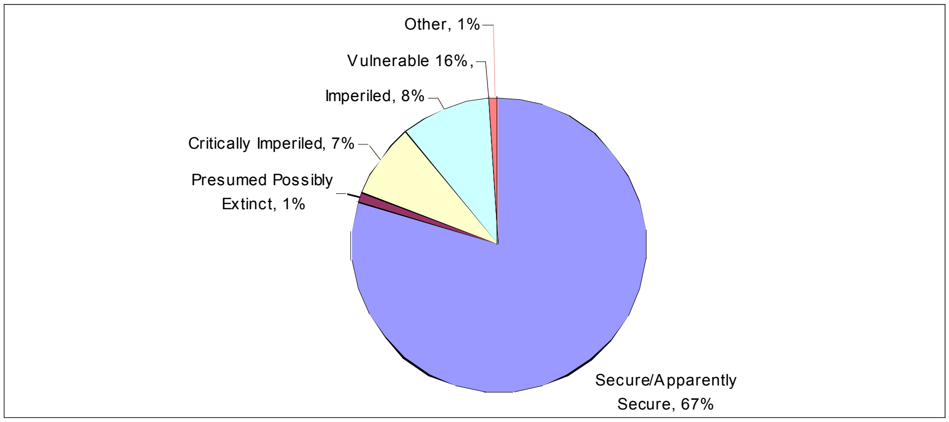
[15] Rashid Hassan, Robert Scholes, and Neville Ash (eds.), *Ecosystems and Human Well-Being: Current State and Trends, Volume 1,,* Washington, D.C.: Island Press, 2005.

[16] World Wildlife Fund, "Tiger Facts and Future."

[17] Hassan, Scholes, and Ash, 2005.

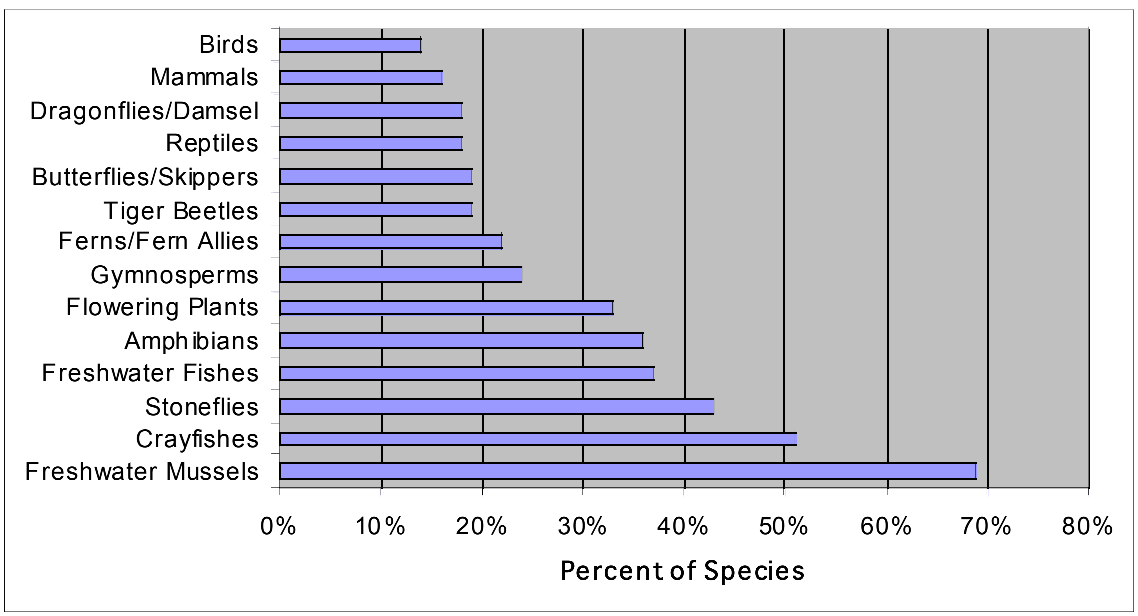
[18] Environmental Protection Agency, *Report on the Environment: Highlights of National Trends*, Washington, D.C: EPA, June 2008. p. 29.

Figure 2.2
Proportion of U.S. Species at Risk



SOURCE: Bruce Stein et al., *Precious Heritage*, Oxford: Oxford University Press, 2000, p. 101.

Figure 2.3
Proportion of Species at Risk by Plant and Animal Group



SOURCE: Bruce Stein et al., *Precious Heritage,* Oxford: Oxford University Press, 2000, p. 101.

Causes of Biodiversity Loss

Throughout the United States, sprawl has caused significant loss of forests, agriculture lands, habitats, and ecosystems.[19] Such development has resulted in fewer large, contiguous tracts of land that have not experienced biodiversity loss. Factor in other activities on federal lands, such as logging, mining, and offroad vehicle use, as well as the effects of pollution, and the result is that many ecosystems and habitats in the United States are being degraded or lost. Such pressures mean that military installations often become islands of key habitats and biodiversity.

Invasive species are considered to be one of the main direct drivers of global biodiversity loss.[20] The introduction of non-native species can decimate an ecosystem because such species often do not have predators to keep them in balance in their non-native environments. Invasive species represent the second leading cause of species extinction and loss of biodiversity in aquatic environments worldwide.[21] Invasive species also have economic implications. Total annual costs, including losses to crops, pastures, and forests, as well as environmental damages and control costs, have been conservatively estimated to be in the hundreds of billions of dollars and possibly more than one trillion.[22]

There is also increasing evidence that climate change causes biodiversity loss. Some analyses suggest that 15–37 percent of a sample of 1,103 land plants and animals would eventually become extinct as a result of climate changes expected by 2050.[23] Changes in the abundance and distribution of species may have serious consequences for human societies. The geographical distribution of species and vegetation types is projected to shift radically

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[19] An ecosystem is an organized system of associated physical and biological components which are interconnected, so that a change in one of the components will affect the other components and the system as a whole; namely, a group of plants and animals living in a defined area and functioning together as a system.

[20] International Union for Conservation of Nature, *IUCN Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species.* Prepared by the Species Survival Commission Invasive Species Specialist Group, and approved by the 51st Meeting of the IUCN Council. Gland, Switzerland: Island Press, 2000.

[21] See Environmental Protection Agency, "Exotic Species."

[22] D. Pimentel, S. McNair, J. Janecka, J. Wightman, C. Simmonds, C. O'Connell, E. Wong, L. Russel, J. Zern, T. Aquino, and T. Tsomondo, "Economic and Environmental Threats of Alien Plant, Animal, and Microbe Invasions," A*griculture, Ecosystems and Environment*, Vol. 84, 2001, pp. 1–20.

[23] Chris D. Thomas et al., "Extinction Risk from Climate Change," *Nature*, Vol. 427, January 8, 2004, pp. 145–148.

due to climate change, with ranges moving from hundreds to thousands of kilometers toward the poles by the end of the 21st century.[24]

Species in the northern latitudes of the globe are particularly vulnerable because some species accustomed to colder climates are unable to adapt to warming temperatures. The subsequent section in this report on climate change explores this issue in more depth.

Interrelationship with Other Trends

Biodiversity loss is closely tied to other trends that we examine in this report, including sprawling communities, climate change, and water scarcity. All three of these other trends can cause biodiversity loss, so any analysis of them needs to take into account their impacts on biodiversity. In addition, biodiversity loss has been linked to increased distribution and rates of infectious disease in humans.[25] The loss of some species has allowed for certain disease-spreading animals (such as ticks and mosquitoes) to explode in population.

Biodiversity loss is also related to sustainable agriculture and community trends because some activities in these areas have the potential to help slow some biodiversity loss. Trends in the use of information technologies can also have an impact on biodiversity loss. For example, because of ubiquitous computing people can work from more and more remote locations, potentially leading to more people living in and telecommuting from less-developed areas, which potentially could cause more or accelerate some biodiversity loss.

What Could Change the Course of Biodiversity Trends

As discussed earlier, if the causes of biodiversity loss—such as increasing sprawl, loss of habitat to agriculture, logging and other extraction industries, pollution, and invasive species—continue in the United States, the loss will continue or even accelerate as these factors cause more declines in habitat and species.

However, there are activities being taken to try to reduce and stop biodiversity loss. In the event that a vulnerable species becomes threatened or endangered, one of the most immediate means to try to save the species is to implement specific policies to protect it. There are already a host of federal, state, and local laws and policies that protect threatened or endangered species. Pollution-prevention policies in particular are one tool that policymakers can use to quickly and directly protect species impacted by point source

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[24] *Global Biodiversity Outlook 3*, 2010, p. 10.

[25] See Montira J. Pongsiri, Joe Roman, Vanessa O. Ezenwa, Tony L. Goldberg, Hillel S. Koren, Stephen C. Newbold, Richard S. Ostfeld, Subhrendu K. Pattanayak, and Daniel J. Salkeld, "Biodiversity Loss and the New Global Disease Ecology," *BioScience,* Vol. 59, No. 11, December 2009, pp. 945–954.

pollution. In addition, policies to stop the introduction of invasive species can slow some biodiversity loss.

One of the main ways to stem biodiversity loss over the longer term is to protect more natural habitat and effectively manage it to preserve ecosystems and biodiversity. Habitat protection and management can be done by limiting urban sprawl, slowing the conversion of natural land to agricultural land, and institutionalizing ecosystem management policies that do not fragment the natural habitat of plants and animals—especially threatened or endangered species—and that manage habitat to help preserve and enhance the health of the ecosystems. Another way to protect natural habitat is to prevent the introduction of invasive species which could decimate local populations of plants and animals because they have no natural predators in their non-native environment.

Over the last couple of decades, collaborative ecosystem management has proven an effective means by which large ecosystems can be managed, maintained, and even enhanced.[26] Collaborative ecosystem management involves diverse organizations such as federal, state, and local governments, NGOs, universities, and private industry working together to manage entire ecosystems (as opposed to slices of those ecosystems) within a participatory, collaborative decisionmaking framework. Such efforts are taking place across the United States to manage such large ecosystems as the Chesapeake Bay, the Florida Everglades, and the Columbia River Basin in the Pacific Northwest.[27]

One of the best examples of collaborative ecosystem management involving the military is the central shortgrass prairie (CSP) ecoregion partnership, in which Fort Carson has played an active role.[28] The CSP partnership is a collaboration of different federal, state, NGO, and private landowners to study, manage, and preserve the CSP ecoregion. Partners include The Nature Conservancy, Colorado Association of Conservation Districts, Colorado state natural heritage programs, Fort Carson, Department of Defense, Colorado Division of Wildlife, U.S. Fish and Wildlife Service, U.S. Forest Service (FS), and other federal, state, and nongovernmental agencies and organizations.

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[26] For examples of collaborative ecosystem management, primarily involving U.S. national forests, see Julia M. Wondolleck and Steven L. Yaffee, *Making Collaboration Work: Lessons from Innovation in Resource Management*, Washington, D.C.: Island Press, 2000.

[27] Andrea Gerlak and Tanya Heikkila, "Comparing Collaborative Mechanisms in Large-Scale Ecosystem Governance," *Natural Resources Journal*, Vol. 46, Summer 2006, pp. 657–707.

[28] See B. Neely et al., *Central Shortgrass Prairie Ecoregional Assessment and Partnership Initiative: Final Report*, Nature Conservancy of Colorado and the Shortgrass Prairie Partnership, November 2006.

Begun in 2004 with the start of a *Central Shortgrass Prairie Ecoregional Assessment*, this partnership's ultimate goal is "to promote the long-term sustainability of all native species, plant communities, and ecosystems within the ecoregion through the collaborative design and conservation of a network of areas and implementation of species conservation guidelines."[29] The CSP focuses on identifying and protecting key ecological patches and conservation corridors so managers can try to maintain a healthy, viable ecosystem. This approach does not try to save everything in the ecosystem; rather, it focuses on saving and managing key pieces to keep the system resilient, healthy, and functioning. By better conserving and managing key pieces of the CSP ecoregion as a healthy viable ecosystem, if successful, this partnership could help CSP recover and prevent any other species from becoming threatened or endangered.

Since climate change has caused some biodiversity loss, taking actions to reduce greenhouse gas emissions could potentially slow the rate of biodiversity loss as well. However, it could take decades for such slowing to take effect.[30]

Implications of Biodiversity Loss for Army Installations

Before discussing the implications of biodiversity loss for Army installations, it is important to understand the context with respect to biodiversity on Army installations.

Biodiversity on Army Installations

First, it is useful to understand who owns the land where most of biodiversity is located and most at risk. In the United States, federally and privately owned lands harbor the greatest number of species and habitats that are at risk, though state lands are also significant. Within the category of federal lands, the U.S. Forest Service, Department of Defense, and Bureau of Land Management are the federal landowners with the most federally listed and imperiled species and populations.[31] Therefore, biodiversity on Army installations (like other U.S.

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[29] Neely et al., 2006, p. v.

[30] For more information about the relationships between climate change, greenhouse gas emissions, and biodiversity see Intergovernmental Panel on Climate Change, *Climate Change 2007: Synthesis Report*, 2007.

[31] It is important to understand the difference between federally listed threatened and endangered species (T&ES) and imperiled species. Federally listed T&ES represent a relatively small portion of U.S. species considered at risk by scientists because of the lengthy process required to add a species to this list. "Imperiled species" refers to a much larger number of U.S. species identified by scientists as being imperiled or vulnerable, which in 2000 was about 2,800 U.S. species compared to 958 federally listed species. Stein, Kutner, and Adams, 2000, pp. 163 and 165.

military installations) is at risk. In fact, looking at the distribution of species and populations on federal lands:

> . . .we find that Department of Defense lands contain the most federally listed species of any agency, with at least one example of about one-fifth (21%) of all federally listed species. This finding is particularly striking, given that these lands represent just 3% of the federal estate. Many military bases turn out to be strategically placed, not just from a military standpoint but also from a biological perspective. Often found in coastal areas with fast-growing human populations, many of the Department of Defense land holdings, such as southern California's Camp Pendleton Marine Base, are becoming islands of natural habitat in rapidly urbanizing regions.[32]

Forest Service lands contain the greatest number of imperiled species at risk (26 percent) and the greatest number of imperiled and endangered populations. Given the amount of federal land that they own, both DoD and FS manage disproportionate numbers of imperiled and endangered species populations.[33] The significance of Army and other DoD lands for maintaining biodiversity is even larger given the designated uses and management practices of FS and BLM lands. These federal lands are managed for mixed uses including logging, grazing, mining, outdoor recreation, and oil and natural gas extraction. These activities are among the leading causes of habitat alteration and loss of species.

Army Activities That Address Biodiversity Loss

Because of threatened and endangered species regulatory problems causing training restrictions, the Army has implemented comprehensive ecosystem management programs at numerous installations, including Forts Benning, Bragg, Carson, and Hood, Joint Base Lewis-McChord (JBLM), and U.S. Army Garrison Hawaii. These progressive programs help to better manage ecosystems, preserve biodiversity, and protect T&ES. Such ecosystem management programs also help maintain realistic habitats and ecosystems for training purposes. They are often implemented with help from The Nature Conservancy and scientists from nearby universities. They have helped installation staff more effectively manage habitats, which has led to some relief on training restrictions and helped protect biodiversity. For example, Fort Bragg, Fort Benning, and other installations in the southeast have been conducting controlled burns and other management actions to help restore and manage the long-leaf pine habitat and ecosystem for red cockaded woodpeckers (RCW) and

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[32] Stein, Kutner, and Adams, 2000, pp. 279–280.
[33] Stein, Kutner, and Adams, 2000, p. 282.

other species of concern. Similarly, Fort Carson, as just discussed, has been a leader in helping to preserve ecosystems and biodiversity in the central shortgrass prairie ecoregion.[34]

The Army also has developed and been implementing the Army Compatible Use Buffer (ACUB) program, which helps protect open space near installations from encroachment pressures and is often used to help protect biodiversity as well. In the next section the ACUB program is explained in more detail; here we give one example of an installation using it to help biodiversity. JBLM is using ACUB to help preserve and restore native prairie habitat and species in partnership with The Nature Conservancy (TNC) and Washington state agencies. TNC, with assistance from Washington state and the U.S. Fish and Wildlife Service, acquired a 127-acre prairie preserve through ACUB. Under the ACUB program, JBLM staff are working to manage additional prairie land acquired by private land conservation groups; restore native prairie on these lands and other protected prairies; and begin reintroduction of four listed candidate species: the Mardon skipper, Taylor's checkerspot, the streaked horned lark, and the Mazama pocket gopher.[35]

More Restrictions on Army Installation Operations Are Likely

It is clear that biodiversity loss is likely to continue. Given this trend and the importance of biodiversity, there are likely to be more political, policy, and regulatory activities protecting biodiversity. Given the declines in biodiversity, the number of threatened and endangered species in the United States is likely to increase at both the federal and state levels, which will place more pressure on installations where such species exist. Specifically, more threatened and endangered species cause more restrictions on testing, training, and other installation operations such as building and road construction. It also becomes more costly because of the cost burden of meeting the regulatory monitoring, reporting, management, and operational requirements. To save money and preserve autonomy in land use on its installations, the Army needs to strategically address this trend now rather than later.

Recommendations for Biodiversity Loss

The Army should take strategic actions now to mitigate future impacts of biodiversity loss. As we discussed earlier, there are many strategic actions, like collaborative ecosystem management, that can be taken to avoid biodiversity loss and help prevent species from becoming threatened or endangered. Army installation ecosystem management programs should continue and be strengthened. In current times of declining budgets, such programs

[34] Lachman et al., 2007.

[35] Beth E. Lachman et al., *Developing Headquarters Guidance for Army Installation Sustainability Plans in 2007*, Santa Monica, CA: RAND Corporation, MG-837-A, 2010.

may not seem like a priority, but they are, given the long-term strategic importance of preventing biodiversity loss and more T&ES restrictions on installation operations. Ecosystem management activities are critical to helping prevent biodiversity loss and maintaining testing and training lands and preserving operational flexibility at installations.

In addition, the Army could and should take a lead role in collaborating with federal, state, and local governments, private companies and individuals (such as large land owners), and NGOs to prevent biodiversity loss. This includes (1) working with other federal agencies (particularly BLM, FS, and F&WS) to manage and protect habitat, (2) working with local communities to manage and protect habitat surrounding installations, and (3) continuing to fund collaborative ecosystem management activities, like the central shortgrass prairie partnership. In addition, the Army should continue to fund ACUB activities and identify which installations' ecosystems are most at risk and be sure that installations are collaborating with other organizations to preserve these ecosystems.

Other federal agency land use policies and activities, especially those of the Department of Interior (DOI) and the U.S Department of Agriculture (USDA), have an important role in helping or hurting habitat and species preservation, so Army leaders should meet with leaders from other federal agencies about preventing biodiversity loss. This will increase communication and visibility regarding policies, activities, and lessons learned across agencies. It could also increase coordination across agencies, since sometimes other agencies that own land near Army posts have limited resources to manage and protect biodiversity that benefits the Army installations. For example, we heard anecdotal evidence that on a National Wildlife Refuge and some National Forest lands in the Southeast, federal staff were not able to do as many proactive activities to maintain and enhance RCW habitat as some nearby Army installations because of limited budgets. The Army needs to do more to show other federal agency leaders the need for more proactive ecosystem management because of the benefits to Army lands. Specifically, senior levels of the Army and the Office of the Secretary of Defense (OSD) should meet with senior levels of DOI and USDA to ensure that they are (1) adequately funding, managing, and protecting biodiversity in ecosystems where there are military installations and (2) fully participating in regional collaborations to protect biodiversity.

Sources for Tracking Biodiversity Trends

In this section we discuss some useful sources that can be used to track biodiversity trends. We begin by mentioning some key organizations and then we provide some examples of useful studies and reports.

Organizations That Track Biodiversity Trends

The International Union for Conservation of Nature (IUCN) supports scientific research, manages field projects all over the world, and brings governments, NGOs, UN agencies, companies, and local communities together to develop and implement policy, laws and best practice. The IUCN's mission is to "influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable."[36] It is a network of more than 1,000 government and NGO member organizations, and almost 11,000 volunteer scientists in more than 160 countries.

The World Resources Institute is an environmental think tank that also addresses global resource and environmental issues. It began in 1982 and currently organizes its work around four programmatic goals: climate protection, governance, markets and enterprise, and people and ecosystems.[37]

The Nature Conservancy was founded in 1951 and addresses threats to conservation involving climate change, fresh water, oceans, and conservation lands. Since its founding it has protected more than 119 million acres of land and 5,000 miles of rivers worldwide. It operates more than 100 marine conservation projects globally, and works in all 50 states and more than 30 countries.[38]

NatureServe is a nonprofit conservation organization whose mission is to provide the scientific basis for effective conservation action. NatureServe was established in 1994 and today its network includes 82 independent natural heritage programs and conservation data centers throughout the Western Hemisphere, with nearly 1,000 dedicated scientists and a collective annual budget of more than $45 million.[39]

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[36] See International Union for Conservation of Nature website at http://www.iucn.org/about/.

[37] See World Resources Institute website at http://www.wri.org/.

[38] See Nature Conservancy website at http://www.nature.org/.

[39] See NatureServe website at http://www.natureserve.org/.

U.S. Fish and Wildlife Service is an agency within the U.S. Department of Interior. Its service dates back to 1871 and its mission is "to conserve, protect and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people."[40]

Studies and Reports on Biodiversity Trends

The United Nations' *Global Biodiversity Outlook 3* (2010)[41] reports on the state of global biodiversity and progress made toward goals outlined in the Convention on Biological Diversity. The report found that the target agreed upon by the world's governments in 2002, "to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on Earth," has not been met.[42] It also found that "there is no indication of a significant reduction in the rate of decline in biodiversity, nor of a significant reduction in pressures upon it."[43]

Another significant UN effort is the United Nations Environment Programme (UNEP) Millennium Ecosystem Assessment, which was carried out between 2001 and 2005 to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being. The Millennium Ecosystem Assessment was guided by a board that included representatives of five international conventions, five UN agencies, international scientific organizations, governments, and leaders from the private sector, NGOs, and indigenous groups. A 15-member assessment panel of leading social and natural scientists oversaw the technical work of the assessment, supported by a secretariat with offices in Europe, North America, South America, Asia, and Africa and coordinated by UNEP. The findings of the assessment are presented in *Ecosystems and Human Well-Being: Current State and Trends*.[44] The findings that specifically related to biodiversity are presented in *Ecosystems and Human Well-Being: Biodiversity Synthesis*. Among these findings: "Human actions are fundamentally, and to a significant extent irreversibly, changing the diversity of life on Earth, and most of these changes represent a loss of biodiversity." The assessment also found that "further significant progress will require a portfolio of actions that build on

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[40] See U.S. Fish and Wildlife Service website at http://www.fws.gov/.
[41] *Global Biodiversity Outlook 3*, 2010.
[42] *Global Biodiversity Outlook 3*, 2010, p. 9.
[43] *Global Biodiversity Outlook 3*, 2010, p. 17.
[44] See Hassan, Scholes, and Ash, 2005.

current initiatives to address important direct and indirect drivers of biodiversity loss and ecosystem service degradation." [45]

Precious Heritage: The Status of Biodiversity in the United States[46] is a landmark study that provides one of the most detailed and comprehensive assessments of biodiversity issues in the United States. The study was sponsored by the Nature Conservancy and NatureServe. It found that more than 200,000 species are now known from the United States (a figure double the previous estimate), but that one-third of U.S. species are at risk and of conservation concern and more than 500 U.S. species are already extinct or missing.

The State of the Birds: United States of America[47] provides the most current assessment of bird populations in the United States. The study found an additional 184 species of conservation concern and identifies the following three threats to birds: resource use, pollution, and climate change.

Finally, *ScienceDaily* is a helpful online resource that tracks and archives scientific articles related to science, health, and the environment.

Urbanization, Increased Development, and Sprawling Communities

Background: Historical Context of Urbanization and Increased Development

People have been migrating to urban areas throughout the world for centuries to find work. In the United States, significant urbanization began in the late 1800s with the development of machines and factories that enabled large numbers of workers to produce goods more efficiently under one roof. Advances in transportation throughout the early to middle 1900s, including public transit and the growth in personal automobile use, enabled people to live further away from the jobs in urban areas, leading to the development and growth of suburbanization. These trends, in addition to new ones such as people wanting larger homes, large tracts of land, and more vacation homes, have contributed to sprawling communities over the last few decades in the United States. More recent advances in computing and communication technologies have enabled more workers to "telecommute," which has contributed to people living even farther from their work places. Similar patterns are

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[45] Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being: Biodiversity Synthesis*, Washington, D.C.: World Resources Institute, 2005.

[46] See Stein, Kutner, and Adams, 2000.

[47] See North American Bird Conservation Initiative, U.S. Committee, *The State of the Birds, United States of America*, Washington, D.C.: U.S. Department of Interior, 2009. .

occurring throughout the world. In this section we discuss such trends, how they are likely to evolve in the future, and their implications for the Army.

However, before we discuss these trends, we briefly set the stage by discussing the general implications of urbanization, increased development, and sprawling communities. As discussed in the previous section of this report, urban sprawl can lead to biodiversity loss. It also causes loss of natural and agricultural lands, increases in air pollution due to longer commuting distances, and water quality and quantity problems. In addition, urbanization and sprawl places additional pressure on public services such as waste, transportation, and infrastructure management. There are also national security concerns from increasing urbanization. In its 2008 report *Global Trends 2025*, the National Intelligence Council (NIC) warned that rapid urbanization without formal sector job growth or adequate services can lead to unrest.[48] This type of pressure is only expected to increase as urbanization continues to rise both globally and in the United States.

For U.S. military installations, besides such environmental and national security concerns, community sprawling can place external pressures on an installation's operations, such as training restrictions resulting because of people complaining about training noise when many homes are built near the installation boundary and the training areas. Such pressures are called encroachment and will be discussed more when we discuss the implications of urbanization, development, and sprawling communities for the Army.

Key Urbanization and Development Trends

We begin this section by discussing some of the global trends related to urbanization, and then we discuss U.S. trends.

Global Trends in Urbanization

Growth in cities throughout the world is often driven by overall increases in population. The United Nations projects that between 2007 and 2050, the global population will increase by 2.5 billion: from 6.7 to 9.2 billion (this increase is equivalent to the overall number of people in the world in 1950).[49] Due to declining population growth, the population of developed countries as a whole is expected to remain virtually unchanged between 2007 and 2050,

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[48] National Intelligence Council, *Global Trends 2025: A Transformed World*, Washington, D.C.: Government Printing Office, 2008, p. 23.

[49] United Nations, Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2006 Revision, Highlights*, Working Paper No. ESA/P/WP.202, 2007, p. vii.

whereas the population of the 50 least developed countries will likely more than double.[50] In this same time period, the global urban population is estimated to nearly double from 3.3 billion to 6.4 billion.[51] If current trends persist, by 2025 about 57 percent of the world's population will live in urban areas (up from about 50 percent today) and the world will add another 8 megacities.[52] Asia and Africa, the most rural continents today, are set to double their urban populations to some 3.4 billion by 2030.[53]

U.S. Trends in Urbanization and Development

Over the last 50 years, the United States has experienced a growth in urban areas. Estimates show a 130 percent increase in census-defined urban areas between 1960 and 2000.[54] Much of this growth during the last few decades is being driven by the growth in suburban areas. Suburban sprawl has increased as homes have been built farther and farther from core city areas. People have been moving away from urban areas, wanting bigger homes and yards and more space, and fleeing inner-city crime and other problems. Cities and surrounding suburbs are now larger, taking up a significant number of acres throughout the country. Between 1982 and 1997, developed area in the United States increased 34 percent and also increased as a percentage of the total land area in the 48 contiguous states from 3.9 to 5.2 percent.[55]

Increasing Sprawl and Development Is Impacting Rural Areas in the United States

Over the last few decades, the United States has seen sprawl spread from city areas into rural areas. In fact, scientists who study U.S. growth patterns have defined a new type of sprawl, "rural sprawl." Rural sprawl is defined as low-density residential development and commercial strip development along roads scattered outside traditional suburbs and cities. Rural sprawl is rural residential development at exurban densities with 1.7 to 20 acres per housing unit.[56] Rural sprawl has become a major development pattern in the United States, and by the year 2000, exurban development had covered 25 percent of the 48 contiguous

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[50] United Nations, 2007, p. ix.

[51] Leiwen Jian, Malea Hoepf Young, and Karen Hardee, "Population, Urbanization and Environment," *World Watch Magazine*, September/October, Vol. 21. No. 5, 2008.

[52] National Intelligence Council, 2008, p. 23.

[53] Kai Lee, *World Is Soon Half Urban*, Worldwatch Institute, May 6, 2008.

[54] U.S. Department of Commerce, Census Bureau, *2001 Statistical Abstract of the United States*, 2001.

[55] U.S. Department of Agriculture, Natural Resources Conservation Service, 2001.

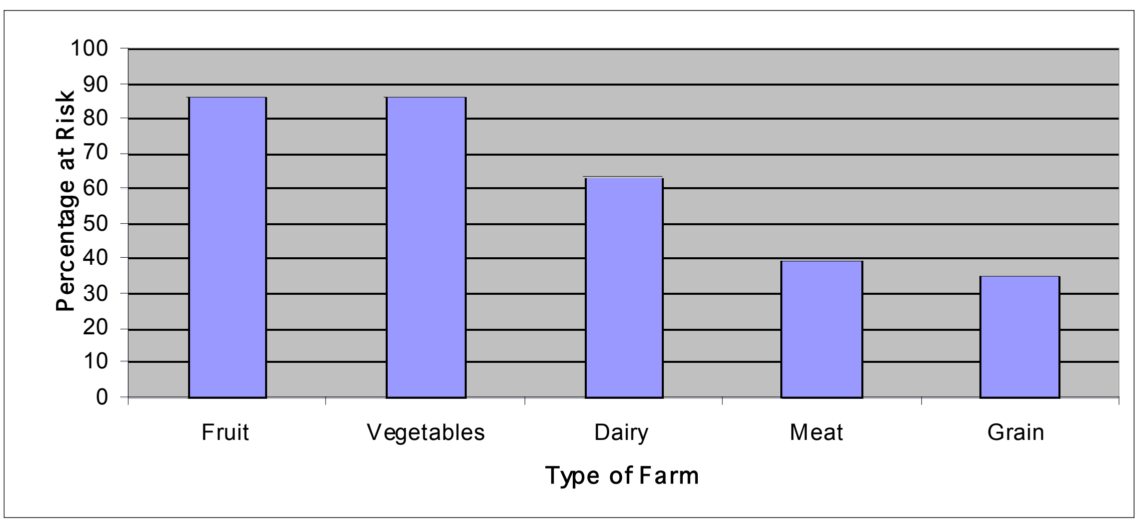
[56] "In some states, exurban areas are defined as having between 1.7 and 40 acres per housing unit, depending on state land use laws. Rural areas have > 20 acres per housing unit (or > 40 acres)." David M. Theobald, *Defining and Mapping Rural Sprawl: Examples from the Northwest US*," Fort Collins, CO: Colorado State University, September 16, 2003, p. 2.

states.[57] More people want to live on multiple acres of land in the countryside. "The foundation of rural sprawl is the proliferation of large, remote parcels rather than compact, efficient and socially vibrant communities. Planners and sociologists observe that this is most likely an attempt to replace the loss of traditional public spaces (parks, theaters, and cafes) with private spaces (landscaped grounds and home entertainment centers)."[58]

Such trends have resulted in significant loss of forest, farmland, and other open spaces in the United States. Between 1982 and 2001, nearly 34 million acres of forest land, crop land, pasture land, range land, and other undeveloped land in the Unites States were converted to developed land. The U.S. rate of development was 1.4 million acres per year between 1982 and 1992 and increased to 2.2 million acres per year between 1992 and 2001.[59]

At current rates, America is losing two acres of farm and ranch land every minute.[60] As a result, some experts see food production in the United States as threatened by sprawl. For instance, more than 80 percent of our fruits and vegetables more than 60 percent of our dairy products are threatened by sprawl (see Figure 2.4).

Figure 2.4
U.S. Farms in the Path of Sprawl



SOURCE: Environmental Defense Fund, "Protect 10 Million Acres From Sprawl," July 2007.

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[57] Andrew J. Hansen et al. (eds.,) "Land-Use Change in Rural America: Rates, Drivers, and Consequences," *Ecological Applications*, Vol. 15, No. 6, 2005.

[58] Chet Boddy, "Rural Sprawl," *Mendocino Coast Real Estate Magazine*, January 1995.

[59] U.S. Department of Agriculture, Natural Resources Conservation Service, *Summary Report: 1997 National Resources Inventory* (revised December 2001), Washington, D.C., 2001.

[60] Environmental Defense Fund, "Protect 10 Million Acres From Sprawl," July 2007.

Causes of Urbanization, Development, and Sprawl

One of the main drivers of urbanization and development is increased population. As the world population grows, there are more people that need places to live and places to work. Land is a finite resource, and more people use this resource more. Similarly, economics and social attitudes also drive urbanization and sprawl. In many developing countries, people migrate to the urban areas because of jobs, the social life, and other amenities that they associate with cities. In the United States over the last few decades, people wanting bigger homes and more property around them have been acquiring these in less expensive suburban and rural areas. The growth in retirement communities and resort and vacation home developments has also contributed to U.S. development and sprawl growth. For example, more people who own a second or even third home whether for retirement or vacation mean more land development. In fact, much of the land development patterns near military installations has been caused by increasing suburban and rural sprawl from commuters, retirement communities, and resort and vacation home developments.[61]

Government policies and regulations can be a large driver in such land development trends. In the United States, federal, state, and local policies such as tax policies, road building, utilities, and other service infrastructure development have tended to encourage suburban and rural sprawl. Expanding an existing highway or building a new one often causes sprawl to spread, especially into more rural areas.[62]

Other reasons include the advances in technology and people's tolerance for longer commutes. In the United States, people are willing to commute longer distances, and communications technologies such as the Internet and cell phones enable people to telecommute and work from increasingly remote areas. Furthermore, as urbanization and sprawl have increased, many of these areas are not as remote from cities as they seem. "For instance, 53 percent of the nation's population lives in a metro area of 1,000,000 or more; 82.6 percent lives in metro counties; 6 percent lives in nonmetro, nonadjacent counties; and 66 percent of those in nonmetro counties, live in counties adjacent to a metro area."[63]

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[61] Lachman et al., 2007.

[62] Lachman et al., 2007, p. 21, and Todd Litman, *Smart Transportation Investments: Reevaluating the Role of Highway Expansion for Improving Urban Transportation*, Victoria, BC, Canada: Victoria Transport Policy Institute, October 1, 2006..

[63] Stephen Gasteyer and Jason Gray, "Rural Sprawl: How Is Infrastructure Development Impacting the Quality of Life in Rural Communities," *Rural Matters*, Summer 2005.

What Could Change the Course of Urbanization and Development Trends

Economics, including housing and gas prices, is one of the main drivers of urbanization and development trends. As has happened in the last few years, a depressed economy has caused many people to sell their second homes or downsize their primary residences. More people may choose to buy an older and smaller home closer into an urban area rather than buy a new one out in the remote exurbs because of commuting costs. Real estate prices may go down and developers may not develop as much land in rural areas as they did during periods of economic growth and increasing real estate prices. Such trends help slow growth in some areas.

Technological changes and societal trends also can impact such trends. For instance, sprawl may increase as advances in communication, computer technologies, and telecommuting allow some workers to work from almost anywhere. Societal trends may also increase or decrease sprawl. For example, if more people have the desire for large homes with lots of land around them, development pressures will continue. However, sprawl trends may decrease somewhat if more people choose to live in condos or smaller townhouses in more urban areas or more traditional neighborhood designs with pedestrian-friendly options, as is discussed in the sustainable communities section in the next chapter.

State and local government policies related to zoning can also be used to slow sprawl and better manage land development, but their limitations must be taken into account. Such zoning policies are often not an effective long-term means to slowing sprawl and managing development, for the following reasons: (1) they differ across municipalities (thereby precluding the employment of a holistic, ecosystems management approach), (2) they can change over time, and (3) zoning exemptions can often be easily obtained (especially as local politics change in response to increases in development pressures). Given the patchwork nature of local governments in many areas and the tendencies of many to want more growth, such zoning policies must be used in conjunction with other mechanisms as part of a more comprehensive growth management plan.

Growth management trends counter sprawl. Comprehensive growth management and “smart growth” strategies are emerging as a countering trend to sprawl. Growth management refers to a planning and administrative approach that focuses on supporting and coordinating the development process. The concept is oriented toward guiding community development rather than restricting growth. Most local, state, and regional growth management plans are focused on accommodating development while maintaining communities’ quality of life, sustaining and enhancing the economic base, and preserving environmental qualities. A practical definition of growth management is “a dynamic process in which governments anticipate and seek to accommodate community development in ways that balance competing land use goals and coordinate local and regional interests."[64] However, the widespread implementation of such growth management approaches also does not appear likely any time soon. We discuss this in greater detail in the chapter on sustainability. In addition, the development of greater job opportunities in rural areas could also decrease the number of workers who relocate to urban areas looking for better job opportunities.

State and local governments also try to mitigate the environmental impacts of community sprawl by acquiring land and conservation easements.[65] Some state and local governments have ambitious land acquisition programs to purchase lands and conservation easements to preserve key natural and cultural areas, to protect T&ES habitat, to form parks, and to create greenways. For example, Florida has been acquiring land through the Florida Forever land acquisition program, a 10-year, $3 billion, land conservation program established by the governor and the Florida legislature.

Land trusts, environmental conservation groups, and other NGOs also actively work to address sprawl and preserve habitat and open space, including farm and ranch lands. A land trust is "a nonprofit organization that, as all or part of its mission, actively works to conserve land by undertaking or assisting direct land transactions—primarily the purchase or acceptance of donations of land or conservation easements."[66] As noted in this definition, land trusts also purchase lands directly and may donate such lands to federal, state, or local governments to manage for conservation purposes, such as parklands. These conservation easement and land acquisition approaches have become so popular to help address sprawl problems that there are numerous national, regional, and local land trusts. Efforts to preserve farm and ranch lands are a key driver for some land trusts and conservation easements because of the impact sprawl has on U.S. farms and ranches, as discussed earlier and shown in Figure 2.4.

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[64] Douglas R. Porter, *Managing Growth in America's Communities*, Washington, D.C.: Island Press, 1997..

[65] A conservation easement is a deed restriction landowners voluntarily place on their property to protect in perpetuity the conservation values of the land.

[66] Land Trust Alliance, *National Land Trust Census*, Washington, D.C., September 12, 2001.

In 2005, there were 1,667 land trusts in operation in the United States, a 32 percent increase from 2000.[67] The pace of private land conservation has tripled by local and state land trusts. From 1995 to 2000, land trusts conserved an average of 337,937 acres per year. That pace soared to 1,166,697 million acres conserved per year, on average, from 2000 to 2005. [68] These organizations have had some impressive results. Total acres conserved by U.S. land trusts increased 54 percent to 37 million acres from 2000 to 2005.[69] National land trusts examples are: The Trust for Public Land (TPL), American Farmland Trust, The Conservation Fund, and The Nature Conservancy (TNC).

Interrelationship with Other Trends

Urbanization, increased development and sprawl are closely interrelated to other trends we examine in this report, including biodiversity loss, water scarcity, and sustainable communities. Urbanization can lead to biodiversity loss, and it can also negatively impact the quality and quantity of water, leading to water scarcity. Already, 8 percent of vertebrate species in the United States have been labeled as "endangered" due to the effects of rapid urban development, and that number may continue to rise with new urban expansion and growth.[70] Later in this report we focus on trends toward sustainable communities that mitigate some pressures caused by urbanization.

Implications of Urbanization and Development for Army Installations

Before we discuss the implications for Army installations, we should point out that the Army has recognized encroachment pressures from sprawl and other factors and is trying to address them in a number of activities. Before discussing this Army context, we present a definition of and overview of encroachment issues from a military perspective.

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[67] Founded in 1982 as a national alliance of land trust organizations, LTA provides resources and training to America's nonprofit land trusts. For more information on LTA see its website, http://www.lta.org/.

[68] Land Trust Alliance, "Talking Points on 2005 National Land Trust Census and Related Trends with Land Trusts."

[69] Land Trust Alliance, 2005 *National Land Trust Census*, Washington, D.C., November 30, 2006.

[70] McDonald, Kareiva, and Forman, 2008.

Definition of Encroachment

"Encroachment can be defined as issues external to military operations that affect or can affect military installation testing, training, and other operations and overall military readiness."[71] In 2007, Army Regulation 200-1 defined encroachment as follows:

> All external influences threatening or constraining testing and training activities required for force readiness and weapons acquisition. Such encroachment stems from environmental (for example, noise, endangered species, cultural resources, UXO, and munitions constituents (MC)), social (for example, urban sprawl), and economic (for example, changing land values) influences.[72]

This Army definition also started to define some of the encroachment threats. OSD and the Services have identified a broad range of encroachment threats and issues:

- urban growth around military installations
- noise pollution
- endangered species and critical habitat
- wetlands
- water quality and supply
- air pollution and quality
- cultural resources
- maritime competition
- competition for airspace
- competition for radio frequency spectrum
- unexploded ordnance and munitions constituents
- energy production.[73]

Many of these issues are caused or accelerated because of community sprawl near an installation. Encroachment concerns evolve and change over time.[74] Such encroachment factors have affected military operations in four main ways: (1) they cause testing, training, and other operational restrictions, (2) they increase operational costs, especially for testing and training exercises, (3) they cause community complaints and damage claims, and (4) they

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[71] Lachman et al., 2007, p. 3.

[72] Department of the Army, "Army Regulation 200–1, Environmental Protection and Enhancement," December 13, 2007.

[73] Lachman et al., 2007, pp. 3–4.

[74] For example, energy production facilities were not originally on OSD's list, but OSD and many installations recognize that they can be a potential encroachment threat as well, such as windmill farms potentially causing interference with helicopter training.

degrade military readiness.[75] The Army has found that more than 40 percent of its installations report encroachment issues.[76] Most military installation encroachment problems have been caused by two main factors: sprawl and loss of biodiversity.[77] Sprawl is the more significant of the two, since it contributes to biodiversity loss and many other encroachment issues. In fact, one Army source states that "Encroachment is defined as urban development surrounding military installations that affects the ability of the military to train realistically."[78]

Army Activities to Address Encroachment Caused by Sprawl

The Army has implemented a range of activities to address encroachment because of a range of Army policies and guidance, such as those specified by Army Regulation 200–1,Environmental Protection and Enhancement.[79] As discussed earlier, the Army has been implementing ecosystem management to minimize and prevent habitat and species encroachment concerns, i.e., biodiversity loss and T&ES problems. The Army also has developed and been implementing the Army Compatible Use Buffer (ACUB) program to help mitigate and prevent encroachment related to land development and use. This activity is the one most directly relevant to addressing the community sprawl problem. ACUB allows Army installations to use funds to enter into partnership agreements with county, state, or municipal governments, as well as with nonprofit organizations, for the partner to purchase tracts of land or easements on lands from willing sellers to establish buffers around installations to maintain current land uses or to protect habitat. Buffer areas are established around Army installations to limit the effects of encroachment by preventing commercial and residential activities along installation boundaries and to maximize use of land inside the installation to support the training and testing mission of installations. In addition, ACUB

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[75] Categorization from Lachman et al., 2007, and U.S. General Accounting Office, *Military Training: DOD Lacks a Comprehensive Plan to Manage Encroachment on Training Ranges*, GAO-02-614, Washington, D.C., June 2002.

[76] U.S. Army, "Army Compatible Use Buffer Program (ACUB)" website..

[77] Lachman et al., 2007.

[78] U.S. Army, "Army Compatible Use Buffer Program (ACUB)" website.

[79] AR 200-1 provides policy for different environmental encroachment issues, from noise to managing T&ES. For example, it states, "Manage operational noise issues and community relations to maintain sustainable testing and training capabilities and prevent encroachment." Department of the Army, "Army Regulation 200–1, Environmental Protection and Enhancement," December 13, 2007, p. 43. For more about Army encroachment guidance, see Office of the Assistant Chief of Staff for Installation Management "Interim Army Implementation Guidance for Encroachment Authorities," DAIM-ISE Memo, February 24, 2012.

activities support the Army's effort to comply with the federal Endangered Species Act, and help prevent future threatened and endangered species listings, which could restrict the training and testing mission of installations. For example, at Fort Campbell, ACUB has been used to protect 248 acres, which will prevent incompatible development from encroaching on night-vision and aviation training. The property, which was formerly threatened by residential development, will remain a working farm.[80] ACUB has also been used to preserve much of a 1,300 acre property adjacent to Fort A.P. Hill in Virginia. The property was within a high-noise area and has been designated a National Historic Landmark due to the artifacts that have been found there.[81]

Implications for the Army

All these urbanization, development, and sprawl trends mean that more people are moving closer to more Army installations. Most parts of the country are no longer remote areas far from any type of residential developments. As a result, installations come under increasing pressures from suburban and rural sprawl. According to a June 2002 Government Accountability Office (GAO) report on military training, 80 percent of communities surrounding military installations were growing faster than the national average.[82] Sprawl and other land development pressures near U.S. installations are likely to continue. Land is a finite resource that continues to be developed, and installations that were once isolated in remote rural areas are no longer isolated. This will result in more encroachment pressures from the surrounding communities.[83]

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[80] *Readiness and Environmental Protection Initiative: Conservation and Compatible Land Use Partnering*, Fourth Annual Report to Congress, Washington, D.C.: Department of Defense, March 2010, p. 15.

[81] *Readiness and Environmental Protection Initiative: Conservation and Compatible Land Use Partnering*, Fourth Annual Report to Congress, Washington, D.C.: Department of Defense, March 2010, pp. 14–15.

[82] See U.S. Government Accountability Office, (GAO), *DOD Report on Training Ranges Does Not Fully Address Congressional Reporting Requirements*, GAO-04-608, Washington, D.C.: Government Printing Office, June 2004, p. 20.

[83] It should be noted that sometimes a large military mission and population growth at an Army installation can contribute to encroachment pressures near that installation, especially in less urban areas. For example, at Fort Bragg, a principal training installation for Special and Airborne Forces, has now absorbed two major headquarters (Forces Command and U.S. Army Reserve Command) that were formerly located at Fort McPherson in Atlanta. Thus thousands of office workers and their families now have been added to the pressure on the local community to provide homes, schools, retail, recreation, and other amenities for them in the communities around Fort Bragg.

Encroachment pressures from development trends have already created a range of problems on installations including environmental issues and operational issues. For instance, encroachment can lead to water and air quality problems, increased pressure on threatened and endangered species, and stress on vulnerable ecosystems such as wetlands. Encroachment can also threaten training, testing, and other operations on installations if noise and other community complaints increase and if competition for radio frequency spectrum and airspace increases as surrounding communities move closer to the installation.

Another implication of increased development is that communities surrounding installations will likely be less economically dependent on those installations. This may bring some new neighbors who know less about the Army and who may not be as supportive of installation operations. Therefore, community relationships will likely become more important to the Army. In order to mitigate these future encroachment concerns, the Army needs to take strategic actions now.

Recommendations

The Army needs to strategically and aggressively address future encroachment now to preserve training and testing areas, maintain installation operational flexibility, and save money over the long term. More emphasis needs to be placed on preventing and mitigating future encroachment concerns now because of the implications of surrounding community growth, loss of biodiversity trends, climate change impacts, and future Army training, testing, and other land use needs.

The Army should establish a high-level organizational element focused on encroachment that is responsible for integrating efforts across different parts of the Army. Currently, Army training, environmental, and community outreach organizations, as well as those concerned with frequency spectrum issues, all have roles in addressing encroachment concerns. There needs to be more coordination between these different organizations regarding encroachment. ACSIM should take a lead role in working with other parts of the Army, including HQDA G-3, to establish such a coordinating organization. ACSIM already has a work group to focus on the ACUB process across different parts of ACSIM. This work group could potentially be expanded by involving other relevant parts of the Army to become the recommended HQDA encroachment organization. Successful Army sustainable installations activities, which have focused on integrating activities across different Army organizational stovepipes, could also serve as a model for such an organizational element.

The Army should develop an integrated, comprehensive, and strategic encroachment action plan that includes diverse effective ways to address different encroachment factors and involves all relevant parts of the Army. Again, ACSIM should take a lead role in developing an encroachment action plan and work closely with IMCOM and other parts of the Army to ensure that it is comprehensive in addressing all Army stakeholder interests and the full range of encroachment threats.

The Army should implement more buffering and other mitigation activities, including dedicated funding for ACUB. With declining Army budgets, such funding may not seem like a priority, but given the fact that it is an up-front investment that can help prevent encroachment, it should be made before the opportunity is lost. With a slow real estate market, the Army has a unique opportunity now to prevent some future encroachment by making land deals. This will cost the Army a lot more or even be impossible to do in the future once the real estate market picks up again. For example, if a developer buys a thousand-acre farm next to an Army training area and puts up one thousand new homes, the opportunity to preserve that land as buffer space is lost.

Lastly, the Army should also conduct a study to identify which installations are most at risk for future biodiversity loss and species issues to help focus resources now, especially with respect to ACUB and other land deals.

Sources for Tracking Urbanization and Development Trends

Organizations That Track Trends in Urbanization and Sprawl

Some of the same organizations that track biodiversity loss, such as *International Union for Conservation of Nature*, *Nature Conservancy*, and *NatureServe*, also track trends in urbanization and sprawl. In addition, the following organizations also track such trends.

Worldwatch Institute is an independent research organization that focuses on three programmatic areas: climate and energy, food, and agriculture, and the green economy. One of the issues that Worldwatch Institute has focused on is population growth and how to meet the needs that arise from it. Worldwatch Institute produces interdisciplinary research that is disseminated in more than 20 languages.

American Farmland Trust works to stop the loss of American farmland, promote healthy farming practices, and support farmers and their families. The organization disseminates information on the rate of farmland loss in the United States. It has partnered with the USDA Natural Resources Conservation Service to develop the Farmland Information Center (FIC), a clearinghouse for information about farmland protection and stewardship.[84]

[84] See the Farmland Information Center website at http://www.farmlandinfo.org.

The USDA *Natural Resources Conservation Service* (NRCS) was originally established by Congress in 1935 as the Soil Conservation Service (SCS). It now works to ensure that private lands in the United States are conserved, restored, and more resilient to environmental challenges.[85] The NRCS has natural resources conservation programs to help people reduce soil erosion, enhance water supplies, improve water quality, increase wildlife habitat, and reduce damages caused by floods and other natural disasters.

Studies and Reports on Urbanization, Development, and Sprawl

The National Intelligence Council's *Global Trends 2025: A Transformed World* (2008) report focuses on the potential U.S. national security implications of global urbanization. The report warns that urbanization can lead to instability and conflict.

The United Nations' *World Urbanization Prospects: The 2007 Revision Population Database, 2007* (2007) reports the findings of a comprehensive UN effort to assess rural versus urban population distribution and growth rates across the globe.[86] The World Urbanization Prospects database is extremely helpful in finding country and regional level data on population distribution and growth rates.

Endangered by Sprawl: How Runaway Development Threatens America's Wildlife (2005) presents the findings of a report sponsored by the American Wildlife Federation, Smart Growth America, and NatureServe.[87] The report identifies risks to wildlife, examines how smarter growth can generate benefits (such as increased tax revenue), and provides examples of cutting-edge ecosystem inventories and regional cooperation.

American Farmland Trust's report on *Working to Preserve Farm, Forest and Ranch Lands: A Guide for Military Installations* (2006) was developed to inform installation commanders of different land use options and ways to preserve land in and around installations. The report offers a helpful primer that lays out different conservation options and the mechanisms to implement them.

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[85] See National Resources Conservation Service website at http://www.nrcs.usda.gov.

[86] See the United Nations World Urbanization Prospects database at http://esa.un.org/unup/.

[87] R. Ewing, J. Kostyak, D. Chen, B. Stein, and M. Ernst, *Endangered by Sprawl: How Runaway Development Threatens America's Wildlife*, Washington, D.C.: National Wildlife Federation, Smart Growth America, NatureServe, 2005.

Climate Change

In this section we discuss climate change and the key trends related to climate change. We begin this discussion with a brief introduction and background on why climate change is important to the military.

Climate Change and National Security

The Intergovernmental Panel on Climate Change (IPCC), the international body charged with assessing the scientific evidence related to climate change, defines climate change as:

> a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.[88]

Climate change is not a new issue on the national public policy agenda. Scientists started seeing signs of climate change in the mid-1980s.[89] While the potential environmental impacts of climate change have been debated over the last two decades, policymakers in the Department of Defense (DoD) and across other U.S. government agencies have increasingly begun to focus on the potential security implications of climate change.[90]

For instance, in the 2010 *Quadrennial Defense Review* (QDR), the potential impacts of climate change received more attention than ever before. The QDR identified climate change as a "powerful trend that is likely to add complexity to the [future] security environment."[91] The QDR claims that climate change is concerning because while it may not cause conflict, it could act as an "accelerant of instability or conflict."[92] The 2010 QDR cites two ways in which climate change will affect DoD specifically: (1) it will shape the operating environment, roles, and missions that DoD will undertake; and (2) DoD will need to adjust

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[88] Intergovernmental Panel on Climate Change, *Climate Change 2007: Synthesis Report*, 2007, p. 30.

[89] See World Meteorological Organization (WMO), "Report of the International Conference on the Assessment of the Role of Carbon Dioxide and of Other Greenhouse Gases in Climate Variations and Associated Impacts," Villach, Austria, 1986, and "Statement of Dr. James Hansen, Director, NASA Goddard Institute for Space Studies," 1988.

[90] See U.S. Joint Forces Command, *The Joint Environment*, 2010.

[91] U.S. Department of Defense, *2010 Quadrennial Defense Review*, Washington, D.C.: Department of Defense, 2010, p. 7. .

[92] U.S. Department of Defense, 2010, p. 85.

to the impacts of climate change on its facilities and military capabilities.[93] In 2008, the National Intelligence Council (NIC) had indicated that more than 30 U.S. military installations were already facing elevated levels of risk from rising sea levels.[94] The potential impacts of climate change pose a significant threat that could affect DoD's operational readiness and training; therefore it is a trend that is examined in this report.

Key Climate Change Trends

Given current conditions, it is likely that climate change will impact Army installations in the 2015–2025 timeframe. There is increasing evidence that the effects of climate change are already being felt around the world. In addition, more scientific evidence indicates that the effects of climate change will not be fully felt until the middle of this century.

Scientific Evidence Indicates That Climate Change Is Increasing

Over the last two decades, there has been debate over whether the Earth's climate is actually changing and, if it is, whether this change is caused by natural fluctuations in the Earth's climate or by human actions. In 2007, the Intergovernmental Panel on Climate Change (IPCC) weighed in on this debate by definitively stating that "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level."[95] In addition, the IPCC found that "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."[96] The Organization for Economic Cooperation and Development (OECD) later estimated that global emissions of greenhouse gases are likely to grow by another 52 percent by 2050.[97] Greenhouse gas emissions include carbon dioxide, methane, tropospheric ozone, CFCs, and nitrous oxide.

In 2008, the National Intelligence Council (NIC) identified climate change as a significant trend that is already occurring and that will have a major impact on the international security environment in 2025. In particular, the NIC also said that in the future, climate change is likely to exacerbate resource scarcities around the globe, particularly water

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[93] U.S. Department of Defense, 2010, pp. 84–85.
[94] U.S. Department of Defense, 2010, pp. 84–85.
[95] Intergovernmental Panel on Climate Change, 2007, p. 30.
[96] Intergovernmental Panel on Climate Change, 2007, p. 39.
[97] Organization for Economic Cooperation and Development, O*ECD Environmental Outlook to 2030*, Paris: OECD, 2008, p. 4.

scarcities and the loss of agricultural land.[98] The NIC also cited various studies that cautioned that by the middle of the century, 200 million "climate migrants" may be permanently displaced due to climate change. This would represent a tenfold increase over the world's current documented refugee and internally displaced populations.[99]

In 2009, the United States Global Change Research Program, composed of 13 U.S. federal agencies, echoed the IPCC's 2007 findings by stating:

> Observations show that warming of the climate is unequivocal. The global warming observed over the past 50 years is due primarily to human-induced emissions of heat-trapping gases. These emissions come mainly from the burning of fossil fuels (coal, oil, and gas), with important contributions from the clearing of forests, agricultural practices, and other activities.[100]

The United States Global Change Research Program also found that the global average temperature has risen by about 1.5°F since 1900 and projected the temperature to rise another 2 to 11.5°F by 2100.[101]

Global Implications of Climate Change

One of the most often cited indicators of climate change is the recent rapid rate of glacial melting. For instance, the National Snow and Ice Data Center has suggested that the Arctic will be ice-free in the summers by 2060, while more recent research has suggested that the date could be as soon as 2013.[102] Notwithstanding the controversy over the rate of glacial melt in the IPCC's *2007 Assessment Report*, there is a large body of scientific evidence indicating that glaciers around the world are melting more rapidly and that the implications of this melting include enlargement of glacial lakes, changes in some Arctic and Antarctic ecosystems, and potential sea level rise.[103]

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[98] National Intelligence Council, 2008, p. viii; pp. 51–54.

[99] See N. Myers, "Environmental Refugees: An Emergent Security Issue*,"* 13th Economic Forum, Prague, May 2005; also see N. Stern (ed.), *The Economics of Climate Change: The Stern Review,* Cambridge: Cambridge University Press, 2006, p. 3.

[100] United States Global Change Research Program, *Global Climate Change Impacts in the United States*, New York: Cambridge University Press, 2009, p. 7; pp. 13–14.

[101] United States Global Change Research Program, 2009, p. 24.

[102] National Intelligence Council, 2008, p. 53.

[103] See D.W. Pierce, T.P. Barnett, K.M. AchutaRao, P.J. Gleckler, J.M. Gregory, and W.M. Washington, "Anthropogenic Warming of the Oceans: Observations and Model Results," *Journal of Climate*, Vol. 19, No. 10, 2006, pp. 1873–1900. Also see S.B. Luthcke, H.J. Zwally, W. Abdalati, D.D. Rowlands, R.D. Ray, R.S. Nerem, F.G. Lemoine, J.J. McCarthy, and D.S. Chinn, "Recent Greenland Ice Mass Loss by Drainage System from Satellite Gravity Observations," *Science*, Vol. 314, No. 5803, 2006, pp. 1286–1289.

In 2004, a landmark article estimated that between 15 and 37 percent of known plant and animal species will be "committed to extinction" by 2050.[104] Some species extinctions have already been linked to climate change. For instance, about two-thirds of the 110 known harlequin frog species are believed to have vanished during the 1980s and 1990s due to a fungus that thrives at higher temperatures.[105] A study released in March 2010, estimated that 20 percent of all lizard species could go extinct by 2080.[106] Other species that face potential extinction due to climate change include coral reefs,[107] king penguins,[108] and polar bears.[109]

Other global implications of climate change include: changes in precipitation,[110] extreme temperatures and heat spells that could alter patterns of monsoon rains,[111] shifts in agricultural patterns;[112] and an increase in waterborne diseases such as cholera and hepatitis, as well as diseases carried by insects such as malaria.[113]

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[104] C.D. Thomas, A. Cameron, R.E. Green, M. Bakkenes, L.J. Beaumont, Y.C. Collingham, B.F.N. Erasmus, M.F.D. Siqueira, A. Grainger, and L. Hannah, "Extinction Risk From Climate Change," *Nature,* Vol. 427, No. 6970, 2004, pp. 145–148.

[105] J. Alan Pounds et al., "Widespread Amphibian Extinctions from Epidemic Disease Driven by Global Warming," *Nature*, Vol. 439, January 2006, pp. 161–167.

[106] Barry Sinervo et al., "Erosion of Lizard Diversity by Climate Change and Altered Thermal Niches," *Science*, Vol. 328. No. 5980, 2010, pp. 894–899.

[107] O. Hoegh-Guldberg et al., "Coral Reefs Under Rapid Climate Change and Ocean Acidification," *Science*, Vol. 318, No. 5857, 2007, pp. 1737–1742.

[108] Celine Le Bohec et al., "King Penguin Population Threatened by Southern Ocean Warming," *Proceedings of the National Academy of Sciences of the United States*, Vol. 105, No. 7, 2008, pp. 2493–2497.

[109] Kassie Siegel, Climate, Air, and Energy Program Director, Center for Biological Diversity, Testimony to the U.S. House of Representatives Select Committee on Energy Independence and Global Warming, January 17, 2008, "On Thin Ice: The Future of the Polar Bear."

[110] X. Wang, F. Chen, and Z. Dong, "The Relative Role of Climatic and Human Factors in Desertification in Semiarid China," *Global Environmental Change*, Vol. 16, 2006, pp. 48–57.

[111] "How Will Climate Change Affect India's Monsoon Season?" *ScienceDaily*, March 12, 2007.

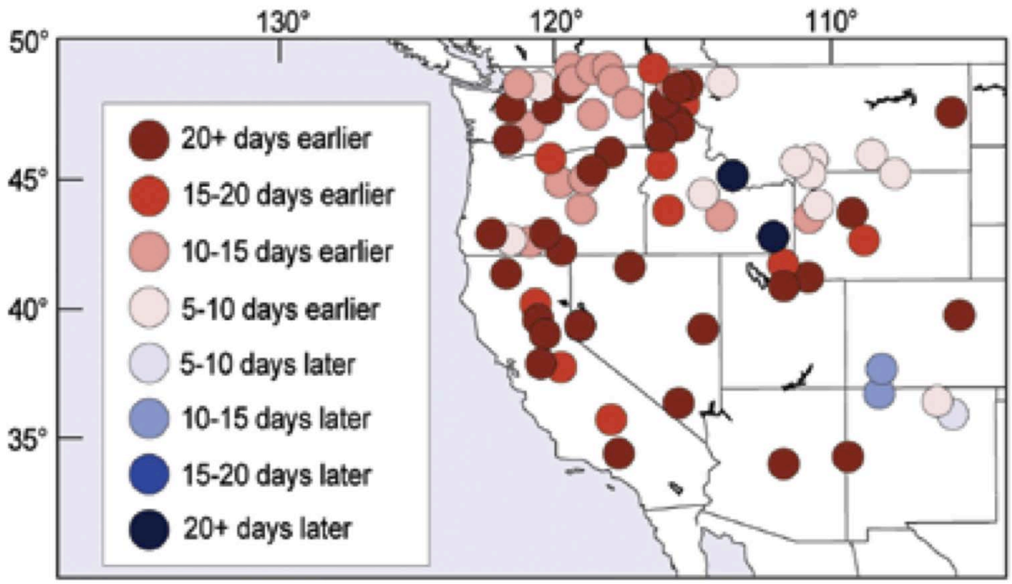
[112] M. Lal, "Implications of Climate Change on Agricultural Productivity and Food Security in South Asia," in *Key Vulnerable Regions and Climate Change—Identifying Thresholds for Impacts and Adaptation in Relation to Article 2 of the UNFCCC*, Dordrecht: Springer, 2005.

[113] P.R. Hunter, "Climate Change and Waterborne and Vector-Borne Disease," *Journal of Applied Microbiology*, Vol. 94, 2003, pp. 37S–46S. Also see A.J. McMichael, D.H. Campbell-Lendrum, C.F. Corvalan, K.L. Ebi, A.K. Githeko, J.D. Scheraga, and A. Woodward (eds.), *Climate Change and Human Health—Risks and Responses*, Geneva: World Health Organization, 2003, p. 333.

Climate Change Is Already Impacting the United States

There is also increasing evidence that climate change is already impacting the United States. For instance, there is evidence that snowfall and rainfall patterns are changing. There is also evidence that spring in the United States now arrives an average of 10 days to two weeks earlier than it did 20 years ago (see Figure 2.5).[114]

Figure 2.5
Observed Snowmelt Dates



SOURCE: United States Global Change Research Program, *Global Climate Change Impacts in the United States*, New York, Cambridge University Press, 2009, p. 32.

As much as 75 percent of water supplies in the western United States are derived from snowmelt,[115] therefore the western part of the United States is particularly vulnerable to changes in the volume of snowpack as well as changes in when that snowpack melts. Widespread temperature-related reductions in snowpack in the West have already been observed,[116] and the snowpack is also melting earlier.[117] This has caused recurring drought in some places in the West

[114] United States Global Change Research Program, 2009, p. 80.

[115] U.S. Geologic Survey, *Changes in Streamflow Timing in the Western United States in Recent Decades,* Fact Sheet 2005–3015, March 2005.

[116] S. Feng and Q. Hu, "Changes in Winter Snowfall/Precipitation Ratio in the Contiguous United States," *Journal of Geophysical Research*, Vol. 112, 2007, p. D15109.

[117] See U.S. Geologic Survey, 2005, p. 4.

(particularly the Southwest), and it has also resulted in lower groundwater tables.[118] Increased stress on groundwater systems has led to decreased recharge of aquifers, raising concerns over the safety of drinking water supplies in the West.[119]

In addition, the ski industry in the West is also vulnerable to changes in the volume of snowpack. The state of Colorado has estimated that with no reductions in greenhouse gases, the snowpack at major ski resorts in that state will be reduced by at least half by 2085 (see Table 2.1).

Table 2.1
Projected Loss in Snow Pack by 2085 with
No Greenhouse Gas Reductions

Resort	Loss in Snowpack
Telluride	82 percent
Vail and Beaver Creek	57 percent
Winter Park	54 percent
Breckenridge and Copper Mountain	50 percent

SOURCE: Colorado Office of Economic Development and International Trade, *Colorado Data Book,* Denver: COED&IT, 2006.

Such decreases in snowpack in Colorado are particularly significant because the state's economy is so tied to the ski industry. Just a 1 percent annual decrease in the amount of tourists visiting Colorado's ski resorts could produce a loss of more than $375 million and 4,500 jobs by 2017.[120]

Alaska is also vulnerable to warming temperatures. Alaska has already seen reductions in the extent of seasonally frozen ground and permafrost, which has resulted in the disappearance of lakes due to draining within the permafrost[121] and a decrease in potential

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[118] State of Washington Department of Ecology, "Reduced Snowpack and Earlier Runoff."

[119] National Science and Technology Council, Committee on Environment and Natural Resources, *Scientific Assessment of the Effects of Global Change on the United States*, Washington, D.C., 2008, p. 12.

[120] See Colorado Office of Economic Development and International Trade, *Colorado Data Book,* Denver: COED&IT, 2006.

[121] K. Yoshikawa and L.D. Hinzman, "Shrinking Thermokarst Ponds and Groundwater Dynamics in Discontinuous Permafrost," *Permafrost Periglac.,* Vol. 14, No. 2, 2003, pp. 151–160.

travel days of vehicles over frozen roads in Alaska.[122] The state is so worried about the potential impacts of climate change that in 2007, Governor Palin created the Climate Change Sub-Cabinet to advise the Office of the Governor on the preparation and implementation of an Alaska climate change strategy.

In addition to impacts mentioned above, there is mounting evidence that climate change is impacting plants and animals in the United States. For instance, there is evidence that many migratory bird species are arriving in the United States earlier than ever before and that the ranges of many bird species here have shifted northward and upward in elevation. A study of northeastern birds that migrate long distances found that birds wintering in the southern United States now arrive back in the Northeast an average of 13 days earlier than they did during the first half of the last century. Birds wintering in South America arrive back in the Northeast an average of four days earlier.[123]

There is also evidence that climate change is accelerating the extinction of some species in the United States. For instance, extinctions of two populations of the checkerspot butterfly in the San Francisco Bay area have been attributed to increased precipitation variability due to climate change.[124] Climate change has also been cited as the cause for a drop in the population of three of four species of amphibian once common to Yellowstone National Park.[125]

Climate change also can affect biogeography, i.e., the geographical distribution of plants and animals. For example, warmer winter temperatures permit summer expansion out of existing ranges and colonization of new areas. For instance, invasive species, such as the Mountain Pine Beetle in Colorado, are expanding their range in pine forests.[126] As trees die

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[122] Intergovernmental Panel on Climate Change, "Chapter 3: Linking Climate Change and Water Resources: Impacts and Responses," in *Climate Change and Water,* IPCC Technical Paper VI, 2007, p. 35.

[123] A. Janetos, L. Hansen, D. Inouye, B.P. Kelly, L. Meyerson, B. Peterson, and R. Shaw, "Biodiversity," in P. Backlund et al., *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States*, Synthesis and Assessment Product 4.3, Washington, D.C.: U.S. Department of Agriculture, 2008, pp. 151–181.

[124] John F. McLaughlin et al., "Climate Change Hastens Population Extinctions," *Proceedings of the National Academy of Sciences*, Vol. 9, 2002, pp. 6070–6074.

[125] Sarah K. McMenamin, Elizabeth A. Hadly, and Christopher K. Wright, "Climatic Change and Wetland Desiccation Cause Amphibian Decline in Yellowstone National Park," *Proceedings of the National Academy of Sciences*, Vol. 105, No. 44, 2008, pp. 16988–16993.

[126] D.A. Leatherman, I. Aguayo, and T.M. Mehall, "Mountain Pine Beetle," Colorado State University Extension, April 3, 2012.

from these infestations, erosion increases because ground cover decreases. With increased erosion, water quality suffers in all downstream areas.

Predictions of Future Climate Change Impacts in the United States

Many of the current trends identified above are predicted to continue in the future. For instance, a continued northward shift in the ranges of plant and animal species is predicted,[127] along with earlier snowmelt and significant reductions in snowmelt.[128]

Projections of future precipitation generally indicate that northern areas of the United States will become wetter, and southern areas, particularly in the West, will become drier (see Figure 2.6).[129]

Some have even predicted that climate change will cause a permanent drought in the American Southwest.[130] This could lead to an increased potential for wildfires.[131] On the coasts, scientists anticipate increased coastal erosion, loss of wetland habitat, and increased risk of storm surges from sea level rise.[132]

Warmer temperatures and increased evaporation could lead to lowered lake and river levels, affecting both recreation and shipping.[133] Warming lake and river temperatures could also lead to a decrease in water quality, which could lead to eutrophication, habitat loss, and reductions in many fish stocks.[134]

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[127] Intergovernmental Panel on Climate Change, 2007, p. 33.

[128] K. Hayhoe, C.P. Wake, T.G. Huntington, L. Luo, M.D. Schwartz, J. Sheffield, E. Wood, B. Anderson, J. Bradbury, A. DeGaetano, T.J. Troy, and D. Wolfe, "Past and Future Changes in Climate and Hydrological Indicators in the U.S. Northeast," *Climate Dynamics*, Vol. 28, No. 4, 2007, pp. 381–407; see also I.T. Stewart, D.R. Cayan, and M.D. Dettinger, "Changes in Snowmelt Runoff Timing in Western North America Under a 'Business as Usual' Climate Change Scenario," *Climatic Change*, Vol. 62, No. 1-3, 2004, pp. 217–232.

[129] United States Global Change Research Program, 2009, p. 30.

[130] Richard Seager et al., "Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America," *Science*, Vol. 316, No. 5828, 2007, pp. 1181–1184.

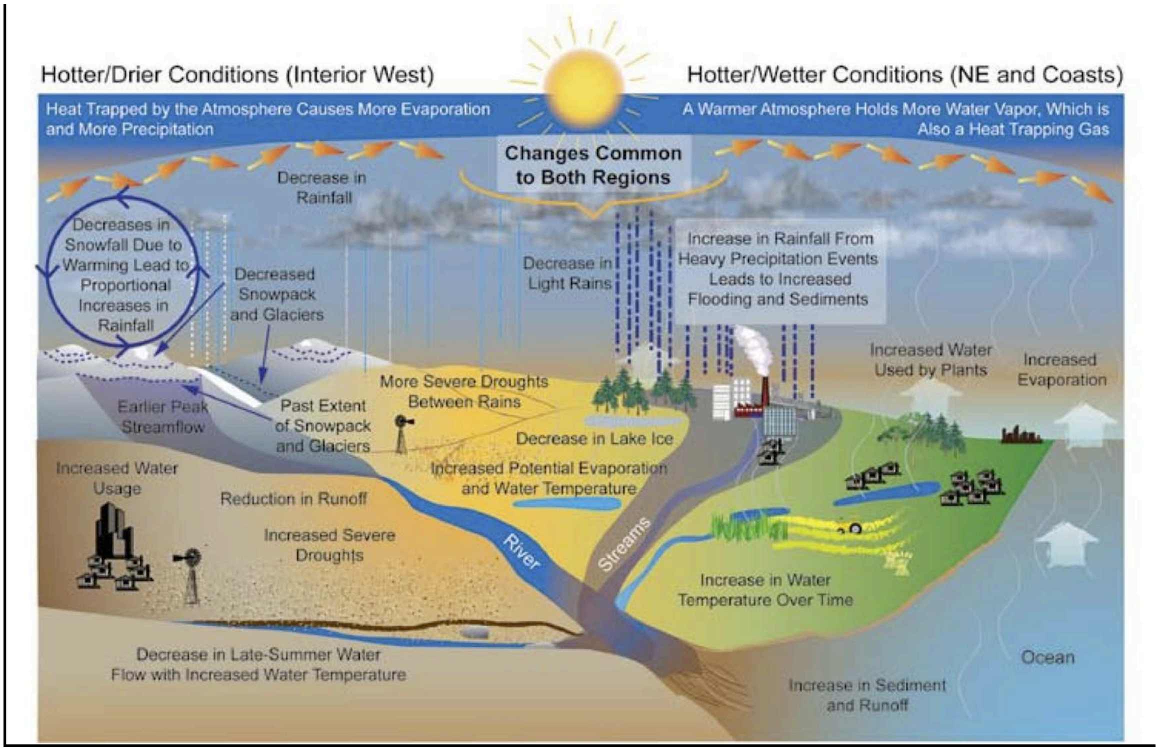
[131] United States Global Change Research Program, 2009, p. 66; also see National Science and Technology Council, Committee on Environment and Natural Resources, *Scientific Assessment of the Effects of Global Change on the United States*, Washington, D.C., 2008, pp. 15-16.

[132] National Science and Technology Council, 2008, p. 69.

[133] United States Global Change Research Program, 2009, p. 49.

[134] A. Janetos et al., "Biodiversity," in P. Backlund et al. (eds.), *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States*, Synthesis and Assessment Product 4.3, Washington, D.C.: U.S. Department of Agriculture, 2008, pp. 151–181.

Figure 2.6
Projected Changes in the Water Cycle Due To Climate Change



SOURCE: United States Global Change Research Program, *Global Climate Change Impacts in the United States,* New York, Cambridge University Press, 2009, p. 42.

What Could Change the Course of Climate Change Trends

The main factors that most scientists believe could alter climate change trends are efforts by individual countries, industry, and the international community to reduce greenhouse gas emissions. While the full brunt of the impacts of climate change may not be felt for decades, most domestic and international policy efforts to mitigate climate change have focused on decreasing the amount of greenhouse gases that are emitted into the atmosphere. In both the domestic and international policy debates, both a carbon tax and a cap-and-trade system have been considered at various times. The United States has unilaterally chosen to decrease greenhouse gases by placing renewed emphasis on energy conservation and cleaner, renewable energy sources such as wind and solar.

Among the international community, tensions have arisen between economic growth and environmental protection. The European Union has been one of the strongest advocates for a global agreement on climate change. However, China and India have opposed international monitoring of emission levels and binding emission cuts. Fueled by economic growth, China is now the world's largest energy producer and the largest emitter of carbon dioxide. Both China and India have claimed that binding cuts would stifle the economic growth that those countries have been experiencing.

Some have proposed geo-engineering, or the deliberate manipulation of physical, chemical, or biological aspects of the Earth, as another set of potential solutions to climate change. Geo-engineering techniques that have been proposed include (1) underground storage of carbon dioxide, (2) wind scrubbers to filter carbon dioxide from the air, (3) "fertilization" of oceans with iron to encourage growth of plankton, (4) petrification of carbon dioxide, and (5) deflection of sunlight from the earth through the use of a giant space mirror spanning 600,000 square miles. These proposed solutions have not gained traction within the international community because they are highly controversial due to the uncertainty regarding their feasibility and safety.[135]

Given difficulties in reaching an international agreement, as well as strong industry and political pressures in many nations against climate change mitigation actions, it is unlikely that there will be significant changes in climate change trends in the immediate future. However, as more scientific evidence illuminates the impacts of climate change and if more problems are directly tied to climate change, more pressure may develop to address the climate change problem.

Interrelationship with Other Trends

Climate change is clearly closely intertwined with other issues such as water scarcity, loss of biodiversity, and sustainable agriculture and food production. Climate change could potentially accelerate water scarcity and loss of biodiversity in certain regions of the United States and the world. Given potential changes in future precipitation and agricultural patterns, climate change could elevate the need for sustainable agriculture/sustainable food production if traditional breadbaskets of agriculture are no longer as productive as they once were.

In addition, climate change is also closely interrelated to energy trends because many current energy trends have been influenced by the perceived need to mitigate against climate change and to minimize greenhouse gas emissions.

Implications of Climate Change for Army Installations

Army installations are likely to experience many of the impacts of climate change. First and foremost, some installations will feel the direct physical impacts of climate change. Such local impacts could include declining water supply, flooding, more uncertainty and wider

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[135] See J. Michael T. Thompson and Brian Launder, *Geo-engineering Climate Change: Environmental Necessity or Pandora's Box?* Cambridge, UK: Cambridge University Press, 2010.

fluctuations in temperatures, changes in habitat, and the subsequent changes to the installation training environment. For instance, installations with part of their property along the coastline or at sea level, like Aberdeen Proving Ground, may need to prepare for potential sea level rise. Climate change will also affect water quantity and quality and the suppliers in the Army's supply chain. For instance, installations located in the American southwest, such as Fort Huachuca, or southeast may need to prepare and plan for extended drought conditions. This, in conjunction with fluctuating temperatures, could potentially have an impact on installations' water supplies or their training environments. The loss of habitat or biodiversity due to climate change could also place additional pressures on the Army to protect threatened or endangered species. Loss of habitat could also affect training environments, for example by causing the loss of natural vegetation.

In addition to these physical changes, Army installations will also feel the impacts of broader energy trends that are intertwined with climate change. For example, given limited supplies of fossil fuels as well as increasing domestic and international pressure to limit greenhouse gas emissions, energy prices are likely to rise in the future. This may increase calls for increased energy conservation or carbon taxes, and it may make investment in renewable energy more economically feasible. Taken together, these energy and climate change trends could increase the importance of energy conservation in Army installation construction and operations. Many of the effects of climate change will be felt in these other areas, such as energy management, natural resource pressures, and water management.

Research About Climate Change's Impact on Military Installations

There are research organizations that are trying to understand these likely effects on Army and other Services' installations. The Department of Defense's environmental research programs—the Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP)—have a Resource and Climate Change program area that funds projects to assess the impact of climate change on military installations. For example, a group of SERDP projects are focused on developing tools for assessing the physical effects of sea level rise and storm surge and the impacts to installations' mission-essential infrastructure. Installation assessments include Naval Station Norfolk and the surrounding Hampton Roads, Virginia; Eglin Air Force Base, Florida; Marine Corps Base Camp Lejeune, North Carolina; and Marine Corps Base Camp Pendleton and Naval Base Coronado, California.[136] The U.S. Army Corps of Engineers (USACE) has

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[136] For more information, see SERDP and ESTCP, "Climate Change and Impacts of Sea Level Rise," no date.

also been doing some of the SERDP, ESTCP, and other research projects related to climate change and installations. For example, researchers with the USACE's Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL) in Champaign, Ill. have a project assessing the potential impact of climate change on Army training areas in Alaska.[137] A researcher with USACE's ERDC in Concord, Massachusetts, has also been examining potential impacts of climate change landscape changes on installation facilities, training, and natural resources.[138]

Recommendations for the Army

Since the impacts of climate change on installations are likely to vary by location and will affect the Army in other key trend areas, such as energy, many of the recommended actions are incorporated in the discussions of these other trends. However, given the threats associated with climate change, we recommend that the Army continue to track the trends, though no immediate actions are needed since they are mentioned in other key areas, including actions related to energy, loss of biodiversity, and water scarcity trends. However, there are three strategic actions that the Army should consider conducting in the next few years. First, sooner rather than later, ACSIM and/or ASA(IE&E) staff should be discussing with DoD and Army research staff about the possibility of one of these organizations conducting a study to assess which Army installations are most at risk from climate change impacts and how. This is a project that SERDP or the USACE Environmental Lab could potentially incorporate into their current research slate. Such a project could build off of the ongoing research of these organizations. Second, ACSIM and IMCOM should conduct periodic reviews of ongoing climate change research about military installations for lessons for Army installations. Lastly, IMCOM should make sure that IMCOM regional offices and local installations most at risk, such as those along the coast, are tracking projected climate change impacts in their regional and local areas and what actions may be needed to address them. These organizations may also be able to suggest areas of future research for DoD and Army research organizations.

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[137] For more details, see SERDP and ESTCP, "Addressing the Impacts of Climate Change on U.S. Army Alaska with Decision Support Tools Developed Through Field Work and Modeling," no date.

[138] Igor Linkov, "Military Installations and Climate Change: Decisions, Decisions, Decisions . . . ," U.S. Army Engineer Research and Development Center, Concord, MA, April 20–21, 2011.

Sources for Tracking Climate Change Trends

Organizations That Track Climate Change Trends

There are a variety of organizations that track trends in climate change and its potential impacts. The most authoritative source on climate change is the Intergovernmental Panel on Climate Change (IPCC), the international body charged with assessing the scientific evidence related to climate change. It was created in 1989 and consists of thousands of scientists from all over the world who contribute to the work of the IPCC on a voluntary basis as authors, contributors, and reviewers. The IPCC does not conduct any research, but rather it reviews and assesses the most recent scientific, technical, and socioeconomic information produced worldwide relevant to the understanding of climate change. The IPCC has produced four comprehensive assessments of the state of climate change science.

In the United States, the United States Global Change Research Program (USGCRP) was created in 1989 to "coordinate and integrate federal research on changes in the global environment and their implications for society."[139] Thirteen departments and agencies participate in the USGCRP (which was known as the U.S. Climate Change Science Program from 2002 through 2008). In addition to coordinating and integrating research, the USGCP conducts a National Climate Assessment (NCA) every four years.[140] The National Oceanic and Atmospheric Administration (NOAA) is a key U.S. federal government organization that monitors, studies, and provides information about U.S. climate change, including drought trends.[141]

Some universities also have strong programs for conducting climate change research, including the Stanford Global Climate and Energy Project (GCEP). GCEP's mission is to conduct fundamental research on technologies that will permit the development of global energy systems with significantly lower greenhouse gas emissions. It was established in 2002 with the support and participation of four international companies: ExxonMobil, General Electric, Schlumberger, and Toyota. The project's sponsors will invest a total of $225 million over a decade or more as GCEP explores energy technologies that are efficient, environmentally benign, and cost-effective when deployed on a large scale. GCEP produces an annual technical report summarizing its research progress.[142]

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[139] See http://www.globalchange.gov/about/overview

[140] The 1990 Global Change Research Act requires this report to Congress on the environmental, economic, health, and safety consequences of climate change.

[141] For more information see http://www.climate.gov/

[142] See Stanford University's Global Climate and Energy Project website at http://gcep.stanford.edu/.

There are numerous documents published on a wide range of climate change issues, including scientific evidence of climate change,[143] regional and local impacts,[144] effects on individual species,[145] etc.

As just noted, the Department of Defense's environmental research programs, SERDP and ESTCP,[146] have a Resource and Climate Change program area that funds projects to assess the impact of climate change on military installations, which is a useful resource as well.

Studies and Reports on Climate Change Trends

Several assessments have been conducted on the global impacts of climate change. One of the most comprehensive scientific reports on the global impacts of climate change is the IPCC's *Climate Change 2007: Synthesis Report: Summary for Policymakers*. The National Intelligence Council, *Global Trends 2025*, provides a comprehensive overview of the global social, political, and economic implications of climate change.

Several assessments have also been conducted of the potential impacts of climate change on the United States. For instance, the U.S. Climate Change Science Program published its *Synthesis and Assessment Report 3.4 in* 2008 as well as its *Global Climate Change Impacts in the United States* in 2009. The National Science and Technology Council published its *Scientific Assessment of Global Change on the United States* in 2008.

There also are a number of journals that track trends related to climate change. These include *Journal of Climate*, which is published by the American Meteorological Society; *Science*, which is one of the leading scientific journals; *Global Environmental Change*, an interdisciplinary journal that spans both the natural and social sciences; and *Climate Dynamics*, which publishes scientific research on all aspects of the global climate system.

In addition, online resources related to climate change are growing. These resources include ClimateWire, which is an online daily newsletter that provides daily coverage of all aspects of climate change issues, and ScienceDaily, which is an online resource that tracks and

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[143] For example, see National Oceanic and Atmospheric Administration, National Climatic Data Center, "State of the Climate in 2011," *Special Supplemental to the Bulletin of the American Meteorological Society*, Vol. 93, No. 7, July 2012; also see Intergovernmental Panel on Climate Change, 2007.

[144] For example, see United States Global Change Research Program, 2009, and U.S. Environmental Protection Agency, *Climate Change Indicators in the United States*, April 2010.

[145] For example, see United Nations Environment Programme (UNEP) and the Secretariat for the Conservation of Migratory Species of Wild Animals, *Migratory Species and Climate Change: Impact of a Changing Environment on Wild Animals*, 2006.

[146] For more information, see SERDP and ESTCP, "Resource Conservation and Climate Change," no date. .

archives scientific articles related to science, health, and the environment. The Daily Climate is a website published by Environmental Health Sciences. It was formed in 2007 and provides a daily summary highlighting current news on climate change from around the globe.

Water Scarcity

Another key trend area relates to water and the ability of nations and communities around the world to have access to clean drinking water and water to grow crops and livestock for food. Historically throughout the world, water has been key to where civilizations have flourished, as well as a source of conflict. Many major cities in the world are located near sources of water, including oceans, rivers, and lakes. However, major cities have also placed increasing demands on their water sources. In the United States, water scarcity is particularly problematic in the western and southwestern regions of the country. The U.S. Census Bureau estimates that 88 percent of the nation's population growth between 2000 and 2030 will occur in the South and West.[147]

Background: Causes of Water Scarcity

Water scarcity can be caused by a degradation of either the quantity or quality of water, or both. For instance, droughts and changing precipitation patterns associated with climate change can cause water supplies to decrease. In addition, water supplies can be depleted due to higher demand for water due to urbanization, sprawl, development, and privatization of water supplies. The quality of water supplies can be severely impacted by pollution, including from industrial pollutants, sanitary systems, agriculture, and acid rain.

Key Water Scarcity Trends

Water scarcity is an increasingly growing problem both globally and in the United States.

Global Water Scarcity Trends

The National Intelligence Council predicts that clean water is set to become the world's scarcest but most-needed natural resource due to new demands resulting from population increases and expectations that climate changes will reduce natural fresh water sources in some areas.[148] The outlook is so dire that the Organization for Economic Cooperation and Development has estimated that the number of people living in water-stressed countries

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[147] U.S. Census Bureau, "Florida, California and Texas to Dominate Future Population Growth, Census Bureau Reports," April 21, 2005.

[148] National Intelligence Council, 2008, p. 47.

could rise to more than 3.8 billion—almost half the world population—by 2030.[149] With water becoming increasingly scarce, especially in Asia and the Middle East, it is likely that more conflict could arise over control of water resources in the future.[150]

U.S. Water Scarcity Trends

Water scarcity is also an increasing problem in the United States. Since 1960, more than half of the rivers and streams measured nationwide have shown major changes in the volume of high and low flows over time.[151] While water scarcity issues have traditionally been thought of as only affecting the western part of the United States, this is changing. It is projected that at least 36 states will face water shortages by 2013 because of a combination of rising temperatures, drought, population growth, urban sprawl, and waste/excess.[152]

Water scarcity has been acute in the western part of the United States, particularly in California, where large cities in Southern California are located in semi-arid regions. The Public Policy Institute of California has estimated that California's cities and suburbs used approximately 8.9 million acre-feet of water in 2000, or about 232 gallons per person per day.[153] In 1960, average urban per capita use of water in California was 185 gallons per day, 20 percent lower than in 2000.

Predictions indicate that future changes in precipitation patterns due to climate change could lead to a major prolonged drought in the southwestern United States. In 2009, the United States Global Change Research Program estimated the potential for conflict over water supplies in the western United States in 2025 (see Figure 2.7). Not surprisingly, the highest potential for conflict is along waterways and in densely populated urban areas.

Due to population growth, urban sprawl, and several prolonged droughts in recent years, water scarcity has also become a major issue in the southeastern part of the United States. The U.S. Census Bureau estimates that Florida, California and Texas alone are expected to

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[149] Organization for Economic Cooperation and Development, *OECD Environmental Outlook to 2030*, 2008.

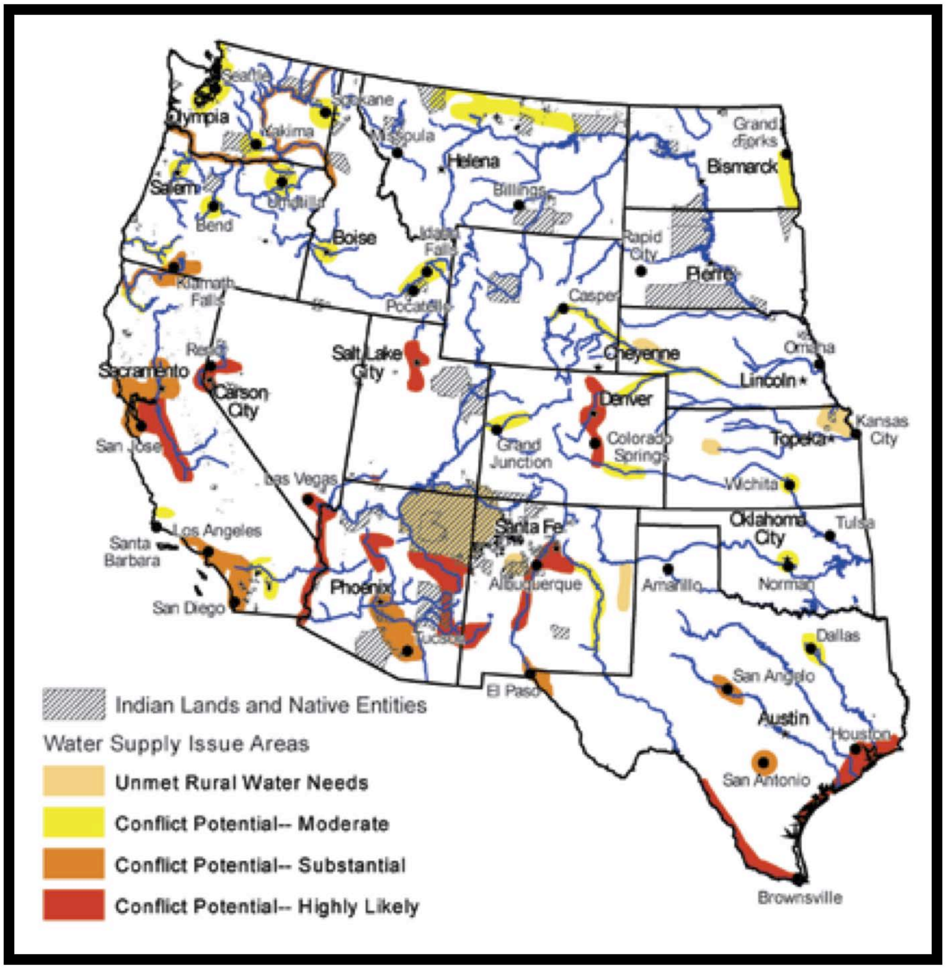
[150] National Intelligence Council, 2008, p. x.

[151] Environmental Protection Agency, *Report on the Environment: Highlights of National Trends*, 2008, p. 11.

[152] U.S. General Accounting Office, *Freshwater Supply: States' Views on How the Federal Government Can Help Them Meet the Challenges of Expected Shortages*, Washington, D.C.: Government Printing Office, June 2003, p. 5.

[153] Ellen Hanak and Matthew Davis, "Lawns and Water Demands in California," *California Economic Policy*, Vol. 2, No. 2, July 2006, p. 3.

Figure 2.7
Potential Water Supply Conflicts in 2025



SOURCE: U.S. Global Climate Change Research Program, *Global Climate Change Impacts in the United States*, 2009.

gain more than 12 million people between 2000 and 2030,[154] putting even more pressures on water sources in these areas.

What Could Change the Course of Water Scarcity Trends

A number of things can cause water scarcity to continue and accelerate. The first is demand: as demand for water continues to increase, so will water scarcity. Other factors that can increase water scarcity, as discussed earlier, include climate change, pollution, and drought.

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[154] See U.S. Census Bureau, "Florida, California and Texas to Dominate Future Population Growth, Census Bureau Reports," April 21, 2005.

The way that water rights are allocated has tended to encourage wasteful water use. For instance, in California, water rights holders must continue using their water or risk forfeiture ("use it or lose it") to the "next-in-line" user or applicant, thus leading to potentially inefficient use of water.

Another factor that can offset some of the water scarcity trends is more efficient management and use of water in industrial and agricultural practices. For example, some irrigation practices save water more than others. An increase in water prices often motivates businesses to become more efficient.

Water policy, laws, and regulations also affect water scarcity trends. Many municipalities across the country have restrictions on when residents can water lawns and what kinds of landscaping they can put around their houses. Violation of these restrictions can lead to a fine.

One of the most effective actions that can help mitigate water scarcity trends are water conservation measures that help decrease use of and demand for water. Water conservation measures can have an immediate and dramatic impact on water scarcity issues, as indicated by several successful water conservation programs from around the country. In Tucson, Arizona, the City's Water Utility and Tucson Water have offered rebates to replace older toilets. More than 3,200 older, high-water-use toilets have been replaced with high-efficiency toilets (HETs) in the past year, and Tucson Water anticipates replacing over 3,700 older toilets through the rebate program in the upcoming year. It is estimated that as much as 40,000,000 gallons of water will be conserved annually by the early replacement of these older toilets.[155]

El Paso and San Antonio, Texas, have some of the most aggressive water conservation plans in the country, and they have also been able to sustain those water conservation plans over time (see Figure 2.8).

These conservation plans include a mix of direct rebates offered to incentivize the exchange of old appliances, ordinances that restrict water usage on certain days or times of the day, and ordinances that limit landscaping to plants that are drought resistant.

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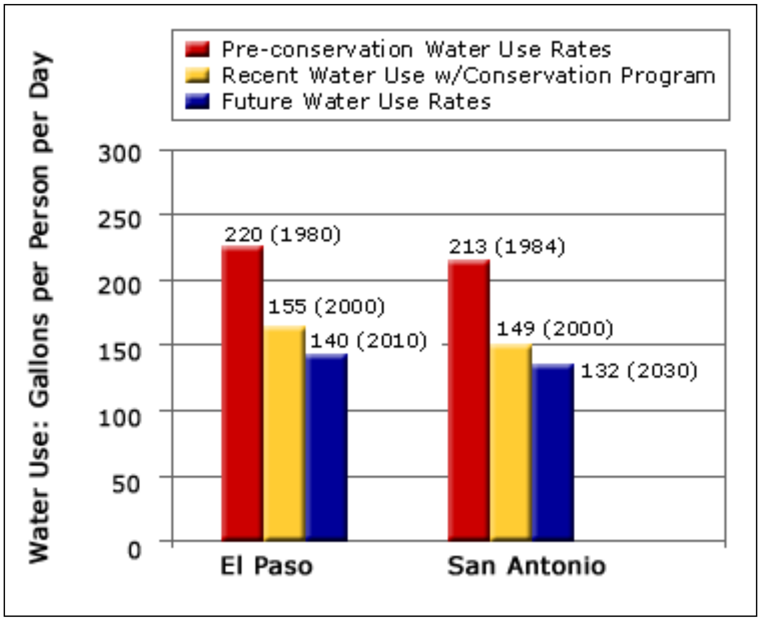
[155] Mark B. Evan, "Tucson Water Continues Successful Rebate Programs," *Tucson Citizen.com*, July 2, 2010.

Figure 2.8
Municipal Water Use in El Paso and San Antonio



SOURCE: Texas Water Matters, "Municipal Water Use: Success Story."

Interrelationship with Other Trends

As discussed in the previous chapters, water scarcity issues are intricately linked to other issues, including urbanization, sprawl, development, climate change, and loss of biodiversity. More urbanization, sprawl, and development place more demand on water and can lead to shortages. Climate change can alter precipitation patterns and cause droughts. Water scarcity can also lead to loss of biodiversity. Therefore, long-term solutions to water scarcity issues must take into account these linkages.

Sustainable community and agriculture activities also may focus on addressing water scarcity issues by addressing water conservation and management activities.

Implications of Water Scarcity for Army Installations

Next we discuss the implication of these water scarcity trends for Army installations. However, to help set the context we first provide some background information about water issues at installations today and how some have been implementing water conservation activities.

Army Context with Respect to Water Issues

Issues of water conservation and water efficiency have increasingly become priorities for the Army.[156] The 2006 *Army Energy and Water Campaign Plan for Installations: FY2008–2013* made water conservation a priority on Army installations. It identified water scarcity as one of the most underestimated resource issues[157] and security of the water system supply security "as important as energy security in order to maintain functioning installations."[158] Signed in 2007, Executive Order 13423 directs each agency beginning in FY08 to reduce water consumption intensity, relative to the baseline of the agency's water consumption in FY07, through life-cycle cost-effective measures by 2 percent annually through the end of the fiscal year 2015 or 16 percent by the end of FY15.[159] The 2009 *Army Energy Security Implementation Strategy* also specifically identified water conservation as a related priority.[160] The 2010 *Department of Defense Strategic Sustainability Performance Plan: FY2010* outlined annual targets for meeting the following goals:[161]

- Potable water consumption intensity by facilities reduced by 26 percent of FY07 levels by FY20
- Industrial and irrigation water consumption reduced by 20 percent of FY10 levels by FY20
- All development and redevelopment projects of 5,000 square feet or greater maintain pre-development hydrology to the maximum extent technically feasible

The Army *Installation Management Community Campaign Plan: 2010–2017* elevated energy and water efficiency and security as "key elements in supporting installation readiness"[162] and calls for installations to develop a Garrison Energy and Water Management Program (GEWMP) as well as other actions related to water conservation.[163]

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[156] Hon. Katherine Hammack, Assistant Secretary of the Army, IE&E, "Energy and Sustainability Priorities and Opportunities," *U.S. Army Journal of Installation Management*, Spring 2011, p. 1.

[157] *Army Energy and Water Campaign Plan for Installations: FY2008–2013*, 2006, p. ii.

[158] *Army Energy and Water Campaign Plan for Installations: FY2008–2013*, 2006, p. iii.

[159] See Executive Order 13423. As of June 29, 2010: http://www.epa.gov/greeningepa/practices/eo13423.htm.

[160] *Army Energy Security Implementation Strategy,* 2009, p. 12.

[161] D*epartment of Defense Strategic Sustainability Performance Plan: FY2010*, 2010, pp. II-14 to II-15.

[162] *Installation Management Community Campaign Plan*, 2010, p. F-1.

[163] See Annex F of I*nstallation Management Community Campaign Plan*, 2010.

The Army I*nstallation Management Water Portfolio: 2011–2017* provides an overview of the Army's water management capabilities to eliminate unnecessary consumption, increase efficiency, and expand the use of recycled/reclaimed water. It also embraces the Army vision of a "net zero water installation," which is defined as "an installation that limits the consumption of freshwater resources and returns water back to the same watershed so not to deplete the groundwater and surface water resources of that region in quantity or quality over the course of a year."[164] In April 2011, the Army identified the following six installations to participate in a pilot program to become net zero water installations by 2020:

- Aberdeen Proving Ground, Maryland
- Camp Rilea, Oregon
- Fort Buchanan, Puerto Rico
- Fort Riley, Kansas
- Joint Base Lewis-McChord, Washington
- Tobyhanna Army Depot, Pennsylvania.

The Army also has a broader goal of net zero installations—meaning net zero energy, water, and waste—designed to conserve natural resources and to address the interrelationships between such resources. By definition, "net zero installations will consume only as much energy or water as they produce and eliminate solid waste to landfills."[165] Fort Bliss, Texas and Fort Carson, Colorado were selected to participate in a pilot project aiming to be net zero installations by 2020.

Several Army installations have become leaders in water conservation efforts. For instance, over the past 15 years, Fort Huachuca has reduced groundwater pumping by 60 percent through projects such as installing artificial turf on physical training fields, introducing waterless urinals, installing water-efficient irrigation, and exploiting rainwater for irrigation of grassy areas.[166]

Fort Bragg has reduced its average daily water consumption by four to five million gallons from 2002 to 2010. This reduction was obtained through measures such as the installation of low-flow toilets and showerheads in buildings. In addition, an odd-even

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[164] *Installation Management Water Portfolio: 2011–2017*, 2010, p. 1.

[165] Office of the Assistant Secretary of the Army, "Net Zero Installations Identified."

[166] Jennifer Capriola, "Water Resources Management at Fort Huachuca Continues 15 Years Later."

watering schedule was adopted for outside watering, since usage peaks during summer months.[167]

In 2009, the Tooele Army Depot was awarded the 31st Annual Secretary of the Army Energy and Water Management Award and the 2009 Federal Energy and Water Management Award because water conservation efforts (mainly fixing underground leaks in water pipes) saved the depot more than $60,000 and nearly 100 million gallons of water per year.[168]

It is also important to note that DoD organizations like SERDP and USACE have some limited research related to water scarcity and installations. SERDP and ESTCP have a water conservation program area that includes a focus on developing and demonstrating water conservation technologies. It is fairly new, with only a couple of research projects. One of them, which is being conducted at Fort Irwin, is focused on demonstrating and validating the retrofit of existing building potable-water systems with water conservation and reuse technologies that reduce overall demand and preserve potable water.[169] An example of relevant USACE water research is the USACE Construction Engineering Research Laboratory's Strategic Sustainability Assessment (SSA), a pilot study of installations in the fall line region of the Southeast, which has done some research about future water scarcity at Fort Bragg.[170]

Recommendations for the Army

Given these water trends, Army installations will need to cooperate more with local communities to manage scarce water resources and develop more aggressive water conservation methods and policies. Army HQ will need to try to mitigate future impact by working with other federal agencies, regions, states, and local communities to protect water resources. ACSIM and IMCOM and other Commands (such as Army Materiel Command, the National Guard, and Army Reserve) need to better understand likely future water scarcity problems. To do this they should conduct a study to assess the potential

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[167] During summer 2002, average water consumption peaked at 13 to 14 million gallons a day, while by 2009 it was about 9 million gallons per day. Tina Ray, "Fort Bragg Focuses on Energy, Water Conservation," September 16, 2010.

[168] See http://tooele-army-depot.co.tv/

[169] For more information, see SERDP and ESTCP, "Integrated Water Planning Through Building Level Cascade of Water Use," no date.

[170] For more information, see Elisabeth M. Jenicek, Natalie R.D. Myers, Brad Boesdorfer, and Donald F. Fournier, *Strategic Sustainability Assessment Pilot Study: Fall Line Region of the Southeast*, USACE, ERDC/CERL TR-06-32, November 2006.

implications of water trends by doing regional and individual installation analyses across the country and by examining evolving state and local government policies and actions. Such a study should build off of what organizations like SERDP, ESTCP, and USACE have already done in these areas.

The Army should place more emphasis, analysis, and visibility on water concerns now. The net zero water pilots initiated in spring 2011 are a good first start. However, more needs to be done to ensure that garrison and installation commanders and other installation staff understand the significance of water issues. We recommend three key steps. First, the Army should conduct an analysis using installation and regional water case studies to examine likely installation implications and needs in the future given the likely water trends. Second, ACSIM and IMCOM in collaboration with the DASA(ESOH) should develop an integrated strategic action plan to address water concerns at installations that integrates future trends and scenarios. Such a plan would build off of the Army Energy and Water Campaign plan and other ongoing efforts, but focus more on specific actions to address regional differences and needs. Lastly, individual installation sustainability and strategic plans should place more emphasis on long-term strategic approaches to water issues.

Sources for Tracking Water Scarcity Trends

Organizations That Track Water Scarcity Trends

The UN's *Food and Agriculture Organization* (FAO) is one of the key organizations that tracks global water scarcity trends, especially in the developing world. The *UN's Environment Programm*e (UNEP) also tracks global water scarcity trends and recently published its *Global Environment Outlook* in 2007.

The *Organisation for Economic Co-operation and Development (*OECD) assesses the state of water scarcity issues around the world and how they intersect with economic development. In 2008, the OECD published its *OECD Environmental Outlook to 2030*, which predicted that water scarcity issues would be a major environmental concern in 2030.

Several federal U.S. agencies track trends in water supply, quality, and use, including the *Environmental Protection Agency* (EPA), *Bureau of Land Reclamation,* and the *U.S. Geological Survey*. The EPA publishes its *Report on the Environment: Highlights of National Trends*, which includes water scarcity issues.

The *World Resources Institute* is a key nongovernmental organization that conducts research on global water scarcity issues.

DoD's SERDP and ESTCP[171] have some activities focused on water conservation and other water issues related to military installations and so can also be a useful resource.

Studies and Reports That Track Water Scarcity Trends

The U.S. Global Climate Change Research Program released its report on *Global Climate Change Impacts in the United States* in 2009. This is one of the most comprehensive studies on the impacts of climate change on the United States, and the report discusses water issues extensively.

The Environmental Protection Agency issued its latest *Report on the Environment: Highlights of National Trends* in 2008. An entire chapter of this report is dedicated to water issues and provides a good overview of the types of water issues that the Unites States now faces.

In June 2003, the U.S. General Accounting Office released its report on *Freshwater Supply: States' Views on How the Federal Government Can Help Them Meet the Challenges of Expected Shortages*. This report was a significant study because it surveyed local and state water managers to get their input on how the federal government can help them. The federal government learned much from the interviews that took place and revealed that water managers are far more pessimistic than previously thought.

[171] For more information, see the SERDP and ESTCP web site on water conservation: http://www.serdp.org/Program-Areas/Energy-and-Water/Water-Conservation.

CHAPTER THREE

Sustainability: Communities, Transportation, and Agriculture Trends

This chapter discusses three key areas of sustainability: community, transportation, and agriculture. At first glance, it may not be clear how these trends are relevant to the Army, but they are important to Army installations because of quality of life issues for those who work and live on them. Some of these issues, such as investments in transportation infrastructure, can also have cost implications. These topics are grouped together because of the interrelationships between sustainable communities, transportation, and sustainable agriculture.

We begin by discussing sustainable communities.

Sustainable Communities

In this section we discuss the activities and trends related to sustainable communities and the implications they have for Army installations. The Army has done a lot in sustainability. In fact, some Army installations are leaders in sustainable community activities. Such Army sustainability activities are discussed at the end of this section when we discuss implications for the Army.

Background: Defining a Sustainable Community

The concept of sustainable communities emerged from sustainable development and sustainability efforts across the world. The focus on sustainability activities began in the late 1980s. Different organizations and individuals define these terms differently, but the most commonly used definition for sustainable development was established by the UN's World Commission on Environment and Development (the Brundtland Commission) in its 1987 report, *Our Common Future.*[172] It defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Practical definitions usually recognize sustainability as a process that tries to balance and address environmental, social, and economic issues over the long term.

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[172] World Commission on Environment and Development, *Our Common Future*, 1987.

Many communities and other organizations that are trying to implement sustainability at a local level use the term *sustainable community*, which emphasizes the community aspect of sustainable development. A "sustainable community" is usually defined uniquely by each community, based on its interests, needs, and culture, although there are common elements. It typically involves a long-term, integrated, systems approach to trying to develop and achieve a healthy, enduring community by jointly addressing economic, environmental, and social issues. Building consensus and fostering partnership among key stakeholders about community problems and solutions is also important to such efforts.[173]

Many communities in the United States and other parts of the world started in the 1990s to develop sustainability projects and implement more sustainable practices because of concerns about environmental, economic, and social issues. These communities recognize that many problems, such as urban sprawl, cut across many different segments of community and society. These problems cannot easily be solved using conventional approaches or traditional elements within our society. Many people feel that because such problems involve multiple disciplines, agencies, stakeholders, and sectors, it is better to address them through a collaborative and holistic systems approach. By 2008, at least 72 medium and large U.S. cities had established sustainable development as a city goal or priority.[174]

When examining community sustainability activities, it becomes clear that it is easier to set sustainability goals and start smaller initiatives than to successfully implement large-scale projects that address large-scale holistic issues, like sprawl. Large-scale projects prove to be more difficult to implement for a number of reasons, including budget and political constraints. For example, in one survey only 24 percent of respondents indicated that their city had individuals entrusted with implementing sustainability policies.[175] Portland, Oregon is one of only six cities that has created a dedicated Bureau of Planning and Sustainability that focuses on policies related to green buildings, sustainable food, clean energy, garbage and recycling, sustainable government, and climate protection.[176] Having dedicated staff that

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[173] Beth Lachman, *Linking Sustainable Community Activities to Pollution Prevention: A Sourcebook*, Santa Monica, CA: RAND Corporation, 1997, MR-855-OSTP.

[174] Devashree Saha and Robert G. Paterson, "Local Government Efforts to Promote the "Three Es" of Sustainable Development: Survey in Medium to Large Cities in the United States," *Journal of Planning Education and Research*, Vol. 28, 2008, pp. 21–37.

[175] Saha and Paterson, p. 12.

[176] See the Portland Bureau of Planning and Sustainability website at http://www.portlandoregon.gov/bps/

focus on sustainability has enabled Portland to become a pioneer in developing and implementing sustainability activities.

Portland provides a good illustration of the types of projects that sustainable community initiatives focus on. The city has been on the cutting edge of sustainability for years and has emphasized green buildings, smart growth planning, mass transit, and pedestrian-friendly city access. In 2005, Portland established its Green Investment Fund (GIF), a five-year, $2.5 million competitive grant program that supports innovative green building projects within the city. A total of $425,000 was awarded annually from 2005 through 2009, and 36 high-performance projects are either completed or still in development. Portland has also started Clean Energy Works Portland, a pilot program that will help up to 500 qualified Portland homes finance and install energy efficiency upgrades. In addition, all building projects in Portland with a permit value of $50,000 or more (including construction and demolition phases) are required to separate and recycle certain materials from the job site. Contractors must keep these materials out of the landfill: rubble (concrete/asphalt), land-clearing debris, corrugated cardboard, metals, and wood.

The issues addressed by such community sustainability efforts vary quite a bit but can include economic development, ecosystem management, sustainable transportation and mobility, social and environmental justice, environmentally sound local small businesses, new urbanism, and smart growth planning. Examples of common community sustainability projects include inner-city and brownfield redevelopment, eco-industrial parks, sustainable buildings, renewable energy projects, recycling and waste management, and pollution prevention.

Key Sustainable Community Trends

We identified several sustainable community trends that have implications for Army installations. We have grouped these trends into three categories: (1) emphasis on land use planning, transit-oriented development, growth management and community design, (2) development of industrial ecology/eco-industrial parks, and (3) improved waste management. We discuss each of these below. Some key sustainable community trends, such as transportation and ecosystem management, are not discussed here because they are discussed elsewhere in this document.

Emphasis on Land-Use Planning, Transit-Oriented Development, and Growth Management and Community Design

A key sustainable community trend is improvement through community planning, management, and design. Current trends in this area focus on traditional neighborhood development/new urbanism, compact land use, and more sustainable transportation that focuses on community, accessibility, mobility and environmental benefits. These trends toward sustainable design and smart growth planning and development emphasize the protection of landscape ecosystems, encourage affordable green community designs, support more walkable transit-oriented neighborhoods, and revitalize neighborhoods.

The prevailing concepts in urban design are now traditional neighborhood development (TND)/new urbanism. These approaches to urban design are characterized by compact, pedestrian-oriented developments that provide a variety of uses, feature diverse housing types, and are anchored by a central public space and civic activity. The following are commonly found in TND/new urbanism: parks, schools, civic buildings, and commercial establishments located within walking distance of homes; residences with narrow front setbacks, front porches, and detached rear garages or alley-loaded parking; a network of streets and paths suitable for pedestrians, bicyclists, and vehicles; narrower streets with crosswalks, streetscaping, and other traffic-calming measures; in-scale development that fits the local context; and buildings oriented to the street with parking behind.[177]

Three examples of these types of communities are Prospect, in Longmont, Colorado; Longleaf, in New Port Richey, Florida; and Fruitvale Village, in Oakland, California.[178] In 1996 Prospect won a Governor's Smart Growth Award for its innovative alternative to suburban sprawl. The types of homes in the community include detached houses, townhouses, courtyard houses, apartments, and live/work lofts. The neighborhood is now in its fourth phase of development and will eventually have up to 585 units on 340 lots.

Longleaf was established in 1997 in New Port Richey, Florida. A paved hike-and-bike trail winds throughout the neighborhood, and there is a child-friendly park within two blocks of every home.

Fruitvale Village in Oakland, California is a 257,000 square foot "transit village" built on former Bay Area Rapid Transit (BART) parking lots. The community has 47 units of mixed-

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[177] See Peter Katz, *The New Urbansim: Toward an Architecture of Community*, New York: McGraw-Hill, 1993; Congress for the New Urbanism, "Charter of the New Urbanism," 1996; Andres Duany, Elizabeth Plater-Zyberck, and Jeff Speck, *Suburban Nation: The Rise of Sprawl and Decline of the American Dream*, New York: North Point Press, 2000; Andres Duany, Elizabeth Plater-Zyberck, et al., *Town and Town-Making Principles*, New York: Rizzoli, 1991; Douglas Farr, *Sustainable Urbanism: Urban Design with Nature*, Hoboken, NJ: Wiley, 2008.

[178] "TND Neighborhoods by State and Country," *The Town Paper*, no date.

income housing; 114,000 square feet of community services and office space; and 40,000 square feet of neighborhood retail.[179]

Development of Industrial Ecology/Eco-Industrial Parks

Another key trend is that companies have been working together to implement industrial ecology concepts through eco-industrial parks. Industrial ecology is a concept that came out of the academic and research communities. By definition:

> Industrial ecology is the study of a closed loop in which resources and energy flow into production processes, and excess materials are put back into the loop so that little or no waste is generated. Products used by consumers flow back into production loops through recycling to recover resources. Ideally the loops are closed within a factory, among industries in a region, and within national and global economies.[180]

Industrial ecology concepts have been implemented within industry, through activities like eco-industrial parks, since the 1990s.

> An eco-industrial park is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues, including energy, water, and materials. By working together, the community of businesses seeks a collective benefit that is greater than the sum of individual benefits each company would realize if it optimized its individual performance.[181]

An eco-industrial park is similar to a conventional industrial park because it is a contiguous property containing a number of tenants sharing a common management/ownership, infrastructure, and services and usually has a tenants association, but is different in that it focuses on continuous environmental and societal improvement.[182] The main idea is to create synergies between various industries, agriculture, and communities to convert wastes into valuable products and feed stocks for other entities, and generate a profit. Such efforts are still evolving. Communities that have tried to develop eco-industrial

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[179] The Army may find this example of a dense, urban development suitable for installations with activities such as transient student or large single-Soldier populations.

[180] White House Office of Science and Technology Policy, Environmental Technology Strategy Staff, *Technology for a Sustainable Future: A Framework for Action*, Washington, D.C.: U.S. Government Printing Office, July 1994, p. 54.

[181] The President's Council on Sustainable Development, *Eco-Efficiency Task Force Report*, Appendix B4, Washington, D.C., 1996, p. 4.

[182] Mary Schlarb, *Eco-Industrial Development: A Strategy for Building Sustainable Communities*, Washington, D.C.: U.S. Economic Development Administration, 2001.

parks in the United States include Chattanooga, Tennessee; Northampton County, Virginia; Brownsville, Texas; Burlington County, New Jersey; Skagit County, Washington; Tucson, Arizona; and Baltimore, Maryland. Companies get involved in such efforts because of the economic and community-relationship benefits from working with neighboring companies. For example, some of the industrial by-products and wastes of the Chaparral Steel Company in Midlothian, Texas, have become profitable resources and inputs for neighboring industries. The company's waste slag is being used at a neighboring cement plant. This arrangement has created a competitive advantage for Chaparral Steel, which has increased profits, saved natural resources,[183] and reduced environmental pollution.[184]

The most well-known example of an eco-industrial park is in Kalundborg, Denmark. The town's four main industries (a 1,500-megawatt coal-fired power plant; a large oil refinery; a maker of pharmaceuticals and enzymes; and a plasterboard manufacturer) and several users within the municipality make use of waste streams and energy resources, and turn by-products into raw materials. One of the industries in the park has recorded a 90–95 percent saving in oil consumption after switching to gas supplied by the adjacent refinery. In addition to these reductions, the use of the excess heat from one of the industries for household heating has eliminated the need for about 3,500 oil-burning domestic heating systems.[185] This industrial symbiosis evolved gradually over 25 years without a grand plan.[186]

More recent eco-industrial park examples include Plattsburgh Airbase Redevelopment Corp in Plattsburgh, New York and Keystone Industrial Port Complex (KIPC) in Bucks County, Pennsylvania. Fourteen years after closing, the 2,642 acres of the former Plattsburgh Air Force Base are now home to businesses, nonprofits, residential neighborhoods, community college facilities, and the new international airport.[187] In Bucks County, KIPC occupies a portion of the former U.S. Steel–Fairless Works. Tenants located at the site include companies that recycle concrete and asphalt for reuse and companies that take the

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[183]Natural resources are saved because the waste is used in place of raw natural resources.

[184] The President's Council on Sustainable Development, *Materials: A Report of the Interagency Workgroup on Industrial Ecology, Material and Energy Flows*, Washington, D.C., July 1998, pp. 22–23.

[185] International Institute for Sustainable Development, "Kalundborg," no date.

[186] Noel Brings Jacobsen, "Industrial Symbiosis in Kalundborg, Denmark: A Quantitative Assessment of Economic and Environmental Aspects," *Journal of Industrial Ecology*, Vol. 10, Issue 1, 2006, pp. 239–255.

[187] Plattsburgh Airbase Redevelopment Corporation, undated.

coal residuals from power generation and create roofing materials. Future tenants are locating a plant at KIPC to create bio-fuel from algae.[188]

As such activities become more common and have more success, it is likely that more eco-industrial parks will develop and more businesses may want to take part in their development.

Improved Waste Management

Another key trend in sustainable community activities is improving waste management so that less solid waste goes to landfills and hazardous wastes are disposed of properly. Local governments, along with many states, are doing this by focusing on pollution prevention, recycling, reuse, and composting programs; waste-to-energy projects; and proper disposal of electronic and other hazardous waste. State and local government agencies have long recognized the importance of hazardous and solid waste management because of past pollution problems that have hurt communities, such as Love Canal,[189] and the high costs of managing landfills, especially when new ones need to be built.

State and local incentive and voluntary programs, along with regulations, have helped motivate businesses, industry, communities, and individuals to implement pollution prevention, recycling, reuse, and composting activities. Such incentives and pressures by state and local governments are likely to continue, especially as many communities find their landfills filling up and encounter difficulties in building new ones.

There has been a lot of progress made by industry, communities, and Army installations in areas such as pollution prevention and recycling. Areas that are emerging trends, in which the Army has not yet done as much but that are likely to receive more emphasis in the future are: composting, waste-to-energy technologies, and electronic waste, also called e-waste. We discuss each of these below.

Composting programs offer one of the most effective ways of diverting the largest single component of the residential and municipal solid waste stream. These programs are becoming increasingly popular. Leaf and yard waste alone can represent up to 20 percent of

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[188] Environmental Protection Agency, "Bucks County Eco-Industrial Park and Two Tenants Join EPA Sustainability Initiative, Push Green Commitment Higher," 2009.

[189] The Love Canal development of about 100 homes and a school was built in the 1950s on top of improperly buried toxic industrial waste. It became one of the first widely publicized environmental disasters when rotting drums and the dangerous chemicals they had contained began coming up through the soil in the development in the summer of 1978. For more information, see Eckardt C. Beck, "The Love Canal Tragedy," *EPA Journal,* January 1979.

the residential waste stream and can be processed in a relatively inexpensive manner. With the addition of food waste in a composting program, up to 40 percent of the waste stream potentially can be diverted.[190]

Another emerging trend is the development of waste-to-energy (WTE) technologies. WTE is the creation of heat and/or electricity from the burning of a waste source, such as scrap wood and trash. Burning municipal solid waste (MSW) to create energy is a common technique that has been in practice for a long time and that many communities in the United States and some Army installations already take advantage of. For example, most of the municipal solid waste in Harford County, Maryland is burned at the Harford Waste-to-Energy Facility, and it provides steam heat to Aberdeen Proving Ground (APG). This facility is actually located on a 13-acre parcel of leased APG land.[191]

One of the new emerging technologies in WTE is thermal depolymerization, which converts fats, bones, greases, feathers, and other wastes into renewable diesel, fertilizers, and specialty chemicals. Given the volatility of oil prices over the past several years, there is much interest in maturing this technology. Plasma arc waste disposal is another emerging technology in this area. In this process, highly ionized gas is used to dispose of waste at a very high temperature (between 3,000 and 7,000 degrees Celsius). The advantage to this type of technology is that hazardous and toxic compounds are broken down and there is little air pollution. A commercial plasma arc waste disposal facility was commissioned in 2002 in Japan and now produces steam and hot water for local industries. A facility is planned in St. Lucie, Florida, and it is estimated that the county landfill would be eliminated in 18 years.[192]

The final emerging waste disposal trend that we examine is the disposal of electronic waste, or e-waste. Disposing of the many electronic devices that are part of our daily lives is becoming an increasing problem because these devices are increasing in number, they are replaced quickly, and they contain toxic metals such as cadmium, mercury, and lead. As a result, calls for recycling programs have been increasing. The Sony Take Back Recycling Program was the first national recycling initiative in the United States to involve both a major electronics manufacturer and a national waste management company. The program began on September 15, 2007 in collaboration with a wholly owned subsidiary of Waste

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[190] Federation of Canadian Municipalities, "Solid Waste as a Resource: Guide for Sustainable Communities," 2004.

[191] For more information, see Harford County, "Waste-to-Energy," http://www.harfordcountymd.gov/dpw/envaffairs/index.cfm?ID=438.

[192] Louis Circeo, *Plasma Arc Generation of Municipal Solid Waste*, Georgia Tech Electro-Optical Systems Laboratory, 2010.

Management, Inc., and by 2010 there were 132 dropoff locations in 31 states.[193] Currently, nineteen states plus New York City have passed legislation mandating statewide e-waste recycling.[194]

What Could Change the Course of Sustainable Community Trends

There are many different things that can and are affecting sustainable community trends, including governmental policies and regulations, environmental trends, state of the economy, and technology changes.

State and local government policies and regulations, such as smart growth regulations and recycling programs, affect how much some communities invest in trends like new urbanism and compact land use and recycling. Federal agencies are also assisting in sustainable communities, which also contributes to more activities in this area. For example, the U.S. Environmental Protection Agency, the U.S. Department of Transportation, and the U.S. Department of Housing and Urban Development will use the following six principles as a foundation for interagency coordination of investments relating to sustainable communities:[195]

- Provide more transportation choices
- Promote equitable, affordable housing
- Enhance economic competitiveness
- Support existing communities
- Coordinate policies and leverage investment
- Value communities and neighborhoods.

Environmental trends like climate change, loss of biodiversity, pollution prevention, water scarcity, and loss of agricultural land and open space from sprawl pressures can cause communities to become more concerned about sustainability and implement more sustainability activities.

Economic trends can also impact such activities. As state and local government budgets get tighter, they may choose not to invest in sustainability personnel or implement certain

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[193] Sony Electronics Inc., "The Sony Take Back Recycling Program," undated. As of July 15, 2010:
http://green.sel.sony.com/pages/recycle.html

[194] Californians Against Waste, "E-waste Laws in Other States,"
http://www.cawrecycles.org/issues/ca_e-waste/other_states.

[195] Environmental Protection Agency, "HUD-DOT-EPA Interagency Partnership for Sustainable Communities," June 16, 2009.

sustainability programs. However, in the case of sustainability programs that save money or help with local jobs, such as eco-industrial parks, there may be more interest in developing and sustaining those programs. Also, in some urban areas where the exurbs have been particularly hard hit by the recent economic downturn, there may be more movement from the exurbs to urban areas[196] and more emphasis on new urbanism and compact land use and city redevelopment activities.

Technology can also impact sustainable community activities. As more technologies are developed that benefit the environment and as they become more cost competitive, communities are more likely to employ them. For instance, improvements in renewable energy technologies, especially as the purchasing costs decrease, help motivate more communities to implement programs to invest in them, as is seen in Arlington County, Virginia.[197] Advances in information and communications technologies have enabled many business and government employees to use telecommuting, which decreases reliance on the automobile and enables people to live in more distant locations.

Interrelationships with Other Trend Areas

Since sustainable community programs implement a diverse range of activities, there is significant overlap with other trend areas, especially trends having to do with the environment and sprawling communities. Sustainable community activities supporting ecosystem management and habitat protection can help mitigate biodiversity loss. Communities protecting open and green spaces, managing growth, redeveloping inner-city brownfield areas, and concentrating on new developments in compact land use can help mitigate urban growth and sprawl pressures as well as help address some environmental concerns.

Many sustainable community activities are trying to invest in energy conservation and more green buildings and renewable energy technologies. Communities are making such investments because of concerns about climate change and other environmental issues, rising energy prices, and energy security concerns. Similarly, because of water supply and

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[196] Elizabeth Kneebone and Emily Garr, *The Landscape of Recession*, Washington, D.C.: Brookings Institution, 2009.

[197] Arlington County has been investing in renewable energies, such as solar photovoltaics, for a number of years. The Arlington County Community Energy & Sustainability Task Force even recommended that Arlington County set a goal to "install 160 MW of solar photovoltaics by 2025 Countywide." Arlington County, Virginia, *Arlington County Community Energy & Sustainability Task Force Report: FINAL DRAFT*, March 4, 2011, p. 7.

quality concerns, many sustainable community activities focus on conserving water, addressing storm water runoff, and other water concerns.

Similarly, sustainable transportation is closely integrated with sustainable community activities because transportation and land use planning, policies, and use are so affected by each other. Sustainable transportation practices, like compact land use planning and transit and bike lane developments and incentives, are often part of sustainable community activities, especially because of community concerns about traffic congestion and air pollution.

Sustainable agriculture and food production practices can also be part of sustainable community programs. Communities often implement such practices to help local farmers and to address health and environmental concerns.

Implications of Sustainable Community Activities for Army Installations

Next we discuss the implications of these activities for Army installations. However, first we provide some useful context information about what Army installations are already doing in this area.

Current Army Sustainable Community Activities

Army installations have already been implementing sustainable community activities through their installation sustainability planning programs and activities. Beginning around 2000, a few installations, like Fort Bragg and Fort Hood, started developing and implementing installation sustainability plans because of the operational, financial, and environmental benefits they saw industry and communities experiencing by implementing sustainability approaches. Such plans address long-range mission, community, and environmental issues and priorities. They are developed through a strategic planning process and exist in addition to or are integrated into the installation's strategic plan. Since those first efforts, over 40 installations have been developing or implementing installation sustainability planning activities. Many other installations have been implementing sustainability-related practices, such as pollution prevention, recycling programs, and ecosystem management, because of strong, progressive environmental programs. Some installations have staff dedicated solely to sustainability or staff who spend part time on sustainability and part time on related environmental areas, like pollution prevention.

In 2004, building on this installation sustainability success, the Army issued the "Army Strategy for the Environment,"[198] which has sustainability as its foundation. This document

[198] U.S. Army, "The Army Strategy for the Environment: Sustain the Mission—Secure the Future." Washington, D.C., U.S. Army Environmental Policy Institute, 2004.

states that "a sustainable Army simultaneously meets current as well as future mission requirements worldwide, safeguards human health, improves quality of life, and enhances the natural environment." Since then, Army installations and other parts of the Army are implementing more sustainable practices to benefit the environment, mission, and community.

In fact, in many ways the Army has a stronger sustainability program than most U.S. communities because it has invested more resources than most communities have; the presence of dedicated sustainability staff being a notable example. Some installations are leaders in key sustainability areas, such as ecosystem management; recycling and waste reuse and reduction; and energy efficiency and renewable energy investments.[199] We briefly discuss some of these strengths here. As discussed early in the chapter that covers biodiversity issues, many Army installations also have strong ecosystem management programs to help protect and preserve T&ES, their habitat, and biodiversity.

Some installations, such as Fort Hood, are also leaders in recycling and waste reuse and reduction. Fort Hood has an "Every Waste a Reuse Opportunity" slogan. Materials recycled and reused have included aluminum, plastics, paints, wood, metals, batteries, paper, cardboard, asphalt, mattresses, soil, tires, motor oil, concrete, and antifreeze. In FY06, solid wastes recycled totaled over 49,710 tons and generated a total revenue of $1,738,778.[200] The combination of Fort Hood's qualified recycling program, compost recycling program, inert material management, deconstruction management, special waste management, and electronics waste recycling program saved more than $2.5 million in 2006.[201]

In 2010 the Army set ambitious goals for net zero waste installations, defined as

> an installation that reduces, reuses, and recovers waste streams, converting them to resource values with zero landfill over the course of a year. The components of net zero solid waste start with reducing the amount of waste generated, re-purposing waste, maximizing recycling of waste stream to reclaim recyclable and compostable materials, recovery to generate energy as a by-product of waste reduction, with disposal being nonexistent.[202]

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[199] For examples of the many different types of sustainability activities at Army installations, see Beth Lachman et al., 2010.

[200] Fort Hood, "Solid Waste Annual Report for FY06," Fort Hood, Texas, 2006.

[201] U.S. Army, "Army Environmental Programs Awarded for Making a Difference," *States News Service*, Washington, D.C., June 13, 2007.

[202] Army Energy Program, "Army Vision for Net Zero," no date.

More recently, in April 2011, the Army identified six installation pilots striving to become net zero waste by the year 2020:

- Fort Detrick, Maryland
- Fort Hood, Texas
- Fort Hunter Liggett, California
- Fort Polk, Louisiana
- Joint Base Lewis-McChord, Washington
- U.S. Army Garrison, Grafenwoehr, Germany

As discussed earlier, the Army also announced plans for net zero installations. "A net zero installation is one which applies an integrated approach to management of energy, water, and waste to capture and commercialize the resource value and/or enhance the ecological productivity of land, water, and air."[203] Fort Bliss, Texas and Fort Carson, Colorado were selected to be net zero installation pilots aiming to be net zero installations by 2020.

Installations like Fort Bragg, Fort Carson, and JBLM through their sustainability programs also have been leaders in energy conservation and efficiency. Some installations, such as Fort Carson, have also been leaders in implementing renewable energy projects. Fort Carson built a twelve-acre 2-MW solar array. Since 2007 this solar array has produced 3,200 megawatt-hours of power each year, which is about enough to power 500 installation homes for a year.[204]

Recommendations

Even though some installations are leaders in sustainability, the Army can still learn a lot and benefit from some of the sustainable community efforts and trends in industrial ecology/eco-industrial parks, traditional neighborhood development and compact land use, diverse mobility and transportation planning (discussed in the next section) and sustainable agriculture (discussed in the last section of this chapter). We discuss recommendations regarding the first two here and the others later.

However, first we discuss some basic information-sharing recommendations so that communities and installations can learn from other Army installations' successes, as well as

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[203] Assistant Secretary of the Army for Installations, Energy, and Environment, "Net Zero: A Force Multiplier," no date.

[204] Nancy Mann Jackson, "Fort Carson," *WasteAge*, Penton Media, Inc., September 23, 2010.

the Army learning from communities. Given the strengths of some Army installations' sustainability efforts, the Army should, first, publicize its installation sustainability efforts more. IMCOM should document in-depth case studies of installation sustainability successes and lessons learned, especially how they overcame barriers, and share them across installations. Such information transfer is needed to help other installations implement such practices more widely across the Army. Second, ACSIM and IMCOM and other Commands should ensure that installations collaborate more in regional and local sustainability community efforts. Third, the Army should participate more in other public sustainability forums, such as activities with other federal agencies like EPA.

The Army should also ensure that installation sustainability staff and programs continue despite current budget cuts because of the cost savings and other benefits that they achieve.[205] During summer 2011, some staff at different installations worried that IMCOM was planning to eliminate sustainability staff or programs. Any significant cuts to sustainability staff and programs would be short sighted and not in the long-term strategic interest of the Army.

Because of the land use trends just discussed, ACSIM and IMCOM policies should require installations to include, wherever feasible, TND principles in installation master plans and transportation planning. In 2012, OSD Master Planning guidance and Army draft guidance was starting to encourage more compact development and other sustainable community practice regarding land use.[206] In addition, installations should be required to do sustainable transportation options in growth planning (which is discussed more in the next section).

To take advantage of eco-industrial park trends, installations should try to develop and implement eco-industrial parks with neighboring industry. ASA(IE&E), ACSIM, and IMCOM should help sponsor some initial installation eco-industrial park pilots. IMCOM should also help educate and provide information about such opportunities to installations. Such parks could benefit both the installation and local communities by helping local businesses and reducing waste disposal.

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[205] For examples of cost savings and other benefits, see Lachman et al., 2010.

[206] See U.S. Department of Defense, *Unified Facilities Criteria (UFC): Installation Master Planning,* UFC 2-100-01, May 15, 2012; see also draft of Army Regulation 420-1, "Army Facilities Management," August 2012.

Lastly, ASA(IE&E), ACSIM and/or IMCOM should help installations develop some more waste-to-energy technology demonstration pilots and document and share information about such projects.

Sources for Tracking Sustainable Community Trends

Organizations That Track Sustainable Community Trends

Several government agencies, including the Department of Energy, Environmental Protection Agency, and Economic Development Agency in the Department of Commerce, track trends related to sustainable communities.

In addition, the Urban Institute conducts and disseminates research on sustainable communities.[207] The Urban Institute is a nonpartisan organization that gathers data, conducts research, evaluates programs, and offers technical assistance overseas on social and economic issues. Some of the topics that the Urban Institute focuses on include housing trends, economic development, mobility and transportation, cities and neighbors, and crime and justice.

The Congress for the New Urbanism (CNU) is a nonprofit organization comprised of architects, urban designers, planners, public officials, investors, and community activists that promotes walkable, mixed-use neighborhoods and is the hub of TND/new urbanism.[208] CNU was established in 1993 by architects Andres Duany, Peter Calthorpe, Elizabeth Moule, Elizabeth Plater-Zyberk, Stefanos Polyzoides, and Dan Solomon. Today, CNU has over 3,100 members in 20 countries and 49 states.

Sustainable Communities Online, formerly known as the Sustainable Communities Network, is an online resource that pools information on sustainability.[209] The site contains information related to governance, the economy, the environment, smart growth, and communities.

International Institute for Sustainable Development (IISD) is a nonpartisan, charitable organization specializing in policy research and analysis of issues related to sustainable development.[210] IISD was established in 1988 when Canadian Prime Minister Brian Mulroney announced Canada's plans to establish an international institute dedicated to advancing sustainable development at the United Nations. In addition to its head office in

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[207] See the Urban Institute's website at http://www.urban.org.

[208] See the Congress for the New Urbanism's website at http://www.cnu.org/.

[209] See Sustainable Communities Online's website at http://www.sustainable.org/.

[210] See the International Institute for Sustainable Development's website at http://www.iisd.org/.

Winnipeg, Manitoba, IISD now has branches in Ottawa, Ontario; New York, New York; and Geneva, Switzerland.

Center for Neighborhood Technology (CNT) is an organization that promotes more livable and sustainable urban communities through research and advocacy. CNT was founded in 1978 and focuses on three areas: (1) researching urban issues such as efficient use of resources, strategies for reducing pollution, or ways to improve public transportation; (2) building coalitions to advocate for public policies that can help address urban sustainability issues; and (3) designing, developing, and operating economic development demonstration projects to address urban sustainability in innovative ways.[211]

Studies and Reports

The United Nations report entitled *Trends in Sustainable Development: 2008–2009* highlights key developments and recent trends in agriculture, rural development, land, desertification, and drought: five of the six themes being considered by the UN Commission on Sustainable Development (CSD) at its 16th and 17th sessions (2008–2009). The report identifies where progress has been made in these five areas and where improvement is needed.

The Urban Institute's report entitled *Community Revitalization in the United States and the United Kingdom* (2009) presents the findings of a study that compared trends in community revitalization, community cohesion, and sustainable neighborhoods in cities in the United States and the United Kingdom.

The article entitled "Local Government Efforts to Promote the 'Three Es' of Sustainable Development: Survey in Medium to Large Cities in the United States" in the *Journal of Planning Education and Research* (2008) presents survey results of sustainable development efforts across the United States. It highlights the challenges faced by local government officials.

Sustainable Transportation

In this section we discuss the activities and trends related to transportation and how the concept of "sustainable transportation" captures many of these trends. We begin by discussing a little background about what has been driving U.S. transportation trends. Then we discuss the trends, the implications they have for Army installations, and sources of information.

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[211] See the Center for Neighborhood Technology's website at http://www.cnt.org/.

Background: Congestion and Pollution Concerns Are Driving Transportation Changes

From the very earliest days of transportation, when the invention of the wheel and axle enabled people to transport more than they could carry on their backs, progress in transportation has resulted from the need for mobility combined with technological change. The invention of rails and their deployment on continental scales, the introduction of mechanical motive power, and the linkage between transportation and telecommunications in GPS and other embodiments—to say nothing of the revolutions in transportation by sea and air—have all marked a path forward that continues to revolutionize human mobility.

Over the second half of the 20th century, the United States experienced a significant rise in personal automobile use in particular, which was both a contributor to and a consequence of sprawling cities, growth in suburbs, development of highway and road infrastructure systems, and increasing living standards. Consequently, land use patterns in the United States have become more decentralized, meaning that the proportion of jobs located in center cities declined and the percentage of the population living at fairly low densities (i.e., in suburbs) has been increasing. As cities and suburbs grew and automobiles became more widespread, people moved further from the more compact city areas and their jobs and started commuting longer distances to their workplaces. One result of these trends is an overall increase in the number of miles traveled by private vehicles, as opposed to other modes. In 2001 (the year of the last complete National Household Transportation Survey), just over 85 percent of all trips in the United States were made by car. Furthermore, 65 percent of those occurred in single-occupant vehicles (SOVs), meaning that the driver was the only occupant in the vehicle.[212]

More and more people driving more and more miles has caused congestion problems. Such auto use is responsible for high and growing levels of congestion in cities and towns across the United States, as shown in Figure 3.1. In 2005, congestion cost about $78.2 billion, compared to $73.1 billion in 2004. This includes the cost of hours wasted in delays—4.2 billion hours in 2005—and gallons of wasted fuel—2.9 billion gallons in 2005. Additionally, the average annual cost per traveler (based on wasted time and fuel) has grown, as shown in Figure 3.2. This cost was $707 in 2005, up from $680 in 2004 (using constant dollars).[213]

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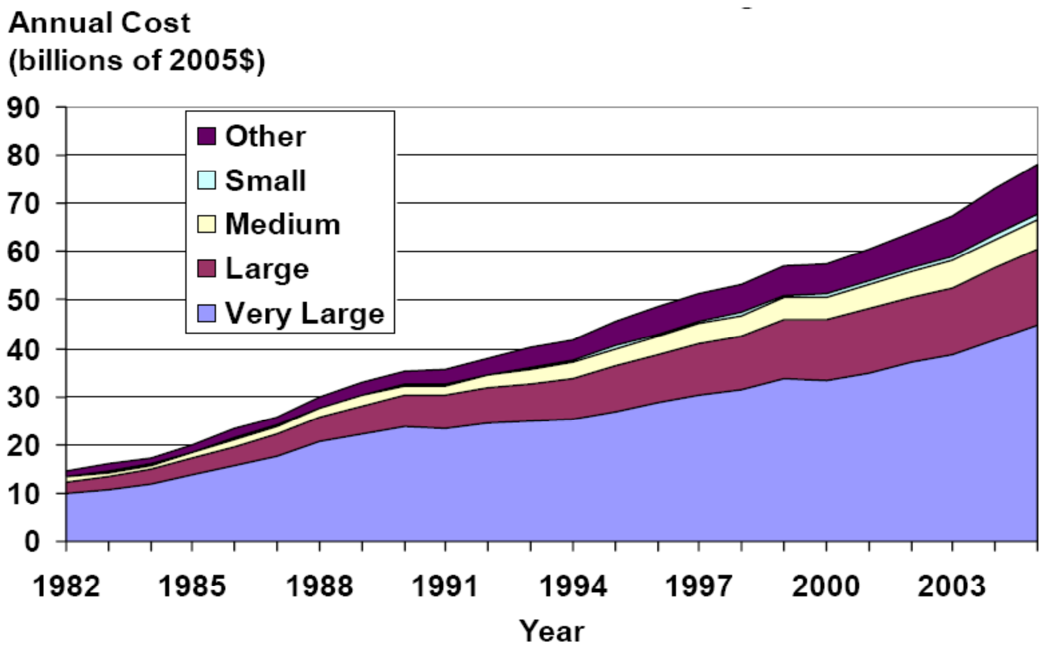
[212] Research and Innovation Technology Administration, Bureau of Transportation Statistics, *National Household Transportation Survey 2001, National Data and Analysis Tool.*

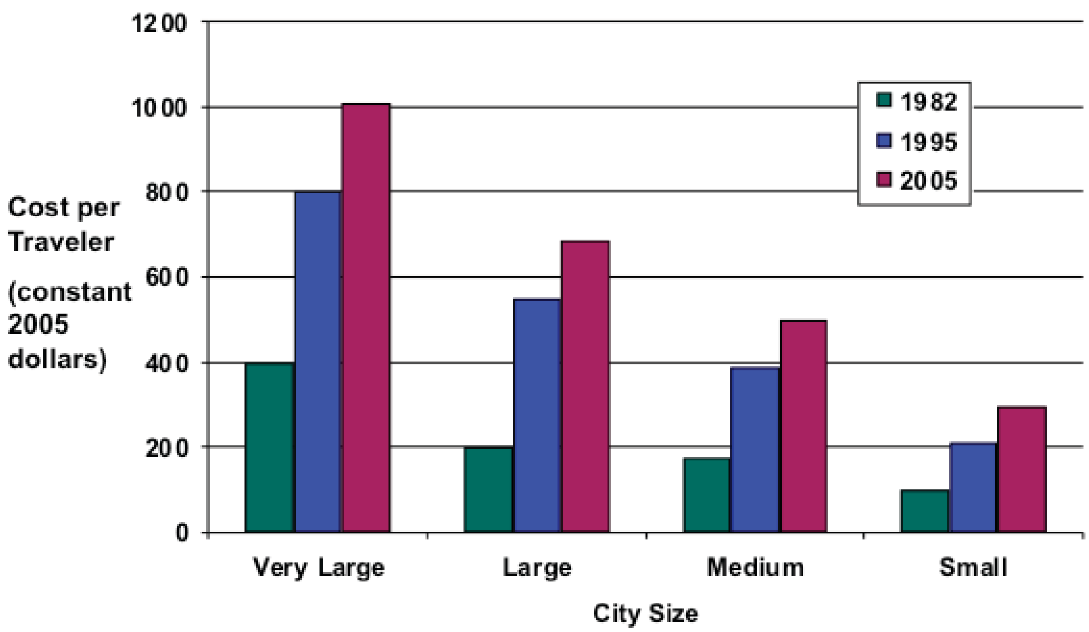
[213] David Schrank and Tim Lomax, *2007 Annual Urban Mobility Report*, College Station, TX: Texas Transportation Institute, 2007, p. B-19.

Figure 3.1
Annual Cost of Congestion Has Grown for All Sizes of Cities, from Small to Very Large



SOURCE: Schrank, 2007, p. B-20.

Figure 3.2
Congestion Costs per Traveler (in 2005 Dollars) Have Grown for Travelers, Regardless of City Size



SOURCE: Schrank, 2007, p. B-21.

This rise in personal vehicles, single-occupant vehicles in particular, is also a major contributor to air pollution and other environmental problems, including water pollution. High concentrations of carbon monoxide generally occur in areas with heavy traffic congestion. In cities, as much as 95 percent of all carbon monoxide emissions may come from automobile exhaust.[214] Other pollutants from motor vehicle exhaust include ozone (the most prevalent chemical in smog), nitrogen oxides, lead, and particulate matter (dust, soot, and other particles suspended in the air). These pollutants are associated with a wide range of health and environmental problems, including higher rates of respiratory illness, cardiovascular disease, hospital admission, and mortality. Research suggests that children and the elderly are particularly vulnerable.[215] As these pollutants and oils from vehicles are washed into storm drains and across the landscape from rain and other participation, they also contribute to water quality problems.

Such congestion and air pollution problems have led to federal, state, and local government activities to try to reduce SOV and focus on more sustainable methods of personal transportation. These efforts largely began with the first Clean Air Act (CAA) which was first passed in 1963 and subsequently amended in 1970 (at which time the EPA was also created) and in 1990. Among other things, the CAA gives the EPA the authority to set limits on key or *criteria* pollutants[216] and to identify states and regions where these limits are exceeded. These are called *nonattainment areas*. The 1990 amendment to the Clean Air Act requires nonattainment areas to develop plans to reduce air pollutants. This includes reducing pollutants from transportation, for example, by requiring employers to institute travel assistance programs to reduce the number of employees who drive to work.[217]

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[214] U.S. Environmental Protection Agency, *U.S. EPA's 2008 Report on the Environment (Final Report)*, 2008, pp. 2–11.

[215] H.S. Koren, "Associations Between Criteria Air Pollutants and Asthma," *Environmental Health Perspectives*, Vol. 103, No. Suppl 6, 1995, pp. 235–242.

Bert Brunekreef and Stephen T Holgate, "Air Pollution and Health," *The Lancet*, Vol. 360, No. 9341, 2002, pp. 1233–1242.

Jonathan M. Samet, Scott L. Zeger, Francesca Dominici, Frank Curriero, Ivan Coursac, Douglas W. Dockery, Joel Schwartz, and Antonella Zanobetti, *The National Morbidity, Mortality, and Air Pollution Study Part II: Morbidity and Mortality from Air Pollution in the United States*, Cambridge, MA: Health Effects Institute Report 94, 2000.

[216] Criteria pollutants—carbon monoxide, ozone, nitrogen oxides, lead, and particulate matter mentioned earlier, as well as sulfur dioxide—are so called because the EPA monitors these pollutants and sets criteria for permissible levels. Sulfur dioxide is the only criteria pollutant that is not produced by vehicles.

[217] Public Law 88-206, Stat. 401, Clean Air Act, 1963.

More recently, concerns about climate change and greenhouse gas (GHG) emissions have motivated people to try to focus more on sustainable transportation because most (over 60 percent) of GHG emissions associated with transportation are produced by personal vehicles: cars, pickup trucks, SUVs, and minivans.[218] Transportation actually accounts for nearly a third of the U.S. GHG emissions, and transportation as a percent of total U.S. emissions is growing—it represents 48 percent of the total increase in GHG emissions since 1990.[219]

Other effects of our current transportation system include noise pollution and urban sprawl, as well as consumption of nonrenewable energy and a high dependence on foreign oil.

Key Sustainable Transportation Trends

Here we discuss the main trends related to sustainable transportation, but first we provide a definition. Sustainable transportation—also called sustainable mobility—is based on the concept of sustainable development. Sustainable development, as discussed earlier, is defined by the Bruntland Commission as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Using this as a basis, sustainable transportation seeks to meet three goals simultaneously: meeting human needs for accessibility and mobility, preserving ecosystems and protecting the environment, and ensuring intra- and inter-generational equity.[220]

Given that personal vehicular traffic and the problems of congestion and pollution are key transportation concerns, sustainable transportation activities tend to focus on reducing personal driving amounts and making driving more efficient, resulting in less congestion and pollution problems. Approaches to reducing driving try to make driving less attractive through market measures (e.g., increasing or changing the costs of driving); make alternative modes (transit, pedestrian, bicycle) more attractive; promote compact land use to make alternative modes more practical; and encourage telecommuting and carpooling. Approaches

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Public Law 91-604, Stat. 1676, 1970 Clean Air Act Amendment, 1970.
Public Law 101-549, Stat. 1630, 1990 Clean Air Act Amendment, 1990.

[218] U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2006,* Washington, D.C., 2008, p. 2-24.

[219] U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2008*, Washington, D.C., 2010, p. ES-8.

[220] Erling Holden, *Achieving Sustainable Mobility,* Burlington, VT: Ashgate Publishing, 2007, pp. 61–64.

to make driving more efficient focus on better fuels that pollute less and have lower GHG emissions, and more efficient system operations (e.g., synchronized traffic signals).

Importantly, efforts to make transportation more sustainable must be considered holistically, in a broader transportation context and a still broader social context. Some actions that seem to promote sustainability may in fact have an overall neutral or negative effect when the full, life-cycle effects of the actions are considered. For example, it may seem plausible that creating more roadways would improve traffic flow. However, the phenomenon of *induced demand*—in which greater supply of an underpriced good results in greater demand and consumption of that good—means that the new capacity is quickly consumed with new drivers and vehicles.[221] Similarly, it may seem plausible that replacing all existing cars with more fuel efficient ones would reduce GHG emissions. However, if one considers the added emissions from producing new cars sooner than would otherwise be necessary, the approach may have an overall negative effect.[222]

Given such approaches, we identified four main transportation trends that have relevance for Army installations and we anticipate will continue in the future:

1. There is increasing recognition about the importance of **compact land use and less personal vehicle travel** because of the benefits to the environment, mobility, quality of life, and community livability.
2. More **electric and other alternative energy vehicles** are being developed and put into service.
3. More **transportation system planning and operations improvements** are being implemented because of the benefits they provide.
4. Increasingly many and increasingly **diverse personal mobility options** are becoming available, such as car sharing, and they are being researched, developed, and implemented.

Technology improvements, such as smart cars, constitute a fifth key transportation trend. Such trends include many of the information technology advancements we describe in Chapter Five in the discussion on pervasive computing. For example, while many technologies to assist drivers are already emerging—such as lane keeping systems that monitor lane markings and adaptive cruise control systems that keep speed with traffic—

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[221] J.J. Leeming, *Road Accidents: Prevent or Punish,* Cassell, 1969

[222] Hyung Chul Kim, Gregory A. Keoleian, Darby E. Grande, and James C. Bean, "Life Cycle Optimization of Automobile Replacement: Model and Application," *Environmental Science and Technology*, Vol. 27, 2003, pp. 5407–5413.

future technologies may include driverless vehicles and vehicles that can communicate with each other and with the surrounding transportation infrastructure. In the future, these technologies may help reduce emissions by enabling vehicles to drive more efficiently and to choose routes that are efficient as well.

These trends are not as relevant to Army installations in 2025 for several reasons. First, they may not be widely implemented by 2025. Second, the widespread implementation of infrastructure technologies depends on actions of transportation agencies like departments of transportation and metropolitan planning organizations, while the adoption of intelligent vehicles depends on the actions of consumers and manufacturers. Third, many of these technologies have high costs for infrastructure development, and the Army is only likely to adapt them after they are widely used throughout the United States. Therefore, the Army's role may be limited, outside of managing its own fleet of vehicles. Therefore, we do not discuss them further in this report, but focus on the four relevant trends.

Emphasis on Compact Land Use and Less Personal Vehicle Travel

One major trend of sustainable transportation is compact land use, which refers to areas of higher population densities and is defined as approximately 13 housing units per acre, while average residential development in the United States was 7.6 units per acre in 2003.[223] Compact land use may also involve mixed-use zoning, meaning that an area is not restricted to either residential, office, or commercial buildings but can have some mixture.

Compact land use is associated with reduced vehicular travel in a number of ways. First, when people use personal vehicles, they travel fewer miles than in low-density areas because distances, for example between a home and the supermarket, are shorter. Second, nonmotorized travel choices such as walking and cycling are also more possible, providing both health and environmental benefits. Third, transit development and use also tend to be more feasible and desirable in compact areas where large numbers of people can be served efficiently. Fourth, ride sharing or carpooling also become practical. Fifth, car sharing—a rental-car model in which participants rent vehicles on an as-needed, short-term basis instead of owning their own vehicles—is also more feasible because cars are needed less often and because enough people can share the vehicles in the same area to make the programs cost-effective and practical.

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[223] Reid Ewing, Keith Bartholomew, Steve Winkelman, Jerry Walters, and Don Chen, *Growing Cooler: The Evidence on Urban Development and Climate Change*, Washington, D.C.: Urban Land Institute, 2008, p. 8.

All of this results in a reduction in the number of miles driven in personal vehicles. Estimates suggest that doubling residential density across a region would reduce the number of miles traveled by residents in the area by about 5 to 12 percent.[224] Another study suggests that by shifting 60 percent of new residential growth across the United States to compact patterns, carbon dioxide (CO2) emissions could decline by 7 to 10 percent from current trends by 2050, or 79 million metric tons annually.[225] The other effects of fewer vehicle miles include better air quality due to lower emissions of conventional pollutants, less gasoline consumption which reduces dependence on oil, more physical activity and better health, less land requirements for roads and parking, and greater equity in mobility between the wealthy and poor. For these reasons, compact land use is a key aspect of sustainable communities in general.

Many communities are trying to encourage compact land use and other land use patterns that reduce driving and improve livability. In the 1990s, Arlington, Virginia encouraged mixed-use, high-density growth along the Washington D.C. Metro light rail line that ran through it. This area is known as the Rosslyn-Ballston Metro Corridor, and it has become a pedestrian and cycle friendly shopping, business, and residential district. Transit use in this area has also significantly increased.[226] Like many towns and cities in the United States, over the last few decades Barnstable, Massachusetts experienced tremendous growth on its outskirts while its once-vibrant downtown began to deteriorate. To combat this, in 2004, the town provided accelerated permitting for downtown developments, invested in infrastructure, and promoted walkable communities, among other measures. This has revitalized the downtown area and, according to reports, created jobs and further spurred the use of green designs.[227] More recently, the city of Palo Alto, California adopted new zoning ordinances that allow for mixed-use buildings and higher densities to increase the neighborhood's walkability.[228]

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[224] Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, *Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions*, Washington, D.C.: Transportation Research Board, TRB Special Report 298, 2009, p. 63.

[225] Ewing et al., 2008, p. 10.

[226] Smart Growth Resource Library, "Smart Growth in Action: Rosslyn-Ballston Metro Corridor, Arlington County, Virginia," 2010.

[227] Smart Growth Resource Library, "Smart Growth in Action: Village of Hyannis, Barnstable, Massachusetts,: 2010.

[228] City of Palo Alto, Title 18, Zoning Code, September 11, 2007.

Policies to encourage more compact land use are complemented by efforts to reduce driving in personal vehicles—known as transportation demand management (TDM). TDM includes a wide range of policies, many of which are highlighted in Table 3.1. Here, we briefly discuss three that are diverse and that may be particularly relevant to the Army. A more complete survey of numerous methods can be found on the Federal Highway Administration's TDM website.[229]

Table 3.1
Transportation Demand Management Includes a Wide Range of Policies and Programs

<u>Road pricing</u> charges drivers for their use of roads. In addition to traditional toll roads, this includes distance-based fees which charge per mile driven and are not limited to highways. It also includes congestion pricing in which charges are increased during peak travel hours and reduced at other times, to combat congestion.

<u>Parking management and pricing</u> limits parking availability or increases the cost of parking, or both, discouraging vehicle trips.

<u>Car sharing programs</u> use a model in which members rent cars on a short-term, hourly basis. By charging for individual trips, car sharing programs discourage trips.

<u>Pay-as-you-drive vehicle insurance</u> policies have premiums that vary depending on how much a vehicle is driven. This motivates policy holders to drive less.

<u>Ridesharing programs</u> encourage travelers to share rides and are typically undertaken by employers to reduce commute trips.

<u>High-occupancy vehicle (HOV) lanes</u> are lanes specifically allocated for ridesharers. They encourage ridesharing by allowing ridesharers to avoid tolls or avoid congestion.

<u>Transit incentives</u> reduce transit fares and thus encourage transit use.

<u>Transit improvements</u> seek to encourage transit use by increasing service, improving convenience, and other measures.

<u>Telework</u> policies encourage employees to work from home (and encourage employers to allow employees to do so), thus avoiding commute trips.

Parking Management and Pricing. Plentiful and free parking encourages driving and in some cases is the main factor in a traveler's choice to drive.[230] Parking management and parking pricing policies try to reduce vehicle trips by reducing the number of parking spots relative to demand, by making parking more expensive, or both. The intent is to encourage people to walk, cycle, or use transit, or to carpool, instead of driving.

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[229] U.S. Department of Transportation, Office of Operations, "Travel Demand Management," 2008.

[230] R. Dowling, D. Feltham, and W. Wycko, "Factors Affecting Transportation Demand Management Program Effectiveness at Six San Francisco Medical Institutions," Transportation Research Board, Record 1321, 1991, pp. 109–117.

For example, in California, many employers offer their employees a cash-out parking option in which they receive cash and forgo the parking space or parking subsidy that their employer would otherwise have provided. One study examined these policies among eight firms—one government agency, three law firms, one accounting firm, and one health care firm. On average, the percentage of employees who drove in single-occupancy vehicles dropped by 17 percent after the cash-out program was implemented. The number of vehicle miles traveled dropped by 12 percent.[231]

Although few cities have instituted widespread paid parking, those that have undertaken it have been successful, if there are enough alternatives for travelers (namely transit). The city of Perth in Australia began charging an annual fee for almost all parking spaces and found significant declines in the percentage of people driving to work. At the same time, jobs in the city grew significantly, suggesting that the program had not caused employers to move outside the area or caused employees to seek employment elsewhere.[232]

Ridesharing. As we have noted, most trips in the United States are made in personal vehicles, and most of those trips are made with only a single occupant in the vehicle. One aphorism in transportation is that the most underutilized capacity in transportation is the three or more empty seats in every SOV. Ridesharing—in which more than one person rides in the vehicle—moves a larger number of people with the same capacity, fuel consumption, and GHGs and is an obvious way to increase efficiency. Ridesharing, of course, occurs without any policy intervention, since many people are willing to share rides for convenience, cost savings, or company. But if there are other ways to encourage ride sharing, gains could be made in congestion, air quality, GHG emissions, and other areas.

Ridesharing is generally divided into carpooling and vanpooling. In carpooling, ridesharers use their personal vehicles and the ridesharing is typically privately arranged. One way to support carpooling is to provide rideshare-matching services, which allow prospective ridesharers to find others who work and live near them. Many firms provide "dynamic ridesharing," which makes quick matches online for one-time rides (as opposed to conventional matching systems in which both ridesharers are interested in ridesharing for an extended period of time). Employers can also encourage carpooling by offering carpoolers preferred parking, cheaper parking rates for carpoolers, etc.

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231 Donald C. Shoup, *Evaluating the Effects of Parking Cash Out: Eight Case Studies*, Sacramento, CA: California Air Resources Board, 1997, p. 3.

232 Sinclair Knight Merz, *Review of Perth Parking Policy*, Perth, WA, Australia, 2007.

The Metropolitan Washington (D.C.) Council of Governments has had a long-running ridesharing program which includes online ride matching and kiosks for ride matching. It found that during fiscal years 2003–2005, ridesharing vehicle trips increased by 5,000 per day and reduced the number of miles traveled by 129,000 miles per day.[233] Rideshare-matching services exist in many towns and cities of varying sizes, from San Francisco[234] to Minneapolis/St. Paul[235] to Nashville.[236] And while many ridesharing programs are run by local governments or commuter assistance organizations, many private companies do so as well.

In vanpooling, on the other hand, employers or third-party companies provide group transportation in larger vans and buses. Many vanpools charge riders a fee to cover operating expenses, and federal law also provides a tax credit for vanpoolers (but not carpoolers). Google, for example, provides vanpooling services free of charge to its employees in Mountain View, California, and bills the service as a job perk. Recent estimates suggest that 1,200 employees use this service—nearly a quarter of its employees at the time.[237]

Telework or Telecommuting. Another approach to reducing transit demand for commuting is to encourage working from home or an alternative location closer to home—called telework or telecommuting. Telework affects employers and employees. Employers generally offer telework as an employee benefit (rather than as a transportation program) for those whose work can be performed away from conventional workplaces.

Surveys suggest that working from home is important to employees. A recent survey commissioned by Cisco Systems surveyed IT professionals around the world and found that 60 percent of workers believed it was unnecessary to be in the office to be productive. Most workers also said they'd take lower pay to telework.[238]

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[233] LDA Consulting, CIC Research Inc., ESTC, Elham Shirazi, and Cheryl Collier, *Transportation Emission Reduction Measure (Term) Analysis Report, FY 2003–2005*, Washington, D.C.: Metropolitan Washington Council of Governments Commuter Connections Program, 2005, p. 26.

[234] For more information about San Francisco's ridesharing program, please visit: https://www.ridematch.511.org/SanFrancisco/

[235] MetroTRansit, website, 2010.

[236] Regional Transportation Authority, website, 2010.

[237] Michael Helft, "Google's Buses Help Its Workers Beat the Rush," *New York Times*, March 10, 2007.

[238] Matt Hamblem, "Survey Shows Mobility Is Mainstream at Work," *Computerworld*, October 19, 2010.

Telework does not have to occur from home—it can occur from telework or co-working centers that are designed to allow many teleworkers to share the same office space (and resources like printers, faxes, and phone services) away from their main place of employment. The U.S. General Services Administration (GSA), for example, has opened fourteen telework centers across the Washington, D.C. metropolitan area for both federal and private employees.[239] Telework.gov is the federal government's official teleworking website for federal employees and provides resources on how to begin teleworking at these centers.

Teleworking generally reduces driving. A pilot program in Los Angeles found that after two years, teleworkers worked from home on average 8 days per month.[240] Another California study of telework centers found that on teleworking days, employees avoided on average 38 miles of driving each.[241]

Cash-out parking, ridesharing, and telework are all examples of commuter assistance or commuter choice programs in which employers offer a wider range of commuting options and incentives to their employees. Commuter assistance includes employer-based transit benefits that allow employers to provide tax-free financial assistance toward employees' transit fares. Commuter choice also includes modified or flexible work schedules in which the typical five-day, 8-hour work week may be replaced, for example, by a four-day, 10-hour week. Other examples include bike and car sharing programs which we discuss later.

Growth in Electric and Other Alternative Energy Vehicles

Another major trend is to change fuels or type of vehicle to reduce the emissions. The aim is to reduce the amount of fuel consumed to travel the same distance and to reduce the air and water pollution and other effects of consuming the same quantity of fuel. Such changes in fuel use mainly affect the emissions of traditional pollutants and greenhouse gases and the dependence on oil, rather than land use, exercise, and other effects associated with less driving. Fuel *improvements* typically involve making changes to traditional fuels, for example by blending ethanol with gasoline to reduce the amount of carbon emitted when the fuel is burned. Alternatively, new types of fuels, such as biofuels and electricity, may be created that potentially pollute less and have lower GHG emissions than conventional fuels. However,

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[239] U.S. General Services Administration, *GSA-Sponsored Telework Centers*, 2010.

[240] Jack M. Nilles, *City of Los Angeles Telecommuting Project: Final Report*, Los Angeles, CA: JALA International, Inc., 1993, p. 19.

[241] Prashant N. Balepur, Krishna V. Varma, and Patricia L. Mokhtarian, "The Transportation Impacts of Center-Based Telecommuting: Interim Findings From the Neighborhood Telecenters Project," *Transportation*, Vol. 25, No. 3., 1998, p. 1.

the full environmental and sustainability costs of individual alternative fuels used would need to be assessed to ensure true environmental benefits, such as less pollution and GHG emissions. For example, corn ethanol production can potentially cause a range of environmental problems, including: soil erosion; large water use; water and soil pollution from the fertilizers and pesticides used to grow the corn; large uses of land, potentially resulting in habitat and biodiversity loss; increasing grain and food prices throughout the world; and even, potentially, increased carbon dioxide emissions from the energy inputs to grow the corn.[242]

Importantly, the development of improved fuels must be accompanied by significant infrastructure investments that make it possible to deliver fuels to consumers, e.g., at the gas pump, and consumers' vehicles must be able to make use of those fuels.

Implementation examples of this trend can be seen with the growing availability and popularity of hybrid electric vehicles (HEVs) and plug-in electric vehicles (PEVs). HEVs combine a traditional combustion engine with an electric propulsion system to improve fuel economy. Newer HEVs typically also take advantage of technologies such as regenerative braking—in which some of the vehicle's kinetic energy is converted back to electricity rather than being lost as heat—in order to further boost fuel economy. The newest model of the Toyota Prius has a combined city and highway fuel economy of 50 mpg,[243] while the newest Honda Civic Hybrid has a combined fuel economy of 41 mpg.[244]

PEVs are just emerging on the market and rely solely on electricity. The environmental effects of PEVs depend on their source of electricity, which is currently coal in much of the United States. However, if electricity can be produced renewably, then PEVs may offer significant environmental benefits.

More Transportation System Planning and Operations Improvements

Another key trend in reducing the effects of driving is to improve how the transportation system is planned, built, maintained, and operated. There are a number of methods by which the transportation system—roads, signals, materials—can be improved.

Very low speeds, rapid acceleration, and very high speeds (above 60 miles per hour) all generally reduce vehicles' fuel efficiency and lead to greater emissions. This can be mitigated

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[242] William Schulz, "The Cost of Biofuels," *Chemical & Engineering News*, December 17, 2007, and Gerrit Buntrock, "Food Prices: Cheap No More," *The Economist*, December 6, 2007.

[243] Toyota, *Prius 10*, specifications, 2010.

[244] Honda, *The 2011 Civic Hybrid*, 2010.

by approaches that make traffic smoother and enable vehicles to travel at speeds that result in less emissions.

Traffic Signal Optimization. Signal optimization, for example, involves careful timing of traffic signals along a traffic corridor so that traffic flows smoothly, with less stop-and-go at each intersection. Traffic signal optimization has been used for decades to combat congestion and save fuel. In 1983, for example, 41 California cities retimed 1,535 signals, and field studies found that fuel use was cut by 6 percent from these signals. They saved approximately 6.4 million gallons of fuel.[245] This equates to 56,898 metric tons of $CO2$. Given advancements in signal technology and traffic models in the last 25 years, this may be lower than the reductions that would possible in the same scenario today. Much more recently, as part of the Clinton Climate Initiative (2009), the City of Portland optimized traffic signal timing at 135 intersections on 16 streets in Portland. This optimization work has saved motorists over 1,750,000 gallons of gas each year.[246]

Speed Reduction and Enforcement. More efficient speeds may be achieved by reducing and enforcing lower speed limits on highways, for example to 45–55 mph. This also improves safety. Few regions have reduced speed limits, in part because there is a culture of driving faster. However, the National Research Council estimated that the former U.S. national 55 mph speed limit reduced national highway fuel consumption by about 2 percent, and that it also probably saved 2,000 to 4,000 lives per year, due to lower fatality rates in highway crashes.[247]

Green Materials. The transportation system can also be made more efficient by the way in which it is built and maintained. Many recycled pavement materials, for example, are both better for the environment and can cost less than traditional materials.[248] Fly ash, a by-product of the combustion of coals to generate electricity at coal-fired power plants, can be used to replace Portland cement in concrete. Portland cement is the binder material in traditional concrete that is associated with numerous environmental impacts ranging from mining the raw material to the large amount of energy required for extraction and

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[245] California Energy Commission, "Fuel-Efficient Traffic Signal Management: Results from the 1983 Program," 1984.

[246] C40 Cities, Climate Leadership Group, Clinton Climate Initiative, *Transport: Portland, United States of America*, 2009.

[247] D.L. Greene and A. Schafer, *Reducing Greenhouse Gas Emissions from U.S. Transportation*, Pew Center on Global Climate Change, Arlington, VA, May 2003.

[248] U.S. Environmental Protection Agency, *Using Coal Ash in Highway Construction: A Guide to Benefits and Impacts*, Report EPA-530-K-05-002, 2005.

manufacture of the raw product, to the emission of CO2 during actual cement production. Fly ash allows the use of locally available materials, reduces costs, increases energy efficiency, and produces a more durable mixture.[249] Such materials have been used by departments of transportation around the country.

Increasing Number of Diverse Shared and Personal Mobility Options

Another key trend is the growth in shared transport and personal mobility options. Shared transport in the broadest sense refers to any situation in which people share a vehicle. Ridesharing is an example of this: people share a car at the same time. Here, however, we focus on shared transport programs in which members do not privately own their cars or bicycles; instead they share the use of these vehicles over an extended time. Personal mobility refers to different ways that individuals can get around whether by car, bike, or other new vehicle alternative. Often personal mobility refers to new types of vehicles that are designed for efficiency, compactness, and travel in congested or urban environments, such as the Segway, as discussed later.

Such options offer a number of benefits, including reduced personal transportation costs, reduced emissions and other environmental impacts, reduced need for space for parking in urban areas, reduced congestion, and the sharing of transportation assets. Importantly, they are most feasible in high-density areas such cities and college, industrial, and other campuses.

Vehicle Sharing. Owning a car involves many "sunk costs"—the purchase price, registration fees, insurance, maintenance, etc.—that are fixed regardless of how much the owner drives the vehicle. For people who drive less, car sharing programs may offer an important, lower-cost alternative. In car sharing programs, members rent vehicles by the hour or day. This differs from conventional rental cars in several ways: it is marketed to residents and businesses in a city, rather than visitors; it provides hourly rates, while most rental car firms charge by the day or week; it positions vehicles throughout an area so that members can walk to them in their neighborhoods; and it emphasizes quick booking when a vehicle is needed. There are numerous examples of car sharing programs, such as Zipcar,[250] Connect by Hertz,[251] and U Car Share[252] by U-Haul.[253]

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[249] U.S. Environmental Protection Agency, *Using Coal Ash in Highway Construction: A Guide to Benefits and Impacts*, Report EPA-530-K-05-002, 2005.

[250] Zipcar, website, 2010.

[251] Hertz Car Rental, website, 2010.

[252] U Car Share, website, 2010.

[253] U-Haul, website, 2010.

Zipcar has been implemented in numerous cities and universities, and we use it to illustrate the impact of car sharing. Zipcar members pay an annual fee and thereafter pay for car usage on an hourly basis. This rental fee includes gas, insurance, maintenance fees, and some mileage. Zipcar claims that each Zipcar takes 15–20 vehicles off the road, while also costing less per mile than owning and maintaining a personal vehicle.[254]

Zipcar is currently located in over 50 U.S. cities in 24 states and D.C., and also in Canada and the UK. Zipcar also has partnerships with more than 100 universities across North America, where it reduces the number of on-campus cars while simultaneously giving members access to off-campus activities or jobs. It additionally offers students reduced membership rates. Some companies also use Zipcar for business travel or as an employee benefit to relieve congestion and parking problems. Zipcar also offers a "FastFleet," a spin-off program that replaces traditional fleets with car sharing fleets. This system is currently being used by the District of Columbia and has replaced the municipal fleet of 360 vehicles with only 58 vehicles. The D.C. mayor predicts savings of $6.6 million over 5 years.[255]

Car sharing's subtle effects may be as or more important than the obvious benefits of cost and reducing the number of privately owned vehicles. When choosing whether to drive or use transit or other means of travel, the immediate costs of the trip play a significant role in the decision. For example, travelers compare the cost of gas, tolls, and parking to the cost of bus or train fare. Because most of the costs of driving are fixed, driving appears cheaper than other transportation modes on a per-trip basis. In car sharing, these costs are variable and incurred largely per-trip, so drivers are more likely to consider the total costs and make fewer trips overall. For example, a study of four car sharing programs—two in Portland, one in San Francisco, and one in Arlington—found that the number of miles that car sharers traveled fell on average by 7 to 43 percent after joining the program. This accounts for both the increase in vehicle travel by those people who otherwise could not travel by car, as well as those people who gave up vehicle ownership, suggesting that the overall effect is positive.[256]

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[254] Zipcar, "Green Benefits," 2010.

[255] Nikita Stewart, "Zipcar to Manage System for Employee Vehicle Fleet," *The Washington Post*, April 28, 2009. As of November 1, 2010: http://www.washingtonpost.com/wp-dyn/content/article/2009/04/27/AR2009042703376.html?hpid=sec-metro

[256] Adam Millard-Ball, Gail Murray, Jessica Ter Schure, Christine Fox, and Jon Burkhardt, "Car-Sharing: Where and How It Succeeds," in *Transit Cooperative Research Program Report 108*, Washington, D.C.: Transportation Research Board, 2005.

Car sharing can also reduce fuel consumption and GHG emissions if the vehicles in the program have higher fuel economy than privately owned vehicles, or if members have the flexibility to choose the size of vehicle that meets their needs for each particular trip—meaning that large and less fuel efficient vehicles may be chosen only when needed. A recent study based on survey responses from over 6,200 car sharing members in North America found that car shared vehicles had higher fuel economies by up to 10 mpg than the vehicles that car sharers had previously owned (32.8 mpg versus 23.3 mpg).[257]

Other shared personal mobility options include bicycle sharing programs that follow a similar model: members pay an annual fee and then can rent bicycles on an hourly basis, picking them up and returning them to stations equipped with technology to secure and pay for the bikes. The SmartBike bicycle share program is one such example and exists in Paris, Barcelona, and Washington, D.C.[258] New York City is currently considering and evaluating bike share options.[259] Low-tech bicycle sharing programs are also possible. These systems use a simple coin-operated mechanism to unlock the bikes.[260]

Bicycle sharing can also be free. Nashville Bike Share in Nashville, Tennessee offers free bikes to all residents and students to improve health, reduce environmental impacts, and improve livability. Renters simply sign up online and provide proof of residence.[261] Free (or very low cost) bike sharing is particularly popular on college campuses where demand among students is high.[262]

There also are multi-modal shared vehicle concepts being considered so users have the flexibility to match vehicle type to each trip purpose. For example, researchers at MIT have been developing concepts and analytical approaches for how such a system might function in their work on mobility-on-demand systems:

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[257] Susan A. Shaheen, Adam P. Cohen, J. Darius Roberts, "Carsharing in North America: Market Growth, Current Developments, and Future Potential," *Transportation Research Record: Journal of the Transportation Research Board*, Issue 1986, 2006, p. 65.

[258] SmartBike, website, 2008.

[259] New York City Department of City Planning, "Bike Share opportunities in New York City 2009," 2010.

[260] The different generations of bike sharing programs are described at the City of Portland's Office of Transportation website.
Portland Bureau of Transportation, "Welcome to the City's Bicycle Sharing Page," 2010.

[261] Bike Share Nashville, website, 2009.

[262] Didi Tang, "Bike-Sharing Programs Spin Across U.S. Campuses," *USA Today*, September 22, 2010.

> Mobility-on-demand systems may use a single vehicle type. However, a more attractive option in larger and more sophisticated systems is to employ multiple vehicle types—providing users with choices among combinations of cost, comfort, and functionality. For example, a user might choose to ride a bicycle to the supermarket, leave it there, and bring back a car to carry the bags of groceries.[263]

Neighborhood Vehicles. Neighborhood vehicles are examples of personal mobility options and are designed for low-speed, short-distance travel. Neighborhood electric vehicles (NEVs) are plug-in vehicles designed for "neighborhood use," with a maximum speed of 20–25 mph, a gross vehicle weight of less than 3,000 pounds, and a typical range of 30 miles. NEVs are substantially more energy efficient than traditional vehicles because of their size, and therefore can reduce GHG emissions from the short-distance trips for which they are designed.[264] For example, it costs two cents to drive one mile in the Chrysler Peapod,[265] in comparison to twelve cents per mile for a 25 mpg vehicle and $3.00 per gallon of gas (fuel economy is not an appropriate measure for comparison, since the vehicle is electric).

Other personal mobility options include the Segway, a two-wheeled self balancing vehicle for individual riders.[266] Segways have had success primarily in police departments, corporate campuses, and industrial sites. Smart cars are on the higher-performance end of the efficient mobility spectrum. The Smart car is a "micro" version of traditional automobiles, typically seating two people, reaching a maximum speed of 90 mph, and with a fuel economy of 33 mpg in the city and 41 mpg on the highway.[267]

Universities are conducting research in technology development and deployment to develop even more diverse personal mobility options. The RoboScooter is a folding electric scooter developed by an MIT-led team of researchers and developers. They are simpler, cheaper, and greener than traditional scooters.[268] Similarly, GreenWheel is an electric-assist bicycle wheel that can be attached to any standard bicycle for easier and more comfortable

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[263] Smart Cities, *Mobility on Demand: Future of Transportation in Cities*, Cambridge, MA: MIT Media Laboratory, June 2008.

[264] An overview of NEVs can be found on the U.S. Department of Energy's website at http://www1.eere.energy.gov/vehiclesandfuels/avta/light_duty/nev/index.html .

[265] Mike Celizic, "Chrysler's Peapod: 2 Cents Per Mile Plus a Smile," *Today*, April 22, 2009.

[266] Segway, website, 2010.

[267] Smart USA, "Pure Coupe Technical Specs," 2010.

[268] Erik Sofge, "With Electric Scooter, MIT Hopes to Rev Up Practical Transport," *Popular Mechanics*, October 1, 2009.

riding.[269] The CityCar is a prototype electric vehicle that weighs less than 1,000 pounds and is expected to get the equivalent of 100 to 200 mpg. CityCar also folds to minimize the space needed to park.[270]

These advances suggest that the number of personal mobility vehicles will continue to grow and allow travelers to choose a vehicle that more precisely meets their needs—reducing fuel consumption, GHG emissions, congestion, and other externalities in the process.

Interrelationships with Other Trends

While the lack of sustainable transportation is a growing concern, its importance may be accelerated by general concerns about sustainable development and sustainable communities, which are all intimately related. For example, the trend toward communities that facilitate healthy living and exercise is challenged by the role that vehicular travel traditionally plays in providing mobility. Compact land use may provide a way of facilitating both sustainable mobility and healthy communities.

The need for sustainable transportation may also accelerate as concerns about biodiversity loss, encroachment, air pollution, water scarcity, and GHG emissions grow. For example, some states have already implemented policies recommending or requiring that transportation agencies address climate change. As concerns over climate change grow, it is expected that new federal legislation may require state departments of transportation and metropolitan planning organizations to address climate change by assessing emissions, setting targets for reductions, and developing ways to mitigate emissions and meet those targets.[271] Federal, state, and DoD requirements to reduce energy use in vehicles are likely to increase because of such environmental concerns and because of energy security concerns regarding the importation of overseas oil.

Information technology trends, such as pervasive computing and online community trends, may have a complex role in sustainable transportation. On one hand, information

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[269] Domenick Yoney, "MIT GreenWheel: Simply an Electric Bicycle Revolution," *Autobloggreen*, February 19, 2009.

[270] William J. Mitchell, Christopher E. Borroni-Bird, and Lawrence D. Burns, *Reinventing the Automobile: Personal Urban Mobility for the 21st Century*, Cambridge, MA: MIT Press, 2009.

[271] Michael Grant et al., *Assessing Mechanisms for Integrating Transportation-Related Greenhouse Gas Reduction Objectives into Transportation Decision Making*, Transportation Research Board, National Cooperative Highway Research Program, Web-Only Document 152, January 2010, provides a summary of recent policy efforts to require transportation decision making to include climate change considerations.

technologies may reduce the demand for transportation by making virtual meetings and telework more effective substitutes for in-person communication. Such advances in telework can decrease transportation needs, but may also promote more sprawling communities because people no longer need to drive into the office for meetings and can live out in the countryside more, which in turn could cause more declines in biodiversity.

Pervasive computing may also be used for vehicle-to-infrastructure or vehicle-to-vehicle communication and coordination, for example to improve transportation flow by dynamically setting speed limits and to enable better vehicle routing through the system. Such advances in general may make the transportation system more efficient and could promote sustainable transportation. On the other hand, the ability to be constantly connected to the Internet and to others while traveling, e.g., with wireless Internet on airplanes, may make it easier to continue working while traveling. This reduces the cost of travel in terms of lost work hours or lost productivity, and therefore may make travel *more* appealing and increase demand.

Implications of Sustainable Transportation Trends for Army Installations

Next we discuss the implications of these transportation trends for Army installations. However, to help set the context we first provide some background information about transportation issues at installations today and how some are starting to implement sustainable transportation activities.

Army Context with Respect to Transportation Issues

As was discussed earlier in the section on urbanization and sprawling communities, many Army installations have seen the growth of communities around them already, and this trend is likely to continue. With this growth has also come the growth of traffic and traffic congestion at an increasing number of installations. In fact, today many Army installations, especially those that are growing or near urban areas, face transportation-related pressures of traffic congestion and/or air quality concerns. Installations that have or will see significant operational and population growths from 2005 BRAC changes, such as Fort Belvoir and Fort Bliss, contribute to growing transportation concerns and problems. At many installations, the traffic concerns have to do with getting on and off the installation. Because of security concerns, limited entry points and access gates limiting access to installations, security policies at such entrance gates, standard work hours for installation Soldiers and civilian employees, and the fact that more and more Soldiers live off post, many installations experience rush hour traffic congestion at installation entry and exit points.

Policy and regulatory pressures from air quality, energy, GHG emissions, and other environmental concerns from transportation can also affect installation operations. For example, JBLM is within a nonattainment area for air quality under the Clean Air Act Amendments and the air quality restrictions limit this post's ability to operate new smoke generators. Such pressures are likely to increase in the future and affect more Army installation operations. It is more cost-effective, especially when transportation infrastructure is involved, to strategically plan and address such issues now rather than later. In addition, federal and Army policies and requirements to reduce energy use in transportation and increase renewable energy use are likely to occur in the future because of GHG and energy security concerns.

Land use concerns and constraints at Army installations are increasing. Installation land is a finite resource with many competing interests that need to be strategically managed. Compact land use and TND concepts enable more efficient use of land. Growth management and transportation planning are key parts of land management. Some Army installations already recognize the need to implement such concepts and are starting to try to do so. For example, Fort Belvoir has been implementing new urbanism principles with pedestrian-friendly mixed-use development in new housing projects. They have a main street with small shops that are walking distance from many homes, and above the shops are about two dozen two-story apartments.[272]

Installations also recognize the need to try to reduce personal vehicle travel, such as installing more bike lanes, facilitating commuter vanpools, providing post buses, and facilitating more use of public transit. We provide several installation examples. Aberdeen Proving Ground (APG) staff, given their anticipated employee growth from BRAC and growing transportation concerns, is working with Maryland state, county, and transit authorities to enable commuter train access to APG. Fort Bragg incorporates both pedestrian and bicycle facility elements into all new construction projects as part of its sustainability program because they are in the installation design guide requirements.[273] Some installations, such as Fort Bragg and JBLM, have post bus systems, though ridership is sometimes low, especially when the hours of operation and frequency of the buses are not

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[272] For more information, see Natural Resources Defense Council, "Smart Growth in Uniform: Fort Belvoir's Example," *Natural Resources Defense Council Switchboard Staff Blog*, July 15, 2008, at http://switchboard.nrdc.org/blogs/kbenfield/smart_growth_in_uniform.html.

[273] Lachman, et al., 2010, pp. 26–27.

convenient enough.[274] To deal with such low ridership on bus routes, some installations, such as Fort Bragg and Fort Carson, have conducted studies about the reasons why and have changed the bus routes to improve ridership. At White Sands Missile Range, over 70 vanpools help commuters share the ride to work each day.[275] At Fort Bliss in 2009, an Energy Security Tiger Team recognized growing transportation and congestion concerns and recommended incentives and activities to reduce single occupancy vehicle trips on the installation.[276] One of the most successful Army examples of reducing SOV travel and using mass transit occurred at USAG Presidio Monterey, California, which partnered with Monterey-Salinas Transit (MST) in 2009 to implement a Presidio Express bus line for commuters. By spring 2011, an estimated 600 cars were taken off of the road and there had been a reduction in 3 million privately owned vehicle miles of travel.[277] Because of such results, this effort won an Exemplary Practice award in 2011 as part of the Army Communities Excellence Awards.

Starting in late 2011, some installations, such as Forts Bragg, Carson, and Shafter, have begun car sharing programs through their Army and Air Force Exchange Service (AAFES) contract affiliate Enterprise Rental Car's WeCar program.[278] This Zipcar type of service is designed to provide convenient low-cost cars to Soldiers, Families, and other people on post and also provide revenue back to Soldier and Family programs.

Some installations, especially those already dealing with traffic concerns, are also implementing transportation system planning and operations improvements. Such installations have implemented changes in security gate policies, road infrastructure, and number of security entryways, among other things, to help facilitate more efficient movement of traffic. For example, Fort Bliss recognizes the need to implement more traffic

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[274] Some Soldiers, spouses, and service providers brought such post bus concerns up in the RAND study looking at Soldier and Family problems and installation support needs from frequent deployments. The Soldiers and Families wanted to use post buses but did not find them convenient enough. For more information on this study, see Appendix B.

[275] For more information, see http://www.militaryvanpool.com/White_Sands_Missle_Range.html

[276] U.S. Army, Office of the Deputy Assistant Secretary for Energy and Partnerships, *Energy Security Tiger Team Assessment—Fort Bliss, Final Report*, Washington, D.C., April 14, 2009, p. 19.

[277] The Army Chief of Staff, "Army Communities Excellence Awards 2011," U.S. Army, 2011.

[278] For more information, see http://www.enterpriseholdings.com/press-room/army-and-air-force-exchange-service-enterprise-rent-a-car-bring-car-sharing-to-us-military-bases.html.

optimization measures and "new access control points to keep traffic moving efficiently and alleviate congestion."[279] In addition, some installations are implementing more green practices in building roads, most notably, reusing concrete demolition waste in gravel roads to garner waste disposal cost savings. For example, Fort Campbell successfully grinds concrete from demolished structures into gravel for reuse in road and other projects. Grinding concrete results in a significant increase in waste diversion from demolition projects. This process cost $5.86 per ton of concrete and saved $30 per ton. As of September 2007 it resulted in an annual cost avoidance of $600,000.[280]

Electric vehicles already have a role at Army installations. The National Defense Authorization Act of 2010 and Executive Order 13514 build on prior federal requirements to reduce non-combat-vehicle petroleum through the procurement and use of renewable fuels and alternative fuel and flex-fuel vehicles and electric or hybrid vehicles. The Army currently has 40,000 alternative fuel vehicles, but a lack of fueling stations has limited their impact.

In 2009, the Army committed to leasing 4,000 neighborhood electric vehicles over three years, which promises to offer a number of benefits. The cost for all the charging infrastructure necessary for the vehicles was estimated at $800,000 or $200/vehicle[281] based on one to two vehicles garaged at the same location using 110V outlets for an overnight charge. The total cost savings over six years was projected at $45.8 million[282] and with resulting energy savings of $740 per car per year. It was estimated that this would also reduce oil consumption by 11.5 million gallons and eliminate 115,000 tons of CO_2 over 6 years.[283] However, the U.S. Department of Energy (DOE) changed the cost estimates, and future charging station infrastructure costs will be significantly higher based on charging station level, location, wiring requirements, electric grid capability, and desired charge duration per

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[279] U.S. Army, Office of the Deputy Assistant Secretary for Energy and Partnerships, *Energy Security Tiger Team Assessment—Fort Bliss, Final Report*, Washington, D.C., April 14, 2009, p. 19.

[280] Fort Campbell, "Army Installation Success Stories: Demolition Concrete Waste Diversion," fact sheet, undated.

[281] U.S. Department of Energy, Federal Management Program, *U.S. Army Charges Ahead in Using Electric Vehicles*, 2009.

[282] Jeremy Hsu, "Who Killed the Electric Car? Not the Army," *Popular Science*, January 15, 2009.

[283] Paul Boyce, "Army Announces Historic Electric Vehicle Lease," United States Army Press Release, January 12, 2009.

number of vehicles.[284] Unfortunately, in 2012 because of increased cost considerations and budget constraints, such neighborhood electric vehicles are no longer affordable at most Army installations.

Recommendations

Given this Army context and the trends just discussed, we have some sustainable transportation recommendations in each of the four relevant trend areas.

First, installations should do more strategic transportation and land use growth planning and management that involves compact land use and efforts to decrease SOV travel. Specifically, ACSIM/IMCOM should encourage installations in master and transportation planning to engage in more compact land use and TND practices, and promote policies that encourage decreased personal vehicle travel. In 2012, both OSD and Army master planning policies have started to emphasize such items more.[285] Such policies can include more incentives for biking, using buses, and other transit. Large installations should have free or low cost and convenient post buses to encourage some Soldiers and Family members to forgo personal vehicle travel to commute to work or to run errands during the day. Convenient locations, frequencies, and hours of operation are needed to ensure use. More efforts should be made to partner with local governments and communities on providing transit, like the USAG Presidio of Monterey did. In fact, this experience should be analyzed and written up as an in-depth case study to help other installations learn from this USAG's success. Designing bike lanes and bike racks for bike parking in key cantonment areas is another important activity.

Installations that face significant population growth because of BRAC and other Army installation population changes especially need to ensure that strategic planning of land use and transportation infrastructure, such as compact land use, is conducted sooner rather than later, because once the infrastructure—namely, the roads and buildings—,is in place, it cannot easily be changed. It will be much more costly to do such things later or the opportunity may be lost altogether.

Second, ACSIM/IMCOM should encourage installations in their transportation planning to do more transportation system planning and operations improvements to ensure efficient

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[284] For more details, see DOE cost estimates briefed at the 2012 FEDFLEET conference, June 25–28, 2012, in Louisville, Kentucky.

[285] See U.S. Department of Defense, *United Facilities Criteria (UFC): Installation Master Planning*, UFC 2-100-01, May 15, 2012; and draft of Army Regulation 420-1, "Army Facilities Management," August 2012.

flow and management of traffic and other transportation infrastructure. Such planning is especially needed regarding issues with on- and off-post traffic access points.

Third, IMCOM should help implement more car sharing pilots (like what was started in 2011 at Fort Bragg and Fort Carson) by encouraging car sharing implementation experiments at other large posts with population growth and transportation problems, like Fort Bliss. Such car sharing pilots should be at a low cost or even free and need to be available at convenient locations to benefit Soldiers and their Families. Lessons learned from the initial pilots at places like Fort Bragg and Fort Carson should be used to improve other installations' implementation of such car sharing programs. University campus programs can also be models for such implementation. IMCOM should also explore doing a free or fee-based shared bicycle system or even a multi-model system installation pilot that involves bicycles and cars. Such personal mobility options are an opportunity for Army installations to provide alternative transportation options that could help with quality of life issues, post congestion and parking issues, air quality concerns, GHG emissions, and other environmental concerns. Potential quality of life benefits include total transportation cost savings to Soldiers, reduced commute times, and better mobility. Single and younger Soldiers are likely to experience significant benefits given the high cost of automobile ownership. In addition, many Soldiers often sell personal vehicles before deploying or moving to a new post and may go days or weeks without vehicle access. This transportation issue has been mentioned as a problem by Soldiers and Families at installation Army Family Action Plan conferences. A car sharing program at low or no cost would be very useful for such Soldiers.

Fourth, the Army should do several things to ensure the effective and efficient use of electric vehicles. The Army should compare costs and benefits of electric, hybrid, plug-in hybrid, and alternative fuel vehicles for different uses, and plan for electric charging infrastructure, including appropriate locations, metering, and voltage. As more and more electric vehicle options are developed in the future, this charging infrastructure will become more and more important.

Lastly, the Army should consider the costs and benefits of bundling renewable power and distributed generation with charging infrastructure. Obviously, the benefits will vary by installation given the availability of renewable resources. For example, solar power provides more opportunity at places like Fort Irwin, Fort Carson, and Fort Bliss, which have strong solar resources, than installations in the Northeast.

To summarize, such strategic installation transportation planning and investments now can help save costs; save valuable installation land space; improve installation quality of life; reduce traffic congestion, reduce air pollution and other environmental problems; help preserve installation operational flexibility from air quality and other regulations; and help meet future federal, OSD and Army energy requirements.

Sources for Tracking Sustainable Transportation Trends

A number of studies and reports track trends in sustainable transportation. The Texas Transportation Institute publishes an *Annual Urban Mobility Report* that tracks traffic patterns and changes in congestion and mobility in the Unites States.[286] The American Association of State Highway and Transportation Officials published a report, *Transportation Invest in Our Future: Future Needs of the U.S. Surface Transportation System.* This report assesses transportation needs today and in the future, and presents the demographic and economic changes that will shape that future.[287] *Mobility on Demand: Future of Transportation in Cities* explores the future of personal mobility options, including car and bike sharing, with new vehicles and new models of use.[288] The Intergovernmental Panel on Climate Change (IPCC) published a report on mitigating climate change which includes a chapter on the GHG emissions from the transportation sector globally, as well as strategies for mitigating those effects.[289] These are only a few of the many recent studies. Given the pace of research in this area, it is particularly important to ensure that new research is included in future assessments of transportation sustainability trends.

Numerous organizations and institutions also conduct transportation research or track trends. The U.S. Department of Transportation provides a wide range of information on transportation trends and houses the Federal Highway Administration, the Bureau of Transportation Statistics, and a number of other relevant divisions.[290] The Transportation Research Board is one of the six major divisions of the National Research Council and

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[286] Texas Transportation Institute, *Urban Mobility Information*, 2009.

[287] American Association of State Highway and Transportation Officials, *Transportation Invest in Our Future: Future Needs of the U.S. Surface Transportation System*, Washington, D.C., 2007.

[288] Smart Cities, *Mobility on Demand: Future of Transportation in Cities*, Cambridge, MA: MIT Media Laboratory, 2008.

[289] Suzana Kahn Ribeiro, Shigeki Kobayashi, Michel Beuthe, Jorge Gasca, David Greene, David S. Lee, Yasunori Muromachi, Peter J. Newton, Steven Plotkin, Daniel Sperling, Ron Wit, and Peter J. Zhou, "Transport and Its Infrastructure," in B, Metz, O.R. Davidson, P.R. Bosch, R. David, and L.A. Meyer (eds.), *Climate Change 2007: Mitigation.* Contribution of Working Group III to the Fourth. Assessment Report of the Intergovernmental Panel on Climate Change, New York: Cambridge University Press, 2007.

[290] U.S. Department of Transportation, website, 2010.

finances research, holds annual meetings of the transportation research community, and provides a variety of resources related to transportation trends.[291]

There are a number of university or university-affiliated transportation research institutes. The Texas Transportation Institute, affiliated with Texas A&M University, conducts research in all areas of transportation. TTI publishes the *Annual Urban Mobility Report* discussed earlier. The Institute of Transportation Studies[292] at the University of California Berkeley also conducts research on all aspects of transportation and houses a number of specific research centers such as the Transportation Sustainability Research Center[293] and the UC Berkeley Center for Future Urban Transport.[294] The University of Michigan Transportation Research Institute also conducts transportation research and largely focuses on issues of safety and efficiency.[295] MIT conducts research to develop and analyze new transportation technologies and transportation concepts.[296]

Sustainable Agriculture

In this section we discuss some of the key sustainable agriculture trends and their implications for Army installations. Some readers may wonder why we even examined agriculture trends. However, there are some interesting developments from sustainable agriculture trends that have the potential to help improve Soldier and Family health at very little cost and may even help improve some encroachment and community relationship issues with local farmers and ranchers. Also, given the rise in U.S. obesity trends (which are discussed later in this section), some U.S. Army installations and MEDCOM have already started to look at some agricultural issues because of weight, nutrition, and health concerns. Because of all these reasons we present sustainable agriculture trends.

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[291] Transportation Research Board of the National Academies, website, 2010.

[292] Institute of Transportation Studies, Berkeley, website, 2010.

[293] University of California, Berkeley, "Transportation Sustainability Research Center," 2010.

[294] Institute of Transportation Studies, Berkeley, "UC Berkeley Center for Future Urban Transport," 2009.

[295] University of Michigan, "Transportation Research Institute," 2010.

[296] MIT, "Intelligent Transportation Research Center," website.

Background: Definition of Sustainable Agriculture

Sustainable agriculture is an emerging U.S. and international trend. The Food, Agriculture, Conservation, and Trade Act of 1990 (U.S. Public Law 101-624) defines sustainable agriculture as:

> An integrated system of plant and animal production practices that enhances environmental quality and the natural resource base upon which the agricultural economy depends; makes the most efficient use of nonrenewable resources and on-farm resources; integrates, where appropriate, natural biological cycles and controls; sustains the economic viability of farm operations; and enhances the quality of life for farmers and society as a whole.[297]

Sustainable agriculture also integrates three main goals—environmental health, economic profitability, and social and economic equity[298]—and it includes the concept of minimizing the distance that food must be transported to the consumer.[299]

Sustainable agriculture offers many benefits. In particular, the food can be healthier because fewer pesticides and fertilizers are used, no hormones are used to raise the animals, and, since the food is grown locally, it can be delivered to the consumer fresher. Sustainable agriculture can also help to protect and preserve the environment by helping to conserve topsoil, improve water quality, protect native biodiversity, and reduce waste. Lastly, sustainable agriculture can potentially help improve quality of life because it provides consumers wider access to healthier produce, and can help facilitate the economic viability of family farms.

Organic food is often a central part of sustainable agriculture as well. The USDA's National Organic Program regulates organic agricultural products in the United States.[300] Organic production is a system that is managed in accordance with the Organic Foods Production Act (OFPA) of 1990 and regulations in Title 7, Part 205 of the Code of Federal

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[297] See U.S. Public Law 101-624, Title XVI, Subtitle A, Section 1603.

[298] Patricia Allen, Debra Van Dusen, Jackelyn Lundy, and Stephen Gliessman, "Integrating Social, Environmental, and Economic Issues in Sustainable Agriculture," *American Journal of Alternative Agriculture*, Vol. 6, 1991, pp. 34–39.

[299] About 80 percent of energy used in the U.S. food system goes to processing, packaging, transporting, storing, and preparing food. On average, produce in the United States travels 1,300–2,000 miles from farm to consumer. See National Sustainable Agriculture Information Service, "Reducing Food Miles," April 26, 2012.

[300] See U.S. Department of Agriculture, "National Organic Program," website.

Regulations.[301] To be sold or labeled as an organically produced product, an agricultural product must:[302]

1. Have been produced and handled without the use of synthetic chemicals.
2. Not be produced on land to which any prohibited substances, including synthetic chemicals, have been applied during the previous three years preceding the harvest of the agricultural product.
3. Be produced and handled in compliance with an organic plan agreed to by the producer and handler of such product and the certifying agent.

Prior to the establishment of this legal definition in 1990, there was much confusion and controversy over what could or could not be considered "organic."

Key Sustainable Agriculture Trends

Like many of the other trends we have discussed, sustainable agriculture is an emerging trend both internationally and domestically in the United States.

Global Trends in Sustainable Agriculture

Sustainable agriculture is a key component in the global trend toward sustainable development. There has also been a global rise in organic farming, an 118 percent increase since 2000.[303] In 2007, farmers in about 140 different countries managed 32.2 million hectares of agricultural land organically, which is 5 percent more land area than in the previous year.[304] Consumer demand led to $46 billion of global sales of organic food and drink products in 2007.[305] The European Union (EU) accounts for 54 percent of this revenue,[306] and the United States accounts for 43 percent of the global revenue stream.[307]

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[301] See Organic Foods Production Act of 1990 [As amended through Public Law 109-97, November 10, 2005].

[302] See Organic Foods Production Act of 1990, Section 2105 [7 U.S.C. 6504].

[303] Alice McKeown, "Organic Agriculture More than Doubled Since 2000," *Vital Signs*, Washington, D.C.: Worldwatch Institute, 2010.

[304] McKeown, 2010.

[305] Organic Monitor, "Organic Monitor Gives 2009 Predictions."

[306] Amarjit Sahota, "The Global Market for Organic Food and Drink," in Helga Willer and Lukas Kilcher (eds.), *The World of Organic Agriculture Statistics and Emerging Trends 2009,* Bonn: Research Institute of Organic Agriculture (FiBL), International Federation of Organic Agriculture Movements (IFOAM), and International Trade Centre (ITC), 2009, pp. 59–60; Susanne Padel, Diana Schaack, and Helga Willer, "Development of the Organic Market in Europe," in Willer and Kilcher (eds.), p. 156.

In addition, there has been a growing international movement toward sustainable agriculture labeling. The Social Accountability in Sustainable Agriculture (SASA) project as a major effort designed to improve social auditing processes in agriculture. It was a collaborative effort between Sustainable Agriculture Network (SAN), Social Accountability International (SAI), Fair Trade Labelling Organizations (FLO), and International Federation of Organic Agriculture Movements (IFOAM).

U.S. Sustainable Agriculture Trends

In addition to the sustainable agriculture trends noted above, we identified three other current trends in the United States: community supported agriculture (CSA) has been increasing; restaurants are increasingly buying locally grown food and supporting community and sustainable agriculture; and local and community gardens are a growing trend. We discuss each below.

Support for CSA has also been increasing in the United States. CSA farms provide a weekly delivery of sustainably grown produce to consumers who pay a subscription fee. Some CSA farms also expect members to work on the farm at least once during the season. CSAs ensure that fresh and diverse local produce is accessible, and the trend also helps to save small, family farms. In 2007, 12,549 U.S. farms marketed their products through CSAs.[308]

Another trend in the United States is that some restaurants are buying locally grown food and supporting community and sustainable agriculture. Some restaurants are marketing the fact that they use only sustainable agricultural products or only what is in season and available locally.

Community gardening is also a current U.S. trend. This was spurred by concerns about costs and nutrition and has received attention as more people want to buy fresh and therefore buy local.[309] Michelle Obama's vegetable garden at the White House has also increased the visibility of community gardens. In addition, other potential benefits of community gardens are: helping improve the quality of life for people in the community; providing a catalyst for neighborhood and community development; beautifying

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[307] Organic Trade Association (OTA), *2009 Organic Industry Survey*, Executive Summary, Greenfield, MA: May 2009, p. 2; Helga Willer, "Organic Agriculture Worldwide," FiBL, March 10, 2009.

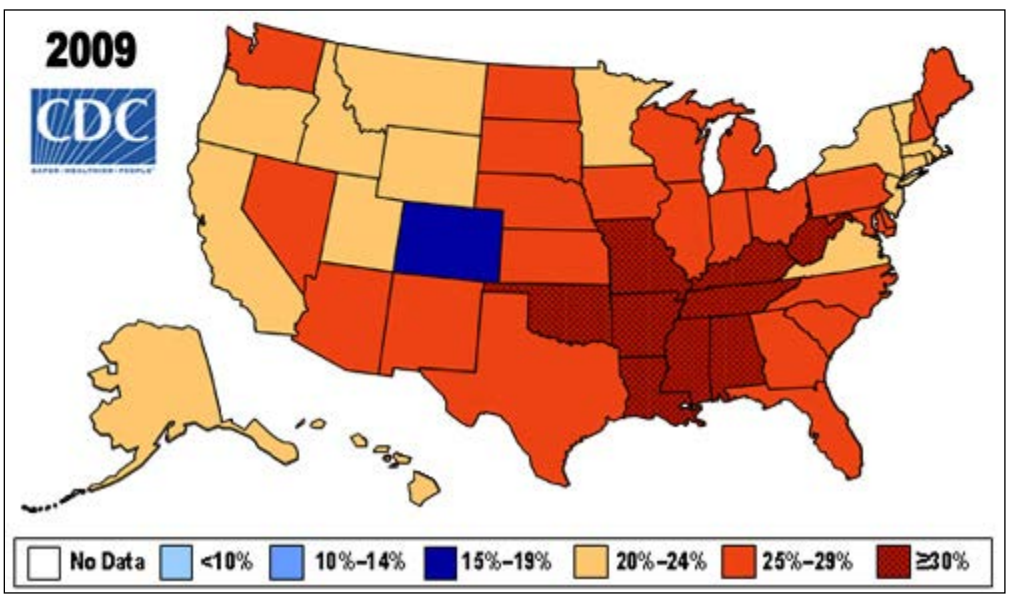
[308] U.S. Department of Agriculture, National Agricultural Statistics Bureau, *USDA Census of Agriculture-State Data*, 2007.

[309] Mary Reid Barrow, "Community Gardens a Growing Trend," *The Virginian-Pilot*, July 12, 2009; Monte Whaley, "Community Gardens a Hot Trend in Recession," *Denver Post*, May 4, 2009.

neighborhoods; reducing family food budgets; conserving resources; creating opportunity for recreation, exercise, therapy, and education; preserving green space; and reducing city heat from streets and parking lots.[310]

Many of these sustainable agriculture trends have arisen in response to the growing obesity problem among children and adolescents in the United States. Results from the 2007–2008 National Health and Nutrition Examination Survey, using measured heights and weights, indicated that an estimated 16.9 percent of children and adolescents aged 2–19 years are obese.[311] Currently, 66 percent of U.S. adults (ages 20 years or older) are overweight or obese; 16 percent of children (ages 6–11) and adolescents (ages 12–19) are overweight, and 34 percent are at risk of overweight. Obesity is also a problem for adults (see Figure 3.3). By 2015, 75 percent of U.S. adults ages 20 years or older will be overweight or obese, and 41 percent will be obese.[312]

Figure 3.3
Percent of Obese (BMI ≥ 30) in U.S. Adults



SOURCE: Centers for Disease Control and Prevention, "Behavioral Risk Factor Surveillance System, 2009."

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310 American Community Gardens Association, "What Is a Community Garden," website.

311 Cynthia Ogden and Margaret Carroll, "Prevalence of Obesity Among Children and Adolescents: United States, Trends 1963–1965 Through 2007–2008," June 2010.

312 Youfa Wang and May A. Beydoun, "The Obesity Epidemic in the United States—Gender, Age, Socioeconomic, Racial/Ethnic, and Geographic Characteristics: A Systematic Review and Meta-Regression Analysis," *Epidemiological Reviews*, May 17, 2007.

Emerging Future Sustainable Agriculture Trends

In addition to the current trends discussed above, there are four emerging future sustainable agriculture trends: urban agriculture, vertical farming, sustainable food systems, and food security.

Urban agriculture entails producing food in the urban environment. Namely, food is grown in urban places, such as vacant lots, patios, and rooftops. In 2000, the city of Chicago installed a rooftop garden on top of City Hall.[313] Advocates of urban agriculture argue that it reduces energy costs and pollution from transport and storage, reduces packaging and spoilage, offers a viable use for urban waste (such as wastewater for irrigation), creates economic development, and improves availability of food in poor communities. For example, rooftop gardens, once reserved for flower gardening only, have started focusing on agricultural production and may do so more in the future.[314]

Another emerging trend is vertical farming, which is the visionary idea of growing food in skyscrapers.[315] Advocates for vertical gardening argue that it is a better way to farm because it is a closed loop system, crops are protected from weather and bugs, and food is not transported great distances.

A third emerging trend is a movement toward sustainable food systems. Such systems take into consideration the entire life cycle of producing, preparing, serving, consuming, and disposing of food. Sustainable packaging issues and composting are key components of any sustainable food system. Some restaurants, including Otarian in New York City and London, are taking sustainability into account in every aspect of the food cycle, including restaurant design and waste disposal.[316]

Lastly, since 9/11 there is more concern over protecting the food supply, sometimes referred to as food security. Unlike large agrobusiness farming that often produces monoculture crops, sustainable agriculture helps maintain genetic diversity because it calls

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[313] See City of Chicago, "City Hall's Rooftop Garden," no date.

[314] Unlike green roofs, rooftop gardens are specifically engineered to conform to heavier load requirements (e.g., more soil and people walking around on them). See American Planning Association, *Planning and Urban Design Standards*, Hoboken, NJ: John Wiley & Sons, 2006, p. 106.

[315] Dickson D. Despommier, "A Farm on Every Floor," *New York Times*, August 23, 2009.

[316] See Otarian's website at http://www.otarian.com/love-the-planet/environmental.html.

for integrated pest management, crops to be rotated, and for fields to lay fallow.[317] Methods used to increase crop yield (including planting crops closely, soil tilling, and planting the same crop year after year in the same field) can deplete the soil nutrients available for uptake and therefore lower crop nutritional quality. Conventional farmers typically use seeds bred for high yield, pest resistance, and other qualities rather than for nutritional value.[318]

Due to the fact that it is isolated, Hawaii is particularly concerned about food security issues.[319] For instance, Hawaii only has one milk processor; the stakes are high if it would need to shut down for some reason. Given its vulnerability to invasive species that may be transported onto the islands aboard boats and planes, Hawaii heavily monitors cargo for invasive species that may devastate native food sources.

What Could Change the Course of Sustainable Agriculture Trends

The biggest factor that could change the course of sustainable agriculture trends are consumer preferences and buying habits. If consumers demand more products that are grown in a sustainable manner, producers will respond to that market demand.

Environmental trends like loss of biodiversity, water scarcity, and loss of agricultural land and open space from sprawl pressures could also cause communities to become more concerned about sustainability and implement more sustainable agriculture activities.

Interrelationships with Other Trend Areas

Sustainable agriculture trends intersect with other trends that we discuss in this report including loss of biodiversity, water scarcity, energy, and transportation. Sustainable agriculture can help prevent the loss of biodiversity, improve water quality and quantity, and decrease the amount of energy required to transport agricultural products. This could also decrease pollution. Transportation miles would decrease as well. Societal trends related to nutrition and obesity problems also relate to sustainable agriculture. Namely, some of the sustainable agriculture activities, like community gardening, have the potential to help provide healthier food and help some people avoid or fix their obesity problems.

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[317] Jean M. Rawson, *Sustainable Agriculture*, Congressional Research Service Report No. 95-1062, 1995.

[318] American Public Health Association, "Policy Statement No. 200712: Toward a Health, Sustainable Food System," November 6, 2007.

[319] See Governor of Hawaii, "Protecting Our Food Security," fact sheet.

Implications of Sustainable Agriculture Trends for Army Installations

Installation sustainability efforts are starting to consider and even implement sustainable agriculture and food production activities. For instance, Joint Base Lewis-McChord has started providing community garden plots on post. In fact, Soldiers of the 23rd Chemical Battalion, 555th Engineer Brigade, are growing and eating vegetables and fruits in a small "Victory Garden" near their headquarters building. 23rd Chemical Battalion commander Lieutenant Colonel Sean Kirschner said about the garden, "I think it's the right thing to do for the environment, for health, for nutrition."[320] In addition, Fort Hood, Fort Carson, JBLM, and other installations are implementing composting projects and programs to compost organic wastes. Again JBLM is a leader, with a 21,600 square foot facility that composts food and yard waste. In fact it produces about 5,000 yards of compost per year.[321] Concerns about the food life cycle were also identified at the Sustainability IPR held at Fort Bragg January 12–14, 2010. MEDCOM staff have also considered Army-wide options for having on-post farmers' markets because of the potential health benefits.

Sustainable agriculture is also an opportunity to help improve Soldier and Family health, given U.S. obesity trends. During the past 20 years there has been a dramatic increase in obesity in the United States.[322] In 2009, only Colorado and the District of Columbia had a prevalence of obesity less than 20 percent (see Figure 3.3). This increase in obesity rates is impacting military recruits as well as Army Soldiers and Families and will become more significant in the future.[323] As Major General Thomas Bostick of the Army Recruiting Command stated, obesity will be "a bigger [recruiting] challenge for us in the years ahead" than other problems that restrict young people from entering the Army, including lack of high school diplomas, misconduct, criminal behavior, and other health problems.[324] To address such problems, more and more parts of the Army are looking at improving nutrition and fitness for Soldiers and Families. For example, the Army had a registered dietitian review

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[320] Marisa Petrich, "Soldiers Leave Legacy of Sustainability," *Northwest Guardian*, August 18, 2011.

[321] Diane Mettler, "Making Compost Military Style," *WHEN, Waste Handling Equipment News*, September 2011.

[322] Centers for Disease Control and Prevention, "U.S. Obesity Trends," no date.

[323] For detailed data on overweight and obese 18 year old applicants over time, see Lucy L. Hsu et al., "Trends in Overweight and Obesity Among 18-Year-Old Applicants to the United States Military, 1993–2006," *Journal of Adolescent Health*, Vol. 41, Issue 6, December 2007.

[324] Susan M. Schafer, "Top Army Recruiter Weighs Fat Camp for Recruits," *Army Times*, January 12, 2009.

the Army food system at a basic training post, Fort Leonard Wood, and she was "appalled by what the Army was serving young soldiers." The Army has since redesigned its food system for training posts. Now there "are still eggs, bacon and gravy, but all of the deep-fried stuff is gone, replace by whole grains, low-fat yogurt and sliced fruit. It's a complete dietary reversal."[325] Sustainable agriculture activities could potentially help play a role in such nutrition programs by providing more local fruits and vegetables at installations.

Some individual installations are also starting nutrition programs. For example, at Fort Hood, the Resiliency Campus (which operates to ensure wellness for its Soldiers, Families, and Retirees) includes a facility that teaches Soldiers and their Families about nutrition and provides nutritious cooking classes.[326] Some installations are also exploring buying more local produce because of nutritional benefits and to help local farmers.

Lastly, sustainable agriculture helps support local farms and ranchers surrounding installations and can also help address sprawl and encroachment concerns. By supporting local farmers and ranchers, they are less likely to sell their land to developers, helping keep open space near installations. It also helps improve community relationships.

Recommendations

There are a number of steps that installations could take related to community agriculture. First, ACSIM/IMCOM should help installations participate in community supported agriculture (CSA) and purchase more produce from local growers. This could be done by encouraging the food services on installations to explore CSA opportunities and to purchase more produce and other food produces from local farmers and ranchers. These food services include the commissary, on-post restaurants, and food vendors. ACSIM/IMCOM would need to work with other organizations to begin such a process, such as the Defense Commissary Agency (DeCA) regarding commissaries and the Army and Air Force Exchange Service regarding their fast food restaurants and other stores that they manage onpost that provide food. A good way to start such a process is to have a few installations do demonstration projects in CSA or buying local produce and have them work with their local DeCA and AAFES staff. Another option is to have some of the local day care centers on posts begin to purchase local produce or participate in CSA. If day care centers participate in

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[325] Frank Morris, "Army Boot Camp Embraces New-Age Fitness," National Public Radio from KCUR, December 28, 2010.

[326] For more information, see Fort Hood, "Fort Hood Resiliency Campus," undated. As of September 27, 2011:
http://www.hood.army.mil/resiliencycampus/

CSA, the post could get the military families involved and also make the effort into an educational opportunity about nutritious food and where food comes from. Any such pilot projects should be documented and shared across installations to help encourage others to do the same.

Second, installations could facilitate on-post farmers markets and facilitate military families and staff participating in CSA and on-post community gardens. ACSIM/IMCOM should issue a policy encouraging installations to do on-post farmers markets, to offer CSA to military families and staff on post, and to provide community garden plots to Soldier and Military Families on post, as JBLM has done. Again ACSIM/IMCOM could begin by having a few installations do demonstration projects and then share the lessons learned with other installations. They should also document and share the current JBLM experience to help encourage other installations.

Last, installations should compost most of their organic wastes. Composting is part of the net zero waste process, which is a good way to help some installations focus more on composting. However, to ensure wider implementation of compost projects, ACSIM/IMCOM should encourage installations to compost and to use the compost on post. They should discuss the benefits to such composting. It is important that installations include food wastes in this process, not just landscape, training, and packaging waste.

The types of recommendations suggested here could, with very minimal investment of installation resources, help improve the nutrition and health of Soldiers and their Families; help prevent encroachment; help to support the local community, local farmers, and the local economy; and help improve community relationships.

Sources for Tracking Sustainable Agriculture Trends

Organizations That Track Sustainable Agriculture Trends

The *U.S. Department of Agriculture (USDA)* is the primary U.S. government department that tracks domestic sustainable agriculture trends. The *U.S. Agency for International Development (USAID)* is the primary U.S. government agency that tracks global sustainable agriculture trends.

The *National Sustainable Agriculture Information Service* is funded under a grant from the U.S. Department of Agriculture's Rural Business-Cooperative Service and managed by the National Center for Appropriate Technology (NCAT).[327] It provides information and other

[327] See the National Sustainable Agriculture Information Service website at http://attra.ncat.org.

technical assistance to farmers, ranchers, Extension agents, educators, and others involved in sustainable agriculture in the United States.

Worldwatch Institute is a key nongovernmental organization that tracks global sustainable agriculture trends.

Studies and Reports That Track Sustainable Agriculture Trends

One of the best studies that examines current trends related to food and agriculture is Worldwatch Institute's *Vital Signs 2010*. This report also specifically examines trends in organic agriculture, both globally and in the United States.

The *2009 Survey of Community Supported Agriculture Producers* was conducted by the Cooperative Extension Service, College of Agriculture, at the University of Kentucky. The findings of this survey on business and marketing practices of 205 CSA farms in Illinois, Indiana, Kentucky, Michigan, Missouri, Ohio, Pennsylvania, Tennessee, and West Virginia can be found at http://swroc.cfans.umn.edu/organic/csasurvey.pdf.

In 1995, the Congressional Research Service issued a report titled "Sustainable Agriculture." While dated, this report provides a good overview of the emergency of sustainable agriculture in the United States in the 1980s and 1990s.[328]

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[328] See Rawson, 1995.

CHAPTER FOUR

Buildings and Energy Trends

This chapter discusses sustainable buildings and energy trends, which have significant implications for the Army in terms of future costs, the ability to meet future regulations and installation requirements, and the opportunity to obtain future benefits. The topics of sustainable buildings and energy are closely related given that energy management is a key consideration in developing sustainable buildings, and that buildings consume a large portion of installations' total energy use. We begin by discussing sustainable buildings.

Sustainable Buildings

In this section we discuss the activities and trends related to sustainable buildings and the implications they have for Army installations.

Background: Defining Sustainable Buildings

Buildings are long-lived assets that have many benefits and impacts. They are places of shelter, they enable home and work life, and they help shape and foster communities. Buildings also impact life, work, and the environment. For example, the air quality in a building, or the opportunity it offers for exercise can affect the health of its occupants. Well-designed office buildings can have a measurable effect on productivity and morale. Buildings also require energy, water, and other natural resources and therefore also have an impact on the environment. Buildings also involve high costs throughout their life cycle—from design to construction to operations and maintenance to renovation and, ultimately, to decommissioning and demolition.[329]

Building managers across all sectors face the same challenges in managing the costs, benefits, and impacts of their buildings. They seek to understand how buildings can provide better work places, e.g., through designs that promote the emotional and physical health of their occupants, and that foster communication and collaboration in the building

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[329] Greg Kats, *The Costs and Financial Benefits of Green Buildings, a Report to California's Sustainable Building Task Force*, Sacramento, CA: Sustainable Building Task Force, 2003; Judith Heerwagen and Betty Hase, "Building Biophilia: Connecting People to Nature in Building Design," *Environmental Design and Construction*, 2001; and Judith Heerwagen, "Sustainable Design Can Be an Asset to the Bottom Line," *Environmental Design and Construction*, 2002.

community. They also are concerned with the environmental impacts of buildings (such as climate change and indoor air quality) and seek ways of mitigating those impacts. Cost is a major concern, and building managers must determine how much should be spent to operate and maintain existing buildings and how financial resources can be used most efficiently. Similarly, they must determine how resources should be used to improve and renovate buildings, and what aspects of buildings merit the most improvement. Looking forward, they must determine how current and future market trends and public policies will affect their buildings and their missions. In short, they must answer the question *"How do we allocate scarce resources to provide the greatest value?"*

Managers are addressing these challenges by making buildings more sustainable. *Sustainable buildings*—also known as *green buildings*—are defined by the EPA as follows:

> Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:
>
> - Efficiently using energy, water, and other resources
> - Protecting occupant health and improving employee productivity
> - Reducing waste, pollution and environmental degradation
>
> For example, green buildings may incorporate sustainable materials in their construction (e.g., reused, recycled-content, or made from renewable resources); create healthy indoor environments with minimal pollutants (e.g., reduced product emissions); and/or feature landscaping that reduces water usage (e.g., by using native plants that survive without extra watering).[330]

It is important to note that the definitions of a sustainable building vary, especially in implementation activities. However, the definitions tend to have common elements. Such elements include: a focus on a long-term life-cycle design approach; increased energy, water, and resource efficiency; reduction, reuse, and recycling of waste; and the procurement and use of environmentally preferred products.

Building managers are beginning to think longer-term and more strategically, and sustainable buildings offer a number of benefits in the near and long term. They help ensure that buildings comply with new environmental and social policies and prepare for compliance with future policy changes, where sustainability requirements are likely to become increasingly stringent. They enable competitiveness in a changing real estate market where demands for sustainability are growing. Very practically, they also seek to reduce the

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[330] U.S. Environmental Protection Agency, *Green Building: Basic Information*, 2010c.

life-cycle costs of owning and operating the building by reducing energy, water, and resource consumption.[331]

Key Sustainable Buildings Trends

Building owners, architects, developers, and other stakeholders are devoting increasing attention to sustainability. This growing interest is driven partly by trends such as evolving state and municipal building codes, labeling programs, government policies, and best practices.

A number of related trends will shape the future of sustainable buildings, including trends in codes and labeling programs; changes in energy, water, and other resource costs; changes in public policy in the United States and elsewhere; changes in industry and society; and changes in computing and information technology.

We have grouped the key sustainable building trends into five main categories for discussion here:

- State and local building codes, voluntary standards, and labeling programs define higher and higher performance goals.
- Best practices for building management are evolving.
- State and local governments are adopting policies to accelerate sustainable building practices.
- Federal legislation, Executive Orders, and DoD policies continue to increase building sustainability requirements.
- Other important sustainable building trends are emerging.

State and Local Building Codes, Voluntary Standards and Labeling Programs Define Higher and Higher Performance Goals

We begin this trend discussion by summarizing the role that state and local building codes and voluntary standards and labeling activities are having in sustainable building trends.

Stricter State and Municipal Building Codes. State and municipal building codes establish mandatory minimum performance requirements for buildings in a jurisdiction. These are typically based on standards developed by industry and government experts and

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[331] Andy Florance, "The Economics of Green," presented at the EPA Conference on The Power of Information to Motivate Change: Communicating the Energy Efficient of Today's Commercial Buildings, Washington, D.C.: December 2008; Kats, 2003; and Rasika Savkar, "Life-Cycle Cost Assessment as a Tool for Retrofits," *buildings.com*, August 26, 2009.

address almost all aspects of buildings, including the floor plan, energy and water consumption, structural integrity, materials use, and the performance of subsystems such as plumbing and appliances. A broad range of industry and government groups; such as the International Code Council (ICC), the National Fire Protection Association (NFPA), the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), and the American Society of Civil Engineers (ASCE); develop such standards.

Traditionally such standards have focused on safety and structural features. For example, ICC's International Building Code (IBC) introduced in 2000 primarily focuses on the construction and design aspects of fire prevention and the means of egress, access for the disabled, and structural stability with references to the ASCE Standard 7-05. ASCE 7-05 focuses on minimum design loads for buildings and other structures, including provisions for the seismic design of structures and determining live, flood, wind, snow, and atmospheric ice loads. This ICC Building Code has been adopted by all 50 U.S. states and the District of Columbia.

More of these standards are focusing on sustainable building concerns, especially environmental and energy concerns. These environmentally related standards, such as energy efficiency, resource consumption, and air quality, are becoming stricter due to growing concern about the environment and as the effects of buildings on the environment are better understood.[332] For example, consider ASHRAE Standard 90.1-2007, the Energy Standard for Buildings Except Low-Rise Residential Buildings. ASHRAE Standard 90.1 was first issued in 1975 and currently is updated about every three years. The 2007 version provides minimum requirements for the energy efficient design of buildings except low-rise residential buildings, including new buildings and their systems, new portions of buildings and their systems, and new systems and equipment in existing buildings. Table 4.1 shows the topic areas covered by this standard.

ASHRAE Standard 90.1 has placed more emphasis on sustainability issues over time by focusing on stricter energy performances in buildings. ASHRAE Standard 90.1-2007 is about 10 percent more energy efficient than the 2004 version (ASHRAE Standard 90.1-2004). ASHRAE Standard 90.1-2010 has a goal to be 30 percent more energy efficient than the 2004 version. ASHRAE is targeting net zero energy buildings by 2030.[333]

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[332] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Building Energy Codes 101: An Introduction*, Washington, D.C., PNNL-SA-70586, 2010.

[333] ASHRAE 90.1-2007; Ronald Jarnagin, "ASHRAE Standard 90.1-2007: Setting a New Bar," briefing to GovEnergy Conference, August 7, 2007.

Table 4.1
Topic Areas Covered by ASHRAE Standard 90.1-2007

Building envelope	Insulation properties of roofs, walls, floors, doors, windows, skylights; differentiated by climate zones
Heating, ventilating, and air conditioning	Standards for minimum equipment efficiency, ductwork, piping, and system implementation
Service water heating	Standards for load calculations, equipment efficiency, piping insulation, system controls, pools
Power	Building power distribution systems sized to limit maximum voltage drop
Lighting	Interior and exterior features including power, luminaire wattage, lighting controls, lighting power densities
Other equipment	Electric motors

While ASHRAE 90.1 provides a consensus set of *minimum* requirements for energy efficiency for new and retrofit buildings, it does not provide guidance for *exemplary* energy efficient buildings. A 2010 standard from ASHRAE does, however, provide such guidance. ASHRAE Standard 189.1P, the "Standard for the Design of High-Performance, Green Buildings except Low-Rise Residential Buildings," has been developed for buildings that wish to exceed the minimum requirements of Standard 90.1. The "Green Standard" was published in 2010 with a goal of "not just energy efficiency but a balance of environmental responsibility, resource efficiency, occupant comfort and well-being, and community sensitivity, and … sustainable development." Standard 189.1P is consistent with 90.1 but includes "significantly more stringent energy requirements." Because government facilities are required to utilize "high performance" buildings, ASHRAE Standard 189.1P will be the relevant standard going forward, as will be discussed below.[334]

States and local governments are also incorporating more of the voluntary labeling codes into their codes, which we discuss more in the next section after we explain what these voluntary labels are.

More and Stricter Labeling Programs. Labeling and certification programs recognize buildings or building elements that *voluntarily* meet environmental performance requirements above and beyond those that are made mandatory by government. Energy Star, for example, comprises a set of related labeling programs run by EPA and DOE to recognize energy

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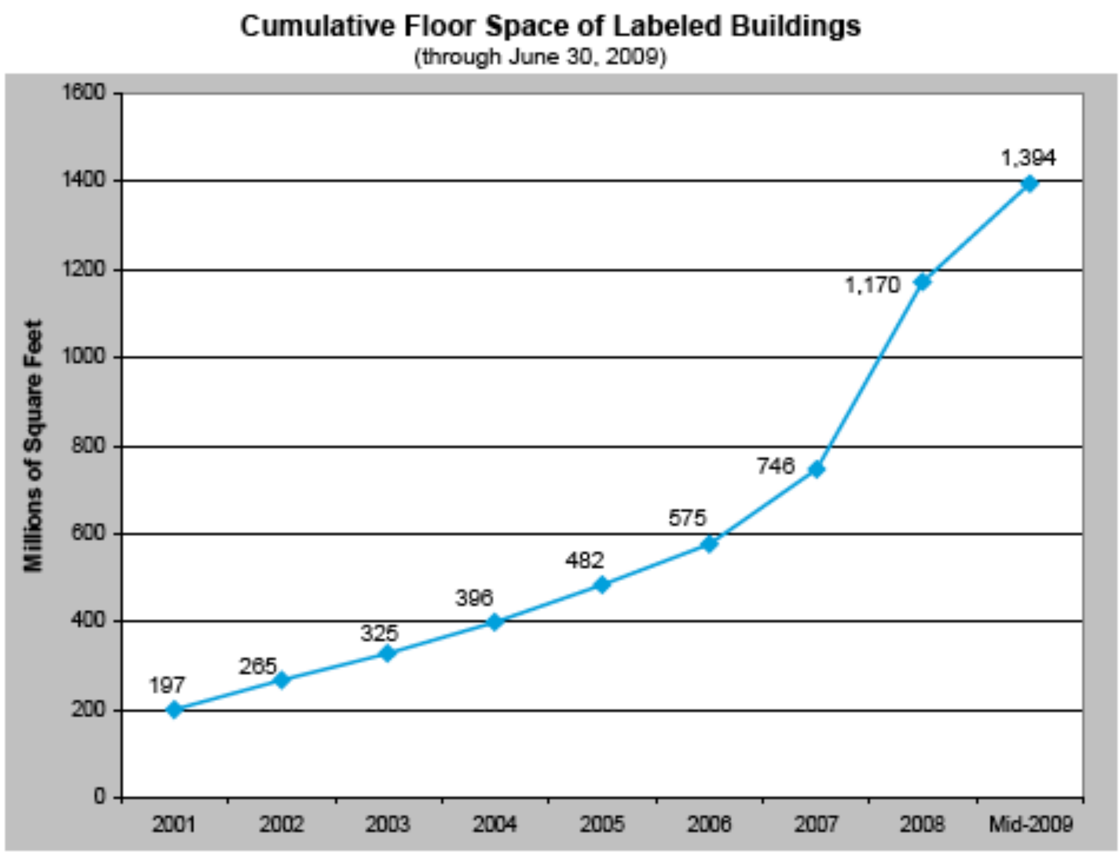
[334] ASHRAE's "Green Standard" can be found at http://www.ashrae.org/publications/page/927. More on the overlaps and differences between the various ASHRAE standards and guidelines can be found at http://www.ashrae.org/technology/page/1040.

efficient consumer products, including heating and cooling systems, lighting, and appliances commonly found in buildings.[335] In an increasingly environmentally conscious market, bearing these labels provides a market advantage to companies. A wider range of labeling programs have been developed to address building sustainability issues from green buildings to forest materials labeling. More and more companies and other organizations are choosing to participate. For example, Figure 4.1 shows how by mid-2009, about 10 percent of commercial office space received the Energy Star label, a significant growth over time. These programs are becoming more important. We discuss some here that have the most relevance for the Army.

Figure 4.1
Commercial Office Space Receiving the Energy Star Label Over Time



SOURCE: U.S. Department of Energy, *Energy Efficiency Trends in Residential and Commercial Buildings*, October 2009.

[335] Energy Star, website, undated a.

The U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) is one of the most well-known building labeling and certification programs, with international reach and recognition.[336] The LEED certificate recognizes buildings that are designed and built with excellence in building sustainability.[337] Buildings receive points for meeting requirements in a wide range of areas, including sustainable siting, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation and design processes, awareness in education, and locations. LEED version 3 (v3), developed in 2009, uses a point-based accounting system, awarding up to 100 points for buildings that meet environmental sustainability requirements. The LEED process also awards additional points for meeting regional priorities, e.g., water efficiency in the American West. Buildings that meet different point thresholds are awarded different levels of LEED certification: basic certification (40–49 points), silver (50–59), gold (60–79), or platinum (80+).[338] Building owners and managers can seek LEED certification by submitting an application documenting compliance with the performance requirements. The applications are reviewed by the Green Building Certification Institute, which verifies that the building complies with the rating system requirements.

Labeling programs and state and municipal codes are complementary—while government regulations continue to raise the lower bound of allowable performance, labeling programs continue to raise the upper bound on best possible practices (see Figure 4.2). Together, they slowly raise the performance of all buildings—the best and the worst. Additionally, more state and municipal governments are choosing to incorporate labeling programs into their policies, codes, and regulations, often making these performance standards mandatory rather than voluntary. We provide three examples here. First, the

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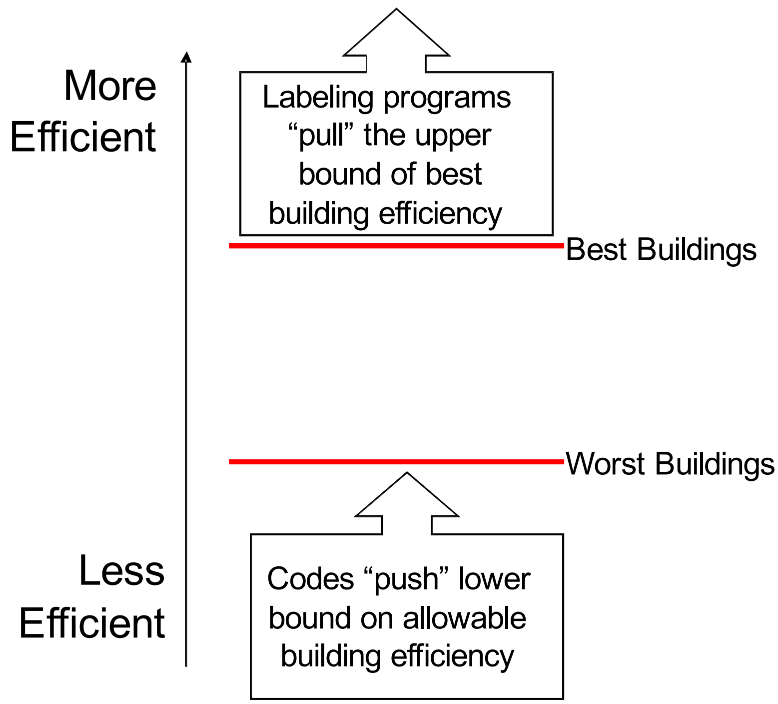
[336] U.S. Green Building Council, *LEED*, 2011b.

[337] As noted earlier, some people have criticized LEED, especially its point system, which they say does not do enough to ensure more sustainable buildings. For example, developers can get the same number of points for installing a bike rack as they do for an expensive water recycling system. In other cases, a developer may put in features that are not appropriate for the regional conditions, such as including more water conservation features at military installations in Alaska where water is abundant instead of including more energy efficiency features that would have more environmental and long-term economic benefits. However, many of these issues can be addressed in oversight of the developer's plans in implementing the standard to ensure that appropriate environmental features are put in given the local circumstances.

[338] U.S. Green Building Council, *LEED 2009: Technical Advancements to the LEED Rating System*, 2011c; and U.S. Green Building Council, *LEED 2009 for New Construction and Major Renovations*, 2008.

Figure 4.2
Labels Pull the Best Performers Up While Codes Push the Worst Performers Up



District of Columbia's Green Building Act of 2006 phases in requirements that new commercial buildings over a specific size meet LEED Silver standards.[339] Second, a borough ordinance in the city of Westchester, Pennsylvania requires that all new construction be designed to be certified by the Energy Star label, and the performance must be benchmarked annually. Third, Denver, Colorado requires new construction and renovations of all government-owned buildings to comply with a similar rule.[340]

Labeling programs like LEED are also becoming increasingly influential and important, in part because they are becoming increasingly stringent and are seen in many ways as leaders in shaping the future of sustainability in buildings. For example, LEED v3 is a revision of earlier LEED versions and, in addition to requiring higher performance in areas such as

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[339] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Energy Codes Program, "Status of State Energy Codes: District of Columbia," 2010.

[340] U.S. Environmental Protection Agency, *Energy Star, State and Local Governments Leveraging Energy Star*, 2010b.

energy efficiency, it awards more points to design elements that have a greater impact on the environment—e.g., energy use and CO_2 emissions—than others.[341]

The array of labeling programs is also large and growing. LEED itself was first developed for new buildings, but has grown to encompass existing buildings, schools, homes, interiors, and neighborhoods. In addition to LEED and Energy Star, there are labeling programs for wildlife impact such as the one managed by the Wildlife Habitat Council,[342] which evaluates projects and recognizes commendable wildlife habitat management and environmental education programs at workplaces. GreenGuard is a set of certification programs that recognize products and buildings that have low emissions and meet high indoor air quality standards.[343] The EPA developed WaterSense, a labeling program for products such as faucets and fixtures, as well as entire buildings, that recognizes water efficiency.[344]

Labels for building materials such as forest products in particular may increasingly shape procurement and sustainability practices, as concerns grow about buildings' environmental footprint and losses to biodiversity. The implication is that forest product labels are likely to become more important in the future. There are two broad aspects to forest certification labels. First, forest operators must show conformance to a set of environmentally and socially sensitive operating principles. This ensures that the originating forests are sustainably managed. For example, the Forest Stewardship Council (FSC) has a set of principles and criteria for forest management that are applicable to all FSC-certified forests throughout the world. These principles and criteria address a range of issues including: legal issues, indigenous rights, labor rights, and environmental impacts surrounding forest management.[345] Table 4.2 provides a list and brief description of their 10 principles.

Second, manufacturers and traders must be able to trace back wood products to the sustainable forest, called a *chain of custody*. This ensures that a product labeled as certified by, for example, the FSC, did indeed come from a sustainably managed forest. Labels such as this may be used on their own or incorporated into other labels and standards. LEED, for example, currently uses the FSC label to give credit for sustainable building products. Building product labels may also become more important as building codes, regulations, policies, and standards incorporate them more, and as procurement decisions use life-cycle

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[341] U.S. Green Building Council, *LEED*, 2011b.

[342] The Wildlife Habitat Council, "Registry of Certified Programs," 2011.

[343] Greenguard, "Greenguard Certification Programs," 2010.

[344] U.S. Environmental Protection Agency, *Water Sense*, undated b.

[345] Forest Stewardship Council, United States; "Mission and Vision," undated.

Table 4.2
Forest Stewardship Council Forest Management Principles

Principle Title	Principle Description
Principle 1: Compliance with laws and FSC principles	Forest management shall respect all applicable laws of the country in which they occur, and international treaties and agreements to which the country is a signatory, and comply with all FSC principles and criteria.
Principle 2: Tenure and use rights and responsibilities	Long-term tenure and use rights to the land and forest resources shall be clearly defined, documented and legally established.
Principle 3: Indigenous people's rights	The legal and customary rights of indigenous peoples to own, use and manage their lands, territories, and resources shall be recognized and respected.
Principle 4: Community relations and worker's rights	Forest management operations shall maintain or enhance the long-term social and economic well being of forest workers and local communities.
Principle 5: Benefits from the forest	Forest management operations shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.
Principle 6: Environmental impact	Forest management shall conserve biological diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and the integrity of the forest.
Principle 7: Management plan	A management plan—appropriate to the scale and intensity of the operations—shall be written, implemented, and kept up to date. The long-term objectives of management, and the means of achieving them, shall be clearly stated.
Principle 8: Monitoring and assessment	Monitoring shall be conducted—appropriate to the scale and intensity of forest management—to assess the condition of the forest, yields of forest products, chain of custody, management activities and their social and environmental impacts.
Principle 9: Maintenance of high conservation value forests	Management activities in high conservation value forests shall maintain or enhance the attributes which define such forests. Decisions regarding high conservation value forests shall always be considered in the context of a precautionary approach.
Principle 10: Plantations	Plantations shall be planned and managed in accordance with Principles and Criteria 1–9, and Principle 10 and its Criteria. While plantations can provide an array of social and economic benefits, and can contribute to satisfying the world's needs for forest products, they should complement the management of, reduce pressures on, and promote the restoration and conservation of natural forests.

Forest Stewardship Council, "Principles and Criteria for Forest Stewardship," Washington D.C., 2002.

analyses to weigh costs and benefits of investments. Thus, while sustainably produced materials may have higher up-front costs, the costs over the life of the building or the material may be lower in comparison to traditional materials.

Importantly, labeling programs are not without controversy. There are currently two main sustainable forest certification programs. The Forest Stewardship Council (FSC) is a nonprofit, international organization.[346] The Sustainable Forest Initiative (SFI) was created and is supported by the timber industry. While the FSC is generally perceived as more stringent and independent than SFI, both have been accused of "greenwashing," i.e., showcasing eco-friendliness, meaningful or not, in order to gain a market advantage.[347] Currently, LEED recognizes only FSC-certified products in its rating system, but SFI certification is being considered, in part because the supply of FSC-certified wood cannot meet demand, and in part because of pressures from SFI itself. However, there is concern that allowing SFI-certified wood in LEED would weaken LEED standards and reduce the environmental benefits of LEED certification.

Best Practices for Building Management Are Evolving

Research has shown that the sustainability of the initial design of a building is not necessarily correlated with the building's operational performance. This is because building management, operation, and maintenance also have a significant effect on performance. Specifically, new buildings often perform below design-based projections,[348] while existing buildings vary widely in their energy performance, even when they have similarly efficient equipment.[349] There is also recognition that, despite the typically lower performance of existing buildings, many have cost-effective opportunities to improve their energy performance.[350]

This improved understanding of the shortcomings in design as well as the potential for improvement is leading to two important "best practices": appropriate operations and maintenance and building commissioning.

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[346] Forest Stewardship Council, home page, 1996.

[347] In 2009, the Sierra Club filed a complaint with SFI against a company using SFI certification for practices that allegedly contributed to several damaging landslides. Also in 2009, the California-based conservation group ForestEthics filed complaints against the SFI with the Federal Trade Commission and the Internal Revenue Service. Washington Forest Law Center, "Sierra Club Files Complaint Against Weyerhaeuser for Logging on Steep and Unstable Slopes," 2009b; Washington Forest Law Center, "Complaints Filed Against SFI," 2009a

[348] See Mireya Navarro, "Some Buildings Not Living Up to Green Label," *New York Times*, August 31, 2009, and Cathy Turner and Mark Frankel, *Energy Performance of LEED for New Construction Buildings*, White Salmon, WA: New Buildings Institute, 2008.

[349] Thomas Hicks and Bill Von Neida, *U.S. National Energy Performance Rating System and ENERGY STAR Building Certification Program*, American Council for an Energy-Efficient Economy, 2003.

[350] Hannah Choi Granade, Jon Creyts, Anton Derkach, Philip Farese, Scott Nyguist, and Ken Ostrowski, *Unlocking Energy Efficiency in the U.S. Economy*, McKinsey & Company, 2009.

Better operations and maintenance can improve building performance in terms of worker productivity, comfort, air quality, health,[351] and safety. Proper operation and maintenance can also increase the lifespan of equipment and reduce energy consumption by 5-20 percent with little capital investment,[352] which in turn reduces operations and maintenance costs. A Department of Energy report describes one example of an operations and maintenance demonstration at a department building:

> A significant component to this demonstration was metering and the tracking of steam use in the building. Within several months, $250,000 per year in steam leaks were found and corrected. These included leaks in a steam converter and steam traps. Because the building was not metered for steam and there was not a proactive O&M program, these leaks were not detected earlier, nor would they have been detected without the demonstration.[353]

This demonstration showed how O&M opportunities in larger buildings do not have to involve complex engineering analysis; that they exist because building operators may not have the information to properly assess day-to-day actions; and that the involvement and commitment by building managers is important for a successful O&M program.[354]

The same report describes a 2001 study that examined four different maintenance regimens for pumps. The first strategy was to allow the system to run to failure and perform maintenance when obvious problems occurred. This strategy resulted in an annual cost of $18 per horsepower per year. A second strategy was to repair problems on a fixed schedule, before problems occurred. This resulted in an annual cost of $16 per horsepower per year. A

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[351] David Wyon, "Enhancing Productivity While Reducing Energy Use in Buildings," in *E-Vision 2000: Key Issues That Will Shape Our Energy Future: Analyses and Papers Prepared for the E-Vision 2000 Conference*, Santa Monica, CA: RAND Corporation, CF-170/1-1-DOE, 2001, pp. 233–254; also see William Fisk, "Health and Productivity Gains from Better Indoor Environments and Their Implications for the U.S. Department of Energy," in *E-Vision 2000,* 2001, pp. 165–201.

[352] G.P. Sullivan, R. Pugh, A.P. Melendez, and W.D. Hunt, *Operations and Maintenance Best Practices: A Guide to Achieving Operational Efficiency, Release 2.0*, Washington, D.C.: U.S. Department of Energy, Federal Energy Management Program, 2004.

[353] J. Claridge, and D. Haberl, "Can You Achieve 150% of Predicted Retrofit Savings? Is it Time for Recommissioning?" American Council for an Energy Efficiency Economy (ACEEE), Summer Study on Energy Efficiency in Buildings, *Volume 5, Commissioning, Operation and Maintenance,* ACEEE, Washington, D.C., 1994. Cited by *Federal Energy Management Program, Operations and Maintenance Best Practices: A Guide to Achieving Operational Efficiency*, 2002, p. 2.3.

[354] J. Claridge, and D. Haberl, "Can You Achieve 150% of Predicted Retrofit Savings? Is it Time for Recommissioning?"

third strategy sought to maintain systems when mechanical or operational conditions warranted, but before obvious problems occurred. This cost $9 per horsepower per year. A final strategy was to utilize predictive and preventative maintenance techniques with root cause failure analysis and advanced installation and repair techniques. This was the most effective and cost only $6 per horsepower per year.[355]

Building commissioning—the process of assessing all subsystems and aspects of a building and ensuring that they met the owner's operational requirements—is an important way to improve performance and is becoming more common. Building commissioning identifies common design, operations, and maintenance problems such as the improper installation and sizing of equipment and HVAC systems, improper control system configuration and sensor installation, improper scheduling of system operations, and deferred or poor maintenance procedures.

A study by the Lawrence Berkeley National Laboratory found that one-time commissioning can provide significant savings that will persist 3–5 years or more. Table 4.3 summarizes the findings from an analysis of a large database of commissioning projects in terms of the median cost of commissioning per square foot (first row), the median energy savings as a percent of total energy costs (second row), the median payback in years, and the median cost of emissions reductions in dollars per CO2 equivalent.

Table 4.3
Cost-Effectiveness of One-Time Commissioning

	Existing Buildings	New Buildings
Median commissioning cost ($/square foot)	0.30	1.16
Median energy savings (percent)	16	13
Median payback times (years)	1.1	4.2
Median cost of greenhouse gas reductions ($/ton CO2 equivalent)	–110	–25

SOURCE: Evan Mills, *Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions*, Sacramento, CA: California Energy Commission Public Interest Energy Research (PIER), 2009.

A closely related study considered the effects of ongoing commissioning, called monitoring-based commissioning:

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[355] J. Piotrowski "Pro-Active Maintenance for Pumps, Archives," Pump-Zone.com, 2001. Cited by Federal Energy Management Program, *Operations and Maintenance Best Practices: A Guide to Achieving Operational Efficiency*, 2002, p. 2.3.

> [Monitoring-based building commissioning] can also be thought of as monitoring-enhanced building operation that incorporates three components: 1) Permanent energy information systems (EIS) and diagnostic tools at the whole-building and sub-system level; 2) Retro-commissioning based on the information from these tools and savings accounting emphasizing measurement as opposed to estimation or assumptions; and 3) On-going commissioning to ensure efficient building operations and measurement-based savings accounting.[356]

The study examined the effects on 24 buildings and found that monitoring-based commissioning can provide ongoing performance improvements; see Table 4.4. It reported cost-effectiveness in terms of the cost of commissioning per square foot (first row), the primary energy savings (second row), the electricity savings (third row), and the peak electrical demand savings (fourth row).

Table 4.4
Cost-Effectiveness of Monitoring-Based Commissioning

	High	Median	Low
Commissioning cost ($/sf)	0.37	1.00	1.62
Primary energy savings (kBTU/sf-year)	25	10	2
Electricity savings (kWh/sf-year)	17	9	1
Peak electrical demand savings (W/sf-year)	11	4	3

SOURCE: Evan Mills and Paul Matthews, *Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects*, Sacramento, CA: California Energy Commission Public Interest Energy Research (PIER) Technology Demonstration Program, LBNL-1972E, 2009.

State and Local Governments Are Adopting Policies to Accelerate Sustainable Building Practices

Many state and local governments have already adopted policies to accelerate sustainable practices in the public and private sectors. For example, in 2004, California Governor Arnold Schwarzenegger required all new state government buildings to be designed and certified as LEED Silver.[357] In 2010, California additionally passed legislation requiring that every new building in the state must reduce water use by 20 percent and recycle 50 percent of construction waste. It additionally requires that commercial buildings must have separate

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[356] Evan Mills, and Paul Matthews, *Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects*, California Energy Commission Public Interest Energy Research (PIER) Technology Demonstration Program, LBNL-1972E, 2009.

[357] Margot Roosevelt, "Environmental Groups Try to Block Parts of California's Green Building Code," *Los Angeles Times*, January 11, 2010.

water meters for indoor and outdoor use, and that inspections of HVAC and mechanical equipment will be required for all commercial buildings over 10,000 square feet.[358]

Arlington County, Virginia set a goal in 2007 to reduce county greenhouse gas (GHG) emissions 10 percent by 2012 and formed a task force on January 1, 2010 to reduce private sector GHG emissions.[359] Also on January 1, 2010, Washington, D.C. began phasing in requirements that commercial buildings measure, benchmark, and disclose their energy performance.[360] As other state and municipal governments follow suit, building developers and managers throughout the country will have to meet increasingly aggressive sustainable building practices.

Such state and local government policies and standards are likely to continue to evolve and become stricter in the future.

Legislation, Executive Orders, and DoD Policies Continue to Increase Building Sustainability Requirements

Federal legislation, executive orders, and other policies are increasing requirements for sustainability in government-owned buildings. We briefly discuss several examples here: Executive Order 13514, National Defense Authorization Act of 2010, the Army's LEED for New Construction Silver requirement, and the "Sustainable Design and Development Policy Update" memorandum from the Assistant Secretary of the Army for Installations, Energy, and Environment in late 2010. Their objectives are summarized in Table 4.5.

Executive Order 13514,[361] "Federal Leadership in Environmental, Energy, and Economic Performance," addressed a wide range of sustainable buildings and communities issues. It required the federal government to design, construct, maintain, and operate high-performance sustainable buildings in sustainable locations. This included increasing energy efficiency, renewable energy use, and production on agency property, and conserving and protecting water resources through efficiency, reuse, and storm water management. It sought to eliminate waste, promote recycling, and prevent pollution, and required agencies to measure, report, and reduce GHG emissions, both from direct and indirect activities.

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[358] California Building Standards Commission, *2010 California Green Building Standards Code, California Code of Regulations, Title 24, Part 11*, applicability January 1, 2011.

[359] Christy Goodman, "Arlington County Board Forms Energy Task Force to Advise on Emissions," *Washington Post*, January 2, 2010.

[360] Saqib Rahim, "Energy Efficiency: Your Building May Soon Be Tested," *ClimateWire*, December 22, 2009.

[361] Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," applicability October 5, 2009.

EO 13514 also sought to strengthen the vitality and livability of the broader community in which federal facilities are located, and to inform federal employees about and involve them in the achievement of building sustainability goals. It further aimed at harnessing the agency acquisition process to foster markets for sustainable technologies and environmentally preferable materials, products, and services.

Table 4.5
Summary of Key Policies Aimed at Increasing Sustainable Buildings Requirements

Policy	Objectives
Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," October 5, 2009	States that federal agencies must: • Increase energy efficiency and renewable energy use and production on agency property • Measure, report, and reduce greenhouse gas emissions from direct and indirect activities • Conserve and protect water resources through efficiency, reuse, and stormwater management • Eliminate waste, recycle, and prevent pollution • Leverage agency acquisitions to foster markets for sustainable technologies and environmentally preferable materials, products, and services • Design, construct, maintain, and operate high-performance sustainable buildings in sustainable locations • Strengthen the vitality and livability of the communities in which federal facilities are located • Inform federal employees about and involve them in the achievement of these goals
National Defense Authorization Act of 2010	• Requires adoption of a unified energy monitoring and management system for military construction and housing • Authorizes the Armed Forces to participate in energy savings and demand-management programs
Army Policy "Sustainable Design and Development Policy Update: Life Cycle Costs" April 27, 2007	• New construction should achieve LEED for New Construction (v2.2) Silver standards at a minimum • Major renovation and repair projects should achieve LEED for Existing Buildings Certified standards when life-cycle cost-effective • New homes should achieve SPiRiT Gold and EPA Energy Star Qualified New Homes standards • New construction must "reduce the energy consumption level by 30%" compared to ASHRAE 90.1-2004. • Major renovations and repairs must reduce energy consumption by 20% compared to pre-renovation levels, if life-cycle cost-effective
Memorandum on "Sustainable Design and Development Policy Update" October 27, 2010	Summarizes and reiterates the goals in the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, EO13423, and EO13514 • Specifically creates a timeline of FY13 for meeting ASHRAE 189 standards for high performance buildings at Army facilities. • Commissioning, measurement and verification, and operations and maintenance are all emphasized • Includes all energy- and water-relevant sustainability requirements to which the Army is subject

The National Defense Authorization Act of 2010 addresses the military in particular and provides authorization for the Armed Forces to participate in energy savings and demand-management programs. It also requires the adoption of a unified energy monitoring and management system for military construction and housing.[362]

The Army itself has increased its sustainability requirements. In 2007, Army sustainability policies required that new buildings should achieve LEED for New Construction Silver standards at a minimum and that major renovation and repair projects should achieve LEED for Existing Buildings Certified standards when life-cycle cost-effective. Army energy policies further require that new construction must be designed to reduce the energy consumption level by 30 percent compared to ASHRAE 90.1-2004.[363] In 2011, Army policy also requires that new homes achieve LEED Silver standards.

In a memorandum from the ASA(IE&E) in late 2010, the many mandates and goals to which the Army is subject were summarized, reiterated, and clarified. This "Sustainable Design and Development Policy Update" provided highlights from the Energy Policy Act of 2005 (EPAct05) the Energy Independence and Security Act of 2007 (EISA07), Executive Orders 13423 and 13514, and other relevant documents and explains their many implications for Army facilities in the United States, its territories, and overseas on permanent Army facilities. Specifically, the requirement that government facilities uphold the standards of "high-performance" buildings means that ASHRAE 189 will apply going forward. The ASHRAE 90.1-2004 standard for minimum performance of all new buildings in the United States applies for FY11 and FY12, but by FY13, the Army standard becomes ASHRAE standard 189.1 for high-performance buildings. This has implications for planning and siting, energy efficiency, metering, and the use of cool roofs.[364] Also, all new construction of a specified size and in certain regions of the country will be required to use solar hot water heating, for example, in accordance with EISA07. With respect to water use, storm water management and indoor and outdoor water consumption guidelines are reiterated dating back from the Energy Policy Act of 1992 (EPAct1992). Special emphasis is made on

[362] National Defense Authorization Act 2010, "To Authorize Appropriations for Fiscal Year 2010 for Military Activities of the Department of Defense, to Prescribe Military Personnel Strengths for Fiscal Year 2010, and for Other Purposes," H.R. 2647, 2010.

[363] Office of the Assistant Secretary of the Army, 2007.

[364] A cool roof is one that on a sunny day stays much cooler because it strongly reflects sunlight, as opposed to a roof that strongly absorbs sunlight. Army installations, especially ones in the sunny Southwest, like Fort Bliss, have been installing cool roofs to save energy. For more information on cool roofs see Department of Energy, "Guidelines for Selecting Cool Roofs," 2010.

extending "beyond construction of renovation" so that performance is monitored and analyzed throughout the life cycle of the facilities and that operation and maintenance procedures are adjusted to meet sustainability policies and objectives.

Other Important Trends Are Emerging

As sustainable building practices evolve over time, it looks like there will be more emphasis on life-cycle analysis, green procurement, and designing buildings for reducing waste and deconstruction. We discuss each of these key trends here. In addition, current activities in Europe are likely to foreshadow U.S. approaches, which we also discuss here.

Life-Cycle Analysis/Assessment (LCA)[365] Will Be Used More and More to Inform Building Standards and Designs. As already is the case in the EU, life-cycle assessment (LCA) will also be used increasingly to inform building standards and designs in the United States. Life-cycle analysis is a method that considers the entire cost of an investment throughout its entire life from cradle to grave. Namely, LCA seeks to account for all of the costs of designing, building, operating, and decommissioning a building, and to then illustrate how the total cost can be minimized over the building' lifetime.[366] As a very simple example, consider the life-cycle costs of an incandescent bulb in comparison to a compact fluorescent light (CFL) bulb that costs six times as much. With an up-front cost analysis, the incandescent bulb would be an obvious choice. However, a life-cycle analysis takes into account that the CFL lasts 10 times longer and uses 25 percent of the energy of an incandescent bulb. The result is that, over the life of the CFL bulb, the cost of incandescent is five times higher than the cost of the CFL, making the CFL a good investment despite the higher initial cost.[367] This analysis can be applied to much larger systems such as HVAC, electricity, or plumbing, or to the building as a whole. Such an approach encourages longer-term thinking that goes beyond capital cost and annual operations and maintenance costs, and it shows how paying more today can reduce future costs and provide a return on investment. In sum, LCA can help buildings become more energy and water efficient, adaptable to changing uses, and able to be deconstructed at lower cost. Many building designers use and some government regulations already require using LCA to determine the

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[365] LCA can mean life-cycle analysis or life-cycle assessment, with the latter becoming a standard more recently. In this document we use the two terms interchangeably.

[366] Sieglinde Fuller, *Life-Cycle Cost Analysis (LCCA)*, National Institute of Standards and Technology, 2010.

[367] This discussion draws upon default values in the CFL calculator provided by the EPA; U.S. Environmental Protection Agency, Energy Star, *Life Cycle Cost Estimate for 1 Energy Star Qualified Compact Florescent Lamp(s)*, undated.

cost-effectiveness and justify the energy and water efficiency performance of new buildings. LCA is used by mandatory codes and voluntary standards to set minimum-efficiency requirements and performance-based standards when they are cost-effective. Army policy already requires life-cycle cost analyses to determine the most effective investments toward sustainable buildings.[368]

Green Procurement Plays an Increasing Role in More Sustainable Buildings. Green procurement—the procurement of environmentally preferable products—will also play an increasing role in creating and maintaining sustainable buildings. Green procurement contributes to the integrated design, construction, operations, and maintenance of sustainable buildings. Already the Department of Defense and the Army have regulations and guidance that require and/or encourage green procurement. For example, DoD Instruction 4170.11 requires that new facilities and major renovations use green products approved by EPA, DOE, DLA, and USDA, and that new buildings perform 30 percent better than ASHRAE 90.1-2004 and consider water-saving, energy-saving, and energy-generating projects when cost-effective.[369] Similarly, Army contracts for most construction, renovation, and demolition projects require that at least 50 percent of construction and demolition waste by weight is diverted from landfill disposal.[370]

Green procurement will continue to evolve and lead to higher performance requirements. EO 13514 requires that 95 percent of new contract actions (excluding weapon systems) be energy efficient, water efficient, bio-based, environmentally preferable, and non-ozone-depleting, contain recycled content, or are nontoxic or less toxic alternatives, where such products and services meet agency performance requirements.[371] GSA, responding to EO 13514, has recommended that federal agencies encourage suppliers to voluntarily disclose certain GHG emissions using standards that will be developed by 2012,

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[368] Office of the Assistant Secretary of the Army, "Sustainable Design and Development Policy Update—Life Cycle Costs," memorandum on Installations and Environment, April 27, 2007.

[369] U.S. Department of Defense Instruction 4170.11, "Installation Energy Management," 2009.

[370] David Barno, Assistant Chief of Staff for Installation Management, "Sustainable Management of Waste in Military Construction, Renovation and Demolition Activities," February 6, 2006.

[371] Executive Order 13514.

recommending that ties between equally qualified vendors be broken based on emissions data.[372]

Buildings May Be Designed for Reducing Waste and Deconstruction. In the future, buildings in the United States and the European Union may be specifically designed to reduce waste and designed for deconstruction. This includes modular buildings which promote reconfiguration and reuse. Several top finishers in the EPA's "Lifecycle Building Challenge," a design competition to shape the future of green building, used modular designs.[373] For example, an entry in the 2007 competition, dubbed the TriPOD, has a center core of the building that accepts living, cooking, and sleeping space "pods" that can be rearranged, removed, or added over time to suit needs.[374] While designs such as this are aimed at pushing the envelope in reconfigurability, the modular buildings industry is growing and commercial solutions are already in use.

The benefits of deconstruction—tearing down a structure in a way that allows its materials to be reused or recycled—is becoming increasingly recognized as an important sustainable building practice.[375] In Wayne County, Michigan, for example, a pilot project to employ workers to deconstruct blighted properties resulted in revenue for the city, diverted waste from landfills, and trained workers.[376] A number of projects are under way to *design* buildings in a way that makes their eventual deconstruction more feasible. The Chartwell School in Seaside, California has designed a new campus according to LEED Platinum criteria and incorporates elements of both modularity and design for deconstruction. For example, to allow for changing class sizes, nonstructural partitions were used for the interior walls between classrooms, allowing removal and reconfiguration without structural effects. The Chartwell School also incorporated many design-for-deconstruction principles in its choice of materials and the use of those materials.[377]

European Union Efforts May Inform Future U.S. Approaches. As these trends continue, efforts abroad, particularly in the EU, may inform future U.S. sustainable building efforts. EU policies encourage more sustainable building design, operation, and use by

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[372] Jenny Mandel, "Federal Purchasing Should Be Guided by Emission Disclosures—GSA," *E&E News PM*, July 19, 2010.

[373] See Lifecycle Building Challenge, "2009 Lifecycle Building Challenge 3."

[374] Carnegie Mellon University, *The TriPOD House*, undated a.

[375] Katherine Salant, "Deconstructing an Old Home Can Give You Building Blocks for a New One," *Washington Post*, December 13, 2008.

[376] D. Miller, "Deconstruction Projects Reduce Waste, Create Jobs," *County News*, August 17, 2009.

[377] U.S. Environmental Protection Agency, *Design for Deconstruction*, undated.

focusing on green procurement, building energy performance, and solid waste management. EU policies also instruct member states to consider the environmental impacts of government procurement decisions. In particular, they recommend that procurement be informed by *life-cycle assessments*—analyses that consider the entire cost of an investment throughout its life. This allows more accurate analysis of the benefits and costs of individual procurement options. Life-cycle assessments for buildings would include all initial costs (purchase, delivery, installation, commissioning, etc.), all operating costs (including energy, spares, and maintenance), and end-of-life costs, such as decommissioning and removal.[378]

Additionally, a 2008 change in EU waste management policy seeks to move the EU closer to a "recycling society." For example, one requirement of this directive is that producers may be held responsible for the life cycle of their products, including being required to accept returned products and remaining wastes, and they are financially liable for related costs. Additionally, member states may encourage the design of products with reduced environmental and waste impacts.[379] These steps in the EU may serve as signposts of possible future policy in the United States.

What Could Change the Course of Sustainable Building Trends

A major driver that affects these sustainable building trends is U.S. federal, state, and local government codes, regulations, and policies regarding the design, construction, operation, use, maintenance, and deconstruction of buildings. If these requirements focus more or less on sustainability effects, the rate of sustainable building implementation will vary. Changes in voluntary labeling programs and how much industry adopts them will also affect sustainable building implementation. Advances in sustainable building practices and requirements in other parts of the world, like the EU, will also affect such trends.

Costs and technology advances, such as the development of cheaper green products from carpeting to building and roof materials, also affect the rate of sustainable building implementation. As green building materials and practices become more cost-effective,

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[378] Davis Langdon Management Consulting, *Life Cycle Costing (LCC) as a Contribution to Sustainable Construction: A Common Methodology—Draft Methodology: Key Issues and Outline Framework*, 2006; "Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings," *Official Journal of the European Union*, June 18, 2010; European Commission Environment Directorate-General, "Overview of the EU Legislation with Reference to Green Public Procurement," 2009.

[379] "Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives," *Official Journal of the European Union*, November 22, 2008.

industry and others will implement them more. If energy and other resources prices rise at higher rates, it will motivate more investment in sustainable building practices that conserve such resources.

Environmental and health concerns, like indoor air quality, water scarcity, biodiversity loss, landfill space, and climate change, are also key drivers. If these concerns grow, the demand or requirements for sustainability, including sustainable buildings, may grow as well. For example, if there is less landfill space and disposal costs go up, more attention will be paid to building waste issues, especially deconstruction, since building deconstruction produces large amounts of solid waste. If there are more concerns about loss of rainforests, old-growth forests, and forest biodiversity loss, then sustainable forest products will become more important.

Finally, U.S. public expectations and practices with respect to green buildings will also impact the rate of government green building requirements, industry adoption, and even technological advancements. If people want more investment in sustainable buildings, there will be more pressures to do more sustainable buildings.

Interrelationships with Other Trend Areas

The trend toward increasingly sustainable buildings is one aspect of a broader trend toward increasing sustainability in communities, agriculture, transportation, and other areas. Given that sustainability (or a lack of sustainability) in one area is likely to have an effect on other areas, future demand and directives may require integration of sustainable building and community designs, for example, or may require that sustainable buildings foster sustainable transportation as well.

Sustainable buildings are motivated in large part by the environmental trends discussed in other chapters, such as the loss of biodiversity, urbanization and urban sprawl, climate change, and water scarcity.

Sustainable building trends are also closely tied to energy trends. Buildings in the United States account for 72 percent of all U.S. electricity consumption and 55 percent of all natural gas consumption. In aggregate, they account for 40 percent of total U.S. energy consumption and GHG emissions. Thus, concerns about the effects of nonrenewable energy production increase, and changes in energy costs have significant implications for sustainable buildings. This is discussed further in the second half of this chapter.

Implications of Sustainable Buildings Activities for Army Installations

Here we discuss what sustainable buildings activities means for Army installations now and out to 2025. We begin by discussing the Army context with respect to sustainable buildings in the Army today and then present some specific recommendations for the Army.

Army Context with Respect to Sustainable Buildings

The Army owns and/or operates 146,910 buildings, with 954,371,710 building square feet and $296 billion plant replacement value.[380] Most of these buildings have been operating for decades, including many from the World War II era or even older. The Army is currently making and will need to make significant investments in buildings over the next 15 years for three main reasons. First, the Army needs to retrofit and replace aging buildings. Second, as the Army implements BRAC and other Army transformation growth changes at installations, many new buildings are being built. Third, Army installations need to meet increasingly stricter building and environmental requirements. Strategic investments in sustainable buildings now, such as LEED and energy efficiency investments, can save large amounts of dollars in building operating and life-cycle costs. If such investments are not made it will cost the Army more to make them in the future.

As discussed earlier, the Army has LEED Silver requirements already. In addition, installation sustainability activities, such as at Fort Bragg, Fort Carson, Fort Hood, and JBLM, have included the building of LEED buildings and the implementation of other more sustainable building activities, including using LCA. For example, Fort Hood has built a few buildings with agriboard[381] and installed a sustainable roofing product with high solar reflectance and with minimal waste compared to the traditional process of applying tar and asphalt shingles. This green building roof keeps the building cooler, saves energy, and had a cost avoidance of $400,000.[382] The Army's new net zero waste, energy, and water installation activities should also help spur more sustainable building activities. The Army also is already doing modular building and other activities that move toward buildings designed for

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[380] U.S. Army, Office of Assistant Chief of Staff for Installation Management, "Real Property Summary Installation and Site Statistics for Fiscal Year 2009 Quarter 4," September 30, 2009.

[381] An agriboard is a structural insulated panel made from compressed wheat or rice straw that is twice as energy efficient as wood and more fire and pest resistant than wood.

[382] Christine Luciano, "Going Lean, Clean, and (Army) Green: DPW Tackles Environmental Issues," Fort Hood Department of Public Works Environmental News Release, Fort Hood, TX, July 2007.

reducing waste and deconstruction. Installations using modular designs in some of their buildings include Fort Bragg, Fort Stewart, and Fort Gordon.[383] Energy efficiency has been part of the driver for the Army's use of modular buildings. For example, JBLM was the site of the DoD's first Energy Star modular construction for energy efficient housing in 2006 and 2007. The project consisted of 864 modular homes as part of a 50-year housing privatization contract with the U.S. Army.[384]

However, despite such progressive green building efforts, the Army has had some difficulties in achieving higher building performance and actually implementing more sustainable buildings. First, often there are "color of money" problems when sustainable building investments, such as higher military construction costs to meet LEED Gold or Platinum standards, requiring additional up-front costs that are not funded because the savings from such investments occur in a different budget account. For example, MILCON dollars pay for the new LEED building, and savings occur in reduced operations and maintenance costs for energy, water, or wastewater disposal. Fort Carson has found that being able to find and invest "capital to support higher first cost of sustainable construction in order to achieve life-cycle savings" is an impediment to more sustainable buildings.[385]

Second, even though the Army has a LEED requirement, LEED requirements are not always being implemented. When there are cost overruns, LEED features have been cut to save money or dropped because USACE staff claim that LEED was not applicable even though it is an Army standard.[386] Because of the additional cost of certification, as of January 2010, the Army did not require any of its projects to be officially certified by the U.S. Green Building Council (USGBC), only that they be built to "certifiable" standards. LEED certification usually costs around 1 to 2 percent of the overall building construction cost.[387]

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[383] Rob Pavey, "Fort Gordon Contract Awarded for New Modular Barracks," *The Augusta Chronicle*, May 12, 2009.

[384] U.S. Department of Energy, "Fort Lewis Army Base," *Building America Best Practices Series: Volume 5—Builders and Buyers Handbook for Improving New Home Efficiency, Comfort, and Durability in the Marine Climate*, February 2006.

[385] Fort Carson, *Fort Carson 2006 Sustainability Report*, Fort Carson, CO, 2006, p. 8.

[386] Lachman, et al., 2010, p. 69.

[387] When the USGBC certifies a building it reviews extensive documentation to verify that it meets the LEED requirements. Most of the certification costs come from preparing the documentation that must go to the USGBC, which includes extensive receipts to verify that green building features, such as energy efficient light bulbs, were purchased and installed.

Without official third-party certification for LEED implementation, it is too easy for LEED features to be cut because of cost concerns and other issues.

Third, sometimes there are operations and maintenance problems that cause the buildings not to achieve higher performance in areas such as energy efficiency and water conservation. Sometimes maintenance personnel do not have the training and experience to properly maintain and operate new building systems with the more energy or water efficient features. In the energy area, staff also sometimes have problems getting parts, so in their rush to get the heat or air-conditioning back on, they fix equipment without including the energy efficiency features, thus eliminating the energy benefits of the system.[388]

Because of all these issues, some Army buildings are not achieving the higher performances of sustainable buildings, and this results in inefficiencies that will incur significant costs to the Army over time.

Given the trends just discussed, installations will be required to improve their building efficiencies and reduce waste, resource use, and other impacts of their buildings because of likely higher and higher federal, state, and local performance standards and requirements. Ensuring true sustainable buildings will become even more important. The Army needs to make improvements and investments now in more sustainable buildings to save significant costs in the future. Next, we discuss specific recommendations to help make this happen.

Recommendations for Army Buildings

We have four main recommendations for the Army regarding sustainable buildings:

First, the Army should have a policy to design buildings to exceed LEED Silver, i.e., to attain LEED Gold or Platinum, and give attention to regional and local priorities. Unfortunately, the National Defense Authorization Act (NDAA) for Fiscal Year 2011 (Section 2830) prohibits the use of funds to be used for the LEED Gold and Platinum certification. Waivers are allowed if the Secretary of Defense submits notification that includes a cost-benefit analysis of the decision and demonstrates payback for the energy improvements or sustainable design features. Where possible the Army should do such analyses and submit such notification. So even though it is difficult to do right now given the NDAA of 2011 legislation, the Army should strive to have a policy to design buildings to exceed LEED Silver, because investing properly now in energy and water efficiency improvements will provide years and even decades of savings at current prices. In addition,

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[388] Beth E. Lachman,, Kimberly Curry Hall, Aimee E. Curtright, and Kimberly M. Colloton, *Making the Connection: Beneficial Collaboration Between Army Installations and Energy Utility Companies*, Santa Monica, CA: RAND Corporation, MG-1126-A, 2011.

high building sustainability standards will provide even greater savings if resources become scare and prices rise and green building investment requirements increase. Given the likely energy, biodiversity, land use, and water scarcity trends discussed elsewhere in this report, resources will likely rise in price, and given the sustainable building trends, requirements are likely to increase, so such investments now are even more significant in terms of potential long-range cost savings.

Second, the Army needs to ensure it is getting the cost savings from higher-performance buildings. To do this the Army needs to require third-party certification for LEED building performance and improve building operations and maintenance practices. LEED certification should be for both new construction and existing buildings. In 2010, the Army issued a policy that all new construction buildings will require third-party LEED certification starting in FY13, but not for existing building renovations, which "shall incorporate LEED Silver features, but are not required to produce full documentation or receive certification."[389] The Army should ensure that this certification occurs and applies for both new construction and existing buildings. The Army should also increase the use of continuous building commissioning to ensure that the benefits from capital investments are realized.

Third, the Army needs to ensure that appropriate life-cycle analysis is used to properly minimize total costs. Life-cycle analysis is being used for some larger energy investment projects by energy managers, but it is unclear how well it is being implemented. In some cases, as illustrated with the Fort Carson example earlier, this is difficult to do given different budget accounts; however, it is key to help ensure true Army cost savings.

Fourth, in building designs and operations, the Army should place more emphasis on green procurement and designing buildings for reducing waste and deconstruction. Since green procurements, such as sustainable forest products, and designing buildings from the start to reduce waste and for ultimate deconstruction are trends that are likely to increase, both in industry operations and government requirements, the Army should be investing more in such activities now.

We also have two specific recommendations for ACSIM and IMCOM and other Commands that maintain buildings, such as Army Materiel Command, the National Guard, and Army Reserve:

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[389] For more information, see OASA (IE&E), "Sustainable Design and Development Policy Update (Environmental and Energy Performance)," Washington, D.C., 2010.

First, given the types of problems in Army sustainable building implementation that were just discussed, ACSIM and IMCOM and other Commands should conduct studies to assess the progress, barriers, and needed improvements in Army sustainable building implementation, green procurements in buildings, and designing buildings for reducing waste and deconstruction. This analysis should also include assessing the cost and benefits of appropriate implementation. Such analysis would help ensure that implementation activities are actually being implemented, and would identify appropriate policies and other changes needed to make implementation happen. It could also be used to help share lessons about installation successes to educate and motivate other installation staffs in their sustainable building activities.

Second, Army installations have many options for improving building performance and lowering costs, such as innovative efficiency technologies, but it is difficult for individual installations to determine their cost-effectiveness. In addition, individual installations are likely to be risk-averse and may not pursue options aggressively. Given such conditions, ACSIM and IMCOM and other Commands should help identify and evaluate the effectiveness of these options to help the Army maximize the return on its investments; and support installation demonstrations of new technologies and evaluate their performance, such as green roofs. ACSIM and IMCOM and other Commands should also help facilitate installation investment in technologies that are demonstrated to be successful because of the benefits of an enterprise approach and economies of scale.

Sources for Tracking Sustainable Buildings Trends

Many government, nonprofit, and academic organizations provide information on building trends.

Federal Government Sources

Among U.S. government agencies, the U.S. Environmental Protection Agency plays a significant role in green buildings. The EPA provides information resources on green buildings[390] and indoor air quality,[391] and runs a number of voluntary programs for labeling products and buildings.[392] Among the voluntary programs most relevant to buildings are

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[390] U.S. Environmental Protection Agency, *Green Building*, 2010b.
[391] U.S. Environmental Protection Agency, *Indoor Air Quality*, 2011.
[392] U.S. Environmental Protection Agency, *Partnership Programs: List of Programs*, undated a.

Energy Star Buildings and Plants[393] and WaterSense,[394] which address energy and water respectively. Both provide information on trends, facts related to consumption and efficiency, and continually-updated guides to choose resource-efficient products. The EPA's Environmentally Preferable Purchasing (EPP) program seeks to help the federal government both procure green materials and to stimulate market demand for green products and services.[395] The EPA's Industrial Materials Recycling Program provides information on how industrial materials such as construction and demolition debris can be recycled or reused in future construction.[396] Other EPA programs can be found on the EPA's Green Buildings website.[397]

Because of the close relationship between buildings and energy, the U.S. Department of Energy is also a key federal resource for green building trends. DOE's Energy Information Administration (EIA)[398] provides independent statistics and analysis of energy issues, including those related to buildings. For example, EIA conducts and publishes the *Commercial Buildings Energy Consumption Survey* (CBECS) every four years. CBECS provides a national sample survey of the energy-related aspects of commercial buildings.[399] DOE's Office of Energy Efficiency and Renewable Energy (EERE) sponsors the Building Technologies Program. This program funds research and development and market transformation activities focused on improving the energy efficiency of buildings, building subsystems, and appliances.[400] EERE also publishes the *Buildings Energy Data Book* to provide a comprehensive summary of building-related energy use.[401] Through the support of EERE, other federal agencies, and other sponsors, a number of DOE national laboratories also conduct research and publish reports on buildings issues.[402]

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[393] Energy Star, *Buildings and Plants*, undated b.

[394] U.S. Environmental Protection Agency, undated b.

[395] U.S. Environmental Protection Agency, *Environmentally Preferable Purchasing (EPP)*, 2010a.

[396] U.S. Environmental Protection Agency, *Wastes—Resourse Conservation—Reduce, Reuse, Recycle—Industrial Materials Recycling*, 2010e.

[397] U.S. Environmental Protection Agency, 2010b.

[398] U.S. Energy Information Administration, website, 2011a.

[399] U.S. Energy Information Administration, *Commercial Buildings Energy Consumption Survey*, 2007.

[400] U.S. Department of Energy, *Building Technologies Program*, undated.

[401] U.S. Department of Energy, *Buildings Energy Data Book*, 2011.

[402] For example, information on research done at various DOE laboratories can be found at the following websites:

Another federal government source of information on building-related trends is the Building and Fire Research Laboratory (BFRL) of the U.S. Department of Commerce's National Institute of Science and Technology (NIST). BFRL's mission is to "anticipate and meet the measurement science, standards, and technology needs of the U.S. building and fire safety industries in areas of critical national need."[403] Also, The National Academies' Federal Facilities Council provides studies and trends about federal facilities and infrastructure.[404] In addition, the U.S. General Services Administration includes programs focused on high-performance buildings[405] and sustainable design.[406]

Within the Army, the U.S. Army Corps of Engineers' Construction Engineering Research Laboratory (CERL) conducts research and development to increase the Army's ability to "more efficiently construct, operate, and maintain its installations and ensure environmental quality and safety at a reduced life-cycle cost."[407]

Beyond the information and research sources described above, the federal government also sponsors a number of design competitions that may provide an indication of where sustainable buildings are headed. The Lifecycle Building Challenge[408] mentioned earlier challenges industry and university teams to design buildings that are sustainable and have low life-cycle costs. This competition is sponsored by Green Building Blocks, the U.S. Environmental Protection Agency, the Building Materials Reuse Association, the American Institute of Architects, and West Coast Green. The Solar Decathalon is run by the U.S. Department of Energy and challenges college teams to design, build, and operate cost-effective, energy efficient, and attractive solar-powered houses. Awards are given to the

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Lawrence Berkeley National Laboratory (http://btech.lbl.gov/, http://eetd.lbl.gov/r-bldgsee.html, http://cx.lbl.gov/cost-benefit.html)
National Renewable Energy Laboratory (http://www.nrel.gov/buildings/)
Oak Ridge National Laboratory (http://www.ornl.gov/sci/ees/etsd/btric/)
Pacific Northwest National Laboratory (http://eere.pnl.gov/building-technologies/, http://www.buildingsystemsprogram.pnl.gov/)

[403] National Institute of Standards and Technology (NIST), "Building and Fire Research Laboratory Home," August 18, 2010.

[404] For more information, see The National Academies, "Federal Facilities Council," 2012.

[405] U.S. General Services Administration, *High Performance Buildings*, 2011a.

[406] U.S. General Service Administration, *Sustainable Design Program*, 2011b.

[407] U.S. Army Corps of Engineers, *CER Mission*, 2011.

[408] Lifecycle Building Challenge, "2009 Lifecycle Building Challenge 3."

design that optimizes energy production and efficiency while also being affordable and appealing to consumers.[409]

Nongovernment Organizations

There are also many NGOs that provide information on buildings. Among others, the International Code Council,[410] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE),[411] and the American Society of Civil Engineers[412] develop and maintain model codes that are regularly updated and adopted by governments throughout the United States.

The U.S. Green Building Council sets requirements for the different LEED programs, and their website provides information about new and emerging building trends.[413]

Among organizations that have specialized expertise in building-related energy issues are the Building Codes Assistance Project,[414] the Alliance to Save Energy,[415] the American Council for an Energy-Efficient Economy,[416] the National Institute of Building Sciences,[417] and Portland Energy Conservation, Inc.[418] Other organizations that address buildings and how they relate to their broader urban surroundings include the American Institute of Architects[419] and the Urban Land Institute.[420]

There are also a number of local and grassroots organizations around the country that seek to promote green buildings regionally. These organizations play an important role because they recognize and address regional differences in green buildings requirements, due to climate, geography, demographics, and other factors. For example, the Green Building Alliance in Pittsburgh seeks to drive the market for green buildings in Western Pennsylvania. It is run by leaders in the local community and experts in regional green building needs.

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[409] U.S. Department of Energy, *Solar Decathlon*, 2011.
[410] International Code Council, website, 2010.
[411] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), website, 2010.
[412] American Society of Civil Engineers, website, 2011.
[413] U.S. Green Building Council, website, 2011a.
[414] Building Codes Assistance Project, *About Us*, undated.
[415] Alliance to Save Energy, website, 2011.
[416] American Council for an Energy-Efficient Economy, website, 2011.
[417] National Institute of Building Sciences, website, 2011.
[418] Portland Energy Conservation, Inc. (PECI), website, 2010.
[419] The American Institute of Architects, website, 2011.
[420] Urban Land Institute, website, 2011.

Other examples include the Florida Green Building Coalition,[421] Built Green in the state of Washington,[422] and Green Home NYC in New York City.[423]

Academia

Many academic institutions have green building programs. These programs conduct green buildings policy and design research, address green building needs on campus or in the local community, or both. Carnegie Mellon University's School of Architecture is home to several programs that help show where the future of buildings may be headed. These include the Center for Building Performance and Diagnostics[424] and the Intelligent Workplace.[425] The Center for Sustainable Building Research at the University of Minnesota conducts research on a wide range of areas including developing regional green building guidelines, life-cycle assessment tools, and technology development.

The Institute for the Built Environment[426] at Colorado State University largely addresses green building needs and developed green building projects in the local community. The Green Buildings Research Center[427] at the University of California Berkeley focuses on green buildings on its campus, seeking to advance the university's educational goals in green buildings, identify and further opportunities for green design on campus, and provide resources that address unique sustainable building needs for university campuses. At the University of California Santa Barbara, the Center for Energy Efficient Design conducts research on buildings and design and lighting among other areas.[428]

Energy

Background: Greater Interest in Energy Issues

Energy costs have traditionally received relatively little managerial attention, but this has changed recently. The reasons for the greater interest include increasingly global energy

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[421] Florida Green Building Coalition (FGBC), website, 2011.
[422] Built Green Washington, website, 2011.
[423] Green Home NYC, *About Us*, 2011.
[424] Carnegie Mellon University, School of Architecture, *Research*, undated c.
[425] Carnegie Mellon University, School of Architecture, *Facilities*, undated b.
[426] Colorado State University, *Institute for the Built Environment*, website, 2010.
[427] University of California Berkeley, "Green Buildings Research Center," 2009.
[428] University of California Santa Barbara, Institute for Energy Efficiency, *Research*, undated.

market demands and rising U.S. imports of oil,[429] periods of rising energy prices and increased volatility, concerns about climate change and the need to reduce energy-related GHG emissions, and concerns about how to improve the security and reliability of electric power generation and the underlying power grid.

As countries worldwide have sought to respond to these trends, the interconnections between energy markets, technology, and public policy have become clearer. However, the United States and other nations continue to struggle with how to find new supplies of fossil fuels, how to approach nuclear and renewable power energy sources, and how to improve energy efficiency and lower the cost of new technologies.

As one of the largest consumers of energy in the federal government and in the United States, the Army has already been affected by the high cost of energy, and the impact will grow if prices rise in the future. Specifically, the Army's buildings use electricity and natural gas and Army vehicles use liquid fuels in its operations, which could be negatively affected by rising prices, price volatility, and other energy security and reliability issues.

This section explains key energy trends, including what can affect these trends and how they interact with the other trends discussed in this report, along with the implications of these trends and recommendations for the Army.

Key Energy Trends

Trends that will affect energy issues include anything that affects the availability and price of primary energy sources and the conversion of those energy sources into power for vehicles, buildings, and other installation activities. Key trends include growth in global demand for energy, changes in global supplies and sources of energy, changes in how energy is being used and generated, and changes in the policies that influence energy production, conversion, and use, be they at the federal, DoD, Army, or state level.

For discussion purposes we have grouped these trends into five categories:

- Energy demand and prices will continue to rise
- Traditional energy sources will provide most U.S. energy in the future, but the use of renewable power and biofuels will continue to grow

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[429] Natural gas is not mentioned here because natural gas is not generally imported from anyplace but Canada—it would have to be liquefied to do so—and has actually increasingly come from U.S. sources in recent years due to tapping into unconventional resources such as Devonian and Marcellus shale.

- Renewable power generation capacity and use of natural gas are growing and expected to continue to grow
- Energy use and management will become smarter, more efficient, and more reliable
- Federal, OSD, and Army policies are increasing energy efficiency and renewable energy requirements

We discuss each below.

Energy Demand and Prices Will Continue to Rise

One of the most significant trends regarding energy is the likely increase in demand and prices, partly because as these things increase it causes more investments in energy efficiency and increased interest in the development of energy alternatives, such as solar and wind. It appears that global energy demand, supply, technology, and evolving policy will likely lead to higher energy prices, though the magnitude of the increase is uncertain. We present this trend evidence here.

Since many energy resources, especially petroleum products, are bought and sold on global energy markets, all energy consumers are affected by the same forces of supply and demand. An indication of how much supply and demand will change in the future is that global energy demand is expected to grow 44 percent between 2006 and 2030.[430] Further illustrating the nature of these expected changes is that roughly 80 percent of this growth is projected to occur in non-OECD countries. This rapid growth is expected to be driven by rising living standards and growing populations in countries such as India and China. For example, non-OECD Asia is expected to increase demand at 3 percent per year between 2006 and 2030, compared to 0.6 percent per year for OECD North America (see Figure 4.3).

In 2009, U.S. total primary energy consumption, including for electricity generation, was expected to grow 12 percent by 2030 from the base year of 2007, driven primarily by increasing building and transportation consumption. This projection was at a growth rate of about 0.5 percent per year from 2007 to 2030.[431] U.S. energy use would be even greater without significant improvements in energy efficiency.[432] Recent economic declines have

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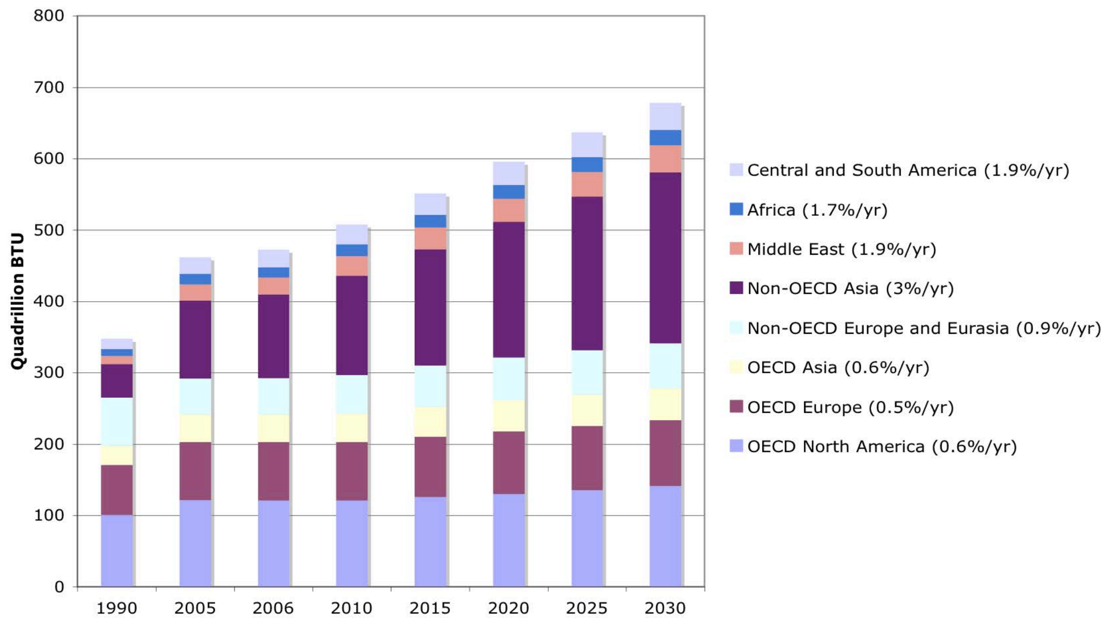
[430] U.S. Energy Information Administration (EIA), *International Energy Outlook 2009*, Table A1, DOE/EIA-0484(2009), 2009.

[431] U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2009*, 2009, Figure 36.

[432] U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2009*, 2009, Figure 35.

Figure 4.3
World Total Primary Energy Consumption by Region, Reference Case, 1990–2030.



slowed these projections slightly. However, in 2011, roughly similar growth rate projections hold for 2030 and continue out to the year 2035.[433]

While oil and gas companies will continue to seek new sources of supply to replace and expand production, experts differ on how easily this can be done and at what cost, since many low-cost and low-risk supplies have already been produced. Meeting rising global demand for fossil fuels may require increasing exploration and production of resources in areas with known remaining reserves (e.g., the deepwater Gulf of Mexico and Marcellus shale in the United States, and Saudi Arabia, Russia, and Qatar internationally) and focusing on new resources with which industry has less experience and that may be more expensive (e.g., unconventional oil and gas sources such as oil sands and shale gas). (See Figures 4.4 and 4.5).[434]

Future prices of fossil energy resources will be determined by the interaction between supply and demand, technological developments, and policy. Energy analysts have tried to

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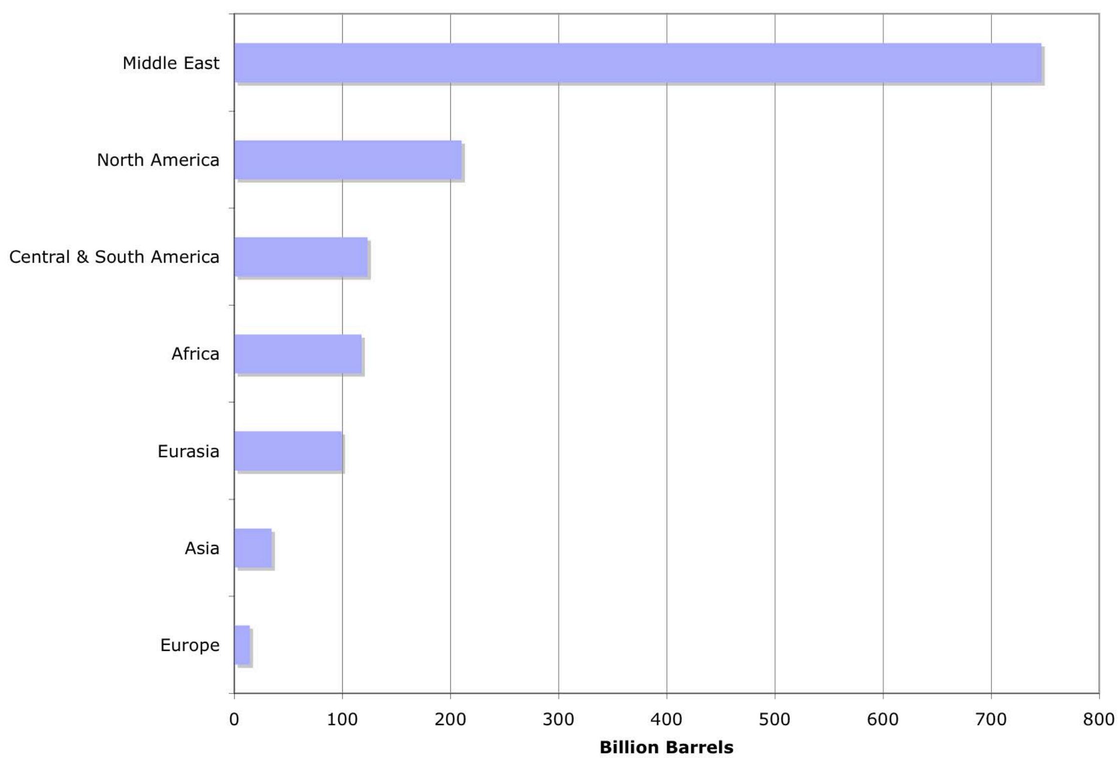
[433] U.S. Energy Information Administration (EIA), *Annual Energy Outlook 2011*, April 2011, Figure 56.

[434] U.S. Energy Information Administration, *International Energy Outlook 2009*, DOE/EIA-0484(2009), 2009b, Figures 32 and 41 and Table 6.

systematically account for these trends to project how energy prices will evolve. The U.S. Department of Energy's Energy Information Administration (EIA) has estimated that U.S. electricity and natural gas prices in 2030 will rise 5 to 10 percent above 2006 prices, *assuming current U.S. laws remain in place* (see Figures 4.6 and 4.7).[435] However, historically such predictions have at times been off, so it is important to acknowledge the uncertainty of such estimates.

Figure 4.4
World Proved Oil Reserves by Geographic Region as of January 1, 2009



[435] U.S. Energy Information Administration, *An Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook*, SR-OIAF/2009-03, 2009c, Tables 8 and 13.

Figure 4.5
World Natural Gas Reserves by Geographic Region as of January 1, 2009

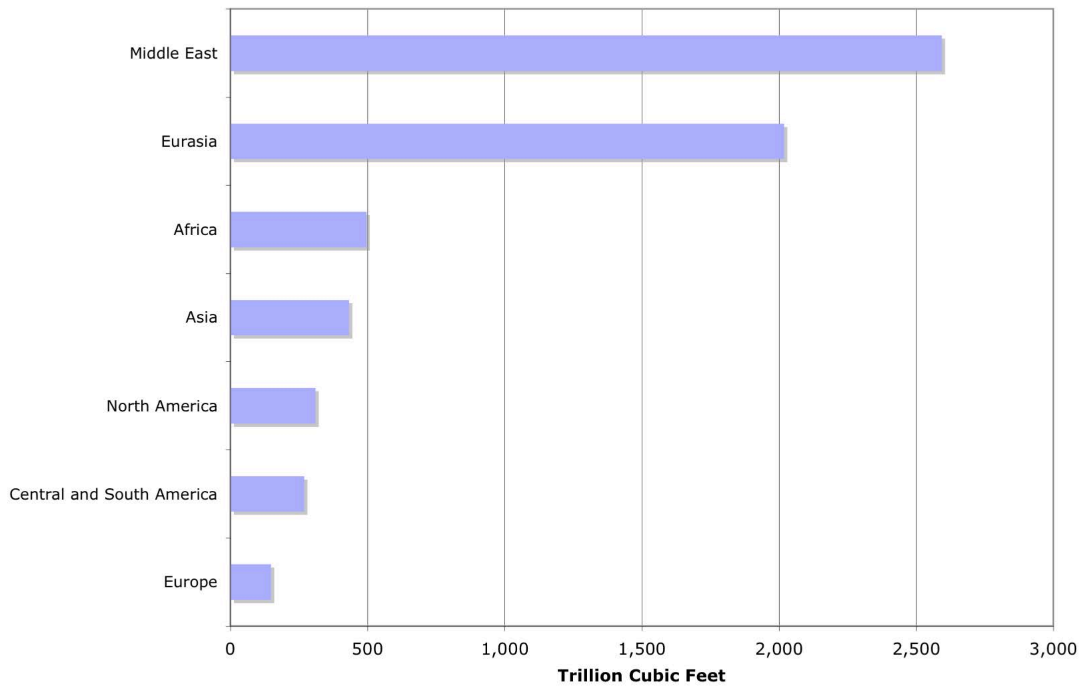


Figure 4.6
Estimated U.S. Electricity Prices Out to 2030

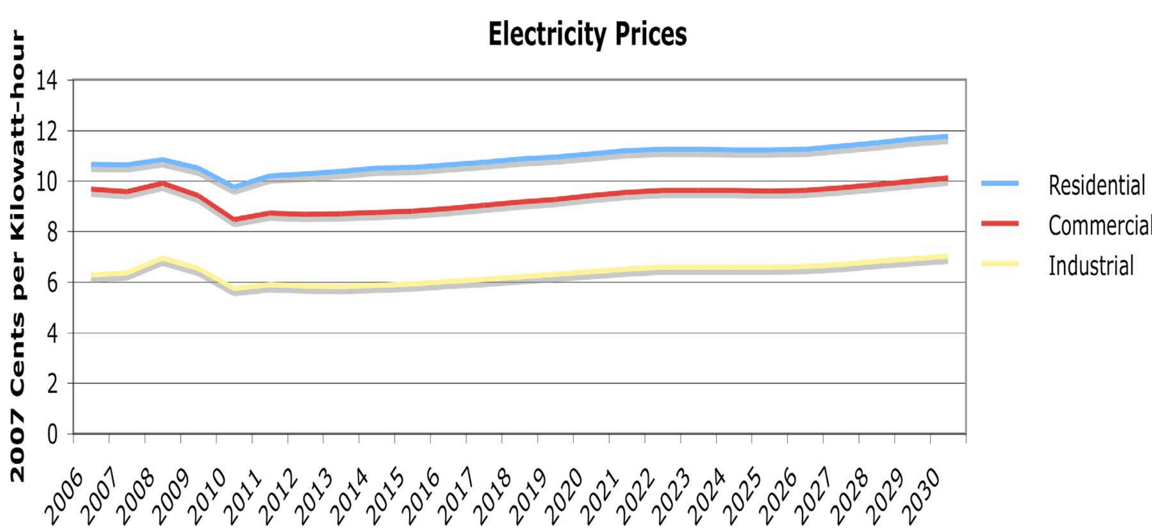
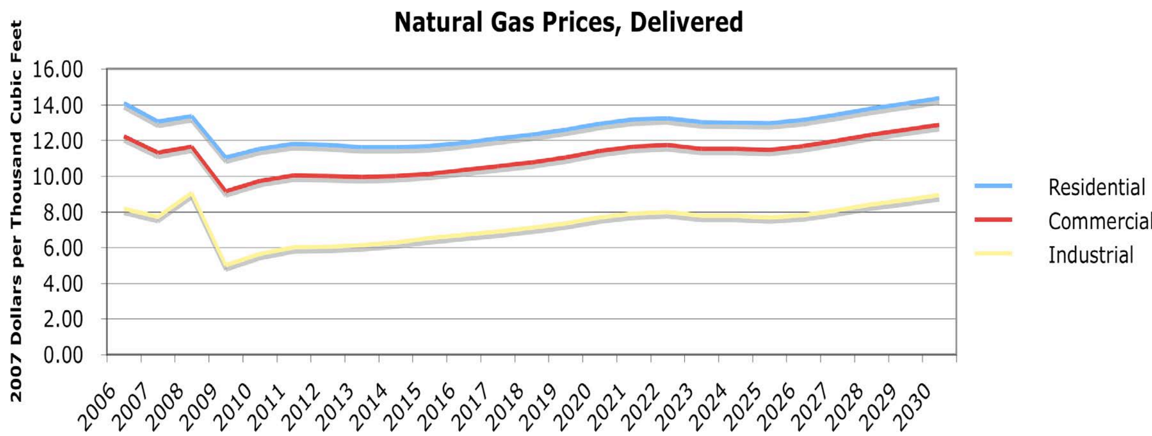


Figure 4.7
Estimated U.S. Natural Gas Prices Out to 2030



Policy and legislative changes also are likely to affect future energy prices. Given current economic challenges in the United States, we are not likely to see legislation that would increase energy prices in the near future. However, given the climate change trends discussed earlier in this document, there is likely to be pressure at some point for U.S. legislation and laws to reduce GHG emissions, which would likely change energy prices. Estimating the impact of such changes on energy consumption, energy prices, and technology is difficult, but analysts have prepared systematic estimates based on legislation that was proposed in 2009 but never became law. For example, EIA analyzed House Resolution 2454, The American Clean Energy and Security (ACES) Act, which passed the U.S. House of Representatives in June 2009. EIA found that by 2020, residential electricity and natural gas prices would increase 9 and 3 percent, respectively, compared to the analysis baseline. By 2030, residential increases relative to the baseline would rise to 17 percent for both electricity and natural gas. Industry would see larger increases in both time periods.

Other analysts, using different models and assumptions, obtain a mix of higher and lower prices than found by EIA. See Tables 4.6 and 4.7 for summaries of estimates for natural gas and electricity prices compiled by the Congressional Research Service.

Table 4.6
Selected Estimates of Natural Gas Rate Impacts from H.R. 2454 Relative to Baseline

Year	2020		2030	
Sector	Residential	Industrial	Residential	Industrial
Study				
ACCF/NAM	-3%	33%	56%	87%
NBCC/CRA	14%	N/A	16%	N/A
EIA	3%	13%	17%	23%
EPA	Average: 9%		Average: 10%	

SOURCE: Larry Parker and Brent D. Yacobucci, *Climate Change: Costs and Benefits of the Cap-and-Trade Provisions of H.R. 2454*, Congressional Research Service, 2009.

NOTES: ACCF = American Council for Capital Formation; NAM = National Association of Manufacturers; NBCC = National Black Chamber of Commerce; CRA = Charles River Associates; EIA = Energy Information Administration; EPA = Environmental Protection Agency.

Table 4.7
Selected Estimates of Electricity Rate Impacts from H.R. 2454 Relative to Baseline

Year	2020		2030	
Sector	Residential	Industrial	Residential	Industrial
Study				
ACCF/NAM	5%	13%	31%	49%
NBCC/CRA	16%	N/A	22%	N/A
EIA	0%	2%	17%	24%
EPA	Average: 13%		Average: 13%	

SOURCE: Larry Parker and Brent D. Yacobucci, *Climate Change: Costs and Benefits of the Cap-and-Trade Provisions of H.R. 2454*, Congressional Research Service, 2009.

NOTES: ACCF = American Council for Capital Formation; NAM = National Association of Manufacturers; NBCC = National Black Chamber of Commerce; CRA = Charles River Associates; EIA = Energy Information Administration; EPA = Environmental Protection Agency; N/A = not available.

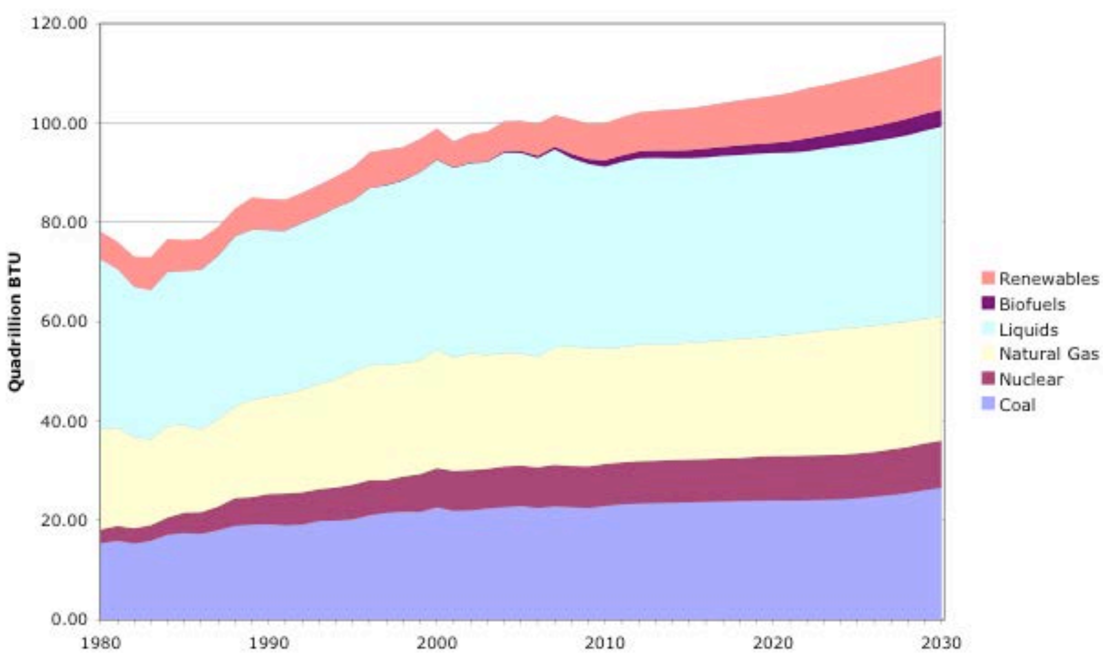
Traditional Energy Sources Will Provide Most U.S. Energy in the Future, but the Use of Renewable Power and Biofuels Will Continue to Grow

Because of concerns about the environmental impact, such as GHG emissions, and the finite nature of fossil fuels like coal and oil, the world has started using more renewable energy resources. Renewable energy resources have multiple definitions, but a widely used definition is "energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action."[436]

As the United States seeks to reduce its GHG emissions, it will continue to support research and development (R&D) and deployment efforts of renewable energy technologies that help lower the cost of low or no GHG-emitting energy.[437] However, given the high cost and the small installed base of alternative technologies compared to their traditional counterparts, the shift is expected to be relatively slow under current laws.

As shown in Figure 4.8, the U.S. Energy Information Administration projects that renewable energy will grow steadily, but even still it will represent less than 13 percent of the nation's primary energy in 2030 *under current laws*.[438]

Figure 4.8
U.S. Primary Energy Use by Fuel, Reference Case, 1980–2030



[436] U.S. Energy Information Administration, "Glossary," undated.

[437] It is important to note that even renewable energy resources can also have environmental impacts. For example, with wind farms there are concerns about turbine impacts on migrating birds and bats and the supporting infrastructure in remote areas, such as transmission lines and roads, having potential impact on biodiversity.

[438] U.S. Energy Information Administration, 2009a, Figure 37.

Renewable Power Generation Capacity and Use of Natural Gas Are Growing and Expected to Continue to Grow

Renewable power generation is growing rapidly and will continue to grow, but it is growing from a small base. Some of the reasons for the slow rate of growth of renewable energy are the number of technologies, the differences in renewable resource availability, cost, and technological maturity. As a result, the adoption of these technologies varies greatly. For example, hydropower and biomass-fired thermal power plants have until recently been the largest sources of renewable power, but they were typically installed decades ago, and little new capacity has been built since.

More recently, wind power has grown rapidly in the United States, which now leads the world in installed wind capacity (25,369 MW). In 2008, 8,545 MW of new wind capacity was added, which meant that 2008 wind installations grew 51 percent over 2007 capacity additions.[439] These additions led wind capacity to increase to 25.4 GW of capacity in 2008 and become the second-largest source of renewable power behind hydropower (see Figure 4.9).[440] However, the installed base of net summer electric generation capacity is so large (1,010 GW)[441] that wind's 2008 capacity represented just 2.5 percent of the total.

Then in 2009, wind experienced record growth in the United States when nearly 10 GW of new capacity was added.[442] In fact, installed wind energy capacity increased almost 14 times between 2000 and 2009 in the United States.[443] Two states now have wind exceeding 10 percent of total generation, Iowa at 13.3 percent and Minnesota at 10.4 percent; and two small U.S. utilities exceed 20 percent: Minnkota Power Cooperatives (22.6 percent, Minnesota and North Dakota), and Empire District Electric Company (20.7 percent, Missouri, Arkansas, Kansas, and Oklahoma). Other notable larger utilities have significant amounts of wind power: Austin Energy at 11.7 percent and Xcel Energy at 10.7 percent.[444]

Costs for wind power have risen, but performance has improved. Recent projects are selling power at an average price of $51.5 per MWh. Sellers also receive a federal production

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[439] Ryan Wiser and Mark Bolinger, *2008 Wind Technologies Market Report*, U.S. Department of Energy, DOE/EERE-LBNL, 2009.

[440] Rachel Gelman and Steve Hockett, *2008 Renewable Energy Data Book*, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, July 2009.

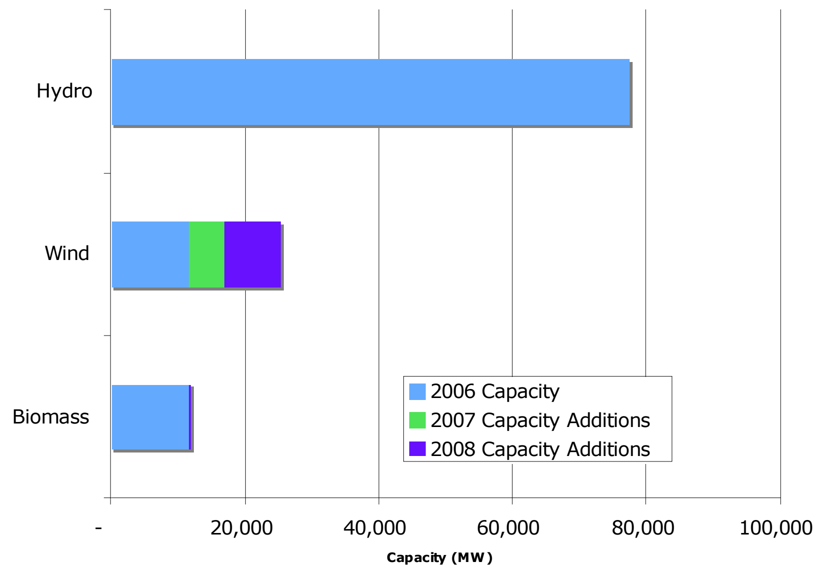
[441] U.S. Energy Information Administration, *Electric Power Annual 2008*, DOE/EIA-0348(2008), 2010, Table 1.1.

[442] Rachel Gelman, *2009 Renewable Energy Data Book*, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, August 2010.

[443] Gelman, August 2010.

[444] Wiser and Bolinger, 2009.

Figure 4.9
Renewable Power Technologies with 10 GW or More of Installed Capacity in the United States



tax credit. Excluding this federal production tax credit, the price would be at least $20 higher per MWh. Average installed project costs in 2008 were $1,915 per kW. Capacity factors for recent installations exceed 35 percent on average.[445] Large amounts of project development planning are also under way for future wind projects.

Solar photovoltaics (PV) are growing rapidly from a small base. Solar PV power represented 1,106 MW of capacity in 2008. In 2008, 335 MW of solar PV was installed, a 44 percent increase from the previous year. Costs were estimated to range between 21 and 81 cents per kWh depending on solar resources and financing.[446] Regional variability, policies, incentives, new business models, and long-term contracts can lower costs. In addition, innovation and capacity expansion continue to lower costs. Solar energy electricity generation nearly quadrupled between 2000 and 2009, but it still represents a very small part of overall U.S. electricity generation.[447]

In 2008, concentrating solar power (CSP) started growing for the first time in a decade. By spring 2009, 80 MW were under construction or had financing. Innovation could steadily

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[445] Wiser and Bolinger, 2009.
[446] Gelman and Hockett, *2008 Renewable Energy Data Book*, July 2009.
[447] Gelman, *2009 Renewable Energy Data Book*, August 2010.

or sometimes dramatically lower costs.[448] CSP represented 419 MW of capacity in 2008. A 64 MW project in Nevada in 2007 helped end a 17-year lapse in project development. In addition, large project orders have been placed in the United States and globally.[449]

And while solar photovoltaic and concentrating solar power have received considerable attention as rapidly growing sources of renewable power with the potential for declining costs,[450] installed capacity of these technologies is currently well behind that of installed geothermal power. And most of the geothermal installed capacity has been in place for decades, though modest capacity additions have occurred for the first time in a decade (see Figure 4.10).[451]

Beyond these technologies, tidal, river, ocean current, and ocean wave pilot projects are also under way, and federal funding to support R&D on these topics has increased in recent years.[452]

If the United States considers changes in energy policy to reduce GHG emissions, growth rates for renewable energy sources could increase significantly, but growth will need to be sustained for many years to have a large impact on the nation's energy system.

The increasing availability of natural gas in the United States has the potential to be a significant trend, especially in the very near term (i.e., the next 5–10 years). This increase in natural gas supply, and the resulting decline in natural gas costs to prices unimagined a decade ago, is a direct result of technological advances that have enabled large deposits of unconventional natural gas in the United States to be tapped (e.g., the Marcellus Shale gas resources). Electricity produced from natural gas is about half as GHG-intensive as coal-based electricity, and natural gas is at historically low prices today. Additionally, if natural gas supply remains high, and prices remain low, there is a potential for natural gas to impact not only the electricity industry (e.g., via replacing coal-fired capacity) but also to impact the transportation sector (i.e., via an increase in natural-gas-powered vehicles, especially fleet

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[448] Bill Scanlon, "Award-Winning Reflector to Cut Solar Cost," National Renewable Energy Laboratory, August 3, 2009.

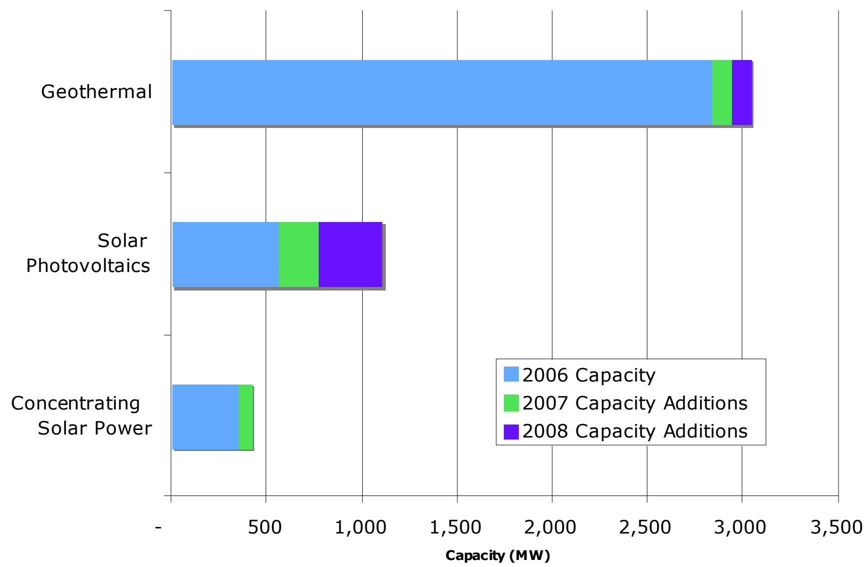
[449] Elizabeth Beckert and Anne Jakle, *Renewable Energy Data Book*, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, September 2008.

[450] Richard Silberglitt, Anny Wong, S. R. Bohandy, Brian G. Chow, Noreen Clancy, Scott Hassell, David R. Howell, Gregory S. Jones, Eric Landree, and Parry Norling, *The Global Technology Revolution China, Executive Summary: Emerging Technology Opportunities for the Tianjin Binhai New Area (TBNA) and the Tianjin Economic-Technological Development Area (TEDA)*, Santa Monica, CA: RAND Corporation, MG-776-TBNA/TEDA, 2009.

[451] Gelman and Hockett, 2009.

[452] Gelman and Hockett, 2009.

Figure 4.10
Renewable Power Technologies with 3 GW or Less of Installed Capacity in the United States



vehicles such as public transport and government vehicles). The largest uncertainties here stem from whether or not the resource is as significant as expected, and in the environmental implications of the extraction practice itself, which has come under scrutiny recently.[453]

Finally, while it is unclear whether public acceptance will allow the significant expansion of nuclear capacity for electricity generation in the United States and elsewhere in the world, it should be noted that nuclear has the potential to significantly reduce the GHG-intensity of electricity production. If CO_2 cap-and-trade or a CO_2 tax is adopted in the United States, nuclear power will certainly become a more attractive potential source of low-carbon electricity.

Energy Use and Management Will Become Smarter, More Efficient, and More Reliable

If energy prices rise or if there are expectations that energy prices will rise in the future, it is likely that energy will be more carefully measured, monitored, and managed, especially electrical systems. Namely, energy use and management is expected to become more efficient and more reliable.

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[453] D.M. Kargbo, R.G. Wilhelm, and D.J. Campbell, "Natural Gas Plays in the Marcellus Shale: Challenges and Potential Opportunities," *Environmental Science & Technology*, Vol. 44, No. 15, 2010, pp. 5679–5684.

Users will improve their energy efficiency to reduce the life-cycle costs of owning and operating buildings, facilities, and vehicles. Improvements in building energy efficiency were discussed in greater detail in the buildings section of this chapter.

The expectation of higher prices along with improving technology will also improve how the electric grid is used to transmit and distribute power from more diverse and often distant sources of renewable power to customers.

Often referred to as "smart grid" technology, some of the simpler technologies are smart meters and sensors that will allow users to measure, monitor, and manage their energy consumption based on real-time electricity prices and other electric power system information (e.g., if the system is under strain, users may be asked or be given incentives to reduce demand). Beyond smart electric power meters and demand response systems, new transmission and distribution technologies also have potential to improve grid efficiency, reliability, and security.[454] These technologies have not been widely demonstrated, however, so their costs and benefits remain uncertain.

Analysts expect that these technologies could reduce both total energy demand and peak energy demand, where peak energy demand is the maximum amount of power required to meet the peak demand over the course of a day (daily peak) or year (annual peak), and thus the amount of capacity that is required to avoid a blackout. While reducing total energy demand lowers GHG emissions, reducing (or shifting) peak demand reduces the amount of generation capacity that has to be built. Reducing total demand reduces customer bills by directly lowering their consumption. Reducing peak demand reduces customer bills indirectly insofar as less investment in rarely used generation is needed. Both types of improvements are expected to benefit customers, including the Army.

Estimating the size of these reductions is once again complex, but independent estimates suggest that these technologies could lead to significant decreases in total energy consumption and in peak energy demand. For example, one study found that improvements in energy efficiency could reduce projected end-use demand in 2020 by 23 percent.[455] Another study projected that peak demand could be reduced by 20 percent in 2020.[456]

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[454] Amin Massoud and John Stringer, "The Electric Power Grid: Today and Tomorrow," *MRS Bulletin*, Vol. 33, 2008, p. 403.

[455] Granade, Creyts, Derkach, Farese, and Nyquist, *Unlocking Energy Efficiency in the U.S. Economy*, July 2009.

[456] The Brattle Group; Freeman, Sullivan & Company; Global Energy Partners LLC, *A National Assessment of Demand Response Potential,* U.S. Department of Energy, 2009.

Federal, OSD, and Army Policies Are Increasing Energy Efficiency and Renewable Energy Requirements

Another key trend is the fact that federal, OSD, and Army policies are increasing requirements for the Army to invest and meet increasingly stricter energy efficiency and renewable energy requirements.

Federal energy policies are requiring federal agencies to improve energy efficiency and increase procurement of renewable energy. For decades, the U.S. Congress has passed legislation and the President has issued Executive Orders to impose requirements on federal agencies to improve their energy use. Over time, these requirements have required higher levels of performance and increasingly addressed new topics. Topics addressed by these policies include:

- improving energy and water use efficiency of new and existing buildings;
- requiring new buildings to meet specific energy performance standards (e.g., as of 2030, new buildings must be "net zero energy," meaning that over a course of a year, they must produce as much energy as they consume);
- procuring green products;
- reporting and reducing direct and indirect GHG emissions;
- increasing the use of renewable energy; and
- assessing and mitigating the risks of extended power outages.

Examples of energy-focused legislation that has advanced one or more of these efforts include the National Energy Policy Act of 1978, the Energy Policy Act of 1992, the Energy Policy Act of 2005, and the Energy Independence and Security Act (EISA) of 2007. Such legislation requires military installations, like other federal agencies, to reduce energy consumption and increase renewable energy use. For example, EISA 2007 directs military installations to reduce their energy consumption 30 percent by 2015,[457] and the Energy Policy Act of 2005 directs them to increase, by 7.5 percent, their use of energy from renewable sources by 2013.

Energy requirements are also often included in nonenergy legislation such as the National Defense Authorization Act of 2010 (which put forth a goal for DoD to establish installation-wide energy monitoring and utility control systems). Examples of executive orders that have set energy and related requirements include Executive Order (EO) 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," January

[457] U.S. Library of Congress (U.S. LOC), "H.R.6 Energy Independence and Security Act of 2007," 2007.

24, 2007, and EO 13514, "Federal Leadership in Environmental, Energy, and Economic Performance." Released in October 2009, EO 13514 directs federal agencies, including the Army, to increase energy efficiency and to measure, report, and reduce their GHG emissions. Each agency has to develop percentage reduction targets for agency-wide reductions of GHG emissions by the year 2020 based on a FY08 baseline, develop and implement plans to achieve these goals, and provide metrics and reports on their progress. Each agency is also directed to develop, implement, and annually update an integrated Strategic Sustainability Performance Plan.

As the need to improve energy efficiency and reduce GHG emissions increases, it is likely that the federal government will continue to set ever-higher standards both to reduce public expenditures on energy and to use federal purchasing power to lead the way in improving energy performance throughout the United States.

DoD and Army policies reflect these federal policies and requirements. As Congress and the President raise these standards, the DoD and the Army will continue to translate these federal requirements into DoD and Army-specific guidance. We briefly discuss some of the relevant DoD guidance, along with some examples of the energy requirements in such guidance. It is important to note that the DoD's Quadrennial Defense Review (QDR), a legislatively mandated review of Department of Defense strategy and priorities, has mentioned energy issues, such as energy security.[458] The 2010 QDR states that "[e]nergy security for the Department means having assured access to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet operational needs."[459] It also discusses how energy efficiency can be a force multiplier and the importance of renewable energy investments.

OSD provides guidance on how to implement energy-related EOs and other federal energy requirements. For example, the Secretary of Defense Memorandum on EO 13423, "Strengthening America's Security and Improving the Environment," issued on February 16, 2007, states:

> As the federal leader in the use of renewable energy, alternative fueled vehicles, and reduced facility energy consumption, the Department has set and should continue to set an example by aggressively implementing the guidance outlined in the EO. In addition, the Department should consider energy efficiency and

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[458] The QDR helps set a long-term course for DoD as it assesses the threats and challenges that the nation faces and rebalances DoD's strategies, capabilities, and forces to address today's conflicts and tomorrow's threats. For more information, see http://www.defense.gov/qdr/

[459] U.S. Department of Defense, *2010 Quadrennial Defense Review*, Washington, D.C.: Department of Defense, 2010, p. 87.

> the ability to use alternative sources in its weapons platforms and tactical vehicles, as identified by the Energy Security Task Force in September 2006, where practical.[460]

OSD has also provided guidance on installation energy management. For example, a memorandum from Philip W. Grone, Deputy Under Secretary of Defense (Installations and Environment), on "Installation Energy Policy Goals," was issued November 18, 2005, and Department of Defense Instruction 4170.11, "Installation Energy Management," was issued on November 22, 2005. These documents established policy and provided guidance for installation energy management, and provided instruction consistent with current legislative, executive order, and Department of Defense requirements.[461] DoD has also provided a handbook for military installation energy managers.[462]

Next, we overview some of the Army guidance. Table 4.8 provides a list of some of the energy-related Army guidance along with examples of the energy requirements in such guidance.

Another key Army guidance document is *The Army Energy Security Implementation Strategy* (AESIS), which sets forth the mission and goals of the Army's energy security plan. The Army energy security mission is:

> Make energy a consideration in all Army activities in an effort to reduce demand, increase efficiency, seek alternative sources, and create a culture of energy accountability, while sustaining or enhancing operational capabilities.[463]

Table 4.9 details the Army's five Strategic Energy Security Goals as set forth in the report.

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[460] Gordon England, Deputy Secretary of Defense, memorandum, "Strengthening America's Security and Improving the Environment," February 16, 2007.

[461] Philip W. Grone, Deputy Under Secretary of Defense (Installations and Environment), memorandum, "Installation Energy Policy Goals," November 18, 2005, and DoDI 4170.11, "Installation Energy Management," November 22, 2005, can be seen at http://www.energytracking.com/download/DOD_417011p.pdf.

[462] Intuitive Research & Technology Corporation, *Department of Defense Energy Manager's Handbook*, Prepared for the Office of Deputy Under Secretary of Defense, Installations and Environment, August 25, 2005.

[463] Department of the Army, *Army Energy Security Implementation Strategy*, January 13, 2009.

Table 4.8
Examples of Key Army Guidance That Addresses Energy Use

Department of Army Guidance	**Energy Goals or Requirements**
Department of the Army, "The U.S. Army Energy Strategy for Installations," July 8, 2005.[a]	Sets forth the Army's energy goals for 25 years, in five major initiatives: • Eliminate energy waste in existing facilities • Increase energy efficiency in new construction and renovations • Reduce dependence on fossil fuels • Conserve water resources • Improve energy security
Department of the Army, "The U.S. Army Energy and Water Campaign Plan for Installations," December 1, 2007.[a]	"The Campaign Plan defines the intermediate actions, approaches, initiatives, and funding over the 25 years to ensure the Army successfully achieves long-range energy and water management goals"; the Campaign plan is reviewed every two calendar years. The document: • "Provides the way ahead for developing initiatives, approaches and funding strategies to meet the Army energy and water goals. • Identifies tools, technologies, policies, management and institutional requirements to achieve initiatives and approaches. • Describes the desired "end state" for the goals and identifies the metrics of success. • Provides a year-by-year resource requirement and investment plan that coordinates all Army energy/water users and policy components (e.g., security, privatization, procurement, technology, construction, and environment) into cohesive and measurable objectives designed to meet the initiatives. Budget requirements are not shown in the public version of the Army Energy and Water Campaign Plan for Installations."
Memorandum from Joseph W. Whitaker, Deputy Assistant Secretary of the Army for Installations and Housing, "Sustainable Design and Development Policy Update - SPiRiT to LEED Transition," January 5, 2006.[b]	Updated the Army strategy for "integrating the principles and practices of sustainability" on installations. • Noted the transition from SPiRiT tool to the USGBC's LEED rating system, effective for FY08

Department of Army Guidance	Energy Goals or Requirements
Memorandum from Richard A. Cody, Vice Chief of Staff, Department of the Army, "Army Energy Conservation," June 22, 2007.[c]	"Requires that the IMCOM commander ensure energy and water conservation responsibilities are included in the position descriptions of IMCOM Region Directors, their subordinate commanders/managers, and others critical to the implementation of the laws, regulations, and Executive Orders governing this program . . . The PMD accomplished the update on October 19, 2007." "The following statement achieved concurrence from the Office of the Assistant Secretary of the Army for Installation and Environment: 'Ensures compliance with Army Energy and Water Conservation Program policies' "
U.S. Army Corps of Engineers, "USACE Army LEED Implementation Guide," January 15, 2008.[d]	Guidance to assist USACE Project Delivery Teams (PDTs) to meet the Army's Sustainable Design and Development policy, including: • Background and requirements • Validation, documentation, and reporting • Frequently asked questions.
Memorandum from Robert Wilson, Asst. Chief of Staff for Installation Management, "Army Energy Savings Performance Contracting (ESPC) Program Guidance," December 22, 2008.[e]	Provides guidance on implementation of the ESPC program consistent with congressional requirements, DOE policy, and GAO and U.S. Army Audit Agency recommendations.
Army Regulation 420-1, "Army Facilities Management," Department of the Army, Facilities Engineering, March 28 2009.[f]	This document "addresses the management of Army facilities. Specifically, it describes the management of public works activities, housing, and other facilities operations and management, military construction program development and execution, master planning, utilities services and energy management, and fire and emergency services. Also, it identifies and synopsizes other regulations that provide detailed facilities management policy. The Army Energy and Water Management Program is in Chapter 22."
Department of the Army, from Katherine Hammack, ASA (IE&E) "Sustainable Design and Development Policy Update" October 27, 2010.[g]	Summarizes and reiterates the goals in EPAct05, EISA07, EO 13423, and EO 13514 (as noted in Table 4.5 above). • Minimize water consumption, optimize energy efficiencies and performance, including renewables feasibility assessments.

[a] http://army-energy.hqda.pentagon.mil/programs/plan.asp
[b] http://www.wbdg.org/pdfs/asaie_sdd_policy_upd.pdf
[c] http://army-energy.hqda.pentagon.mil/vcsa.asp
[d] http://www.vrems.org/ewebeditpro/items/O124F17729.pdf
[e] http://army-energy.hqda.pentagon.mil/docs/ACSIM_approved_22Dec08.pdf
[f] http://army-energy.hqda.pentagon.mil/policies/ar_420_1.asp
[g] http://www.asaie.army.mil/Public/IE/doc/Sustainable%20Design%20and%20Dev%20Policy%20Update.pdf

Table 4.9
The Army's Strategic Energy Security Goals

Reduced energy consumption	Reduce the amounts of power and fuel consumed by the Army at home and in theater. This goal will assist in minimizing the logistical fuel tail in tactical situations by improving fuel inventory management and focusing installation consumption on critical functions.
Increased energy efficiency across platforms and facilities	Raise the energy efficiency for generation, distribution, storage, and end-use of electricity and fuel for system platforms, facilities, units, and individual Soldiers and civilians. This goal also relates to the productivity of a system based on energy requirements and supports the ability to make informed tradeoffs in development, engineering, and deployment of weapon systems.
Increased use of renewable/ alternative energy	Raise the share of renewable/alternative resources for power and fuel use, which can provide a decreased dependence upon conventional fuel sources. This goal also supports national goals related to renewable/alternative energy.
Assured access to sufficient energy supply	Improve and maintain the Army's access to sufficient power and fuel supplies when and where needed. Energy is a critical resource in conducting Army missions. Vulnerabilities to external disruption of power and fuel sources should be minimized, and the potential for industry partnerships to enhance energy security and generate net revenues for the Army should be considered.
Reduced adverse impacts on the environment	Reduce harmful emissions and discharges from energy and fuel use. Conduct energy security activities in a manner consistent with Army environmental and sustainability policies.

SOURCE: Department of the Army, *Army Energy Security Implementation Strategy*, January 13, 2009, p. 4.

What Can Affect These Trends?

These trends could be affected by several types of events. First, changes in global and regional economic growth rates could exacerbate or diminish the competition for energy supplies; this could lead to higher or lower prices. Second, there could be higher energy prices because of rising demand, declining fossil fuel resources, and policies to mitigate GHG emissions, which would increase investments in energy efficiency and renewable energy technologies. Third, technological breakthroughs could lead to the development, demonstration, and deployment of more energy efficient and/or cheaper renewable energy technologies. There could also be lower energy prices due to technological breakthroughs in fossil energy extraction and/or nuclear technologies. Fourth, ongoing economic concerns and energy politics could lead to the development of more U.S. fossil fuel resources becoming a higher priority than reducing GHG emissions; this could result in renewable energy options being less attractive and delay focused action to reduce GHG emissions.

Fifth, abrupt climate change could have severe consequences that would lead decisionmakers to adopt far more aggressive goals for transitioning to low- and no-GHG emissions sources. Sixth, new business models and contracting approaches could help facilitate more investments in alternative energy technologies. Real and perceived security threats, both physical and cyber, to the electric grid, pipelines, and generation could cause energy security to be higher priority, which could lead to a range of different energy investments: from more emphasis on distributed power sources, like fuel cells or solar, depending on the location, to a focus on smart grid technologies. Finally, federal, state, and local government policies, regulations, and requirements could accelerate or slow the transition to new technologies.

Interrelationships with Other Trends

Energy trends will also be affected by other trend areas addressed in this report. Any U.S. and other nation's policy responses to climate change would influence energy trends. Rising concerns about other environmental issues that are impacted by energy development and use, such as criteria pollutants, water use and contamination, and biodiversity trends, can also affect energy developments and investments. Environmental relationships to energy can be complex because they involve many different concerns that vary by region and technologies. Some energy technologies, including renewable ones like wind farms and large solar arrays may have a potential impact on biodiversity. If, for example, wind farm development (including the transmission line development to support it) in the desert Southwest, were determined to impact significant declining species, there could be restrictions on the deployment of such technologies in those regions, while concerns about air quality and water pollution could limit more extraction of coal in certain regions.

Building-related trends, as discussed previously in this chapter, will also affect energy trends. Developments in information technology may also lead to more advanced and lower-cost ways of measuring, monitoring, and improving energy use and management. Sustainable community and transportation trends could also affect energy trends, such as more compact, smaller houses and higher-density neighborhoods with more pedestrian- and transit-friendly options leading to less energy use.

Implications of Energy Trends for Army Installations

Next we discuss the implications of these energy trends for Army installations. However, to help set the context we first provide some background information about energy issues at installations today and how some are already aggressively pursuing energy efficiency and renewable energy projects. Then we discuss the implications of the energy trends for Army installation activities and provide some recommendations given such trends and current Army installation activities.

Army Context with Respect to Energy Issues

To meet the federal, DoD, and Army energy requirements discussed earlier, conserve resources, and save costs, the Army has a strong energy management program in which many installations are actively pursuing energy consumption reduction requirements, energy efficiency, energy security, and renewable energy goals. Many have demonstrated successes in these activities; we provide two installation examples here: Fort Knox and Fort Carson.

Fort Knox has achieved significant energy savings through a range of energy efficiency and projects, including ground source heat pump (GSHP)[464] installations, boiler upgrades and replacements, lighting retrofits, window/roof replacements, HVAC system replacements, occupancy sensor installations, high-efficiency motor retrofits, and Energy Management Control System (EMCS)[465] equipment installation. In fact, between FY96 and FY06, Fort Knox had a 58 percent reduction in absolute energy consumption due to such activities, including installing GSHP projects in over 250 buildings.[466]

In FY07 Fort Carson started building a 2-MW ground-mounted solar PV array on 12 acres atop a former landfill. At the time it was the largest solar array at a U.S. Army facility and one of the largest in Colorado. The array became operational in early FY08, and it generates 3,200 MWh/year and provides Fort Carson with nearly 3 percent of the installation's electrical needs.[467]

As mentioned earlier, the Army's sustainability and net zero installation activities are also motivating installations to conserve energy resources and invest in renewable energy

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[464] A ground source heat pump, also sometimes called a ground coupled heat pump (GCHP) or geothermal heat pump, is a heating and/or cooling system that transfers heat to or from the ground to a building or water supply. It uses the earth as a heat source (in the winter) or a heat sink (in the summer). This system takes advantage of the constant moderate temperatures underground to boost efficiency and reduce the operational costs of heating and cooling systems.

[465] An EMCS is a computerized energy management system that uses control equipment, sensors, and software to monitor and manage buildings' use of energy for heating, ventilation, air conditioning, lighting, and/or other processes. An EMCS can also be used to help with fire control, safety, and security management.

[466] Beth E. Lachman, Kimberly Curry Hall, Aimee E. Curtright, and Kimberly M. Colloton, *Making the Connection: Beneficial Collaboration Between Army Installations and Energy Utility Companies*, Santa Monica, CA: RAND Corporation, MG-1126-A, 2011.

[467] Lachman, et al., *Making the Connection: Beneficial Collaboration Between Army Installations and Energy Utility Companies*..

technologies. Here we elaborate more on the net zero energy activities. In fall 2010, the Army announced this new Army Energy vision for net zero energy installations (NZEI). The Army defines:

> A Net Zero Energy Installation (NZEI) is an installation that produces as much energy on site as it uses, over the course of a year. To achieve this goal installations must first implement aggressive conservation and efficiency efforts while benchmarking energy consumption to identify further opportunities. The next step is to utilize waste energy or to "re-purpose" energy. Boiler stack exhaust, building exhausts or other thermal energy streams can all be utilized for a secondary purpose. Co-generation recovers heat from the electricity generation process. The balance of energy needs then are reduced and can be met by renewable energy projects.[468]

Also, as discussed earlier, the Army has a broader goal of net zero installations, which means net zero energy, water, and waste designed to conserve natural resources. By definition, "net zero installations will consume only as much energy or water as they produce and eliminate solid waste to landfills."[469] In April 2011, the Army announced six net zero pilot installations in each of the energy, water, and waste categories and two integrated installations striving toward net zero by 2020. The two integrated installations are Fort Bliss and Fort Carson. The six NZEI pilots are Fort Detrick, Maryland; Fort Hunter Liggett, California; Kwajalein Atoll, Republic of the Marshall Islands; Parks Reserve Forces Training Area, California; Sierra Army Depot, California; and West Point, New York.

Energy security, including thinking about grid independence in case the public utility grid goes down, is also something that Army headquarters and installations are focused on.[470]

These activities are all progressive energy management steps. However, three main conditions limit the ability of Army installations to pursue such large-scale investments in energy efficiency and renewable projects.

First, the financial, legal, technical, and contracting complexities of large-scale energy projects make it difficult for installations to choose and make such investments. Installation staff often lack the capabilities needed to issue energy-related solicitations, evaluate proposals, and monitor contract implementation. This is because of the technical complexity

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468 Army Energy Program, "Army Vision for Net Zero," no date.

469 Office of the Assistant Secretary of the Army, "Net Zero Installations Identified."

470 For more information about concerns regarding the public electricity grid going down, see Defense Science Board, *More Fight—Less Fuel*, Defense Science Board Task Force on DoD Energy Security, Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, Washington, D.C., February 2008.

of the technologies, complexity and size of the financing options, and the specialized contracts and related laws. In addition, while some of these improvements may lead to net cost savings at current or future energy prices, relatively little information exists in the public domain to help individual installations understand the costs and benefits of these options or how to choose among them.

Second, Army installations have no dedicated consistent funding for energy efficiency or renewable energy investments, which often involve large sums of money. A renewable energy project usually involves millions of dollars of capital investment. In some cases, Army installations can acquire installation operations and maintenance or other Army-appropriated funds for energy efficiency improvements when they upgrade systems or retrofit a building. Also, for FY12–FY17, Army headquarters was able to secure $120 million for installations' utility metering. There also are some limited OSD funding opportunities, such as Energy Conservation Investment Program (ECIP) funding. ECIP provides funding for energy efficiency projects at DoD facilities that reduce associated utility energy and other related costs. However, ECIP funding is a competitive process and limited.[471] In fact, all these sources are limited. Thus, it is often difficult for installations to fund large-scale energy projects. There are also some limited options installations can pursue for third-party financing that involve installations partnering with utilities or industry, such as in a Utility Energy Service Contract (UESC)[472] or an Energy Savings Performance Contract (ESPC),[473] respectively.

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[471] ECIP is a Department of Defense MILCON-funded program. The ECIP program focuses on energy and water savings, implementation of renewable energy, and converting systems to cleaner energy sources. The Army competes with the other Services to obtain these funds. In FY08, the Army was awarded 16 ECIP projects, which totaled approximately $24 million, and in FY09, it was awarded 15 projects, which totaled about $27 million. See Army Energy Program, "Appropriated Funds-ECIP," updated January 4, 2010..

[472] UESCs provide a way to help finance and implement energy efficiency projects at installations. The utility provides the initial investment, and the installation pays it back over the life of the contract, usually ten years. For more information about how the Army has implemented UESCs see: Lachman et al., *Making the Connection: Beneficial Collaboration Between Army Installations and Energy Utility Companies*.

[473] An ESPC is a partnership between the installation and a private sector company, known as an energy service company. With this funding mechanism, installations can implement energy efficiency projects without up-front capital costs or special congressional appropriations. The private company pays for the energy efficiency investments, and the installation pays it back from its energy savings over time.

Third, installation energy managers often do not have the technical training, expertise, and/or time to pursue such projects. In fact, some installations lack a qualified and experienced full-time energy manager. Some installations experience a relatively high turnover rate of installation energy managers and have new and less experienced energy managers. Even when there is a full-time energy manager at an installation, there is often not enough other trained energy staff to support him or her. Energy managers have many responsibilities and need additional qualified energy staff to meet installation energy requirements, especially at larger installations. Part of this issue is the fact that given the energy manager requirements at larger installations, the Army sometimes has difficulty hiring and retaining qualified energy managers because existing Army pay grades are below private-sector salaries for these skill sets. As a result, even when the Army is able to hire someone to fill this position, turnover rates can be high since the individual can make more money in the private sector.[474]

Given the energy trends just discussed, the Army will likely have to continue investing in energy efficient buildings, renewable energy, and other electricity technologies to meet increasingly stringent federal requirements. While these investments may require larger near-term capital investments than would otherwise be required, they may provide years or decades of energy or other savings if prices rise or if the nation adopts policies designed to reduce GHG emissions. It is also important to note that renewable energy will become more cost competitive over time, making it easier to invest in such options.

Recommendations for the Army

Given these energy trends and this Army context, we have six main categories of recommendations for the Army.

First, the Army should accelerate its efforts to improve energy efficiency and lay the foundation to aggressively implement more rigorous standards. Installations will have to improve the energy efficiency of their buildings because of future stricter federal, OSD, Army, and even state requirements. Energy investments also will provide years or decades of savings at current prices and even greater savings if energy prices rise. New construction energy standards should be more aggressive than for retrofits because new buildings are likely to be in place longer and changes are usually more expensive after construction. For new construction, the Army should set a goal to be at least 65 percent more efficient than the ASHRAE 90.1-2004 standard, which is projected to reduce building energy consumption

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[474] Lachman et al., *Making the Connection: Beneficial Collaboration Between Army Installations and Energy Utility Companies.*

by 50 percent compared to the Army's 2010 standard. Such a high standard is achievable given the work of the 2009 Energy Security Tiger Team Assessment at Fort Bliss.[475] Given fiscal challenges these days, such increases in standards are difficult to get implemented, especially when they involve MILCON dollars, but they can be justified because of the long-term savings in energy use and dollars. ACSIM should do cost-benefit analysis to show the savings of such a standard over time to help in its justification and implementation. Such standards should be revisited every couple of years and likely made stricter as technologies and policies advance.

Second, the Army should have a centralized headquarters organization of expertise that assists installations with technical, financial, legal, and contracting issues regarding large-scale energy investments. In many cases, the expertise needed to issue solicitations, evaluate proposals, award contracts, and provide oversight of energy technologies may be beyond the capabilities of individual installations, and these installations need assistance. Such an assistance organization should provide technical and financial assistance on renewable energy as well as large-scale energy efficiency projects and help evaluate the cost-effectiveness of the many options for improving energy performance. It should work with installations as they need help and take into account the unique implementation circumstance of each installation. This organization could be located in ASA(IE&E), at ACSIM, or at IMCOM headquarters or some combination of these organizations. In 2011, ASA(IE&E) acquired staffing and funding for such a center, called the Energy Initiatives Task Force, which focuses on helping installations implement large-scale renewable energy projects. This is a good first step, but such help is also needed to assist installations with large-scale energy efficiency projects.

Third, ACSIM and IMCOM and other Commands should help installations by supporting demonstrations of new energy technologies and evaluating their performance. In the near term, such demonstrations should focus on innovative energy efficiency and renewable energy technologies. For the longer term, such demonstrations should focus on distributed generation, energy storage, and "smart grid" technologies or alternative grid

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[475] "Expert team members in building energy conservation found that at least 65% reduction in energy consumption beyond the ASHRAE energy standard for new buildings is highly likely to be cost-effective at current energy prices paid by Fort Bliss. Moving from 30% to 65% beyond ASHRAE 90.1-2004 represents a 50% reduction in building energy consumption." U.S. Army, Office of the Deputy Assistant Secretary for Energy and Partnerships, *Energy Security Tiger Team Assessment—Fort Bliss, Final Report*, Washington, D.C., April 14, 2009, p. 9.

architectures. Some demonstration activities are already going on; for example, the Installation Technology Transition Program (ITTP) is a multimillion-dollar program that helps transfer innovative technologies that improve infrastructure design, operation, and maintenance on Army installations. Through this program, installations use OACSIM operations and maintenance funds to test a technology, including energy technologies. ACSIM and IMCOM and other Commands should partner more with other organizations that help facilitate the development and implementation of energy technologies, such as the Army RDT&E community, USACE, and DOE, on such demonstrations.

Fourth, ACSIM and IMCOM and other Commands should help installations collaborate more with utilities and industry to develop renewable and other energy resources or infrastructure when beneficial to installations. Such collaborations are especially important for acquiring funding for large-scale energy efficiency and renewable energy project investments. Installation partnerships with utilities and industry can help Army installations increase their energy efficiency and renewables, as the Fort Knox and Carson examples discussed earlier demonstrated.[476]

Fifth, ACSIM and IMCOM and other Commands should also help installations identify low-cost opportunities to procure renewable power for sources inside and outside installations and move toward the energy monitoring and management systems standard as discussed in FY10 Defense Authorization, Subtitle D.

Lastly, ACSIM and IMCOM and other Commands should help installations promote competitive hiring and salaries for full-time energy managers and staff at installations to attract and retain qualified and skilled staff.

Sources for Tracking Energy Trends

Many government, private, and nonprofit organizations produce publications on differing aspects of energy trends.

Among U.S. government sources, the U.S. Department of Energy's (DOE) Energy Information Administration (EIA)[477] provides independent statistics and analysis of U.S. and international energy issues. Among its annual publications are the U.S.-focused *Annual*

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[476] For an overview of the many benefits from collaboration between Army installations and energy utilities, see Lachman et al., *Making the Connection: Beneficial Collaboration Between Army Installations and Energy Utility Companies*.

[477] For more information on U.S. Energy Information Administration data, see their web site at http://www.eia.gov/.

Energy Outlook[478] and the broader *International Energy Outlook*.[479] EIA also provides a monthly *Short–Term Energy Outlook*.[480] These documents summarize EIA's views of supply, demand, current policies, and price projections.

DOE's Office of Energy Efficiency and Renewable Energy (EERE) supports a broad range of R&D and publishes many reports describing technology, market adoption, and policy issues. Two annual publications that track deployment trends are the *Renewable Energy Data Book*[481] and the *Wind Technologies Market Report*.[482]

DOE's Office of Electricity Delivery and Energy Reliability (OE) also funds R&D on the transmission and distribution aspects of electric power, including smart grid technologies. For example, OE published *The Smart Grid: An Introduction*[483] in 2008.

DOE also includes offices focused on fossil and nuclear energy. These offices also support R&D and publish reports on these topics. DOE's national laboratories (e.g., the National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, National Energy Technology Laboratory) also produce many energy-related reports; most of these reports are funded by DOE program offices, so we do not list laboratory publications separately.

Private-sector firms that produce regular assessments of energy supply and demand trends include the major oil and gas companies, including BP, Shell, and ExxonMobil. McKinsey & Company and IHS Cambridge Energy Research Associates are just two of many private-sector consulting firms that analyze energy issues, though most of their research is proprietary and available for purchase.

A large number of nongovernment organizations (NGOs) track energy trends. Internationally, the International Energy Agency follows global energy trends (e.g., supply, demand, technology) and produces the annual *World Energy Outlook*[484] as well as other annual reports that probe specific issues more deeply (e.g., technological advances, sequestration).

Within the United States, a small selection of other NGOs that regularly provide information on these topics include the Electric Power Research Institute (EPRI), the

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[478] U.S. Energy Information Administration, *Annual Energy Outlook 2011 Early Release Overview*, 2011b.

[479] U.S. Energy Information Administration, *International Energy Outlook*, 2010.

[480] U.S. Energy Information Administration, *Short-Term Energy Outlook*, 2011c.

[481] Rachel Gelman, *2009 Renewable Energy Data Book*, U.S. Department of Energy, 2010.

[482] Wiser and Bolinger, 2009.

[483] U.S. Department of Energy, *The Smart Grid: An Introduction*, undated.

[484] International Energy Agency, *World Energy Outlook 2011*, 2011.

American Council for an Energy Efficient Economy (ACEEE), the Alliance to Save Energy (ASE), the U.S. Green Building Council (USGBC), the RAND Corporation, the World Resources Institute (WRI), and the Pew Center on Global Climate Change. EPRI is an electric power industry-funded research, development, analysis, and planning organization that focuses on the generation, delivery, and use of electricity. ACEEE and ASE provide a broad range of information on energy efficiency in particular. Finally, WRI and the Pew Center on Global Climate Change provide a broad range of information on energy in general along with technology and policy.

Numerous peer-reviewed journals also focus on energy, though many are written for audiences with advanced backgrounds in economics, technology, or energy policy. A subset of energy-related journals include *Energy*, *Energy Economics*, *Energy Journal*, *Energy Policy*, and *The Electricity Journal*. Given the large and diverse number of professions active in the energy industry, it is difficult to identify all useful sources of information. For example, a 2008 issue of the journal of the Materials Research Society, the *MRS Bulletin*, focused on innovation in the electric power grid.

Finally, daily news services are also available from Energy & Environment News, Platts, and other publishers.

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CHAPTER FIVE

Information Technology Trends

In this chapter we discuss how key trends in information technology may affect Army installations. We use the term "information technology" to refer to software, computing, and computer-related systems. Our study began with a broad survey of information technology trends, including, among others, pervasive computing, online communities, education technology, biometrics, cyber security, and robotics. This chapter discusses three of these areas that have the most significant implications for Army installations in particular: online communities, pervasive computing, and robotics. Importantly, the other areas, such as education technology and cyber security, do have implications for the Army as a whole and parts of installations, but they were not as directly relevant to installation operations and were already being addressed by other parts of the Army that have more direct responsibility over them. Such areas are not covered here because they are areas that ACSIM and the rest of the installation management community do not need to follow as closely because they have a small role at installations and are integrated into installation operations based on the lead of other Army organizations.

Trends in these information technologies may affect Army installations in two key ways. First, younger generations have grown up with information technologies, and it is important for the Army to understand their expectations of information technology use and how it may shape their goals, needs, and behaviors. (The next chapter on social trends, which examines trends among youth, explores such issues in more depth.) Second, to different degrees, developments in these areas provide opportunities for the Army to save money or improve Soldier and Family quality of life.

We begin by discussing online communities.

Online Communities

In this section we discuss the activities and trends related to online communities and what implications they have for Army installations.

Background: Defining Online Communities

"Online communities" are groups of people who interact partly or primarily online via the Internet for social, professional, education, or other reasons. Online communities take place in a wide variety of online environments that offer different tools and features. Simpler environments include chat rooms or discussion boards such as those provided by Google Groups or Yahoo Groups that allow users to chat in real time or to post and reply to each other's messages. Other environments provide richer methods of interacting. Social networking sites like Facebook and MySpace, massively multiplayer online role-playing games (MMORPG), such as World of Warcraft, and 3D virtual worlds such as Second Life enable users to communicate through text, voice, video, images, and actions.

The social networking site Facebook, for example, was launched in 2004 and in six years boasted 400 million active users around the world.[485] Facebook enables its users to build a network of friends and then to communicate and interact with these friends through private email-like messages, instant messages, and status updates. Users can also create "profiles" of themselves that include biographical information, personal views, and hobbies. Users can share pictures and videos, organize events, and play games. Facebook also allows users and third-party developers to create applications and games for Facebook. In large part because of third-party games, approximately 200 million users play games on Facebook monthly.[486]

While Facebook on one hand allows users to communicate, maintain friendships, and build community, users also spend significant amounts of time on the site. One study finds that, in companies that allow access to Facebook at the office, nearly half of office employees used Facebook during work, losing their companies an average of 1.5 percent of total office productivity across the organization.[487] Another survey suggests that over half of all U.S. firms block access to social networking sites like Facebook, out of concerns about loss of productivity and security.[488]

Second Life is the largest of many 3D, online "virtual worlds" that create an environment in which online communities can flourish. Second Life's users can interact with each other through a computer representation of themselves known as an "avatar." "Residents" in Second

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[485] Facebook defines "active users" as users who have returned to the site in the last 30 days. Facebook Statistics, 2010.

[486] Emma Barnett, "200m Facebook Users Play Games Every Month," *The Telegraph*, September 22, 2010.

[487] Based on interviews of office workers, the study estimated that 77 percent of a company's employees have a Facebook account and 61 percent of those employees access Facebook for 15 minutes each day, amounting to a loss of 1.47 percent of its productivity across the company's workforce. Nucleus Research, *Facebook: Measuring the Cost to Business of Social Networking*, 2009.

[488] Robert Half Technology, "Whistle—But Don't Tweet—While You Work," October 6, 2009.

Life socialize, play games, and create, buy, and sell virtual and real goods and services. Use of Second Life is creative and diverse: universities have used Second Life to teach courses,[489] a religious group purchased land in Second Life to allow people to take part in a "virtual" Hajj,[490] and countries have created virtual embassies in Second Life.[491] As these examples suggest, Second Life provides a way for people to interact in a virtual world that mimics an important aspect of the real world: the ability to "be there."

Massively multiplayer online role-playing games (MMORPGs) are online video games that allow thousands of users to play simultaneously, often in 3D environments with avatars in a persistent world. World of Warcraft, said to be the largest of these games by market share, boasts 11.5 million users.[492] One of the most alluring aspects of games like World of Warcraft is the ability to form and join guilds—an association of players and their avatars who agree to work together in the game for companionship, adventure, access to extra game features, greater success in game play, and other benefits. Guilds are much like traditional clubs in that they depend on good leadership, have a schedule of activities (albeit in the gaming world) in which members should participate, and may require applications to join.[493] In part because of this highly social element, massively multiplayer games such as World of Warcraft not only have millions of members, but active members may spend many hours playing the game. One study finds that, on days that gamers play World of Warcraft, 75 percent of them play for more than 1.9 hours on average, and 25 percent play longer than 4.9 hours on average.[494]

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[489] Leslie Jarmon, Tomoko Traphagan, Michael Mayrath, and Avani Trivedi, "Virtual World Teaching, Experiential Learning, and Assessment: An Interdisciplinary Communication Course in Second Life," *Computers & Education*, Vol. 53, No. 1, 2009, pp. 169–182.

[490] The Hajj is a pilgrimage to Mecca in Saudi Arabia that Islam requires all able-bodied Muslims to undertake at least once in their lifetimes. Sky News, "Second Life Visit to Mecca for the Hajj," December 19, 2007.

[491] The embassy of the Maldives can be found at http://slurl.com/secondlife/Diplomacy%20Island/204/95/22/.

[492] Warcraft can be found at www.worldofwarcraft.com. Blizzard Entertainment, "World of Warcraft Subscriber Base Reaches 11.5 Million Worldwide," November 21, 2008.

[493] Wowwiki, "Guild," undated. Dmitri Williams, Nicolas Ducheneaut, Li Xiong, Nich Yee, and Eric Nickell, "From Tree House to Barracks: The Social Life of Guilds in World of Warcraft," *Games and Culture*, Vol. 1, No. 4, 2006, pp. 338–361.

[494] Pin-Yun Tarng, Kuan-Ta Chen, and Polly Huang, "An Analysis of WoW Players' Game Hours," *NetGames '08*, Worchester, MA: 7th ACM SIGCOMM Workshop on Network and System Support for Games, October 21–22, 2008, pp. 40–45.

Online communities can also be created in more passive broadcast environments such as web logs or "blogs," in which individuals or organizations regularly post commentaries about news, hobbies, events, or any other topic. Blogs can use images, video, and music as well as text. Microblogs such as Twitter enable bloggers to communicate by short, text-based messages called "tweets" and to subscribe to each other's tweets.[495] A community may be formed by those who follow the same blogs, as those individuals comment on and discuss messages.

Online communities can also facilitate interactions in the real world, for example through the social networking site Meetup. This site enables users to find others in their city or region with common interests, form communities that are organized online, and then ultimately meet in person and develop a community offline. Meetup's features include the ability to create new groups, easily manage memberships and event, collect dues, post photos, and leave messages between participants. Meetup reports 7.2 million members, 79,000 groups, and 250,000 monthly in-person get-togethers in over 45,000 cities around the world.[496]

Key Online Community Trends

The membership and activity on sites such as Second Life, Facebook, and Meetup speak to the importance of online communities, which have grown rapidly over the past several years. One study reports on the growth in social networking site use:

> In 2005, only 5 percent of the public used social networking sites. That share grew to 11 percent in 2006 and 27 percent in 2008. In the current survey, 41 percent say they have created their own profile on a social networking site, such as Facebook, MySpace or LinkedIn.[497]

The number of Facebook users, for example, appears to have grown very rapidly from its beginnings in 2004. Use of social media sites is particularly evident among younger people. One study focusing on American users found that 75 percent of "Millennials" (the first to have started college in or after the year 2000 and who are now 18–29 years old) have a social networking profile of some kind. Moreover, nearly 30 percent of this group visit those sites

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[495] For more information about Twitter, please visit http://www.twitter.com.

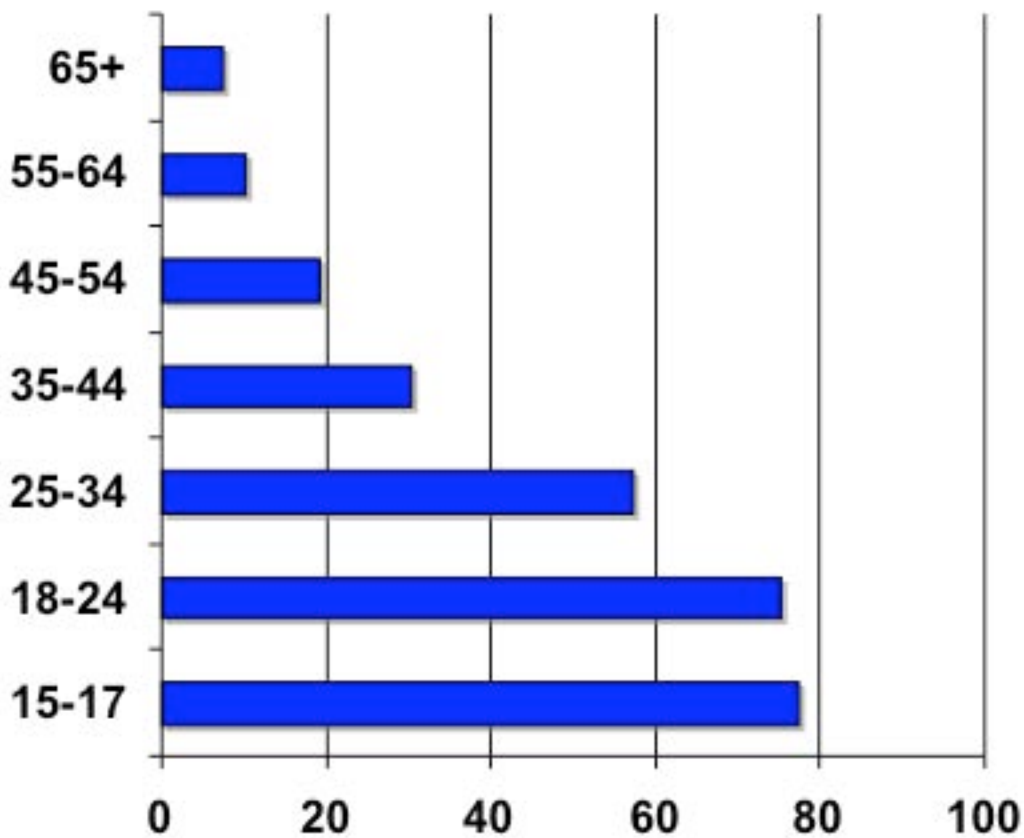
[496] Meetup can be visited at http://www.meetup.com.
Statistics retrieved on August 14, 2010, from http://www.meetup.com/about/.

[497] Pew Research Center, *Millennials: A Portrait of Generation Next: Confident, Connected, Open to Change*, Washington, D.C.: February 24, 2010, p. 28.

several times a day, and about another 25 percent visit once a day.[498] Figure 5.1 shows the percent of Internet users with social networking profiles.

There is also some evidence that use of social networking sites varies by education level, and this data is presented in Figure 5.2. The implications of this data are unclear, however, given that education is confounded with age. That is, those with less than high school or some college education are likely to be still in high school or college and therefore likely to be young,

Figure 5.1
Percent of Internet Users by Age with Social Networking Profile



NOTE: This chart combines data from two sources that surveyed teens and adults between 2006 and 2008. Data for those 18 years and older was taken from Amanda Lenhart, "Adults and Social Network Websites," *Pew Internet and American Life Project*, January 14, 2009a. Data for 15–17 year olds was taken from Amanda Lenhart, "It's Personal: Similarities and Differences in Online Social Network Use Between Teens and Adults", *Pew Internet and American Life Project*, May 23, 2009b.

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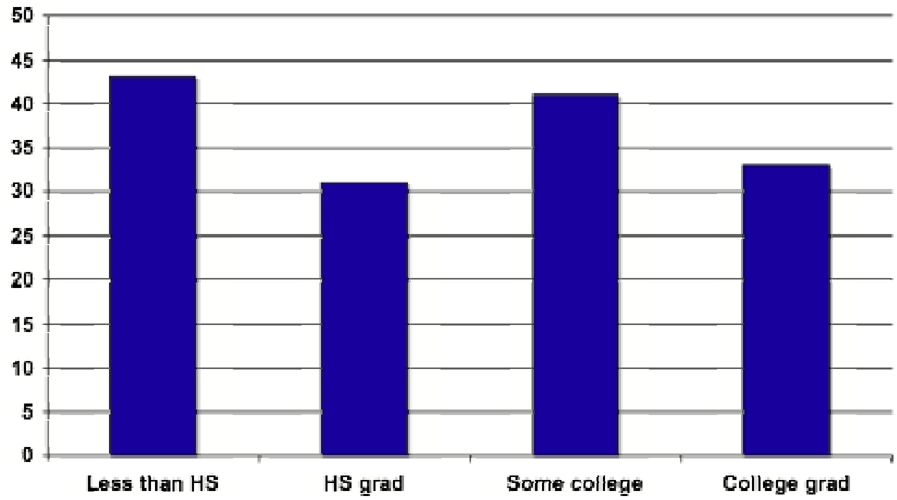
[498] Pew Research Center, *Millennials: A Portrait of Generation Next: Confident, Connected, Open to Change*, Washington, D.C.: February 24, 2010.

Figure 5.2
Percent of Social Networking Site Users by Education Level



Data for those 18 years and older was taken from Amanda Lenhart, , "Adults and Social Network Websites," *Pew Internet and American Life Project*, January 14, 2009a.

which is a key predictor of social networking site use. On the other hand, those who completed high school or college may be at any age, and their use of social networking sites may have little to do with education and much more to do with their age. However, it is clear that at least 30 percent of people at every education level are using social networking sites.

Another institution projects that by 2011, 80 percent of active Internet users will have a "virtual" life on the Internet.[499] The number of users may eventually stabilize, but as new applications and environments emerge, the diversity and importance of these communities will continue to grow.

Anecdotal evidence and research both suggest that online communities may offer important social benefits. One study found a strong link between Facebook use and social capital among college students, enabling them to more easily maintain relationships with high school friends, while also helping them maintain ties with friends and acquaintances in their college communities.[500] Anecdotal evidence suggests that Facebook may help new students

[499] Gartner, "Gartner Says 80 Percent of Active Internet Users Will Have a 'Second Life' in the Virtual World by the End of 2011," April 24, 2007.

[500] N.B. Ellison, C. Steinfield, and C. Lampe, "The Benefits of Facebook 'Friends': Social Capital and College Students' Use of Online Social Network Sites," *Journal of Computer-Mediated Communication*, Vol. 12, No. 4, article 1.

adjust to a new college environment by enabling them for example to meet future roommates and classmates before they arrive on campus.[501]

Simultaneously, online communities pose some risks. For instance, although most teenagers manage privacy settings in their online communities,[502] their notions of what constitutes privacy may be very different from those of older generations.[503] Younger users regularly post pictures, political views, family and religious details, and other information that older users might consider private. Posting private information may create risk to personal safety. Also, the use of online communities may consume substantial amounts of time and take time away from other activities. One study found a negative correlation between GPA and Facebook use in college.[504]

Online communities also have been used to target individuals for crimes or to help organize criminal activities. Sex offenders have used online communities like MySpace and Facebook to target children; in a case in San Antonio, Texas, police caught a known sex offender using these tools to find his victims.[505] Twitter and Facebook were also used by rioters in England to encourage public disorder that led to burglary and violence, such as a Facebook posting on "Let's start Bangor riots."[506] In fact, British officials are meeting to see what actions can be taken to prevent people from using such online communities to plot "violence, disorder and criminality."[507]

Online communities that are MMORPGs, like World of Warcraft, also may lead to excessive and addictive use of the Internet, which can create debilitating problems at work or in relationships. Such problems, known as problematic internet use (PIU) or Internet addiction, are discussed at length in the next chapter on societal trends.

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[501] Johanna Peace, "Facebook Eases Freshmen Fears, Fosters Friendship," *CNN*, September 7, 2007.

[502] Amanda Lenhart, "Teens, Privacy and Online Social Networks," *Pew Internet and American Life Project*, 2007.

[503] Ofcom, *Social Networking: A Quantitative and Qualitative Research Report into Attitudes, Behaviours and Use*, April 2, 2008.

[504] A.C. Karpinski, and A. Duberstein, "A Description of Facebook Use and Academic Performance Among Undergraduate and Graduate Students," poster presented at *American Educational Research Association Annual Meeting*, 2009.

[505] KHOU.com, Houston, Texas, "Police: San Antonio Sex Offender Targeted Victims on Facebook, Myspace," July 16, 2011. Also, for more discussion about such types of crimes, see Byron Acohido, "Sex Predators Target Children Using Social Media," *USA Today*, March 1, 2011.

[506] BBC Mobile News UK, "Twitter, Facebook and Blackberry to Attend Riot Summit," August 25, 2011; and Tom Pugh, "Man Charged for Riot Incitement Using Facebook," *The Independent*, August 11, 2011.

[507] BBC Mobile News UK, "Twitter, Facebook and Blackberry to Attend Riot Summit," August 25, 2011.

What Could Change the Course of Online Community Trends

Continued technology advancements and community attitudes could change the course of online community trends. For example, pervasive computing advances will enable people to interact with their online communities in any part of their home or office, through furniture and smart walls, without being limited to the computer, which could increase the use of such tools. Similarly, nanotechnology may enable interaction through smart clothing. Community attitudes and acceptance of online communities also will determine their future. Given their current and ever-increasing acceptance, attitudes are likely to be favorable and will continue to increase their use.

Interrelationship With Other Trends

As just discussed, the phenomenon of online communities obviously interrelates with pervasive computing. It also relates to societal trends, especially trends among youth and issues of excessive and addictive Internet use, which are discussed in the next chapter. There are some relationships with building and energy trends as well. For instance, electricity usage and demand goes up as people spend more and more time on electronic devices participating in online communities. With respect to buildings, the use of space and desires for space usage can be related to online community participation. For example, common areas may not be as popular in dorms on college campuses as more students spend time participating in online communities. This type of trend is already being seen at some Army installations where common areas are no longer being used because the single Soldiers are in their rooms socializing through online communities instead of socializing with fellow Soldiers in the common areas.

Implications of Online Communities for Army Installations

Next we discuss the implications of these online community trends for Army installations. However, to help set the context we first provide some background information about how Army communities are already participating in many different online communities.

Army Context with Respect to Online Communities

Those in the Army and other parts of the military already use online communities extensively. For instance, the Facebook application "My Military Experience" enables military personnel to locate and communicate with their colleagues online.

Another military online community example is Smart Soldier, which is a private, subscription-based online community. It is run by current military personnel and recent veterans from all branches of the United States Armed Services with the goal to provide a supportive online resource to help new recruits, enlisted members and military veterans make informed choices throughout their military careers.[508] Smart Soldier is not owned, operated, or officially affiliated with the U.S. military, and the number of users is not publicly available.

A third example, the Army Wife Network, offers resources and a community for wives of Soldiers, and it facilitates communication through Facebook, Twitter, blogs, and message boards simultaneously. Army Wife Network's message board has nearly 1,000 members, and it has over 3,000 followers on Twitter.[509]

There are also many individual examples of the use of online communities for facilitating interpersonal relationships in the Army and other Services. Soldiers have used Facebook to watch family members' graduations online,[510] military families have used it to find emotional support after a loss, and military leaders have held e-town hall meetings to reach a broader audience.[511] The military has also started taking advantage of the anonymity of online environments to conduct online mental health screenings.[512]

Online communities are also used to facilitate online and in-person group meetings to support Army Soldiers and Families. For example, the social networking site Meetup is used unofficially by individuals to create social and support groups for Soldiers and their Families. We provide two examples. At Fort Bragg, "Fayetteville Living with Disabilities Meetup Group" is a Meetup group for amputees, wounded Soldiers, persons with disabilities, and their spouses in the Fayetteville/ Fort Bragg and surrounding areas.[513] Near Fort Carson, "Colorado Springs Military Wives" was a "meetup group for wives of all branches of the military in the Colorado Springs area."[514]

There also are official Army installation outreach efforts through these online communities by different Army organizations. For example, many installation Morale, Welfare and Recreation (MWR) offices have Facebook pages to help provide support to Soldiers and Families, such as

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[508] For more information on Smart Soldier, see its website at http://www.smartsoldier.com/.

[509] Army Wife Network can be found at http://www.armywifenetwork.com/. Statistics about message board use were obtained from the forum page at http://www.armywifenetwork.com/forum/ on August 2, 2010. Statistics about Twitter followers were obtained from the Twitter page at http://twitter.com/ArmyWifeNetwork on August 2, 2010.

[510] "Soldiers to Watch Family Members' Graduations Online," *MSNBC*, May 18, 2006.

[511] Wisconsin Department of Military Affairs, "Adjutant General Holds e-Town Hall," *Wisconsin National Guard News*, June 25, 2009.

[512] Military Pathways, *Welcome to the Screening Program*, 2009.

[513] "Fayetteville Living with Disabilities Meetup Group," website, at http://www.meetup.com/disability-48/

[514] "Colorado Springs Military Wives," Meetup group website. As of August 25, 2011: http://www.meetup.com/colorado-springs-military-wives/

Forts Belvoir, Benning, Bliss, Bragg, Campbell, Carson, Drum, and Hood. Some Family Readiness Groups (FRGs) at different installations use Facebook to outreach and provide support to deployed Soldiers and their Families. Many of these installations also have Facebook pages hosted by other organizations on post, such as a unit or for the fort as a whole, such as at Forts Carson and Drum. Fort Bliss's Public Affairs Office has a Facebook page, as does the post newspaper at Fort Campbell. In fact, by early 2013 many large Army installations have numerous installation organizations that have created Facebook pages to share information about installation services. Spouses have also created Army spouse Facebook pages at Fort Bliss and Fort Bragg.

Online communities will be an increasingly important part of Soldiers' lives in the coming decades, and Soldiers will expect to be able to continue participating in their "online life" in their "Army life." This has both benefits and risks. Online communities offer many opportunities to connect Soldiers with each other, with their Families, and with their superiors, as has already been demonstrated. However, many of these Army communities so far appear to be largely local grassroots effort without coordination with other parts of the Army, or unofficial efforts by spouses and others.

As noted, however, online communities, especially the unofficial ones, pose some risks. Different notions of privacy suggest that Soldiers may share sensitive military information, political information and views, information that identifies their colleagues, or information that reflects negatively on the military. Soldiers may also spend too much time on their online communities, to the detriment of their community in the "real" world, and to the detriment of other activities.

However, the benefits of online communities can outweigh the risks if the Army develops clear policies, educates new Soldiers, and uses technology that makes it possible for Soldiers to adhere to these policies. As one Army social media and public affairs expert put it, "The military needs to embrace social media because it represents a remarkable change in communication."[515]

Recommendations Regarding Online Communities

The Army should consider expanding its use of online communities to better use them to help support Soldiers and Families and its installation operations. However, first the Army should conduct an analysis to see what current online communities the Army is sponsoring across all parts of the Army, as well as the unofficial ones that help support Soldiers and Families; how best to use these and others to support Army Soldiers and Families and operations; and how

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[515] Jesse Stanchak, "Making a Military-Grade Case for Social Media," *SmartBlog on Social Media*, April 23, 2010.

best to mitigate security issues (namely, address operational security (OPSEC) issues) and other risks from the use of such online communities.

More specifically for installations, ACSIM, IMCOM and the rest of the installation management community should conduct an installation-specific analysis consisting of two parts. The first part should identify the online communities that support Soldiers and Families, both officially and unofficially, and develop specific guidance and policy on their use, both to bring some consistency in their use across installations and to address the OPSEC concerns. This assessment should also identify new opportunities for taking advantage of online communities. The second part of the analysis should assess and identify areas where installation operations and staff could benefit from online communities. For example, Second Life, Facebook, or other social media could be used to help facilitate information sharing across installations for different staff professionals, such as Army Community Service (ACS), Financial Readiness Planners (FRPs), or energy management staff.

Then, based on these analyses, ACSIM and IMCOM should issue official policy and guidance on the use of online communities and officially support their development and use for MWR communities of interest; to help Families keep in touch with Soldiers when deployed or stationed at a different installation; to help Soldiers and Families prepare for relocation between installations; and to support different functional areas of interest and professional staff where it seems beneficial to installation operations. Then, because of the dynamic nature of online communities, the Army installation community should frequently monitor how online communities are evolving and their own participation in them, and revise their online community programs accordingly.

Sources for Tracking Online Community Trends

There are numerous sources for tracking trends related to online communities. We identified a few key publications for recent information and analysis of online communities, though this is an active area of research and new studies are continually emerging. Boyd (2007) examines how American youth use social networking sites and how features of those sites affects how they interact with one another.[516] In his thesis, Budiman (2008) extensively examines why and how people use online communities, how online communities differ from traditional communities,

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[516] Danah Boyd, "Why Youth (Heart) Social Network Sites: The Role of Networked Publics in Teenage Social Life," in David Buckingham (ed.), *Youth, Identity, and Digital Media*, Cambridge, MA: MIT Press, 2008, pp. 119–142.

and how they shape users' views.[517] Ofcom (2008) has also examined how people use social networking sites and their attitudes towards these sites.[518] The Pew Research Center's report on Millennials reports extensively on their use of social networking sites.[519] Another report by the Pew Internet and the American Life Project reports on adults' use of social networking and online communities.[520] Czincz et al. (2009) survey the research on problematic internet use and Internet addiction and report on a range of findings include definitions, research areas, risk factors.[521]

A number of journals address online communities. *The Journal of Computer Mediated Communication* publishes social science articles on communication via the Internet, including within online communities.[522] *New Media and Society* focuses on the implications of new media development.523 The proceedings of the annual Conference on Online Communities and Social Computing specifically addresses online communities and social networks.

Several institutions have initiatives or programs to analyze the role of and trends in online communities. The Berkman Center for Internet and Society[524] at Harvard University Law School is a research center that seeks to explore and understand cyberspace, including social dimensions of the Internet. The Berkman Center also hold gatherings and provides online lectures and discussions. The Pew Research Center's "Internet and American Life" project[525] produces reports that examine the impact of the Internet on all aspects of life, from families to education to health care. The Pew Research Center's related initiative on "Millennials" examines the lives of the generation that has grown up with the Internet, and extensively

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[517] Adrian M. Budiman, *Virtual Online Communities: A Study of Internet Based Community Interactions*, dissertation, Athens, OH: Scripps College of Communications of Ohio University, 2008.

[518] Ofcom, *Social Networking: A Quantitative and Qualitative Research Report into Attitudes, Behaviours and Use*, April 2, 2008.

[519] Pew Research Center, *Millennials: A Portrait of Generation Next: Confident, Connected, Open to Change*, Washington, D.C.: February 24, 2010.

[520] Lenhart, 2009a.

[521] Jennifer Czincz and Regina Hechanova, "Internet Addiction: Debating the Diagnosis," *Journal of Technology in Human Services*, Vol. 27, No. 4, October 2009, pp. 257–272..

[522] The *Journal of Computer-Mediated Communication* can be found at http://jcmc.indiana.edu/.

[523] New Media and Society can be found at http://nms.sagepub.com/.

[524] The Berkman Center for Internet and Society's website can be found at http://cyber.law.harvard.edu/.

[525] The Internet and the American Life Project can be found at http://www.pewinternet.org/.

addresses media and youth. Similarly, the MacArthur Foundation's Digital Media and Learning initiative supports projects and research on how digital technologies affect youth.

Pervasive Computing Trends

In this section we discuss the activities and trends related to pervasive computing and what implications they have for Army installations.

Background: Defining Pervasive Computing

The term "pervasive computing" refers to settings in which computing and communication capabilities are extensive, and also gracefully integrated.[526] Pervasive computing is also known as "ubiquitous computing." Most homes and offices already have very basic examples of computing technology integrated into operational systems, such as thermostats, fire alarms, and security systems. Similarly, vehicles are increasingly drive-by-wire, relying on computers and electronics to control the vehicle's steering, acceleration, and braking, instead of the traditional mechanical systems. Similarly, the interface to the vehicle's performance information, such as speedometers, odometers, and engine health, is computer based. The vision of pervasive computing is that processing devices such as these will be present in *all* aspects of everyday life, and these devices will be integrated and networked together seamlessly and will also be unobtrusive to the user.

Early literature on pervasive computing provides some scenarios that illustrate this idea:

> Fred is in his office, frantically preparing for a meeting at which he will give a presentation and software demonstration. The meeting room is a 10-minute walk across campus. It is time to leave, but Fred is not quite ready. He grabs his PalmXXII wireless handheld computer and walks out of the door. Aura [the pervasive computing system] transfers the state of his work from his desktop to his handheld, and allows him to make his final edits using voice commands during his walk. Aura infers where Fred is going from his calendar and the campus location tracking service. It downloads the presentation and the demonstration software to the projection computer, and warms up the projector. Fred finishes his edits just before he enters the meeting room. As he walks in, Aura transfers his final changes to the projection computer. As the presentation proceeds, Fred is about to display a slide with highly sensitive budget information. Aura senses that this might be a mistake: the room's face detection and recognition capability indicates that there are some unfamiliar faces present. It therefore warns Fred. Realizing that Aura is right, Fred skips the slide. He moves on to other topics and

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[526] Federal Office for Information Security, *Pervasive Computing: Trends and Impacts*, 2006.

> ends on a high note, leaving the audience impressed by his polished presentation.[527]

This example may seem a bit dated because of the reference to a PalmXXII wireless handheld computer. However, more recent developments in smart phones, handheld tablets, and easy-to-use mobile apps make such a scenario even more likely. In the updated scenario, the office, the handheld device (which would likely be a smart phone or tablet now), and the meeting room are networked together. The pervasive computing environment manager, Aura, acts as a single interface for Fred so that the different devices and environments are gracefully integrated from Fred's point of view. Additionally, Fred interacts with Aura using voice commands, which is a more human-oriented approach than traditional methods of entering commands on a keyboard or through a menu.

This scenario also demonstrates another aspect of pervasive computing—that environments can be intelligent and anticipate or respond to user needs as Aura does. When pervasive or ubiquitous computing environments include intelligent systems that are sensitive and responsive to the presence and needs of people, it is often referred to as "ambient intelligence."[528] Here, Aura anticipates where Fred is going by examining his calendar and then responds by preparing the room and presentation. Later, Aura has awareness of the sensitivity of Fred's presentation, observes the presentation room, and alerts Fred of the security risk. A pervasive computing setting with less ambient intelligence might require Fred to explicitly command Aura to prepare the room and presentation and to check for security risks.

Key Pervasive Computing Trends

Pervasive computing is still a young field, and many of the anticipated outcomes, such as the above scenario, are still areas of active research. Nevertheless, many commercial applications are already emerging, and apps on handheld devices will help facilitate them in the future. For example, consumers can purchase systems that can send an email or a text message or notify a mobile home security app when a door or window opens at home and that automatically turn off all the lights in the home when the security system is activated. These systems can be customized to react under different circumstances, for example to send alerts between certain

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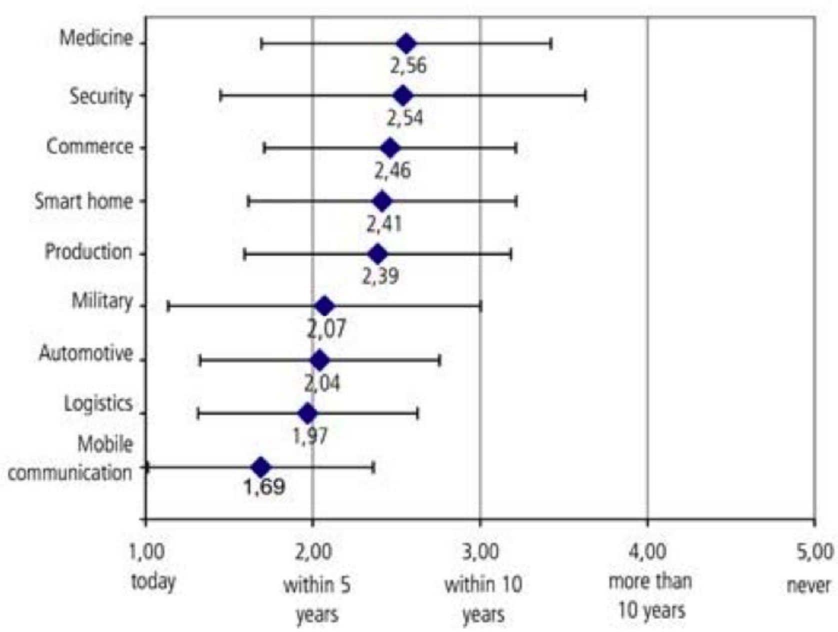
[527] M. Satyanarayanan, "Pervasive Computing: Vision and Challenges," *Personal Communications IEEE*, Vol. 8, No. 4, 2001, p. 12.

[528] Diane J. Cook, Juan C. Augusto, and Vikramaditya R. Jakkula, "Ambient Intelligence: Technologies, Applications, and Opportunities," *Pervasive Mobile Computing*, Vol. 5, No. 4, 2009, p. 279.

hours or when the system is armed. Importantly, many such technologies still use traditional user interfaces with menus and program commands, rather than more natural interfaces.[529]

The trend is toward more, more diverse, and more capable pervasive computing settings. A survey of experts in 2006 by the German Federal Office for Information Security, for example, found that pervasive computing may affect many application areas within the next 10 years, including medicine, security, commerce, smart homes, manufacturing and production, military, automotive industry, logistics, and mobile communications.[530] The results of this survey are presented in Figure 5.3. The article "Ambient Intelligence: Technologies, Applications, and Opportunities" examines the resulting applications that ambient intelligence in particular enables, such as smart homes, health monitoring and assistance, hospitals, transportation, emergency services, education, and workplaces.[531] We discuss a few of these areas next.

Figure 5.3
Expected Breakthrough of Pervasive Computing in Selected Application Areas (diamond = average, line = standard deviation)



SOURCE: Federal Office for Information Security, 2006, p. 20.

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[529] These solutions are sold by online retail stores such as SmartHome. As of August 31, 2010: http://www.smarthome.com/

[530] Federal Office for Information Security, *Pervasive Computing: Trends and Impacts*, 2006, p. 20.

[531] Cook, Augusto, and Jakkula, 2009, pp. 277–298.

Pervasive Computing in Automotives and Transportation

New, high-end vehicles include a number of safety- and efficiency-oriented pervasive computing technologies. Collision detection and warning systems use sensors to monitor the area around the vehicle and warn the driver when the vehicle is too close to other vehicles or objects. Lane-keeping technologies monitor lane markings and assist the driver in staying within the lane, either by alerting the driver when the vehicle is veering from the lane or, on highways, by taking control of the steering. Adaptive cruise control senses the distance to the preceding vehicle and changes the cruise control speed to dynamically keep pace with highway traffic. This prevents many of the rear-end collisions that can occur when using cruise control in congested or abruptly changing traffic, and results in smoother travel. Driver monitoring systems observe eye movements and behavior and warn the driver when he or she appears distracted or inattentive. Finally, route navigation systems primarily use GPS to provide directions to a destination, but may also use real-time traffic information to find more efficient routes.[532] As vehicles increasingly take over driving tasks, drivers may eventually be able to continue their other activities seamlessly from home to vehicle to office.

In addition to in-vehicle environments, pervasive computing is improving transportation infrastructure operation and maintenance. Research is under way to develop networked sensors that are embedded into roads and bridges to detect strain and hazardous conditions, and to provide damage assessments after a natural disaster when infrastructure may not be accessible to humans.[533] Such instrumentation could increase safety and efficiency if they alert operators to hazardous conditions sooner or better than manual inspections do, and may, in turn, enable agencies to use resources more efficiently for infrastructure maintenance.

Other types of pervasive computing technologies may be on the horizon for the transportation system. Vehicle-to-vehicle and vehicle-to-infrastructure technologies seek to enable communication and cooperation between vehicles and between vehicles and the transportation infrastructure. For example, the surrounding traffic infrastructure may monitor congestion and hazardous conditions and transmit that information directly to vehicles to improve routing, avoid accidents, and keep occupants informed. Vehicles and parking garages

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[532] The U.S. Department of Transportation's Research and Innovative Technology Administration (RITA) has a comprehensive website on advanced driver assistance systems. It can be accessed at http://www.itsoverview.its.dot.gov/DAS.asp.

[533] David Mascareñas, Eric Flynn, Michael Todd, Gyuhae Park, and Charles Farrar, "Wireless Sensor Technologies for Monitoring Civil Structures," *Sound and Vibration*, Vol. 42, No. 4, 2008, pp. 16–20.

may communicate so that parking availability information is sent directly from the garage to the vehicle, eliminating the hunt for open spaces.[534]

Pervasive computing is not limited to vehicular travel. A researcher describes another scenario with the Aura system that explores how pervasive computing might increase productivity during travel:

> Jane is at Gate 23 in the Pittsburgh airport, waiting for her connecting flight. She has edited many large documents, and would like to use her wireless connection to e-mail them. Unfortunately, bandwidth is miserable because many passengers at Gates 22 and 23 are surfing the Web. Aura observes that at the current bandwidth Jane won't be able to finish sending her documents before her flight departs. Consulting the airport's network weather service and flight schedule service, Aura discovers that wireless bandwidth is excellent at Gate 15, and that there are no departing or arriving flights at nearby gates for half an hour. A dialog box pops up on Jane's screen suggesting that she go to Gate 15, which is only three minutes away. It also asks her to prioritize her e-mail, so that the most critical messages are transmitted first. Jane accepts Aura's advice and walks to Gate 15. She watches CNN on the TV there until Aura informs her that it is close to being done with her messages, and that she can start walking back. The last message is transmitted during her walk, and she is back at Gate 23 in time for her boarding call.[535]

Pervasive Computing in Health Care

Pervasive computing is also being applied extensively in a variety of health care contexts.[536] A radio frequency identification (RFID) system is under development to enable hospitals to better manage resources in mass casualty situations. This system tracks patients, equipment, and staff, and integrates their position information with personnel, medical, and other databases.[537] In homes, behavioral systems are being developed to monitor the ability of frail or

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[534] Pervasive computing in vehicles is discussed in a number of publications, including Uwe Hansmann, Lothar Merk, Martin S. Nicklous, and Thomas Stober, *Pervasive Computing : The Mobile World*, Springer, August 2003; K. Ducatel, M. Bogdanowicz, F. Scapolo, J. Leijten, and J.C. Burgelman, *ISTAG, Scenarios for Ambient Intelligence in 2010*, Seville, Spain: IPTS, 2001; Federal Office for Information Security, 2006; and Research and Innovative Technology Administration. "Achieving the Vision: From VII to IntelliDrive," U.S. Department of Transportation Policy White Paper, 2010.

[535] Satyanarayanan, 2001, p. 12.

[536] Carsten Orwat, Andreas Graefe, and Timm Faulwasser, "Towards Pervasive Computing in Health Care: A Literature Review," *BMC Medical Informatics and Decision Making*, Vol. 8, No. 26, 2008.

[537] Emory A. Fry and Leslie A. Lenert, "MASCAL: RFID Tracking of Patients, Staff and Equipment to Enhance Hospital Response to Mass Casualty Events," *AMIA Annu Symp Proc*eedings, 2005, pp. 261–265.

elderly individuals to look after themselves and accomplish household tasks and to alert health care providers when help may be needed.[538] The NOCTURNAL assisted living system, for example, is an in-home system that seeks to provide specialized nighttime support for people in early stages of dementia.[539]

Pervasive computing is also being used *on* and even *in* patients. At MIT's Media Lab, researchers are developing a mobile system consisting of a wearable device and a phone application to deliver cognitive behavioral therapy (CBT) for patients with drug addiction and post-traumatic stress disorder (PTSD).[540] Researchers have also developed a wearable remote arrhythmia monitoring system that sends electrocardiogram (ECG) and location/GPS data to a remote station for recording and monitoring.[541]

Some pervasive computing technologies are also being implanted. For example, researchers in Germany are developing an implantable electromyography device that can report on lesions and possible muscle impairment.[542] As another example, a networked blood flow monitoring system makes it possible for health care providers to monitor trends during patients' daily lives outside the hospital.[543] PervasiveHealth 2011, the annual conference on ubiquitous computing

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[538] A. Gaddam, S.C. Mukhopadhyay, and G.S. Gupta, "Smart Home for Elderly Care Using Optimized Number of Wireless Sensors," *Lecture Notes in Electrical Engineering*, Vol. 64, 2010, pp. 307–328; and Anthony P. Glascock and David M. Kutzik, "The Impact of Behavioral Monitoring Technology on the Provision of Health Care in the Home," *Journal of Universal Computer Science*, Vol. 12, No. 1, 2006, pp. 59–79.

[539] W. Carswell et al., "The NOCTURNAL Ambient Assisted Living System," Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2011 5th International Conference on Pervasive Computing Technologies for Healthcare and Workshops, May 23–26 2011, pp. 208–209.

[540] R.R. Fletcher et al., "Mobile Application and Wearable Sensors for Use in Cognitive Behavioral Therapy for Drug Addiction and PTSD," *Pervasive Computing Technologies for Healthcare (PervasiveHealth)*, 2011 5th International Conference on Pervasive Computing Technologies for Healthcare and Workshops, May 23–26 2011, pp. 202–203.

[541] Kathy J. Liska, Michael A. Mackin, Michael J. Lichter, David W. York, Dilip Pillai, and David S. Rosenbaum, "Keeping a Beat on the Heart," *IEEE Pervasive Computing*, Vol. 3, No. 4, 2004, pp. 42–49.

[542] S. Weber and T.C. Lueth, "Concept and Realisation of an Implantable EMG and Motion Measuring Device," *Pervasive Computing Technologies for Healthcare*, pp. 165–168, January 30, 2008–February 1, 2008.

[543] Barbro Kjellström, David Ingel, JoAnn Abraham, Tom Bennett, and Robert Bourge, "Trans-telephonic Monitoring of Continuous Haemodyncamic Measurements in Heart Failure Patients," *Journal of Telemedicine and Telecare*, Vol. 11, No. 5, 2005, pp. 240–244.

in health care, offers many more examples of diverse technology applications of pervasive computing in health.

Pervasive Computing in Homes and Workplaces

As described earlier, homes and offices are key settings for pervasive computing. In the future, pervasive computing may enable truly smart homes and offices. In a recent white paper, IBM researchers suggested that the most likely near-term applications of smart homes are entertainment, energy management, safety and security, and health and wellness.[544] The report goes on to describe an example of smart entertainment in the home:

> A consumer electronics company creates an open platform for its new line of flat panel televisions that features a portal that personalizes entertainment content across numerous broadcasters. Over time, such devices might be subsidized by better targeted advertising with a potential to share profits with other TV manufacturers with similar capabilities. This can lead to a win–win–win situation: reducing the number of commercials viewers have to watch, enabling broadcasters and advertisers to deliver more personalized entertainment options and targeted advertisements, and giving TV manufacturers an opportunity to differentiate their products.[545]

They also describe the role that smart energy management may play as energy concerns grow:

> Future demands on the electrical grid will encourage minute by minute home appliance compliance to prioritize energy services while delivering automatic savings to owners. Automatically synchronizing lighting, home appliances, climate control sensors, and other home electronics minimizes energy use based on changing exterior conditions and usage patterns in the home. Smarter homes boost consumers' choice to save, while raising overall societal benefit.[546]

A building could also observe and learn the water usage patterns of its occupants and heat water when it is likely to be needed. Buildings may also have windows that close in the rain, or shades that, when exposed to sunlight, are automatically drawn down in the summer to keep the building cool or are automatically raised in the winter to warm the building. Such systems can offer significant benefits to building operations and maintenance. Such concerns and the technologies to address them are applicable to homes, offices, and a wide range of other environments, including military installations.

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[544] IBM, "IBM's Vision of a Smarter Home Enabled by Cloud Technology," *Insights from IBM Global Electronics Industry*, 2009, p. 1.

[545] IBM, 2009, p. 5

[546] IBM, 2009, p. 5.

Pervasive computing can also be used to enhance security and safety, for example with systems that monitor occupants in a home or workplace and monitor suspicious or unusual behavior that might signal an intruder or other breach of security. Such technologies may also provide assistance in hazardous situations such as fires. One can imagine a building in which the fire system, in addition to warning of smoke or fire, detects the location of a fire and illuminates the safest exit routes.

Occupant convenience is a key application of pervasive computing. The following scenario describes how household chores may be made easier through such technologies:

> Opening your refrigerator to take out a soda, you notice that there is only one can left. You scan its UPC with the scanner attached to your refrigerator. This action adds soda to your shopping list. You plan to have guests over this weekend, and make a note on your ScreenFridge that you need to replenish your supply of drinks by Friday. The next day, on your drive home from work, you happen to approach a local supermarket. Your GPS-enabled AutoPC, previously informed by your refrigerator that purchases need to be made, signals that you are near a grocery store, and if it is convenient, that you should stop by the supermarket on the way home. Suppose you do not act on the opportunity, and Friday rolls around and you still have not visited the supermarket; in this case, a message to buy drinks is sent to your pager, or an alarm is triggered in your PDA, or both.[547]

This example also illustrates how multiple pervasive computing settings—the home and the vehicle—may be linked together.

Technologies That Enable Pervasive Computing

Advancements in pervasive computing are largely a consequence of trends in a wide range of other technology areas, including sensors and processing, communication networks, and interfaces. Figure 5.4 shows the results of a survey of experts on how different areas are relevant for pervasive computing. We discuss a few of these areas here.

First, the increasing miniaturization of sensors and processors makes it possible to embed devices in almost any location—in appliances, walls, clothing, and in and on humans. Processors and sensors are also becoming more powerful and much cheaper.[548]

Second, pervasive computing also depends upon advancements in communication, and a variety of standards and technologies have emerged that allow communication power and

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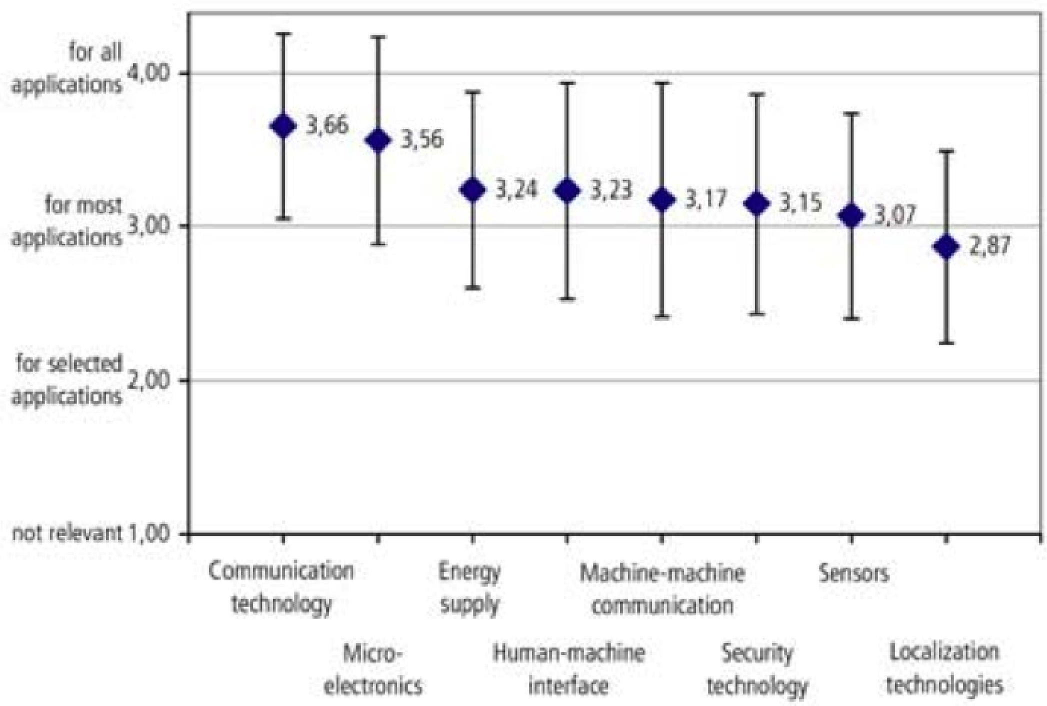
[547] Andrew C. Huang, Benjamin C. Ling, Shankar Ponnekanti, and Armondo Fox, "Pervasive Computing: What Is It Good For?" *Proceedings of the ACM International Workshop on Data Engineering for Wireless and Mobile Access*, 1999, p. 85.

[548] Gordon E. Moore, "Cramming More Components onto Integrated Circuits," *Electronics*, Vol. 38, No. 8, 1965, pp. 82–85.

Figure 5.4
Relative Importance of the Eight Technology Fields for Pervasive Computing



SOURCE: Federal Office for Information Security, 2006, p. 31.

range to be tailored to pervasive computing applications. The ZigBee protocol, for instance, was developed specifically for low-power, low-data-rate applications such as in-home pervasive computing environments.[549] Such advances mean that data can be transmitted efficiently with smaller devices and for less cost and power than ever before.

A third underlying trend is the ongoing advancement in human-machine and machine-machine interfaces. Researchers are developing ways for computing environments to detect, classify, and respond to human activities and intentions, rather than having to be instructed explicitly.[550] Moreover, humans are able to interact with technology in intuitive ways, with touch or voice, and via interfaces that have a more natural, user-oriented design.[551] The

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[549] John Adams and Bob Heile, "Busy as a ZigBee," *IEEE Spectrum*, 2006.

[550] D.H. Wilson and C. Atkeson, "Simultaneous Tracking & Activity Recognition (STAR) Using Many Anonymous, Binary Sensors," *Lecture Notes in Computer Science*, Vol. 3468, 2005, pp. 62–79.

[551] Michael Lew, Erwin M. Bakker, Nicu Sebe, and Thomas S. Huang, "Human-Computer Intelligent Interaction: A Survey," *Lecture Notes in Computer Science*, Vol. 4796, 2007, pp. 1–5.

development of touchscreen smart phones and tablets with easy-to-use mobile apps are a key part of this trend.

Security and Privacy Risks Associated with Pervasive Computing

Although pervasive computing is likely to continue to advance because of advancements in these underlying technologies, the social aspects of pervasive computing are becoming an important concern, specifically, issues of privacy and security. How can one's privacy be maintained and how can one's information be secured if all information is accessible from anywhere? Additionally, how might and how should information gathered in pervasive computing environments be used by, for example, employers, the government, and corporations or advertisers? These issues are explored in a number of reports,[552] one of which offers the following illustrative scenario:

> Mala felt as if she was being observed, which she was, but she knew about that as she had subscribed to a medical monitoring service with her local medical practitioner. As part of this new service, she had been put on a course of agentX "programmable" pills funded by her health care policy a few weeks ago. AgentX pills were the ultimate in silicon designer pills; they were in fact nanoscale agents that were injected into the body to repair problems (in her case to seek and destroy fatty deposits clogging her arteries). The much advertised advantage was that the agents provided feedback on what they found, and could either reprogram themselves, or be reprogrammed by specialists remotely. Avoiding an operation was something Mala liked. What she didn't know was that the agents also recorded other, wider, biological data from within her body primarily aimed at providing better analysis to improve the treatment she was receiving, together with helping the scientists improve their technique. This was all perfectly legal as the small print of the agreement, which Mala hadn't read, detailed such possibilities. Unfortunately for Mala this wasn't the end of it as during the period she was on the course of agentX pill, the agents recorded she ignored the strict regime the doctors had spelt out for her and she was thus required to pay for the treatment herself because of her flagrant abuse of the contract.[553]

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[552] Reports that explore risks associated with pervasive computing include: Michael Friedewald, Elena Vildjiounaite, Yves Punie, and David Wright, "Privacy, Identity and Security in Ambient Intelligence: A Scenario Analysis," *Telematics and Informatics*, Vol. 24, No. 1, 2006, pp. 15–29; Vic Callaghan, Graham Clarke, and Jeannette Chin, "Some Socio-Technical Aspects of Intelligent Buildings and Pervasive Computing Research," *Intelligent Buildings International Journal*, Vol. 1, No. 1, 2008, pp. 56–74; and Roy Campbell, Jalal Al-Muhtadi, Prasad Naldurg, Geetanjali Sampemanel, and M. Dennis Mickunas, "Towards Security and Privacy for Pervasive Computing," *Lecture Notes in Computer Science*, Vol. 2609, 2003, pp. 77–82.

[553] Callaghan, Clarke, and Chin, 2008, p. 61.

If these concerns become mainstream and are not addressed with policy measures, it may slow the adoption of such technologies.

Interaction with Other Trends

Pervasive computing is likely to be affected primarily by trends in technology areas on which it depends, such as advancements in sensors, communication, and microprocessing. As these areas advance, the sophistication and availability of pervasive computing settings will advance.

Pervasive computing may also have a range of implications for other, nontechnological trends, such as sustainable buildings, energy, and transportation. As we have described, advancements in pervasive computing in homes and buildings may make it cheaper or easier to monitor energy use and increase efficiency. Therefore, pervasive computing may have implications for achieving goals associated with sustainable buildings and energy. Pervasive computing in the transportation system—for example, with vehicle-to-vehicle and vehicle-to-infrastructure technologies—may enable better navigation, routing, and incident management. This could reduce congestion and reduce distances traveled in personal vehicles, thereby contributing to the achievement of sustainable transportation goals.

Pervasive computing may also make online communities, such as Facebook, easier to access. Already it is possible to access Facebook and other social networking sites and to play games like World of Warcraft on one's television. Such accessibility may increase the importance of online communities in daily lives.

Implications of Pervasive Computing for Army Installations

Pervasive computing applications are most likely to be implemented in Army energy systems, buildings, and other infrastructure first. Such infrastructure would include barracks and other residential buildings, office buildings, vehicles, and transportation infrastructure. However, the supporting infrastructure would need to be built to enable networking. Energy applications are likely to emerge faster than some other areas, such as transportation, because of current private-sector systems in this area, and the cost and energy consumption savings from implementation.

In fact, Army installations are already starting to use some of these pervasive computing types of applications in energy management. Some Army installations are using sensors and sophisticated energy management control systems (EMCS) to manage energy and save on its consumption and cost. For example, at Fort Knox, lights are controlled by motion sensors in office buildings and barracks, and the EMCS is used to closely monitor and manage energy use in over 250 buildings. Similarly, at Fort Campbell over 300 buildings are on this post's EMCS, which is also used to closely monitor and control room temperatures. In fact, each barracks room has individual occupancy sensors, and when no one is present, the EMCS drops the temperature to 60 degrees in the winter and raises it to 80 degrees in the summer. The system restores a more comfortable temperature when the occupant returns. The system allows for plus or minus 5 degrees adjustment by the individual occupant.[554] In 2007, with only 227 buildings on the EMCS, the annual energy savings was estimated to be $1,275,085.[555]

Since such applications have demonstrated energy and cost savings, they are likely to continue. Other pervasive computing technology investments are likely to be slower, because the upfront and ongoing costs can be high and the benefits may not be as significant or as money-saving, or they may be harder to quantify. For example, operations and maintenance of sensor networks may be expensive, even while they aid in infrastructure O&M. Different return on investment (ROI) estimation strategies may be needed to measure benefits and justify investments. In such areas, Army installations are likely to adopt these technologies as private industry and commercial sectors adopt them. Namely, as they become more cost-effective and common practices in buildings, transportation infrastructure, and other systems, then they will naturally be adopted at Army installations.

Recommendations for Army Installations Regarding Pervasive Computing

Given all these implications, ACSIM and the installation management community should continue to monitor pervasive computing technology trends, but not address them in current installation planning. As just discussed, installations will naturally adopt these technologies in installation infrastructure systems as the broader U.S. society does.

Sources for Tracking Pervasive Computing Trends

A number of studies track the technological forces behind pervasive computing, its applications, and its social implications. The article "Ambient Intelligence: Technologies, Applications, and Opportunities" described earlier surveys both technologies and applications of ambient intelligence.[556] Similarly, the German Federal Office for Information Security conducted and reported on a study that examines trends in and impacts of pervasive computing from technical, economic, and social perspectives. This report includes a mapping

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[554] Lachman et al., *Making the Connection: Beneficial Collaboration Between Army Installations and Energy Utility Companies.*

[555] Dewayne Smith, "Lessons Learned: Utility Energy Services Contracts," briefing, IMCOM/Southeast Region Energy Managers Forum, Atlanta, GA, February 13, 2008.

[556] Cook, Augusto, and Jakkula, 2009, pp. 277–298.

of additional key trends, developments, and dependencies in pervasive computing and presents the results of an international online survey and interviews with experts in various fields to determine the importance of pervasive computing in different areas, the speed of development, and other trends.[557]

The European Commission's joint research center published a series of scenarios for ambient intelligence that were used to discuss the kinds of technological advancements on which ambient intelligence might rely, and in turn the kinds of research and development that are necessary today. While this report was published nearly a decade ago, ambient intelligence is still an area of active research, and the scenarios described remain valid visions of the future.[558]

Other reports also provide a rich collection of pervasive computing scenarios from which we have drawn. Huang et al. describes the scenario in which home appliances and vehicles are networked together to enable easier shopping.[559] Satyanarayanan describes the scenarios involving the pervasive computing system coined Aura.[560] Callaghan et al. provide a number of scenarios examining privacy concerns of pervasive computing, including the example noted earlier of Mala, who is using personalized, networked medication.[561] Friedewald et al. analyze the privacy, security, and identity implications of pervasive computing in a wide range of scenarios developed by others that span home, work, health, shopping, mobility, and other domains.[562]

Several journals are dedicated to pervasive computing research, including the *Journal of Pervasive and Mobile Computing*,[563] *IEEE Pervasive Computing Magazine*,[564] *Personal and Ubiquitous Computing*,[565] and *Ubiquitous Computing and Communications Journal*.[566] These journals each cover a

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[557] Federal Office for Information Security, 2006.

[558] Ducatel et al., 2001.

[559] Huang et al., 1999.

[560] Satyanarayanan, 2001, p. 12.

[561] Callaghan, Clarke, and Chin, 2008, pp. 56–74.

[562] Friedewald et al., 2006, pp. 15–29.

[563] For more information about the *Journal of Pervasive and Mobile Computing*, see http://www.journals.elsevier.com/pervasive-and-mobile-computing/.

[564] For more information about *IEEE Pervasive Computing Magazine*, see http://www.computer.org/portal/web/computingnow/pervasivecomputing

[565] For more information about *Personal and Ubiquitous Computing*, see http://www.springerlink.com/content/106503/.

[566] For more information about *Ubiquitous Computing and Communications Journal*, see http://www.ubicc.org/.

wide range of pervasive computing issues, from technologies to privacy and security to applications to broader social impacts.

A number of institutions, particularly computer science and engineering universities, conduct research in pervasive computing and are useful for tracking trends. MIT's Media Lab includes several pervasive computing research groups, including the "Fluid Interfaces" group, which researches more natural interfaces, the "Information Ecology" group, which examines how to connect information sources to physical environments, and the "Smart Cities" group, which explores how pervasive computing can be used to make cities responsive to inhabitants.[567] Other universities involved in pervasive computing include Carnegie Mellon,[568] Georgia Tech,[569] and the University of Washington.[570]

Research arms of corporations also conduct extensive research on pervasive computing. Intel Labs also conducts research in a wide range of pervasive computing areas, including developing systems that can infer a user's context and activities through observation and systems that can monitor and assist the elderly.[571] The Palo Alto Research Center (PARC) also conducts research in this area, and many of the underlying goals and principles of pervasive computing were developed by Mark Weiser of PARC.[572]

Robotics

In this section we discuss activities and trends related to robotics and what implications they have for Army installations.

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[567] A list of the MIT Media Lab's research groups can be found at http://www.media.mit.edu/research/groups-projects.

[568] A list of projects at Carnegie Mellon's Human Computer Interaction Institute related to pervasive computing can be found at http://www.hcii.cmu.edu/research/projects.

[569] A list of projects at Georgia Tech's Ubiquitous Computing Group can be found at http://home.cc.gatech.edu/ubicomp.

[570] A list of projects at the University of Washington's Human-Computer Interaction and Design group can be found at http://dub.washington.edu/projects.

[571] Intel Labs project descriptions can be found on their site-specific web pages. These research areas are addressed in the Seattle lab. See http://www.intel.com/content/www/us/en/research/intel-research.html

[572] PARC's research areas can be found on its website, http://www.parc.com/work/focus-areas.html.

Background: Defining Robotics

Although there is no consensus on the definition of "robot," the term can be used to refer to any physical system that has some type of sensing and artificial intelligence capability that enables it to interact with the world around it. Today, robots have a presence in virtually every field, from industry to education to health care to art. We consider a few key examples to illustrate the range of applications.

In the military context in particular, robots are well suited to tasks that are dull, dirty, or dangerous—the "Three Ds." Global Hawk and BigDog are two diverse examples of robots in the military that perform such tasks. Global Hawk is a high-altitude, long-range unmanned aerial vehicle used by the Air Force primarily for intelligence, surveillance, and reconnaissance. Global Hawk uses GPS and other sensors to fly autonomously, and it can also be remotely piloted by a human operator.[573] BigDog is a four-legged rough-terrain robot currently being developed by Boston Dynamics. BigDog (shown in Figure 5.5) is designed to carry heavy loads and provide logistical aid to Soldiers.[574]

Robotic systems have been used for decades in industry and have become increasingly sophisticated, moving from highly structured tasks such as placing parts on an assembly line to unstructured activities like moving goods through a warehouse.[575]

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[573] U.S. Air Force, *RQ-4 Global Hawk*, factsheet.

[574] Marc Raibert, Kevin Blankespoor, Gabriel Nelson, Rob Playter, and the BigDog Team, "BigDog, the Rough-Terrain Quadruped Robot," Seoul, South Korea: *Proceedings of the 17th World Congress, The International Federation of Automatic Control*, 2008.

[575] Bob Trebilcock, "The Robots Are Coming: Robotic Materials Handling Technology Is Changing the Way We Move Products in the Plant and the Distribution Center," *Modern Materials Handling*, August 19, 2010.

Figure 5.5
Boston Dynamics BigDog Robot Carries Loads for Soldiers

Robots have become increasingly important in medicine. A number of high-precision robotic systems assist doctors in performing such medical procedures as knee replacement surgery,[576] neurosurgery,[577] and radiosurgery,[578] as well as performing routine hospital functions such as delivering medication.[579] For example, the MAKO Tactile Guidance System (shown in Figure 5.6) is a robotic arm and visualization system that offers surgeons the precision needed to perform minimally invasive knee replacement surgery.

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[576] Andrew D. Pearle, Daniel Kendoff, Volker Stueber, Volker Musahl, and John A. Repicci, "Perioperative Management of Unicompartmental Knee Arthroplasty Using the MAKO Robotic Arm System (MAKOplasty)," *American Journal of Orthopedics*, Vol. 38, No. 25, 2009, pp. 16–19.

[577] Shawna Pandya, Jason W. Motkoski, Cesar Serrano-Almeida, Alexander D. Greer, Isabelle Latour, and Garnette R. Sutherland, "Advancing Neurosurgery with Image-Guided Robotics," *Journal of Neurosurgery*, Vol. 111, No. 6, 2009, pp. 1141–1149.

[578] È. Coste-Manière, D. Olender, W. Kilby, and R.A. Schultz, "Robotic Whole Body Stereotactic Radiosurgery: Clinical Advantages of the CyberKnife® Integrated System," *International Journal of Medical Robotics Computer Assisted Surgery*, Vol. 1, No. 2, 2005, pp. 28–39.

[579] University of Maryland Medical Center, "Robot Delivers Medication at University of Maryland Shock Trauma Center: Advanced Technology Allows Robot to Steer Around Obstacles and Call for Elevators," Baltimore, MD, May 10, 2004.

Figure 5.6
The MAKO Tactile Guidance System Assists Surgeons in Minimally Invasive Knee Replacement Surgery

Key Robotics Trends

Much evidence suggests that the field of robotics is growing and will continue to do so, and that robots are having an impact in an ever-growing number of fields. One market research firm predicts, for example, that the market for personal robotics—e.g., those in indoor populated environments such as homes and offices—will grow from $1.16 billion in 2009 to over $5 billion in 2015.[580] A report on the medical robotics market finds that the U.S. market was worth an approximately $650 million in 2008 and was projected to grow to $1.5 billion by 2014.[581] An annual study by the International Federation of Robotics suggests, as shown in Figure 5.7, that the worldwide operational stock of industrial robots is expected to grow as well.[582] The growth in robotic systems does differ by sector, as Figure 5.8 suggests.

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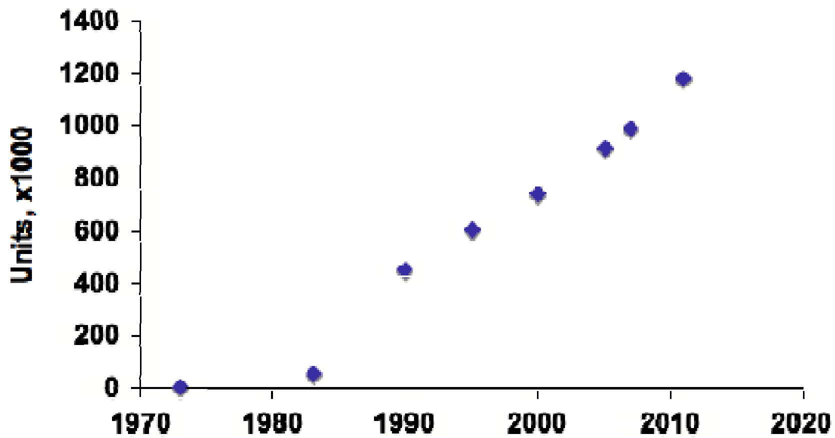
[580] ABI Research, "Personal Robotics 2009: Task, Security and Surveillance/Telepresence, Entertainment and Education Robots, and Robotic Components Markets Through 2015," 2009.

[581] BCC Research, "Medical Robotics and Computer-Assisted Surgery," June 1, 2009.

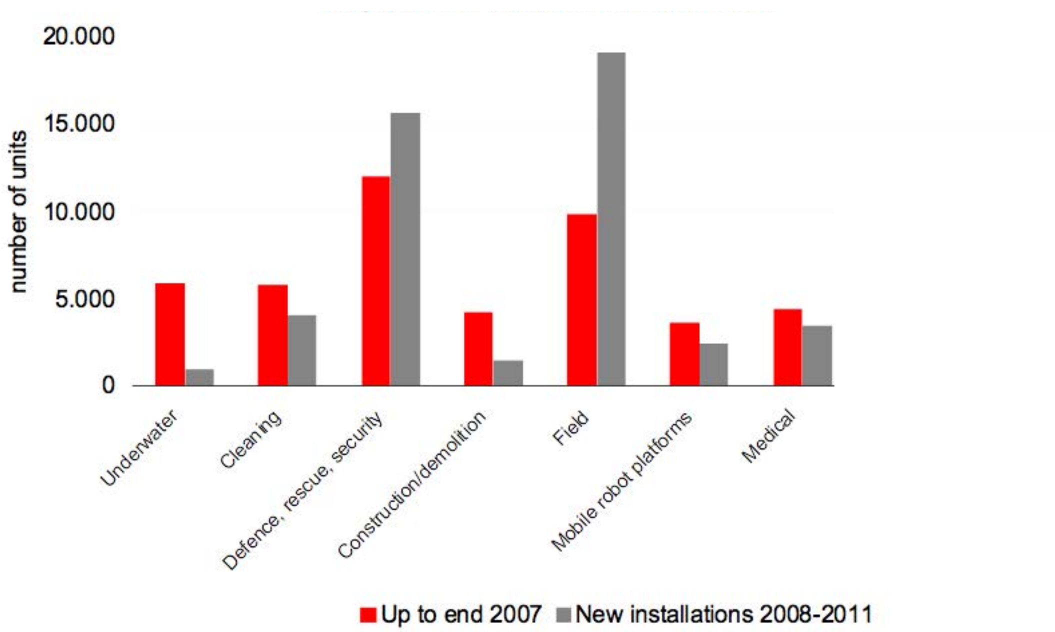
[582] International Federation of Robotics, "2007 World Robot Market: Executive Summary," *World Robotics 2008,* 2008.

Figure 5.7
Estimated Worldwide Operational Stock of Industrial Robots



SOURCE: International Federation of Robotics, *World Robotics 2008*, June 2008, p. 2.

Figure 5.8
Service Robots for Professional and Personal Use:
Stock at the End of 2007 and Projections for 2008–2011



SOURCE: International Federation of Robotics, *World Robotics 2008*, June 2008, p. xiv.

There is also anecdotal evidence that the number of robotic courses and degrees offered in postsecondary education is growing rapidly.

Importantly, near-term growth has been affected in the near term by the economic downturn. A more recent report from the International Federation of Robotics finds that although the market for industrial and service robots is also expected to grow in the future, the recent global economic downturn has seen a notable and expected decline in that market.[583]

Although current data suggests modest growth in robotics, the industry today has frequently been compared to the personal computing field in the 1970s—modestly growing now, but with the potential to affect every facet of life. Bill Gates wrote in 2006:

> Imagine being present at the birth of a new industry. It is an industry based on groundbreaking new technologies, wherein a handful of well-established corporations sell highly specialized devices for business use and a fast-growing number of start-up companies produce innovative toys, gadgets for hobbyists and other interesting niche products. But it is also a highly fragmented industry with few common standards or platforms. Projects are complex, progress is slow, and practical applications are relatively rare . . . No one can say with any certainty when—or even if—this industry will achieve critical mass. If it does, though, it may well change the world.[584]

This analogy to the early days of the personal computer, if true, suggests that the impact of robotics in the coming decades may be massive and affect all aspects of our lives the way that computing has, from personal life and leisure, to travel, to business and commerce, to education. Just as youth today wonder how the world worked before the Internet, future generations may wonder how the world worked before robots.

Technology Trends and Needs In Robotics

Like pervasive computing, the growth of the robotics industry rests on advancements in sensors, artificial intelligence, processing, and other technologies, which will make it possible to have cheaper, smarter, and more capable systems. Currently, even moderately sophisticated robots, e.g., in the military or in medicine, are still very expensive.[585] For example, robots need sensors to interpret the world around them. While there is a wide range of sensors, including GPS, cameras, sonar, laser, radar, and inertial navigation systems, much of the challenge in

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[583] International Federation of Robotics, *Executive Summary of 1. World Robotics 2009 Industrial Robots and 2. World Robotics 2009 Service Robots*, 2009, p. ix.

[584] Bill Gates, "A Robot in Every Home," *Scientific American*, January 2007.

[585] Richard Silberglitt, Philip S. Anton, David R. Howell, Anny Wong, Natalie Gassman, Brian A. Jackson, Eric Landree, Shari Lawrence Pfleeger, Elaine M. Newton, and Felicia Wu, *The Global Technology Revolution 2020, In-Depth Analyses: Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications*, Santa Monica, CA: RAND Corporation, TR-303-NIC, 2006.

robotic sensing involves enabling robots to usefully interpret the massive amounts of raw data that sensors can provide. Thus, advancements in robotic sensing depend on advancements in artificial intelligence and processing. The same advancements are necessary for truly sophisticated systems that are capable, for example, of performing a wide range of tasks and learning new tasks rather than being highly specialized but limited to a single task.

Another key need in the field of robotics is the development of standards for system platform and infrastructure.[586] Standards are needed to ensure that different kinds of robots (with different functions and produced by different manufacturers) can work together and work in the same setting. This is analogous, for instance, to Internet standards that enable different computers and browsers to interpret and present the same websites and information.

Robotic systems may have significant implications for the settings in which they are intended, particularly with infrastructure, operations, maintenance, training, and safety. That is, settings in which robotic technologies will be used—such as homes and offices—are likely to require infrastructure that facilitates robotic activity. For example, buildings may require elevators that can be called by robots via a wireless network, navigation systems such as markers on the ceiling that allow for navigation, and power stations for systems to charge. In the future, such infrastructure may become commonplace, or it may be unnecessary if robots achieve a sophistication that enables them to use the environment the way humans do, e.g., to push elevator buttons and to navigate buildings with signs and markers that people use.

Robots also have ongoing energy, operation, and maintenance costs, as well as the initial acquisition costs. Like other areas, assessments of costs, benefits, and effects of robotics must include life-cycle analysis of those costs and benefits. Such effects include, for example, the training that is necessary for users of robotics systems to interact with robots.

Implications of Robotics for Army Installations

Obviously, as mentioned above, the Army is using robots in tactical operations. However, so far there have not been applications at installations. Promising applications for the future at installations include office robots that would transport documents, sort mail, fetch coffee, and perform other simple tasks, and O&M robots that would clean and maintain facilities. However, such robots would likely be adopted by industry and the commercial sector before Army installations because of their high operational costs.

In fact, system operational costs will likely limit widespread application of such robots for quite awhile and thereby limit implementation at Army installations. As just explained, such

[586] Gates, 2007.

robots will have ongoing high costs of acquisition, operation, maintenance, and energy usage. Buildings would require special infrastructure to facilitate robot activity. Staff training would be required as well. People would need to be trained in how to use and interact with the robots for the safety of both humans and machines. Given such costs, pilot robot experiments would be needed to see if benefits outweigh the costs. Niche applications are likely to develop first.

One area in which robots may hold the most promising opportunity for Army installations in the near future is security. A number of applied research projects are developing robots that can patrol large areas continuously and identify intruders or suspicious activity. At Carnegie Mellon University, researchers developed autonomous all-terrain vehicles (ATVs) to secure borders and perimeter facilities and provide operators with live video and audio data.[587] Samsung is in the process of commercializing a robotic system that is being used to patrol the demilitarized zone between North and South Korea.[588] A key strength of this robot, besides its ability to tirelessly survey this wide area, is its color camera that can identify a target at a distance of 500 meters in illumination equivalent to a starlit night. The Army may be able to use similar types of technologies in the coming years to provide security and to patrol installations.

Security robots have the best potential for near-term application at Army installations because of the chance to ultimately lower manpower costs and enhance security. However, given the developmental, operational, and cost challenges of such robots and tight Army installation budgets, the installation community should not be investing in such robots any time soon. But it is potentially a good investment area for the Army R&D community, which could potentially do a research and demonstration project at a couple different installations within the next few years. Another reason for doing pilots of such robots at Army installations is the potential to help test and learn about such systems for application at forward operating bases (FOBs) and in other tactical situations.

Recommendations for Army Installations Regarding Robots

Given all these implications, ACSIM and the installation management community should continue to monitor robotic trends, but not address them in current installation planning. Robots are not likely to have much application at installations even by 2025, with the possible exception of security robots, and even there it would be longer than that before the Army

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[587] Bradley Hamner, Sanjiv Singh, Stephan Roth, and Takeshi Takahashi, "An Efficient System for Combined Route Traversal and Collision Avoidance," *Autonomous Robots*, Vol. 24, No. 4, May, 2008, pp. 365–385.

[588] Jean Kumagai, "A Robotic Sentry for Korea's Demilitarized Zone," *IEEE Spectrum*, 2007.

would likely see any widespread application. One near-term action that the installation management community could pursue is to explore the potential with the Army R&D community of having some security robot research and demonstration pilots at installations.

Sources for Tracking Robotics Trends

There are numerous sources for tracking trends in robotics. In terms of recently published work, Silberglitt et al. (2006) provide an in-depth discussion of a wide range of technology trends, including robotics. They discuss the arenas in which robotics is likely to have an impact in the coming decade, and they assess which countries are likely to be ready to take advantage of those developments.[589] Petrina (2008) describes the current state of robotics and likely advances in the field and its applications, and also anticipates an emerging technological revolution.[590] The *Springer Handbook of Robotics* (Siciliano and Khatib, 2008) largely focuses on industrial applications and examines the foundations of robotics and explores emerging application areas.[591]

A number of journals focus exclusively on robotics and subareas in the field. The *Journal of Robotics and Automation*[592] and the *International Journal of Robotics Research*[593] publish articles of broad interest to the robotics community. while the *Journal of Field Robotics*, as the name suggests, focuses on outdoor robotic systems.[594]

Several meetings are also important for tracking trends, such as Robotics: Science and Systems,[595] which is a single-track, highly selective conference, while the International Conference of Robotics and Automation[596] is one of the largest robotics conferences, in terms

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[589] Silberglitt, 2006.

[590] A. M. Petrina, "Robotics: Present and Future," *Scientific and Technical Information Processing*, Vol. 35, No. 2, 2008, pp. 73–79.

[591] Bruno Siciliano and Oussama Khatib (eds.), *Springer Handbook of Robotics*, Berlin: Springer-Verlag, 2008.

[592] The *Journal of Robotics and Automation* can be found at http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=56. Last accessed September 10, 2010.

[593] The *International Journal of Robotics Research* can be found at http://www.irr.org. Last accessed September 10, 2010.

[594] The *Journal of Field Robotics* can be found at http://www.journalfieldrobotics.org/Home.html. Last accessed September 9, 2010.

[595] Information about Robotics: Science and Systems can be found at http://www.roboticsconference.org/. Last accessed September 10, 2010.

[596] The International Conference on Robotics and Automation does not have a single website. Instead, a new website is created for each year's conference and maintained by the

of both presentations and attendees, and attracts thousands of participants from academia and industry.

A number of institutions and organizations are dedicated to robotics research and applications. The International Federation of Robotics (IFR) is an alliance of robotics organizations and publishes an annual report, *The World Robotics Report*, which examines market trends for industrial and service robots.[597] There are numerous important academic institutions that focus on robotics. The Robotics Institute at Carnegie Mellon University conducts a wide range of robotics research—from medicine to field and service robotics to robot teams.[598] Other notable academic institutions that specialize in robotics research include the Robotics and Intelligent Machines Center at Georgia Tech,[599] the Stanford Artificial Intelligence Lab at Stanford University,[600] the Computer Science and Artificial Intelligence Laboratory at MIT,[601] and the University of Southern California's Robotics Research Lab.[602]

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institution hosting the conference. The 2010 conference information can be found at http://icra2010.grasp.upenn.edu/. Last accessed September 10, 2010.

[597] The International Federation of Robotics can be found at http://www.ifr.org/. Last accessed September 9, 2010.

[598] The Robotics Institute can be found at http://www.ri.cmu.edu. Last accessed September 9, 2010.

[599] The Robotics and Intelligent Machines Center at Georgia Tech can be found at http://robotics.gatech.edu/. Last accessed September 9, 2010.

[600] The Stanford Artificial Intelligence Lab can be found at http://robotics.stanford.edu/. Last accessed September 9, 2010.

[601] The Computer Science and Artificial Intelligence Laboratory can be found at http://www.csail.mit.edu/. Last accessed September 9, 2010.

[602] The Robotics Research Lab at the University of Southern California can be found at http://robotics.usc.edu/. Last accessed September 9, 2010.

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CHAPTER SIX
Relevant Societal Trends

U.S. society has changed significantly in the last 50 years. For instance, fewer families today resemble the idealized family of the 1950s and 1960s—the house in the suburbs, a working father and stay-at-home mother, two children. Instead, extended and nontraditional families are common, as are households in which both parents work. Simultaneously, there has been a tremendous rise in new media—television, video games, the Internet—that have shaped the way people live, work, learn, play, and engage in their communities.

In this chapter we discuss how key social trends may affect Army installations in the future. We use the term "societal trends" to refer to trends in the ways people live and their relationships with each other and the world around them. We focus on those trends that are most relevant to Army installations. We have grouped them into three categories for this discussion:

1. **General changes in U.S. society**, including a changing sense of community trends in U.S. society,
2. **Trends and implications for youth**, including physical activity and media use trends among youth,
3. **Excessive and addictive use** of the Internet.

As the second and third trend categories suggest, we pay particular attention to social trends among children and young adults over the last several decades, as trends in this population may point to important characteristics of today's and future Army recruits. We then discuss how these trends may affect Army installations today and in the future. In this discussion we also draw on some other RAND research that helps shed light on current conditions in the Army that relate to these societal trends.

Before discussing the trends, we should point out that this chapter is a little different from the others. We do not have the subsections on what might change the trends or interrelationships with other issues, since these trends are more subjective. In general, such trends are affected by lifestyle choices and cultural changes that are hard to predict. Technology changes and innovation of their use, especially information and communications technologies, come into play as well. But even there it is hard to predict how new inventions will change things. For example, who 15 years ago would have predicted how technological innovations such as the iPod, smart phones, texting, and social media would so dramatically change how young people and other people communicate and interact with the world?

Relevant General Changes in U.S. Society

The last 50 years have seen tremendous changes in U.S. society, particularly in families and communities. For instance, there has been a well-documented increase in the number of women in the labor force. In 1950, only 34 percent of working-age women participated in the labor force, but by 1998, this figure had jumped to nearly 60 percent and by 2010 it was 66 percent.[603] Additionally, the proportion of families with two working parents had increased from approximately 20 percent in 1960 to approximately 40 percent in 1988.[604] In 2009, 55 percent of married couples were both in the labor force.[605] Besides such changes in families, our sense of community has been changing over the last 50 years.

Changing Sense of Community

Some researchers state that there is a declining sense of local place-based neighborhood community in U.S. society at large over the last 40 to 50 years and a growing importance of broader support networks and connections as part of one's sense of community.[606] Today, people are less likely to be as connected to their physical neighbors as people were 50 years ago, and instead are more connected and supported by a network of relationships with relatives, co-workers, and friendships/interest groups that can be spread across a region,

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[603] Howard N. Fullerton, "Labor Force Participation: 75 Years of Change, 1950–98 and 1998–2025," *Monthly Labor Review*, December 1999, p. 4; and Bureau of Labor Statistics, "Women in the Labor Force, 2010," December 23, 2011.

[604] Howard V. Hayghe, "Family Members in the Work Force," *Monthly Labor Review*, March 1990, p. 16.

[605] Because definitions of families have changed over the last several decades, the data from 1940, 1988, and 2009 may not be directly comparable. U.S. Census Bureau, "America's Families and Living Arrangements: 2009," "Table FG-1: Married Couple Family Groups, by Labor Force Status of Both Spouses, and Race and Hispanic Origin/1 of the Reference Person: 2009."

[606] For examples, see Keith Hampton and Barry Wellman, "Neighboring in Netville: How the Internet Supports Community and Social Capital in a Wired Suburb," *City and Community*, December 2003; Robert Putnam, *Bowling Alone: The Collapse and Revival of American Community*, New York: Simon and Schuster, 2000; and Jo Anne Schneider, "The Role of Social Capital in Building Healthy Communities," Baltimore, MD: Annie E. Casey Foundation, November 2004.

state, the country, and even the world.[607] Changes in communication, transportation, family structures, social capital, and television viewing habitats, along with the growth of the Internet, have likely contributed to changes in the sense of community. Here we discuss these various trends.

According to some research, the last 30–40 years have seen a decline in some indicators of place-based "social capital." Social capital broadly refers to features of social life: the strength of social networks, social norms, and a sense of trust in other people.[608] Thus, local civic disengagement and a decline in trust may signal a decline in community social capital.

One key researcher found empirical evidence that place-based community civic engagement had declined from the 1970s to the 1990s. For instance, membership in community groups dropped by a quarter from 1974 to 1994,[609] rates of social trust—the percent of people who agree that most people are trustworthy—fell by a third from 1974 to 1994,[610] and voter turnout has also steadily declined.[611] This early work on the importance of social capital has spawned an entire stream of literature focused on the role of social capital in the health of local communities.[612]

Perhaps most significantly, this early research also noted the beginnings of a shift away from local, place-based community interactions to broader, social interactions that encompass a changing sense of community:

> the proportion of Americans who socialize with their neighbors more than once a year has slowly but steadily declined over the last two decades, from 72 percent in 1974 to 61 percent in 1993. On the other hand, socializing with

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[607] Keith Hampton , and Barry Wellman, "Neighboring in Netville: How the Internet Supports Community and Social Capital in a Wired Suburb," *City and Community*, December 2003.

[608] Robert D. Putnam, "Tuning In, Tuning Out: The Strange Disappearance of Social Capital in America," *PS: Political Science and Politics*, Vol. 28, No. 4, December 1995, pp. 664–665.

[609] Robert D. Putnam, "The Strange Disappearance of Civic America," *The American Prospect*, Vol. 24, Winter 1996, p. 35.

[610] Robert D. Putnam, "Bowling Alone: America's Declining Social Capital," *Journal of Democracy*, Vol. 6, No. 1, January 1995, p. 73.

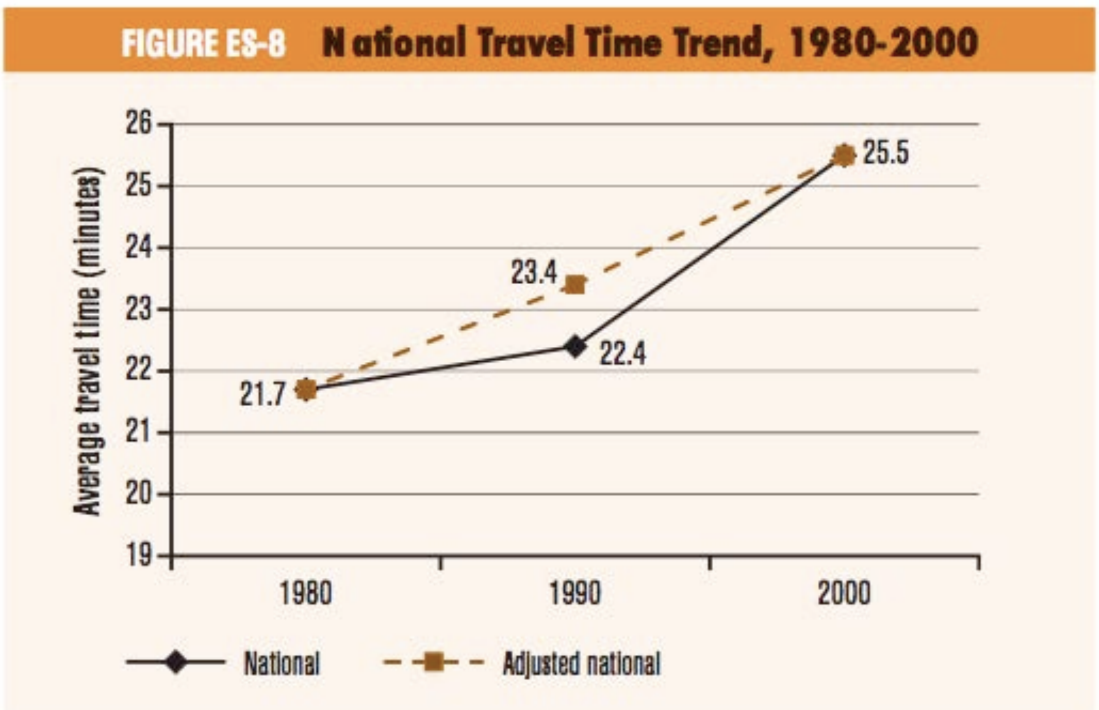
[611] Robert D. Putnam, "Tuning In, Tuning Out: The Strange Disappearance of Social Capital in America," *PS: Political Science and Politics*, Vol. 28, No. 4, December 1995, pp. 675.

[612] For instance, see Jo Ann Schneider, *The Role of Social Capital in Building Healthy Communities*, The Ann E. Casey Foundation, November 2004; also see Lynne C. Manzo and Douglas D. Perkins, "Finding Common Ground: The Importance of Place Attachment to Community Participation and Planning," *Journal of Planning Literature*, Vol. 20, 2006, pp. 335–350.

> "friends who do not live in your neighborhood" appears to be on the increase, a trend that may reflect the growth of workplace-based social connections.[613]

One important trend that may be changing local, placed-based sense of community is that people are also spending more time commuting, which reduces time at home. The average commute in 1980 was 21.7 minutes, while in 2000 it was 25.5 minutes, as shown in Figure 6.1.[614] While this change appears slight, the number of workers with commutes longer than one hour grew by 50 percent between 1990 and 2000, suggesting an increase in long-distance commutes.[615]

Figure 6.1
Average Commute Times from 1980 to 2000



SOURCE: Alan E. Pisarski, "Commuting in America III: The Third National Report on Commuting Patterns and Trends." *TR News* 247, 2006, p. xxii.

NOTE: In the report, the data for 1990 were adjusted upward "to compensate for truncated data that understated travel times."

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[613] Robert D. Putnam, "Bowling Alone: America's Declining Social Capital," *Journal of Democracy*, Vol. 6, No. 1, January 1995, p. 73.

[614] Alan E. Pisarski, "Commuting in America III: The Third National Report on Commuting Patterns and Trends," *TR News* 247, 2006, p. xxii.

[615] Alan E. Pisarski, "Commuting in America III: The Third National Report on Commuting Patterns and Trends," *TR News* 247, 2006, p. 27.

Also, as people are working farther from home they develop relationships with people in their workplace who more often live farther away from them when compared to workplace friends' homes when people worked closer to their homes. The result is that people are now connected with more friends from work who are not in the same community.

Some researchers also have attributed some of the decline in local place-based community to the rise in media consumption—primarily television and that television has changed how we view and interact with society. For example, some researchers state that television may induce passivity,[616] that "both the medium and the message have more basic effects on our ways of interacting with the world and with one another,"[617] and that television might be changing our basic physical and social perceptions.[618] In 1950, barely 10 percent of homes had television, whereas by 1960, more than 90 percent did. The amount of time spent watching television in homes that had TVs also grew by 50 percent between 1950 and 1995.[619] TV continues to be a major pastime in an average American's day. Recent surveys find that on an average day, most leisure time is spent watching TV, 2.8 hours per day, as shown in Figure 6.2. This figure also shows how in an average day, people spend 23 minutes playing video games and leisure computer use.

The role of computers, the Internet, cell phones, and ubiquitous communications has also contributed to changes in the U.S. sense of community. An average person's sense of community now has fewer ties to the local, place-based community than it did 50 years ago or even 20 years ago because of the greater participation in geographically dispersed networks fed in part by growing online communities using tools such as email and social networking sites like Facebook. Chapter Five provides more details and evidence about the growth of online communities. Here we provide evidence about how these communities are

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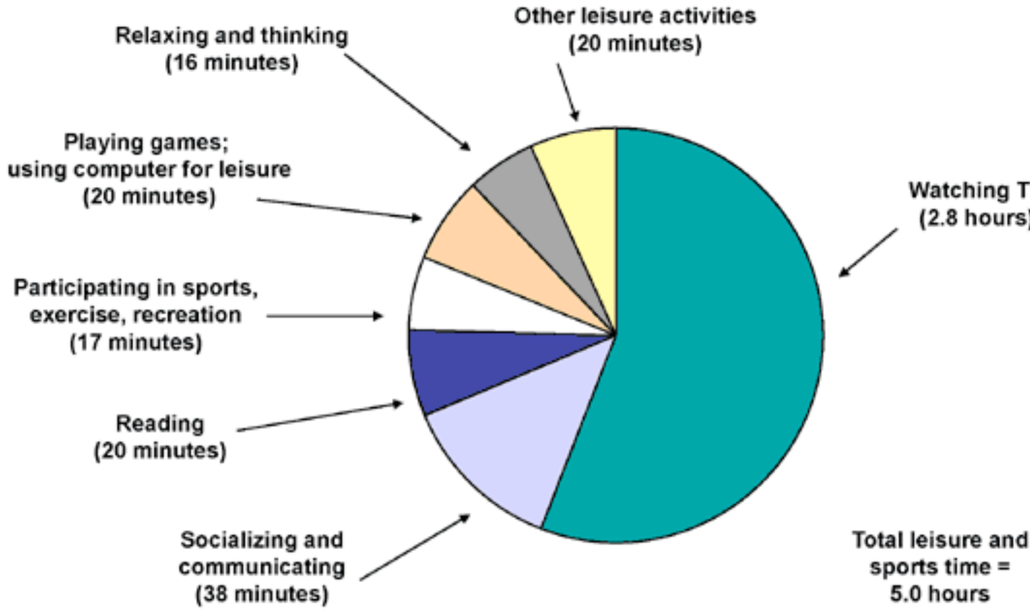
[616] Neil Postman, *Amusing Ourselves to Death: Public Discourse in the Age of Show Business*, New York: Viking-Penguin Books, 1985.

[617] Robert D. Putnam, "Tuning In, Tuning Out: The Strange Disappearance of Social Capital in America," *PS: Political Science and Politics*, Vol. 28, No. 4, December 1995, pp. 679.

[618] Joshua Meyrowitz, *No Sense of Place: The Impact of Electronic Media on Social Behavior*, Oxford University Press, 1985.

[619] Robert D. Putnam, "Tuning In, Tuning Out: The Strange Disappearance of Social Capital in America," *PS: Political Science and Politics*, Vol. 28, No. 4, December 1995, p. 677.

Figure 6.2
Leisure Time on an Average Day



SOURCE: Bureau of Labor Statistics, "American Time Use Survey," 2010 data.

transforming Americans' sense of community. One study that surveyed Americans about their use of the Internet found:

> Instead of disappearing, people's communities are transforming: The traditional human orientation to neighborhood- and village-based groups is moving towards communities that are oriented around geographically dispersed social networks. People communicate and maneuver in these networks rather than being bound up in one solitary community. Yet people's networks continue to have substantial numbers of relatives and neighbors—the traditional bases of community—as well as friends and workmates.[620]

It is important to note that researchers have found that the use of the Internet does not appear to limit contact with local ties, but rather helps strengthen local and far-away connections and this broader sense of community and connections by individuals. One researcher coined the term "glocalization" to refer to the fact that Internet tools are used as

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[620] Jeffrey Boase, John B. Horrigan, and Barry Wellman, *The Strength of Internet Ties: The Internet and Email Aid Users in Maintaining Their Social Networks and Provide Pathways to Help When People Face Big Decisions*, Washington, D.C.: Pew Internet and American Life Project, January 25, 2006, p. i.

frequently to maintain nearby core social ties as they are to maintain long-distance ties and makes the case for "networked individualism":

> Because individuals—rather than households—are separately connected, the Internet and the cell phone have transformed communication from house to house to person to person. There is "networked individualism": Rather than relying on a single community for social capital, individuals often must actively seek out a variety of appropriate people and resources for different situations.[621]

Other researchers also discuss the role that the Internet, social media, and ubiquitous communications have had on a change in the U.S. sense of community and how they can help facilitate different types of community connections, including neighborhood ties.[622] In addition, some research suggests that Internet usage can build social capital and enhance the sense of place-based community by facilitating the mobilization of citizens around local issues.[623]

To sum up, the changing sense of community that exists today and is likely to continue into the future, because of changes in communications and computer technologies and uses, transportation and workplace choices, leisure activities, and family dynamics. Local place-based neighborhoods are less important to our sense of community and support. They still play a role, but broader support networks with family and friends across the world[624] also now play a role and are likely to play a stronger role in the future. Today's sense of community is best summed up by two researchers as follows:

> Communities consist of far-flung kinship, workplace, friendship, interest group, and neighborhood ties that concatenate to form networks providing sociability, aid, support, and social control. Communities are usually not groups, but are social networks that are sparsely knit, loosely bounded, and far flung. The

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[621] Jeffrey Boase, John B. Horrigan, and Barry Wellman, *The Strength of Internet Ties: The Internet and Email Aid Users in Maintaining Their Social Networks and Provide Pathways to Help When People Face Big Decisions,* Washington, D.C.: Pew Internet and American Life Project, January 25, 2006, p. ii.

[622] For examples, see Caroline Haythornthwaite and Lori Kendall, "Internet and Community," *American Behavioral Scientist*, February 2010; and Nicole Ellison et al., "The Benefits of Facebook "Friends:" Social Capital and College Students' Use of Online Social Network Sites," *Journal of Computer-Mediated Communication*, 2007.

[623] See Keith Hampton and Barry Wellman, "Neighboring in Netville: How the Internet Supports Community and Social Capital in a Wired Suburb," *City & Community*, Vol. 2, No. 4, December 2003, pp. 277–311.

[624] Besides workplace friends, such networks can include a wide range of other personal networks of school, cultural, religious, workout, and other types of leisure and hobby friends.

> typical network community in North America consists of a small number of densely-knit immediate kin and a larger number of sparsely-knit friends, neighbors, workmates, and extended kin. Such networks can furnish opportunity, maneuverability, and uncertainty. Opportunity to find resources in a number of social circles; maneuverability to avoid the controlling nature of a single network member or constrictive group; uncertainty because the low density and porous boundary of any one network makes it harder to identify with than a single solitary group. . . . Neighborly relationships remain important, but as a minority of ties within the overall network community.[625]

This quotation also illustrates how some researchers view that the nature of such networks is such that people are less likely to identify with a single group, thus any one group would be less able to exert influence over them. If this is true, one could hypothesize that given such network conditions, people in the Army today and in the future will be less likely to identify with the Army and Army culture. We will revisit this issue later when we discuss implications for the Army.

Such diverse networks of community are likely to become even more important in the future because of trends among youth and their use of the Internet and cell phones, which is discussed more in the next section.

Trends Among Youth

We now turn to trends that are specific to youth—how have the activities and attitudes of youth changed over time, and what might early indicators say about today's and tomorrow's young recruits? Today's youth are defined in large part by a decline in physical activity and play and by their heavy use of media—the Internet, video and computer games, television and movies, and music. New terms like "Generation M" (for media) and "the Net Generation" have been coined to reflect such trends and youth today. In this section we examine these changes in physical activity, play, and media use. However, we want to caution readers from generalizing too much from some of these trends regarding youth; there will always be differences in human beings' activities and how they view the world. Also, before this youth trend discussion, we provide a little background information about these generational terms.

Some researchers and journalists have used the term Baby Boomers to refer to the generation born between 1946 and 1964, Generation X for those born between 1965 and

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[625] Hampton and Wellmanpp. 278–279.

1980, and Net Generation for those born between 1981 and 1994.[626] Others use the term Net Generation or Generation Z for those born between the early 1990s and early 2000s.[627] Some use Generation M for those who started college in the last 15 years. Other researchers have used Generation M for those who were 8 to 18 in 2009.[628] Clearly, there is inconsistent use of such terms. In this document, we use Generation M to refer to young people today generally between the ages of 8 and 29.

Decline in Physical Activity and Increase in Obesity

It is well documented that physical activity among youth has declined. For example, in a survey of physical activity in children, one researcher cites literature suggesting that between 1977 and 1995, walking and cycling declined among U.S. children by 37 percent. Participation in high school physical education (PE) classes also fell, from 65 percent in 1984 to 52 percent in 1990. Children's participation in daily PE fell from 42 percent in 1991 to 28 percent in 2003.[629]

There is also a trend toward poor nutrition across the country. According to the Centers for Disease Control (CDC), U.S. women and men increased their daily calorie consumption by 22 percent and 7 percent between 1971 and 2000, and most of this nutrition was from an increase in carbohydrate intake rather than nutrient-rich foods.[630] Poor nutrition is growing among children as well. Table 6.1 highlights a few examples of changes in girls' nutritional intake in the 1970s versus the 1990s. For example, sugar and sweets intake has increased by 13 grams, and carbonated soft drink intake has increased by 94 grams, while vegetable intake has declined by 42 grams. Importantly, this decline in vegetable consumption includes an *increase* in intake of fried white potatoes (i.e., French fries), suggesting that the loss of *nutritional* vegetables may be much higher. Boys' nutritional intake was similar to that of girls.

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[626] Diana Oblinger and James L. Oblinger (eds.), *Educating the Net Generation*, EDUCAUSE, 2005.

[627] For examples, see Sherry Posnick-Goodwin, "Meet Generation Z." California Teachers Association, February 2010, and Don Tapscott, *Grown Up Digital: How the Net Generation Is Changing Your World*, McGraw-Hill, 2008, pp. 15–16.

[628] Victoria Rideout, Ulla G. Foehr, and Donald F. Roberts, *Generation M²: Media in the Lives of 8–18 Year Olds,* Kaiser Family Foundation, January 2010.

[629] J. Dollman, K. Norton, and L. Norton, "Evidence for Secular Trends in Children's Physical Activity Behaviour," *British Journal of Sports Medicine*, Vol. 39, 2005, p. 893.

[630] Centers for Disease Control and Prevention, "Calorie Consumption on the Rise in United States, Particularly Among Women," February 5, 2004.

Table 6.1
Girls' Nutritional Intake of Different Foods (grams)

	1970s	1990s
Sugar	28	41
Soft drinks	106	200
Vegetables	159	116

SOURCE: Cecilia Wikinson Enns, Sharon J. Mickle, and Joseph D. Goldman, "Trends in Food and Nutrient Intakes by Children in the United States," *Family Economics and Nutrition Review*, Vol. 14, No. 2, 2002, p. 59.

Together, these trends have contributed to a surge in overweight and obese children. Weight health classifications are typically based on body mass index (BMI), which compares weight to height.[631] BMI for adults is calculated as weight (in kilograms) divided by height squared (in meters). Thus, BMI = w/h^2, and is typically written without units. *Normal* weight corresponds to a BMI between 18 and 25 (e.g., a 5'11" person who weighs between 130 and 170 pounds), *overweight* corresponds to a BMI between 25 and 30 (e.g., a 5'11" person who weighs between 170 and 210 pounds), and *obese* corresponds to a BMI of over 30 (e.g., a 5'11" person who weighs over 210 pounds).[632] BMI for children takes into account age and gender.

According to the 1999–2002 National Health and Nutrition Examination Survey undertaken by the CDC, overweight children ages 6–19 have increased from 4 to 5 percent of the population in 1963–1970 to 16 percent of the population in 1999–2002.[633] These trends are shown in Figure 6.3. Obesity has also increased among all children, including early preschool-aged children, as shown in Figure 6.4, which shows obesity incidence in children from 1963 through 2008.

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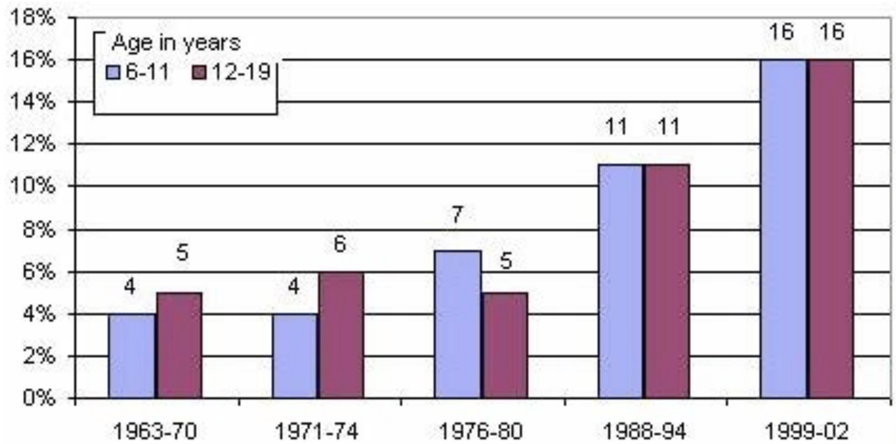
[631] Other measures include the body volume index, which takes into account shape and weight distributions and body fat percentages.

[632] The CDC's healthy weight website with BMI calculator can be found at http://www.cdc.gov/healthyweight/assessing/index.html.

[633] U.S. Department of Health and Human Services, "Childhood Obesity."

Figure 6.3
Prevalence of Overweight Among Children and Adolescents Ages 6–19 Years

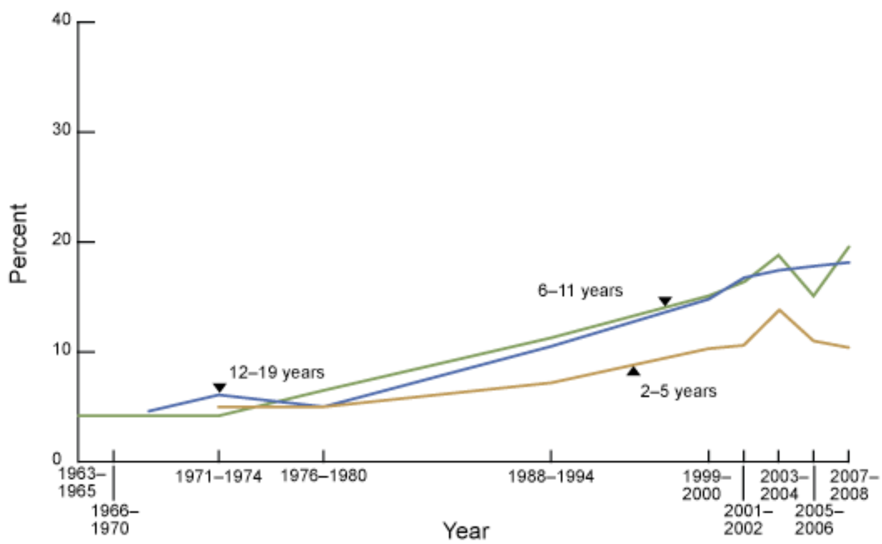


NOTE: Excludes pregnant women starting with 1971-74. Pregnancy status not available for 1963-65 and 1966-70. Data for 1963-65 are for children 6-11 years of age; data for 1966-70 are for adolescents 12-17 years of age, not 12-19 years.

SOURCE: CDC/NCHS, NHES and NHANES.

SOURCE: U.S. Department of Health and Human Services. *Childhood Obesity*. As of February 2, 2011: http://aspe.hhs.gov/health/reports/child_obesity/.

Figure 6.4
Incidence of Obesity in Children from 1963 to 2008



NOTE: Obesity is defined as body mass index (BMI) greater than or equal to sex- and age-specific 95th percentile from the 2000 CDC Growth Charts.
SOURCES: CDC/NCHS, National Health Examination Surveys II (ages 6–11), III (ages 12–17), and National Health and Nutrition Examination Surveys (NHANES) I–III, and NHANES 1999–2000, 2001–2002, 2003–2004, 2005–2006, and 2007–2008.

There are a number of likely reasons for this loss in physical activity. Children have less time for play and physical activity because they spend more time in school and in daycare than ever before. Children also have less access to opens spaces and unstructured play areas, in part because of growing concerns about safety. Additionally, media use and screen time have displaced time for physical exercise. We explore these issues in turn.

Decline in Unstructured and Neighborhood Play

In comparison to earlier decades, children today spend more time in school, studying, and structured activities and spend less time in unstructured play than previous generations. For 6–17 year olds, time in school increased by 6 hours a week between 1981/82 to 2002/03.[634] For younger children, this change was even more dramatic. Children aged 6–8 spent nearly 2 hours more in school *each day*, from 4 hours 52 minutes to 6 hours and 46 minutes.[635] Many students today have more homework than previous generations. Most other uses of time are comparable—eating, personal care, reading, art activities. The two big differences are an increase in computer time and the time spent in school and structured activities. Computers were not yet in the home in 1981/82, but by 2002/03, computers took up nearly 3 hours of time each week, and this figure has increased since then. One study reports that in 2004, 8–18 year olds spent an hour on the computer *each day*, presumably translating to over 7 hours a week on the computer.[636] With the more recent development and widespread use of smart phones this has likely increased, and overall media use is even higher with youth, as we discuss later in this chapter.

In contrast, time spent in outdoor activities has dropped significantly. In the early 1980s, children spent 1 hour and 40 minutes per day in outdoor activities (not including structured sports). By 2002/03, this dropped to 50 minutes.[637] In a recent survey of mothers in the United States, 70 percent of mothers reported playing outside daily as children' versus only

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[634] F. Thomas Juster, Hiromi Ono, and Frank Stafford, *Changing Times of American Youth: 1981–2003*, Ann Arbor, MI: University of Michigan Institute for Social Research, November 2004, p. 8.

[635] F. Thomas Juster, Hiromi Ono, and Frank Stafford, *Changing Times of American Youth: 1981–2003*, Ann Arbor, MI: University of Michigan Institute for Social Research, November 2004, p. 10.

[636] Victoria Rideout, Donald F. Roberts, and Ulla G. Foehr, *Generation M: Media in the Lives of 8–18 Year Olds*, Kaiser Family Foundation, March 2005, p. 37.

[637] F. Thomas Juster, Hiromi Ono, and Frank Stafford, *Changing Times of American Youth: 1981–2003*, Ann Arbor, MI: University of Michigan Institute for Social Research, November 2004, p. 8.

36 percent of their children. Additionally, 56 percent of mothers reported remaining outdoors for three or more hours at a time, compared to 22 percent of their children.[638]

There is also a shift in the kinds of outdoor activities children engage in today than in earlier generations. Mothers reported playing games in which children are "in charge" of the game much more often than their children. These include games like "tag" (93 percent versus 64 percent), hopscotch (85 percent versus 33 percent), and playground games (approximately 65 percent versus 42 percent). Earlier generations reported engaging in imaginative, "made-up" games much more than their children (78 percent versus 57 percent) and in nature play. Approximately 53 percent of mothers reported exploring nature versus 47 percent of their children, and approximately 55 percent of mothers reported climbing trees in comparison to approximately 25 percent of their children.[639]

Part of this loss of nature and outdoor play is due to parents placing greater restrictions on their children. For instance, in a 2002 survey, 56 percent of parents in the United States said they were allowed to walk or bike to school alone, but only 36 percent said their kids should (and presumably could) do the same.[640] Younger children are constrained physically rather than by rules. A study in Scotland which used accelerometers to objectively monitor children's activities found that toddlers were active for only 20 minutes a day.[641] One expert attributes part of this to the fact that toddlers' outdoor time is frequently spent in strollers, car seats, and other "containers."[642] This restriction on children's movement is attributed to a growing but irrational fear that parents have for their children's safety. He remarks that the fear of kidnapping, murder, and other severe crimes is high but grossly disproportionate to the actual incidence of these crimes. He attributes this fear largely to the sensationalism of these crimes by the media.[643]

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[638] R. Clements, "An Investigation of the State of Outdoor Play," *Contemporary Issues in Early Childhood,* Vol. 5, No. 1, 2004, p. 72.

[639] R. Clements, "An Investigation of the State of Outdoor Play," *Contemporary Issues in Early Childhood,* Vol. 5, No. 1, 2004, p. 72.

[640] John Fetto, "Separation Anxiety," *American Demographics,* Vol. 24, No. 11, December 2002. As cited in Richard Louv, *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder*, Chapel Hill, NC: Algonquin Books, 2008, p. 123.

[641] J.J. Reilly, D.M. Jackson, C. Montgomery, L.A. Kelly, C. Slater, S. Grant, and J.Y. Paton, "Total Energy Expenditure and Physical Activity in Young Scottish Children: Mixed Longitudinal Study," *The Lancet*, Vol. 363, Issue 9404, January 17, 2004, pp. 211–212.

[642] Richard Louv, *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder*, Chapel Hill, NC: Algonquin Books, 2008, p. 35.

[643] Richard Louv, *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder*, Chapel Hill, NC: Algonquin Books, 2008, pp. 123–129.

There are also fewer environments in which children can engage in nature play. One expert explores this phenomenon extensively, first noting that neighborhood woods, creeks, and other natural areas have been lost to rapid development and ever-expanding suburbs. Where they remain, play in such areas is frequently "criminalized." Increasingly, many homes are governed by homeowners associations, for example, many of which prohibit construction of tree houses or forts—a staple of nature play in previous generations—or play near and around creeks. This expert argues that this is in part due to the fear of lawsuits and in part due to the growing pursuit of order and tidiness.[644]

Importantly, research suggests that unstructured play and nature play have important roles in childhood development and may offer benefits that some of today's children do not have. One study examined the role that nature may play as a buffer between children and stress. It measured both the amount of nearby nature in a child's environment, the stressful life events that the child experienced, and the child's level of stress. The study found that the impact of life stress was lower among those with high nearby nature, and the authors suggest that nature may help with coping skills and improve self-esteem.[645]

Nature may also promote self-discipline. In another study, researchers worked with children who had been randomly assigned to different units in apartment buildings with different views of nature. The children were given tests of concentration, impulse inhibition, and delayed gratification. Their findings suggested that, at least for girls, a better view of nature improved performance on these tests.[646] They hypothesize that "Self-discipline . . . may draw on directed attention, a limited resource that can be renewed through contact with nature."

Nature may also improve attention and be a tool for managing attention deficit and hyperactivity disorders. One study asked parents of children with attention deficit hyperactivity disorder (ADHD) to rate the aftereffects of a wide range of after-school and weekend activities. These activities were evaluated by the extent to which they involved time in or around nature, and their impact on ADHD symptoms. The study found that ADHD symptoms declined with activities in nature, suggesting that exposure to nature may be a tool

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[644] Richard Louv, *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder,* Chapel Hill, NC: Algonquin Books, 2008, pp. 27–31.

[645] Nancy M. Wells and Gary W. Evans, "Nearby Nature: A Buffer of Life Stress Among Rural Children," *Environment and Behavior,* Vol. 35, No. 5, May 2003, pp. 311–330.

[646] Andrea Faber Taylor, Frances E. Kuo, and William C. Sullivan, "Views of Nature and Self-Discipline: Evidence from Inner City Children," *Journal of Environmental Psychology*, Vol. 22, No. 1-2, March 2002, pp. 49–63.

in treating ADHD.[647] A related study conducted controlled field experiments in which children were asked to take walks in three different environments, one in nature and two in well-controlled urban environments. Researchers measured their concentration on a standardized concentration test. They found that the effect of a 20-minute walk was substantial—approximately as large as the attention deficit due to ADHD, and approximately equivalent to the effect of certain prescription drugs.[648]

Research further suggests that nature promotes unstructured play and imaginative games, and affords children a wider range of activities and opportunities that are not available in other play environments.[649] Experts explain the role of nature:

> While playing outdoors a child is likely to encounter opportunities for decision making that stimulate problem solving and creative thinking because outdoor spaces are often more varied and less structured than indoor spaces. In addition, there are usually fewer constraints outdoors on children's gross motor movement and less restriction on their range of visual and gross motor exploration. Together these factors that do not prescribe or limit activity induce curiosity and the use of imagination.[650]

They further note that, in addition to promoting fitness and health, unstructured imaginative play promotes a range of cognitive and emotional skills, especially social skills:

> Unstructured active play with others, including with parents, siblings, and peers, is a major opportunity to cultivate social skills. This is because all play with others requires solving some form of a social problem, such as deciding what to play, who can play, when to start, when to stop, and the rules of engagement. Solving these dilemmas and conflicts that arise in play encourages children to compromise and to cooperate. This process can cultivate a range of social and

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[647] Frances E. Kuo and Andrea Faber Taylor, "A Potential Natural Treatment for Attention-Deficit/Hyperactivity Disorder: Evidence from a National Study," *American Journal of Public Health,* Vol. 94, No. 9, September 2004, pp. 1580–1586.

[648] Frances E. Kuo and Andrea Faber Taylor, "A Potential Natural Treatment for Attention-Deficit/Hyperactivity Disorder: Evidence from a National Study," *American Journal of Public Health,* Vol. 94, No. 9, September 2004, pp. 1580–1586.

[649] Ingunn, Fjørtoft, "The Natural Environment as a Playground for Children: The Impact of Outdoor Play Activities in Pre-Primary School Children," *Early Childhood Education Journal*, Vol. 29, No. 2, Winter 2001, p. 112; and Hillary Burdette and Robert C. Whitaker, "Resurrecting Free Play in Young Children: Looking Beyond Fitness and Fatness to Attention, Affiliation, and Affect," *Archives of Pediatrics and Adolescent Medicine*, Vol. 159, No. 1, January 2005, p. 48.

[650] Hillary Burdette and Robert C. Whitaker, "Resurrecting Free Play in Young Children: Looking Beyond Fitness and Fatness to Attention, Affiliation, and Affect," *Archives of Pediatrics and Adolescent Medicine,* Vol. 159, No. 1, January 2005, p. 48.

> emotional capabilities such as empathy, flexibility, self-awareness, and self-regulation. Such capabilities, sometimes referred to together as "emotional intelligence," are essential for successful social interactions in adult life.[651]

In sum, unstructured play, especially in nature, offers a wide range of physical, emotional, and mental benefits for children, but many of today's children have fewer and fewer opportunities for unstructured play and skill development. Their interaction with other children is largely monitored by adults in structured environments, and they have less opportunity for playing together and resolving conflicts by themselves. The decline in play also contributes to overweight and obesity. When considered in conjunction with media trends (which we discuss next), we hypothesize that some young adults of the future may be less likely to have as strong social skills, coping skills, and self-esteem.

Increase in Media Use

If children are not spending time outdoors playing, what has taken the place of these activities? Certainly longer school hours, more homework, and structured activities play a role. But the role of media cannot be understated. We discussed youth and media briefly earlier, and turn to it now in greater detail.

Media use among youth has increased significantly. Such media include television, computers, and cell phones. One study that examined the role of media in youth's lives shows the large amount of time 8–18 year olds spend with such media each day; see Figure 6.5. On an average day, U.S. 8–18 year olds engage in over 4.5 hours of television, 2.5 hours of music, 1.4 hours of computers, and 0.4 hours of movies. These numbers are not additive, however, because youth use multiple media at the same time—texting on the phone while watching TV and playing a computer game, for example.[652] According to another report, the generation of students entering college during the last 15 years has by the age of 21 spent 10,000 hours playing video games, 20,000 hours watching TV, and 10,000 hours on cell phones. In contrast, they have spent only 5,000 hours reading.[653]

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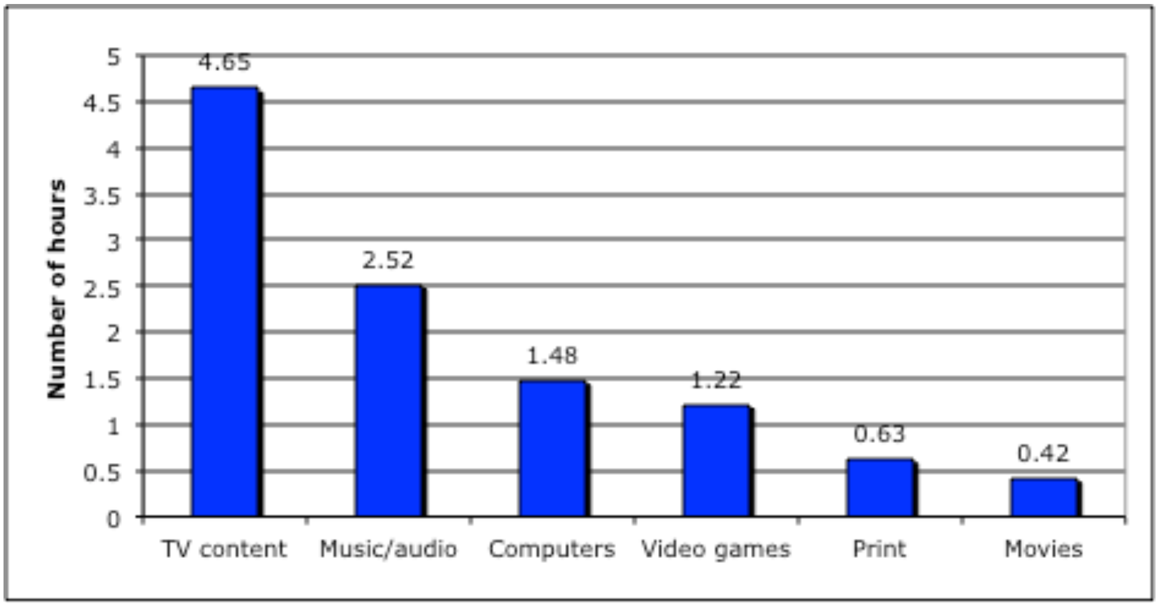
[651] Hillary Burdette and Robert C. Whitaker, "Resurrecting Free Play in Young Children: Looking Beyond Fitness and Fatness to Attention, Affiliation, and Affect," *Archives of Pediatrics and Adolescent Medicine*, Vol. 159, No. 1, January 2005, p. 48.

[652] Victoria Rideout, Ulla G. Foehr, and Donald F. Roberts, *Generation M^2: Media in the Lives of 8–18 Year Olds,* Kaiser Family Foundation, January 2010, p. 11.

[653] Marc Prensky, "Digital Natives, Digital Immigrants, Part II: Do They Really Think Differently?" *On the Horizon*, Vol. 9, No. 6, December 2001, p. 1.

Figure 6.5
Amount of Time Spent with Media in a Typical Day by 8 to 18 Year Olds



SOURCE: Adapted from a table in Victor C. Strasburger, Amy B. Jordan, and Ed Donnerstein, "Health Effects of Media on Children and Adolescents," *Pediatrics*, Vol. 125, No. 2, April 2010.

Mobile phones are increasingly used to access music and videos and to play games, in addition to making calls. A 2009 study found that cell phone ownership has become mainstream in teens and adults. It reports that 75 percent of teens and 93 percent of adults now own a mobile phone. Importantly, 58 percent of twelve year olds have mobile phones—up from 18 percent in 2004.[654]

As we have noted, because of this heavy media use, new terms like "Generation M" (for media) and "the Net Generation" have been coined to refer to teens and younger adults.

Effects of Heavy Media Use on Health and Well-Being

These findings confirm that youth are heavy consumers of media, particularly television. Unfortunately, research shows that heavy media use is associated with a wide range of negative outcomes.[655] Television viewing in particular has been studied extensively, and there is much evidence that high television use is associated with poor nutritional choices and obesity. One review of the literature finds, for example, that the odds of being overweight

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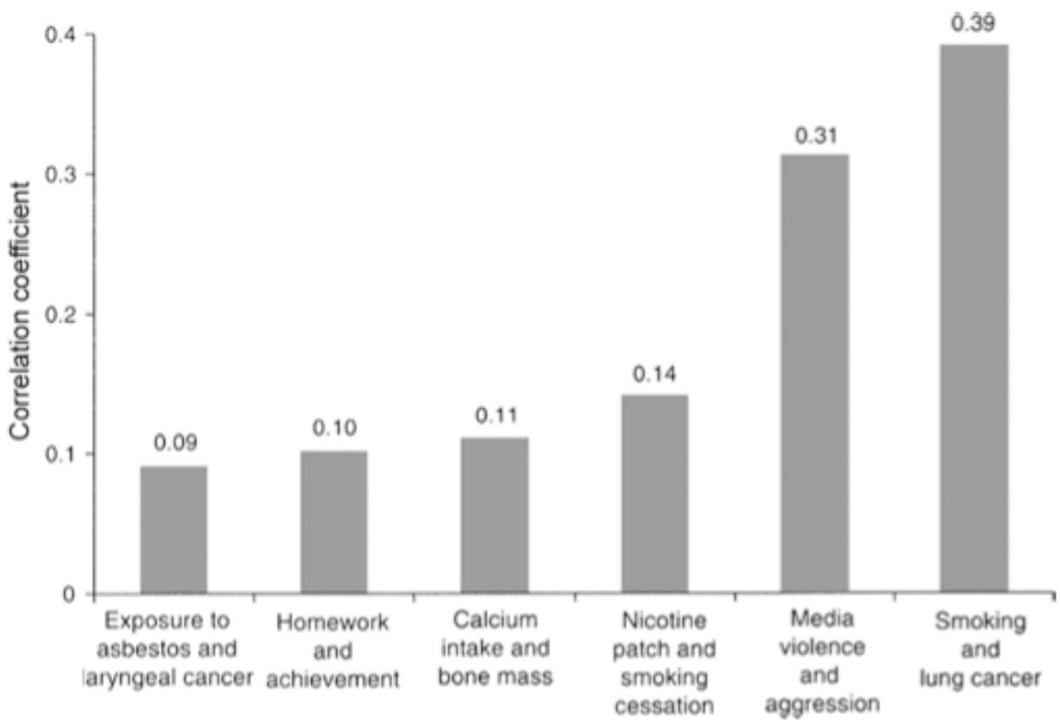
[654] Amanda Lenhart et al., *Social Media and Mobile Internet Use Among Teens and Young Adults*, Pew Research Center, February 3, 2010, p. 4.

[655] Because definitions of high, moderate, and low media use vary between studies, we define these terms in the context of each study.

were 4.6 times higher for youth who watch more than 5 hours of television, compared with those who watched 0–2 hours of television.[656]

Media use also has a wide range of other effects. One survey of research on the effects of television viewing finds that heavy viewing (defined here as more than 2–3 hours a day) is associated with hypertension, asthma, depression, and potentially higher rates of attention deficit disorder in early childhood.[657] There is also evidence of increased aggression among youth who are exposed to violent content. As Figure 6.6 shows, the correlation between

Figure 6.6
Correlation Between Media Violence and Aggression, and a Wide Range of Public Health Risks



SOURCE: Victor C. Strasburger, Amy B. Jordan, and Ed Donnerstein. "Health Effects of Media on Children and Adolescents." *Pediatrics*, Vol. 125, No. 2, April 2010, p. 759.

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[656] Steven Gortmaker et al., "Television Viewing as a Cause of Increasing Obesity Among Children in the United States, 1986–1990," *Arch Pediatr Adolesc Med.*, Vol. 150, No. 4, 1996, pp. 356–362.

[657] Victor C. Strasburger, Amy B. Jordan, and Ed Donnerstein, "Health Effects of Media on Children and Adolescents," *Pediatrics*, Vol. 125, No. 2, April 2010, p. 761.

media violence and aggression is in fact stronger than many commonly recognized public health risks. TV also simply takes time away from other activities.[658] In most cases, strong causal links have not been established but have been hypothesized.

Some studies also find that media use (including forms other than television) is also associated with less contentedness and more sensation seeking. One of these studies defines media use differently: low media use is less than 3 hours per day, moderate is 3–16 hours, and heavy is more than 16 hours (and therefore does not take into account multitasking). Contentedness is defined as agreement with statements like "I have a lot of friends," "I have been mostly happy at school this year," and "I get along well with my parents." The study notes a strong association between levels of media use and a lack of contentedness:

> As we move from the high- through the moderate- to the low-contentedness groups, at each step there is a statistically reliable increase in the amount of overall media exposure. Kids classified as low on the contentedness index report 1:22 more overall media exposure than those in the moderate group, and 1:37 more exposure than those in the high-contentedness group. A large portion of the difference in overall media exposure derives from low-contented kids' greater exposure to music and video games, but the pattern of more exposure with less contentedness holds for every medium except print.[659]

"Sensation seeking" describes a need for stimulation and risk taking. Indicators include agreements with statements such as "I like friends who are exciting, even if they are wild," "I sometimes choose friends my parents disapprove of," and "I like new and exciting experiences, even if I have to break the rules." Sensation seeking is also associated with higher media use:

> Sensation seeking is reliably related to TV exposure, music exposure, and overall media exposure. Both high and moderate sensation-seekers report more TV exposure than low sensation-seekers; although high sensation-seekers watch TV 27 minutes more daily than do moderate sensation-seekers, the difference is not statistically reliable. High sensation-seekers also report substantially more music listening and more overall media exposure than kids in either the low or moderate sensation seeking groups.[660]

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[658] Victor C. Strasburger, Amy B. Jordan, and Ed Donnerstein, "Health Effects of Media on Children and Adolescents," *Pediatrics*, Vol. 125, No. 2, April 2010, p. 759.

[659] In this passage, 1:22 means a 1 to 22 ratio and 1:37 means a 1 to 37 ratio. Victoria Rideout, Donald F. Roberts, and Ulla G. Foehr, *Generation M: Media in the Lives of 8–18 Year Olds*, Kaiser Family Foundation, March 2005, p. 51.

[660] Victoria Rideout, Donald F. Roberts, and Ulla G. Foehr, *Generation M: Media in the Lives of 8–18 Year Olds*, Kaiser Family Foundation, March 2005, p. 50.

Experts summarize the effects of media use on youth's behavior and health:

> More than 50 years of media research attests to the significant influence of media on child and adolescent health. Both "old" media (television, movies, magazines) and "new" media (the Internet and social networking sites, video/computer games, cell phones) can have an impact on virtually every health concern that practitioners and parents have about young people, including aggressive behavior, risky sexual behavior, substance abuse, and disordered eating. Although the media are not the leading cause of any of these problems, the research reviewed here suggests that they are significant.[661]

Nevertheless, there are also some possible positive outcomes of media use, depending on the content to which youth are exposed and for how long. For example, educational programming and programs that demonstrate diversity may teach empathy and tolerance. TV and other media can also be a medium for disseminating public and social information.[662] For example, one study found that 31 percent of teen Internet users have used the Internet to find health, dieting, or physical fitness information; 22 percent have used it to find information about a health topic that is difficult to talk about (e.g., with parents or friends); 30 percent have used it to look for a job online; and 26 percent have looked for religious or spiritual information.[663]

Effects of Heavy Media Use on Academic Performance and Learning Styles

The effects of media use on academic performance and learning styles may have particular relevance for the Army and its efforts to train a new generation of recruits. The research on academic performance is mixed. One report cites several studies that demonstrate a negative relationship between television viewing and other media use and academic performance.[664] However, another study found no statistically significant relationship between student's self-reported grades and their media use, even among heavy users (defined as those exposed to more than 13 hours of media use). The study explored possible explanations:

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[661] Victor C. Strasburger, Amy B. Jordan, and Ed Donnerstein, "Health Effects of Media on Children and Adolescents," *Pediatrics*, Vol. 125, No. 2, April 2010, p. 757.

[662] Victor C. Strasburger, Amy B. Jordan, and Ed Donnerstein, "Health Effects of Media on Children and Adolescents," *Pediatrics*, Vol. 125, No. 2, April 2010, pp. 756–767.

[663] Amanda Lenhart, Mary Madden, and Paul Hitlin, *Teens and Technology: Youth Are Leading the Transition to a Fully Wired and Mobile Nation*, Pew Research Center, July 27, 2005, p. vi.

[664] Victor C. Strasburger, Amy B. Jordan, and Ed Donnerstein, "Health Effects of Media on Children and Adolescents," *Pediatrics*, Vol. 125, No. 2, April 2010, p. 761.

> These findings—that is, the lack of strong negative relationships between most media use and grades—are somewhat surprising. Several earlier studies that reported a positive relationship between grades and reading, also found significant negative relationships between grades and exposure to other electronic media as well as to overall media exposure . . . It may be that as media become more and more integrated into the lives of young people, the differences once located by academic performance are attenuating. To the extent that this is the case, it appears to be because kids who earn higher grades are engaging in more media use. That is, there is no change from 1999 . . . to 2004 in the amount of media exposure among kids reporting fair or poor grades. Among those reporting good grades, however, media exposure has increased by 43 minutes, reducing the differences between the two groups in overall media exposure to the point that it is no longer statistically reliable. The upshot is that while there still seems to be a tendency for kids who earn high grades to spend slightly less time with media, the difference is not nearly as great as has been found in previous research.[665]

A subsequent study using similar methodology found, however, that heavy media use—defined here as more than 16 hours of media in a day—*is* associated with poorer academic performance. Nearly half of heavy media users said they got fair or poor grades, in comparison to only 22 percent of light media users (those who consume less than three hours of media). Thus the evidence is mixed with respect to the relationship between media use and achievement. It might not be so much just how long the use is, but rather how young people are using the media. For example, some teenagers may spend hours listening to music on their iPods or have the TV on while doing their homework, while others are just intensely playing online video games for long hours.

Generation M's media use may also more fundamentally affect learning styles and expectations. For instance, most students regularly multitask with media while doing homework, as shown in Figure 6.7. While there has been much concern that this multitasking limits concentration, productivity, and understanding,[666] in some circumstances it could be advantageous. Experts cite an anecdote from industry:

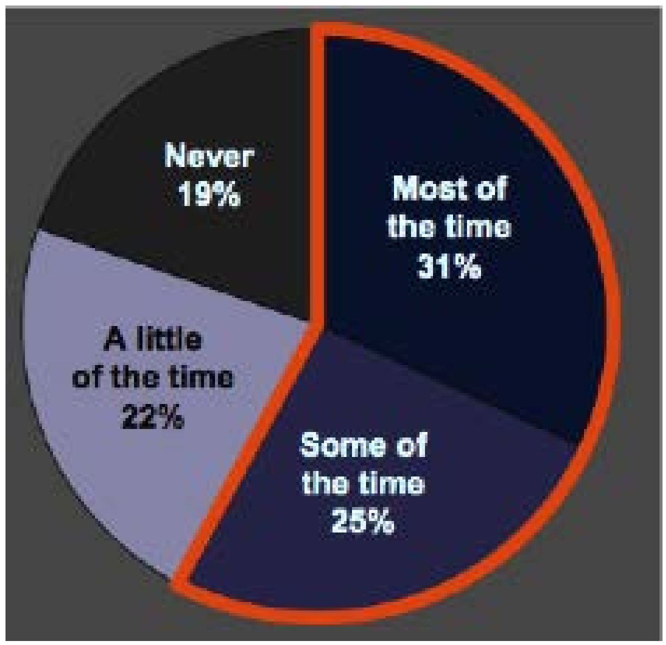
> Rebecca Ryan of Next Generation Consulting says she has recently gained a new appreciation for young workers' capacity to multitask even when it seems rude and inattentive. In an email, she explained: "We currently have an intern who's working on several critical projects. She's brilliant and a great fit for our

[665] Victoria Rideout, Donald F. Roberts, and Ulla G. Foehr, *Generation M: Media in the Lives of 8–18 Year Olds*, Kaiser Family Foundation, March 2005, p. 48.

[666] Lee Rainie, "Digital 'Natives' Invade the Workplace: Young People May Be Newcomers to the World of Work, But It's Their Bosses Who Are Immigrants into the Digital World," Pew Research Center, September 27, 2006, p. 4.

> team. At meetings, she's online the whole time. At first, I was totally put off by this—Why isn't she looking me in the eye? But then I realized that our 'to do' lists were a LOT shorter after these meetings because she would locate the information we needed in real time, which eliminated the need for a lot of follow-up work. So, something that I initially perceived as 'poor manners' on her part actually ended up being a great efficiency in our team meetings."[667]

Figure 6.7
Proportion Who Say They Use a Computer, Watch TV, Play Video Games, Text Message, or Listen to Music While Doing Their Homework



SOURCE: Victoria Rideout, Donald F. Roberts, and Ulla G. Foehr, *Generation M: Media in the Lives of 8–18 Year Olds*, Kaiser Family Foundation, March 2005, p. 34.

In a synthesis of research on learning styles of the "Net Generation," one study suggests that members of this generation also tend toward independence and autonomy in their learning styles and may also have a greater desire for active, engaged learning experiences:

> students express a need for more varied forms of communication and report being easily bored with traditional learning methods . . . [They also] need self-directed learning opportunities, interactive environments, multiple forms of

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[667] Lee Rainie, "Digital 'Natives' Invade the Workplace: Young People May Be Newcomers to the World of Work, But It's Their Bosses Who Are Immigrants into the Digital World," Pew Research Center, September 27, 2006, p. 4.

> feedback, and assignment choices that use different resources to create personally meaningful learning experiences.[668]

Related to this is their need for and expectation of immediate answers, which some researchers attribute to the heavy use of the Internet that provides instant information. An illustrative anecdote occurred at an elementary school in Australia, where during class a child asked about what kangaroos eat. The teacher said that she did not know and would get back to them later with an answer. One student rose from his seat and offered to find the answer through the web "real quick."[669]

Researchers have argued that today's students also lack information literacy and critical-thinking skills. They have difficulty finding and assessing large amounts of complex information that libraries and databases provide. Instead, they prefer simplistic but responsive web searches like Google. One study cites the experience of employers of this generation:

> Sandra Gisin, who oversees knowledge and information management at reinsurance giant Swiss Re, says her colleagues marvel at the speed with which younger workers communicate and gather information. Still, she has had enough bad experiences with credulous younger workers accepting information from the top link on a Google search result that she says the firm will begin new training programs next year to teach workers how to evaluate information and to stress that "not all the best information is free."[670]

The preference for simplistic, immediate answers could be a consequence of information illiteracy. Alternatively, information illiteracy could be a consequence of the availability of simplistic, immediate answers.

The trends toward independence, individualism, autonomy, and immediacy have led some to rename this cohort "Generation Me" or the "Entitlement Generation." Researchers have argued that this generation is more self-satisfied, has high expectations, is more materialistic, is more confident in their future performance, and has a greater desire for leisure than previous generations. For example, they are likely to agree with statements like "You shouldn't care what other people think of you" and "You should never give up on

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[668] Kassandra Barnes, Raymond C. Marateo, and S. Pixy Ferris, "Teaching and Learning with the Net Generation."

[669] L.E. Hay, "Educating the Net Generation," *The Social Administrator,* Vol. 57, No. 54, 2000, p. 9.

[670] Lee Rainie, "Digital 'Natives' Invade the Workplace: Young People May Be Newcomers to the World of Work, But It's Their Bosses Who Are Immigrants into the Digital World," Pew Research Center, September 27, 2006. p. 3.

your dreams." These can be positive traits but, in excess, may also lead to narcissism, overconfidence, and a sense of entitlement. Many might agree with statements like "I *deserve* the best" and "I should get an A because I tried hard."[671] However, some experts have disputed claims that this generation is different with respect to having a sense of entitlement, arguing that the inferences are based on anecdotal evidence and unreliable methodology.[672]

Importantly, it is difficult to generalize personal characteristics and traits to an entire generation, particularly given wide variations in upbringing. Specifically, we want to caution readers from generalizing too much from some of these trends regarding youth. Children are raised different ways. There are numerous anecdotes of children who are not allowed to watch much TV or use computers much and some who are not allowed at all. Some pediatricians and teachers also recommend parents restrict "screen time," especially with younger children, which some parents follow. There are also still parents who let their children play outside in the neighborhood and nature. In addition, there are examples of children who are very understanding and sensitive to other people's needs and do not feel so entitled.

Excessive and Addictive Use of the Internet

As use of media increases, there is a growing concern about *addiction* to activities enabled by the media, particularly to activities on the Internet. "Problematic Internet Use" (PIU) is the term used to describe addictive or excessive use of the Internet.[673] These concerns have been fueled by cases of excessive Internet use leading to divorce, child neglect, and job losses, as well as health effects like seizures.[674] For example in 2010, a Florida woman pleaded to second degree murder for shaking her 3-month-old baby to death. The woman apparently became angry with the baby because it was crying while she was playing the game *Farmville* on Facebook.[675] A South Korean couple was also prosecuted for allowing their 3-month-old

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[671] Jean M. Twenge, "Generational Changes and Their Impact in the Classroom: Teaching Generation Me," *Medical Education*, Vol. 43, May 2009, pp. 398–405.

[672] Kali H. Trzesniewski, M. Brent Donnellan, and Richard W. Robins, "Is 'Generation Me' Really More Narcissistic Than Previous Generations?" *Journal of Personality*, Vol. 76, No. 4, August 2008, pp. 903–918.

[673] Other people use the term "compulsive Internet use" for PIU. Throughout this discussion we use the tern PIU.

[674] Jennifer Czincz and Regina Hechanova, "Internet Addiction: Debating the Diagnosis," *Journal of Technology in Human Services*, Vol. 27, No. 4, October 2009, p. 258.

[675] David Hunt, "Jacksonville Mom Shakes Baby for Interrupting Farmville, Pleads Guilty to Murder," *The Florida Times-Union*, October 27, 2010.

baby to starve to death because they were obsessed with raising their "virtual child" online and did not feed their real baby.[676] There have even been some documented cases of death due to prolonged online gaming sessions.[677]

For the purposes of diagnosis, PIU can be defined in a variety of ways. Most simplistically, PIU may also be defined in terms of time spent online. This is not a reliable measure of behavior, however, because many people's work or study depends upon Internet use. PIU can instead be defined as a behavioral addiction like gambling, where one is preoccupied with a behavior or has loss of control over the behavior, which leads to functional impairments. It can also be defined in terms of impairments to daily life—e.g., disruptions in menial daily tasks or debilitating problems at work or in relationships. PIU may be described in terms of the activities that one engages in online excessively—predominantly interactive activities such as gaming or chat rooms.[678]

The incidence of PIU is largely unknown, but one study based on a telephone survey suggests an incidence rate of 0.3–0.7 percent in the general American population.[679] However, certain factors may affect one's risk of PIU. Age is an important factor, and adolescents have the highest risk, since they are still in the process of psychological maturation.

A survey of research suggests a correlation between PIU and a number of other health concerns and pathologies.[680] This includes depression,[681] attention deficit/hyperactivity disorder, obsessive-compulsive disorder, social phobia, and substance dependence.[682] PIU is

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[676] "Couple Let Baby Starve to Death While Raising Virtual Baby Online," *The Huffington Post*, May 5, 2010.

[677] For example, see "South Korean Dies After Game Sessions." *BBC News*, August 10, 2005.

[678] Jennifer Czincz and Regina Hechanova, "Internet Addiction: Debating the Diagnosis," *Journal of Technology in Human Services*, Vol. 27, No. 4, October 2009, pp. 260–262.

[679] Martha Shaw and Donald W. Black, "Internet Addiction: Definition, Assessment, Epidemiology and Clinical Management," *CNS Drug*s, Vol. 22, No. 5, 2008, pp. 353–365.

[680] Jennifer Czincz and Regina Hechanova, "Internet Addiction: Debating the Diagnosis," *Journal of Technology in Human Services*, Vol. 27, No. 4, October 2009, p. 260–262.

[681] Kyunghee Kim, Eunjung Ryu, Mi-Young Chon, Eun-Ja Yeun, So-Young Choi, Jeong-Seok Seo and Bum-Woo Nam, "Internet Addiction in Korean Adolescents and Its Relation to Depression and Suicidal Ideation: A Questionnaire Survey," *International Journal of Nursing Studies*, Vol. 43, Issue 2, February 2006, pp. 185–192.

[682] J. Korkeilaa, S. Kaarlasa, M. Jääskeläinenc, T. Vahlbergd, and T. Taiminene, "Attached to the Web—Harmful Use of the Internet and Its Correlates," *European Psychiatry*, Vol. 25, Issue 4, May 2010, pp. 236–241; and Jennifer Czincz and Regina Hechanova,

also associated with increased aggression and hostility. Some studies find this to be true only in males, and not in females.[683] Others find this link stronger in males but also present in females.[684]

It is not clear, however, what the causal relationship between PIU and these other disorders is: does PIU cause these disorders, do these disorders encourage PIU, or are they both governed by other factors?

Importantly, certain factors such as age, gender, and personality are associated with PIU. Research suggests that adolescents are at highest risk for developing PIU since they are still maturing and are vulnerable to addictive behaviors. Research also consistently shows that males are at a higher risk of developing PIU than females, though the reasons for this difference are not well understood. Potential explanations include that men are more likely to use the Internet than women (globally) and that men are more likely to use highly interactive tools like chat rooms and video games. PIU is also associated with certain personality traits like shyness, low self-esteem, and a lack of social skills. It is possible that the Internet is appealing to those who struggle socially because it is perceived to offer an anonymous, safe environment.[685]

Culture may also play a role in the incidence of PIU, though these links are tenuous. PIU has been observed in nations throughout the world, including the United States, Asia, and Europe, and across cultural boundaries.[686] However, some researchers have found that individualist versus collectivist societies can affect Internet behavior,[687] and that young

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"Internet Addiction: Debating the Diagnosis," *Journal of Technology in Human Services*, Vol. 27, No. 4, October 2009, p. 260–262.

[683] Ju-Yu Yen et al., "The Comorbid Psychiatric Symptoms of Internet Addiction: Attention Deficit and Hyperactivity Disorder (ADHD), Depression, Social Phobia, and Hostility," *Journal of Adolescent Health*, Vol. 41, Issue 1, July 2007, pp. 93–98.

[684] Chih-Hung Ko, Ju-Yu Yen, Shu-Chun Liua, Chi-Fen Huanga, and Cheng-Fang Yen, "The Associations Between Aggressive Behaviors and Internet Addiction and Online Activities in Adolescents," *Journal of Adolescent Health*, Vol. 44, Issue 6, June 2009, pp. 598–605.

[685] Jennifer Czincz and Regina Hechanova, "Internet Addiction: Debating the Diagnosis," *Journal of Technology in Human Services*, Vol. 27, No. 4, October 2009, pp. 260–262.

[686] F. Cao, L. Su, T. Liu, and X. Gao, "The Relationship Between Impulsivity and Internet Addiction in a Sample of Chinese Adolescents," *European Psychiatry*, Vol. 22, pp. 466–471, 2007.

[687] B. Young, "Diffusion and Usage Patterns of the Internet in Korea and Japan: A Comparison of Policy and Cultural Factors," *Development and Society*, Vol. 33, 2004, pp. 229–250.

people who come from collectivist, hierarchical, family-focused societies are able to socialize independently for the first time through the Internet. "It is possible that the opening up of this 'new world' may put youth living in collectivist societies at higher risk for the development of PIU."[688]

While these traits may provide important insights into vulnerabilities of different populations, it is important to remember that PIU crosses gender, age, cultural, wealth, and other boundaries. However, there are concerns about the growing rates of potential Internet addiction problems among adolescents and youth throughout many countries in the world. For instance, researchers are studying Internet addiction problems and rates among youth in Greece,[689] North Cyprus,[690] Norway,[691] Netherlands,[692] Taiwan,[693] China,[694] and South Korea,[695] just to name a few.

Importantly, the incidence of PIU, especially among youth, may be high. For example, a random sample of 2,000 high school students in Taiwan found that 338 participants (17.9 percent) could be classified as having PIU. These students used the Internet more than 20 hours a week and spent significant amounts of time in online gaming.[696] While much

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688 Jennifer Czincz and Regina Hechanova, "Internet Addiction: Debating the Diagnosis," *Journal of Technology in Human Services*, Vol. 27, No. 4, October 2009, pp. 265–266.

689 See, for example, Konstantinos E. Siomos et al., "Internet Addiction Among Greek Adolescent Students," *CyberPsychology & Behavior*, Vol. 11, No. 6, 2008.

690 See, for example, F. Bayractar and Z. Gun, "Incidence and Correlates of Internet Usage Among Adolescents in North Cyprus," *CyberPsychology & Behavior*, Vol. 10, 2007.

691 See, for example, A. Johansson et al., "Internet Addiction: Characteristics of a Questionnaire and Prevalence in Norwegian Youth (12–18 years), *Scandinavian Journal of Psychology*, 2004.

692 Antonius J. Van Rooij et al., "Compulsive Internet Use: The Role of Online Gaming and Other Internet Applications," *Journal of Adolescent Health*, Vol. 47, 2010, pp. 51–57.

693 For examples of the range of Internet problems being studied in Taiwan, see Chin-Sheng Wan and Wen-Bin Chiou, "Why Are Adolescents Addicted to Online Gaming? An Interview Study in Taiwan," *CyberPsychology & Behavior*, Vol. 9, No. 6, 2006; and Chin-Shan Wu and Fei-Fei Cheng, "Internet Café Addiction of Taiwanese Adolescents," *CyberPsychology & Behavior*, Vol. 10, No. 2, 2007.

694 G. Gao and L. Su, "Internet Addiction Among Chinese Adolescents: Prevalence and Psychological Features," *Child Care Health and Development*, No.33, 2007.

695 See, for example, Moon-Soo Lee et al., "Characteristics of Internet Use in Relation to Game Genre in Korean Adolescents, *CyberPsychology & Behavior*, Vol. 10, No. 2, 2007.

696 Ju-Yu Yen et al., "The Comorbid Psychiatric Symptoms of Internet Addiction: Attention Deficit and Hyperactivity Disorder (ADHD), Depression, Social Phobia, and Hostility," *Journal of Adolescent Health*, Vol. 41, Issue 1, July 2007, pp. 93–98.

research addresses the nature of PIU in Asia, such findings suggest that PIU may be high in the United States as well.

Additionally, some researchers are finding that online video game playing, especially MMORPGs,[697] may be more subject to addiction than other forms of Internet use.[698] In South Korea, adolescent "excessive online game use, especially has emerged as a major social concern due to the social and family conflicts."[699] Researchers also are exploring what make such games more addictive and found three key aspects to the MMORPGs that likely make them more addictive than other Internet use. First, such online video games share characteristics of gambling games, like slot machines, that have a role in "pathological gambling." "For example, games contain aural and visual stimulus rewards, peer group attention and/or approval, the requirement of total concentration, the keeping of a digital score, and incremental rewards for winning which reinforce 'correct' behavior."[700] Second, such games offer strong social interaction, pressure, and rewards. As one group of researchers put it, MMORPGs "are run continuously in real time on the Internet. They feature strong social and competitive aspects, making devotion to the game mandatory."[701] Third, such online games usually require more time than offline games, "especially, online role-playing games (in which the gamer develops a character over time) are very time consuming.[702]

Some researchers in Taiwan have also been studying the psychological needs and motivations of adolescents who are addicted to online gaming. They have categorized them into seven themes:

- Entertainment and leisure,
- Emotional coping (diversions from loneliness, isolation and boredom, releasing stress, relaxation, discharging anger and frustration),
- Escaping from reality,

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[697] MMORPGs were explained in Chapter Five in the background section of the online communities discussion.

[698] See for example, Antonius J. Van Rooij et al., "Compulsive Internet Use: The Role of Online Gaming and Other Internet Applications," *Journal of Adolescent Health*, Vol. 47, 2010, pp. 51–57.

[699] Moon-Soo Lee et al., 2007, p. 278.

[700] Antonius J. Van Rooij et al., 2010, p. 52.

[701] Moon-Soo Lee et al., 2007, p. 279.

[702] Antonius J. Van Rooij et al., 2010, p. 52.

- Satisfying interpersonal and social needs (making friends, strengthening friendships, and generating a sense of belonging and recognition),
- The need for achievement,
- The need for excitement and challenge, and
- The need for power (the sense of superiority, the desire for control, and facilitation of self-confidence).[703]

These and other researchers also point out that those who become addicted to MMORPGs often are finding such things in this virtual world because they can't or don't think they can find them in their real lives. For example, some researchers state that "the type of individual most likely to be susceptible to such games . . . [is] somewhat marginalized socially, perhaps experiencing high levels of emotional loneliness and/or difficulty with real life social interactions."[704]

It is important to note that some researchers have also found that "social networking" has the "strongest association" with PIU "after gaming and shows a strong increase in use."[705]

Obviously, some of this research is fairly recent, and more studies need to be done to understand the nature and extent of PIU. However, these trends tend to indicate that PIU is a growing concern, especially with youth. As MMORPGs and social networking use grows, PIU is most likely, when combined with other trends about youth, to grow as well.

Implications for the Army

Next we discuss the implications of these societal trends for the Army of today and the future. Collectively, these trends may have many implications for Army installations. It is clear that a higher percentage of youth are overweight and less physically fit than in previous generations. Other trends are less clear, and we must be careful in generalizing. However, there are indications that among today's youth a higher percentage may have less-developed social and coping skills, lower self-esteem, and excessive Internet use and addiction

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[703] Chin-Sheng Wan, and Wen-Bin Chiou, 2006, p. 763.

[704] From U.S. Council on Science and Public Health, *Emotional and Behavioral Effects, Including Addictive Potential, of Video Games*, CSAPH Report 12-A-07, 2007, p. 4. See also S.E. Allison et al., "The Development of the Self in the Era of Internet and Role-Playing Fantasy Games," *American Journal of Psychiatry*, Vol. 163, 2006, , pp. 381–385; and Brian D. Ng and Peter Weimer-Hastings, "Addiction to the Internet and Online Gaming," *CyberPsychology & Behavior*, Vol. 8, No. 2, 2005, pp. 110–113, 2005.

[705] Antonius J. Van Rooij, 2010, p. 55.

problems. Youth are also more likely to expect instantaneous access to information, expect learning and information to be entertaining, multitask regularly, have less patience with slow procedural processes, and want more constant communication with friends and family.

However, to better discuss such implications, we also discuss the current Army context. Then we discuss recommendations for the Army.

Societal Changes Being Reflected in Today's Army

Already the Army is experiencing the effects of some of these societal changes, such as more recruits who are not as physically fit. As the Army's deputy surgeon general and others have stated, their recruits have changed, namely, "current enlistees grew up on the couch playing video games, rather than horsing around outside."[706]

> "You'd be surprised, the soldiers that we get today," says Frank Palkoska, who directs the Army's fitness school. "They can't do simple motor function movements, like a shoulder roll, the ability to skip—so we've got to lay a base of foundational fitness, without injuring them."[707]

Army organizations like MEDCOM and training posts have placed greater emphasis on nutrition and fitness because of such external society trends regarding weight and nutrition problems. Similarly, the Army's physical fitness programs are emphasizing social, family, emotional, spiritual, and physical fitness, and even nutrition to better address such Soldier fitness needs, as seen in the Comprehensive Soldier Fitness (CSF) Program. The physical dimension of CSF is defined as "Performing and excelling in physical activities that require aerobic fitness, endurance, strength, healthy body composition and flexibility derived through exercise, nutrition, and training."[708]

Other RAND research also has found some indications regarding some of the other trends discussed here. We briefly provide some background about this work. RAND conducted a study for ACSIM to examine demands for individual and family support and how these are changing in the face of lengthy, repeated deployments, availability and sufficiency of support services, and alternatives and resource requirements for improving installation services. For this study, RAND researchers held 60 focus groups with Soldiers, spouses, and service providers at installations and Reserve Component events across the country and interviewed about 100 installation and military staff. Total people interviewed

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[706] Frank Morris, December 28, 2010.
[707] Frank Morris, December 28, 2010.
[708] U.S. Army, "Comprehensive Soldier Fitness," undated.

and in the focus groups numbered over 730.[709] These focus groups and interviews helped RAND researchers to understand the range of problems and needs that Soldiers and Families face, identify the best installation practices that are being implemented to address such problems, and identify the most promising and feasible ideas to address the wide range of problems and needs. During these interviews and focus groups there were some indications of a changing sense of Army community, anecdotal evidence that some younger Soldiers lack coping and social skills, and anecdotal examples of video game and Internet addiction problems.

Changing Sense of Army Community

In these interviews and focus groups, RAND researchers heard that the sense of Army community and culture has changed. RAND researchers heard from numerous Soldiers, spouses, and service providers at multiple installations who have had long-term experience with the Army (either because they come from a military family or they have been in for a long time) that the Army's sense of community has been decreasing. They gave several examples of this trend. Unit leaders are focused so much on the mission, requirements, and benchmarks that they spend less time on the people side. As a result, for some Soldiers and spouses, the leadership is perceived as no longer encouraging community on the installation. Soldiers stated that many unit leaders no longer socialize after hours with Soldiers; nor do they inspect the barracks or military family housing areas as much; nor do they watch over the young Soldier as much. For example, one NCO at a large rural installation, recalling how NCOs used to look out for the young Soldiers to keep them from getting in trouble with such issues as weekend drinking or brawling, stated that now many of the NCO take the attitude "if they [the Soldiers] get in trouble the county police can handle it." More people living off post contributes to this sense of lack of community. RAND researchers heard repeatedly that other than in the housing areas the post becomes a "ghost town after 5:00 pm." Some spouses and FRG leaders point toward the trend away from Army caring and community as well. For example, spouses at different installations stated that Army families used to take care of Army families in the past, but this is less true today. Other spouses and FRG leaders commented that there are fewer intimate events, like neighborhood barbeques, and that personal, one-on-one FRG communications have been replaced by mass emails,

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[709] For more information about these interviews and focus groups, see Appendix B and Beth E. Lachman et al., *Helping Soldiers and Families Cope with the Stress of War*," Santa Monica, CA: RAND Corporation, forthcoming.

which by their nature are less personal and reduce FRG leaders' information on the particular problems and needs of the families in their groups.

This changing sense of Army community fits in with the broader U.S. sense of community that is no longer so place-based, instead consisting of individual multi-dimension support networks of friends and relatives in more places and connected by modern communications tools such as cell phones and the Internet. It also fits with the fact that because of such networks people are less connected with any single group, including the Army. Additional evidence from the interviews and focus groups occurred in discussion with some younger Soldiers and spouses of how tools like Facebook and Skype help them stay in contact with their spouse, friends, family, and other support networks during deployment. Some other Soldiers and Families anecdotally mentioned how they relied on other social networks for support, such as through their off-post communities, churches, and family members living in other states. Having such additional support networks can actually be a beneficial thing for many Soldiers and Families, especially during deployments.

Given such community and support network changes in society and as they are reflected in today's Army, what does this mean for the Army? Since such trends appear to be continuing, it is likely that fewer Soldiers and Families in the future will feel as connected and part of the Army family, and that they will increasingly rely on a broader network of support from outside interest groups and friends. This means the Army will have to work harder to develop a strong sense of Army community and accept the fact that many may not choose to identify with the Army as much. It also means that broader communities of support will become more important to Soldiers and their Families and that ACS and other parts of the Army need to be tied into communities more. Partnerships with other support systems for Soldiers and Families are likely to become more important.

Some Young Soldiers, Especially Single Ones, Lack Social and Coping Skills, and Expect More

NCOs, service providers, and others in the focus groups and interviews also consistently stated how many younger Soldiers, especially the single ones, often lack coping and social skills, as well as maturity and responsibility. For example, one chaplain from Fort Carson discussed how young single Soldiers often lack coping and social skills and stated that they "know how to text and play video games, but when problems arise they do not know how to deal with them." A senior MEDCOM social worker/counselor at another installation summed it up by saying, "The coping skills of these junior soldiers is not very high."

RAND researchers also heard how life in the barracks can contribute to some single Soldiers being more isolated, withdrawn, and depressed. As one enlisted Soldier at one installation said, "The barracks will kill you. . . . I have no social life." Often many single Soldiers go back to their rooms alone with their video games, televisions, and computers. Housing service providers at Fort Hood described how they no longer need common rooms in barracks because Soldiers no longer use them, instead spending so much time in their rooms alone.

RAND researchers also heard from some Soldiers, spouses, and service providers at multiple installations who have had long-term experience with the Army that they saw more young Soldiers and Families who feel that the Army is a job and not a career. There is a also a sense that young recruits want a lifestyle that they cannot afford and simultaneously lack coping skills, life skills, and a sense of personal responsibility.

RAND researchers also heard how some Soldiers and their Families expect more and feel they are entitled to more support and services from the Army. For example, some service providers reported that more spouses now say things like "My husband is deployed so you owe us this," and some Soldiers say "I was being shot at and deserve . . ." This sense of entitlement was seen as stronger among the younger Soldiers and Families. For example, a Soldier at one installation stated "There is a greater sense of entitlement. I joined with little expectations except to work hard. Kids now don't even try."

Such comments are anecdotal evidence, but could they be a reflection of some of these trends with youth, that a greater percentage may lack coping and support skills and expect more out of the Army? Other reasons could account for some of these differences as well, such as Army recruiting methods in an all-volunteer force that persuades young people to join the Army because of the numerous benefits they will receive, thus leading them to expect the Army to provide them with more support and services. No matter the specific reasons, such trends are likely to continue, and the Army needs to be prepared to deal with them.

Anecdotal Examples of Video Game and Internet Addiction Problems Within the Army

During the interviews and focus groups RAND researchers also heard anecdotal examples of how video games and excessive Internet use is becoming a problem in today's Army. Excessive video game and Internet use, along with alcohol abuse and drug abuse, were mentioned as problems for some Soldiers. Alcohol, video games, and Internet use were viewed as ways of coping with deployment stresses. Some Soldiers use such diversions as recreation, to self-medicate, and to escape from their stresses. One medical professional from an installation hospital stated how she thought the Soldiers used video games in excess to self-medicate in dealing with post traumatic stress (PTS) and other emotional problems.

Many Soldiers felt these activities are widely accepted and experienced by many Soldiers until they become excessive and cause problems in their lives. For example, at another installation a Soldier told us how a fellow Soldier from that post is now in jail at Fort Leavenworth because he fell asleep on duty and neglected his baby because he was playing video games all the time. The Soldier's 9-month-old child weighed only 8 pounds. Another Soldier recalled how when she was deployed in Iraq, her National Guard commander banned video games because some Soldiers played over four hours a day, having friends bring them food so they could keep playing, to the extent that some "couldn't pass their PT tests anymore." An ACS family support provider described how some deployed Soldiers "get hooked" on video games, especially World of Warcraft, when deployed and then see it cause relationship problems with spouses and families when they return because they continue to devote long hours to the game.

Since young men are more at risk of PIU and the Army recruits so many Soldiers from this population, PIU might become a significant issue of concern for the Army in the future, as problems with alcohol and drug abuse are today. Given the addictive nature of online games, especially MMORPGs like World of Warcraft, and that more and more teenagers are playing such games, and how much Soldiers already seem to be playing such games, it is likely that PIU is already a problem today and likely will become a more significant concern for the Army of the future.

Recommendations for the Army Given Such Societal Trends

Given such societal trends and some of these insights about today's Army, we present some recommendations for the Army. First, for all the trends the Army should continue to track and monitor such changes as they evolve, especially among young people.

Second, Army Community Service (ACS), mental health, and other installation support and services will likely have to deal with more Soldiers and Families having potentially more needs related to less developed social and coping skills, lower self-esteem, and Internet addiction problems. However, it is unclear how widespread such issues are or will become, but they are likely to increase. The Army should try to monitor and study these issues more to understand the need. Where needed, ACS staff, Child, Youth and School (CYS) services staff, and other service providers should do more to try to support and educate younger people who may not have as strong social and coping skills and other emotional issues.

MEDCOM should do clinical research about PIU in the Army to see how widespread a problem it is and develop appropriate interventions. Medical professionals, ACS and CYS Services staff, and other support staff should be educated more and on the lookout for signs of PIU so that appropriate interventions and support can be provided. If PIU seems to be a problem, IMCOM staff could work with Army Substance Abuse Program (ASAP), Army Continuing Education System Division, Department of Defense Dependents Schools (DoDDS), and MEDCOM staff on formulating awareness and prevention programs to mitigate the preponderance of Internet addiction.

ACS and other installation support and service providers should strengthen community relationships, locally as well as regionally and nationally. Given how Soldiers and Families will likely depend more on their broader community and social networks, Army installation support staff relationships with broader support communities will become more important.

The Army will also need to place more emphasis on nutrition and physical exercise education and activities. Army activities like the Comprehensive Soldier Fitness Program should continue and be expanded. Sustainable transportation activities that promote more daily exercise such as walking, bike riding and using mass transit for commuting, as discussed in Chapter Three, can also potentially help reduce overweight trends in adults and children and contribute to healthier lives. There also is potential synergy here with sustainable agriculture trends, like CSA and buying more produce from local farmers, which we discussed in Chapter Three.

Lastly, the Army will need to adapt communication styles, approaches, and media technologies to better address youths' expectations. This includes more use of online communities, such as Facebook, as well as iPhone/iTouch apps. The chapter on information technologies, Chapter Five, explores this issue more.

Sources for Tracking Societal Trends

A number of books provide useful information on these trends. In his book *Bowling Alone: The Collapse and Revival of American Community*, Putnam describes the deterioration of American local civil life and offers potential solutions to this problem such as community programs and education.[710] Louv, in his book *Last Child in the Woods*, reviews the changing role of nature in children's lives, and the implications of those changes on childhood, society, nature, and the future.[711] In the book *Generation Me: Why Today's Young Americans Are More Confident, Assertive, Entitled—and More Miserable Than Ever Before*, Twenge explores how

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[710] Robert Putnam, *Bowling Alone: The Collapse and Revival of American Community*, New York: Simon and Schuster, 2000.

[711] Richard Louv, *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder*, Chapel Hill, NC: Algonquin Books, 2008.

today's youth could be considered more individualistic, narcissistic, and self-important than previous generations.[712]

The Ann E. Casey Foundation sponsored a study entitled *The Role of Social Capital in Building Healthy Communities* that examines the link between social capital and healthy communities. the See Ann E. Casey Foundation website at: http://www.aecf.org/upload/publicationfiles/cc3622h755.pdf.

In addition, the *Journal of Planning Literature* explores issues such as the role that community participation plays in the importance of place attachment.

Several institutions have conducted studies on "Generation M," such as the Kaiser Family Foundation, which has undertaken a series of studies on media use and other characteristics. These were undertaken in 1999, 2004, and 2009.[713] See the Kaiser Family Foundation "Generation M" website: http://www.kff.org/entmedia/entmedia030905pkg.cfm.

The Pew Research Center is a nonpartisan "fact" tank that provides facts and data but does not make policy recommendations. The Pew Research Center has an extensive project on "Millennials"—those who transitioned into adulthood at the turn of the century. Their work tracks attitude and behavioral differences between this generation and past generations.[714]

The Berkman Center for Internet and Society at Harvard University is a research center that focuses on various issues related to cyberspace, including governance, privacy, intellectual property, antitrust, content control, and electronic commerce. The Berkman Center also has a "youth and media" project that focuses on "Digital Natives"—those who grew up with digital technologies.[715]

The Center on Child and Media Health at Children's Hospital Boston, Harvard Medical School, and Harvard School of Public Health focuses on understanding and responding to

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[712] Jean Twenge, *Generation Me: Why Today's Youth are More Confident, Assertive, Entitled—and More Miserable Than Ever Before*, Free Press, 2006.

[713] Roberts, Ulla G. Foehr, Victoria Rideout, and Mollyann Brodie, *Kids & Media @the New Millennium*, Kaiser Family Foundation, November, 1999; Victoria Rideout, Donald F. Roberts, and Ulla G. Foehr, *Generation M: Media in the Lives of 8–18 Year Olds*, Kaiser Family Foundation, March 2005; Victoria Rideout, Ulla G. Foehr, and Donald F. Roberts, *Generation M^2: Media in the Lives of 8–18 Year Olds*, Kaiser Family Foundation, January 2010.

[714] Pew Research Center, "Millennials: A Portrait of Generation Next: Confident, Connected, Open to Change," Washington, D.C.: February 24, 2010.

[715] See http://cyber.law.harvard.edu/research/youthandmedia/digitalnatives

the effects of media on children. The center has a searchable website that catalogs the results of various studies that assess the impact of media on children.[716]

There are also a number of journals devoted to societal and youth trends. For example, the *Journal of Community Psychology* deals with a wide range of research on human behavior in community settings.[717] *Youth and Society* includes a wide range of articles on the broad social and political implications of youth culture, including media use.[718] The *Journal of Adolescent Health* focuses on adolescent medicine and health and publishes articles on issues such as attention deficit hyperactivity disorder (ADHD), obesity, and the implications of children's exposure to media.

There are also several journals that focus specifically on the impact of media on children and adolescents. For instance, the *Journal of Children and Media* explores how children consume media, how the media represents children, and media organizations and productions for and by children.[719] The journal *CyberPsychology, Behavior and Social Networking* focuses on the topic of Internet addiction as well as other topics such as epidemiological studies of Internet use and behavior, cyberbullying, and virtual reality therapy.[720] Lastly, the journal *Computers in Human Behavior* examines the use of computers from a psychological perspective.[721]

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[716] See http://www.cmch.tv/SearchAdvanced2.aspx

[717] See http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1520-6629/homepage/ProductInformation.html

[718] See http://yas.sagepub.com/content/current

[719] See http://www.tandf.co.uk/journals/titles/17482798.asp

[720] See http://www.liebertpub.com/products/product.aspx?pid=10

[721] See http://www.elsevier.com/wps/find/journaldescription.cws_home/759/description

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CHAPTER SEVEN
Conclusions and Main Recommendations

In this chapter we present the overarching conclusions and recommendations for this study. We begin by discussing the general and cross-cutting conclusions and then we discuss findings and recommendations in each of the trend areas examined in depth for this study.

Overarching Conclusions

In examining external trends to Army installations out to the year 2025, we found that such trends are likely to impact installations in many different ways and in many different areas. Trends have the potential to cause harm to installation operations including testing, training, and constructing activities; to cost or save the Army significant amounts in the future; to hurt or improve Soldier and Family quality of life; to improve installation operations; to help meet future installation requirements; and to improve or hurt environmental conditions. The different areas include: sustainable buildings, climate change, energy, information technologies, loss of biodiversity, societal trends, sustainable agriculture, sustainable communities, transportation, urbanization and sprawling communities, and water scarcity.

The Army also has the ability with strategic actions to mitigate potentially negative consequences on Army installations from the trends and to take advantage of the potentially beneficially opportunities from the trends. It is important that the Army consider and implement the types of actions identified in this study both in the near term and in its strategic planning to help save costs, to preserve installation operational flexibility, improve Soldier and Family quality of life, and to help meet installation requirements.

Army Process Needed for Tracking Trends

Since the external trends are likely to change and evolve over time, have the potential to impact Army installations in both positive and negative ways in many different areas, and have uncertainty associated with them, the Army installation community needs to continue to monitor and track such trends.

This study provides a methodology and process the Army can use to continue to examine these trends in the future. The Army should continue to examine these trend areas, and new ones as they become more relevant for installations, and assess their implications for Army installations and actions. For each trend area, the Army should continue to examine the types of trends discussed, using the sources identified here and others as they become relevant, and update the answers to the following key questions used in this study:

- What is the likely trend given current conditions?
- What evidence indicates that the trend will continue?
- What could change the course of the trend?
- How does it relate to other trends?
- What are the potential effects on Army installations, both positive and negative, and how significant might they be?
- What is the Army context regarding the trend?
- Given this analysis, what actions, if any, should the Army be taking regarding the trend?

This type of process, applied on a regular basis for the trend areas, will help the Army installation community continue to appropriately address such issues in its installation actions and strategic planning. How soon to reassess a trend will vary depending on its nature and its evolving circumstances. For instance, "online communities" is an quickly evolving area for which it is hard to predict the future, so it would need to be reassessed sooner than, say, "loss of biodiversity," which is a fairly predictable and consistent trend. If there is some major technological breakthrough, such as really cheap solar cells being developed, or significant policy or societal change, such as passing of major climate change legislation, it would be a good time to reassess trends that are affected by that change.

Cross Cutting Issue: Community Relationships Becoming More Important to Army Installations

We also identify an issue that cuts across many different trend areas: community relationships. These community relationships include the local community, broader regional communities, and networks of communities with a shared interest, such as supporting Army Soldiers and Families or collaborating in regional ecosystem management.

First, we noticed that communities are likely to be more interested in installation operations than they have in the past, and this is likely to continue into the future. This community attention is due to a number of reasons: installations are no longer as isolated as they used to be; communities have grown around them, often reducing open space; and many communities are less economically dependent on the installation. In addition, Americans expect and want more of all public lands, including military installations. This results in the public and surrounding communities expecting more from Army installations.

For example, as the amount of undeveloped land in a region declines, the community looks at a large post and wants a piece of it for a highway, park, landfill, or other function. This is true for other Services' installations as well. Other examples of public interests include hunting, fishing, and grazing access, and concerns about training noise. Because of such public interests in installations, Army installations will need to spend more time on community relationships.

Second, community relationships are becoming a more important part of the job of addressing the influences of external trends and their likely impact on installations, from the need to work with communities to prevent encroachment from sprawling home developments, to working together on water scarcity and conservation issues, to regional collaborative ecosystem management to prevent biodiversity loss. Community relationships are also important for addressing transportation concerns and Soldier and Family quality of life issues. In the later case, we found that Soldiers and Families are relying more and more on a network of broader communities for support. As was seen in the recommendations in many of these different trend areas, the need to consider local, regional, and far-flung networks of communities with common interests and to collaborate with them will become more and more important in the future.

Trend Area Conclusions and Recommendations

In this section we summarize each trend area and Army recommendations for it. To help identify priority actions for the Army installation community today we created different categories of actions based on the likely impact the trends will have on the Army in the future. Specifically, the trends in this study fall into the following six categories:

1. Treat strategically now to avoid future harm to military operations.
2. Treat strategically now to avoid high future costs.
3. Treat strategically now to improve capability to meet future regulations and installation requirements.
4. Treat sooner because of the opportunity to get some benefits, such as:
    a. Save money over the long term.
    b. Improve Soldier and Family quality of life.
    c. Improve installation operations.
    d. Improve environmental quality.
5. Trend requires additional research or studies to better understand its impact on the Army and Army installations.

6. Trend requires tracking, but not immediate action.

It is important to note three things: first, the assignment of a trend to a category is generalized based on likely main trend impacts; second, some trends fall across multiple categories; and third, each of these trend areas is complex and a fuller discussion of its implications can be found in its respective chapter. Table 7.1 shows which trends fall in each category. Red in this table means the trend is likely to have a more significant impact in that area, and likely to require higher-priority actions given that category concern. For example, the trend area "sustainable buildings" is likely to imply significantly higher potential future costs if not considered soon; this trend area is likely to have some effect on the categories of meeting future regulations and requirements and opportunity for benefits, but they are not ranked as significant in terms of near-term actions.

Table 7.1
Trends Examined and Their Potential Impact

	Trend Category					
Trend Area	**1: Avoid Future Harm to Operations**	**2: Avoid High Future Costs**	**3: Meet Future Require-ments**	**4: Opportunity for Benefits**	**5: Additional Study**	**6: Tracking but No Action**
Loss of biodiversity						
Urbanization, increased development, and sprawling communities						
Sustainable buildings						
Energy						
Sustainable transportation						
Water scarcity						
Sustainable communities						
Societal trends						
Sustainable agriculture						
Online communities						
Climate change						
Robotics						
Pervasive computing						

Red = high priority/impact. Gray = important but requires less urgency of action.

Most Urgent Trends

During our analysis, we found several high priority/impact actions that the Army can take now to address the trends examined in our study. We summarize some of these key actions here and discuss them more in the trend recommendations. For instance, in order to avoid restrictions on installation testing, training, and construction operations and high future costs, we recommend that the Army should strategically address encroachment caused by urbanization, increased development, and loss of biodiversity. It could address these issues now by having a high-level element focused on encroachment (including ACSIM and HQDA G-3), implementing more proactive ecosystem management activities, and collaborating more with other federal agencies and state, local, and nongovernmental organizations.

Additionally, in order to avoid significant future costs, the Army needs to make strategic building improvements and investments now by requiring a higher LEED standard with third-party certification,[722] ensuring proper life-cycle analysis, and requiring building commissioning and O&M investments.

Similarly, to avoid significant future costs and meet future energy requirements, the Army needs to make energy efficiency and renewables a priority by having higher energy efficiency standards in buildings (especially new construction); having a centralized Army organization that provides technical, legal, and financial assistance information to installations regarding large-scale energy investments; supporting more demonstration projects of new energy technologies at installations; and competitively hiring energy managers.

To avoid significant future costs, to help improve installation operations, and to help benefit Soldier and Family quality of life, the Army should be strategically addressing transportation issues in three main areas. Installations should be doing more compact land use planning and TND practices in their transportation and master planning; doing more transportation system planning and making operational improvements; and taking more

[722] The NDAA of 2011 (Section 2830) prohibited the use of funds to be used for the LEED Gold and Platinum certification. Waivers are allowed if the Secretary of Defense submits notification that includes a cost-benefit analysis of the decision and demonstrates payback for the energy improvements or sustainable design features. Where possible the Army should do such analyses and submit such notification. So even though it is difficult to do right now given the NDAA of 2011 legislation, the Army should strive to have a policy to design buildings to exceed LEED Silver given appropriate implementation and cost-benefit analyses.

advantage of personal mobility options by implementing more car sharing pilot demonstrations.

Lastly, to be able to effectively meet future requirements and needs for water at installations and save money, the Army needs to place more emphasis on water now by developing an integrated strategic action plan for installation water that includes future trend scenarios, educating installation staff, collaborating more with local communities, and conducting detailed installation water trends analyses.

Next, we summarize the findings and recommendations for each trend area.

Biodiversity Loss

Loss of biodiversity is likely to continue into the future and maybe even accelerate, which is likely to result in more T&ESs and thus pressures from federal, state, and local governments to protect them. This trend would probably lead to more restrictions on Army installation operations, including training, testing, and construction activities. If such issues are not addressed soon, it will likely cost the Army significantly more to address them in the future.

The Army should take strategic actions now to mitigate future impacts of biodiversity loss, like participating in collaborative ecosystem management, to help prevent biodiversity loss and species from becoming threatened or endangered. Army installation ecosystem management programs should continue and be strengthened.

In addition, the Army could and should take a lead role in collaborating with federal, state, and local governments, private companies and individuals, and NGOs to prevent biodiversity loss. This includes (1) working with other federal agencies (particularly BLM, FS, and F&WS) to manage and protect habitat, (2) working with local communities to manage and protect habitat surrounding installations, and (3) continuing to fund collaborative ecosystem management activities. In addition, the Army should continue to fund Army Compatible Use Buffering (ACUB) activities and identify which installations' ecosystems are most at risk and be sure that installations are collaborating with other organizations to preserve these ecosystems.

Other federal agency land use policies and activities, especially those of DOI and USDA, have an important role in helping or hurting habitat and species preservation. Therefore, senior leaders of the Army and OSD should meet with senior levels of DOI and USDA to ensure they are (1) adequately funding, managing, and protecting biodiversity in ecosystems where there are military installations, and (2) fully participating in regional collaborations to protect biodiversity.

Urbanization, Increased Development, and Sprawling Communities

Sprawl and other land development pressures near U.S. installations are likely to continue, especially since land is a finite resource being divided up for more and more uses. Such pressures create encroachment for Army and other military installations. Such encroachment pressures can create a range of problems, including more T&ESs; wetlands, water, and air quality problems; competition for airspace and radio frequency spectrum; and more noise, smoke, and other complaints from the community about training, testing, and other installation operations.

The Army needs to strategically and aggressively address future encroachment now. More emphasis needs to be placed on preventing and mitigating future encroachment concerns now because of implications of surrounding community growth, loss of biodiversity trends, climate change impacts, and future Army training, testing, and other land use needs. If not addressed soon, encroachment will likely cost the Army significantly more in the future to address it.

ACSIM should take a lead role in collaboration with the HQDA G-3 and other parts of the Army in establishing a high-level organizational element focused on encroachment that is responsible for integrating efforts across different parts of the Army, including training, testing, environmental, and community outreach organizations. Successful Army sustainability installation activities, which have focused on integrating activities across different Army organizational stovepipes, could serve as a model for such an organizational element.

The Army should develop an integrated, comprehensive, and strategic encroachment action plan that includes diverse effective ways to address different encroachment factors and that includes all relevant parts of the Army. Again, ACSIM should take a lead role in such an activity and work with other parts of the Army.

Lastly, the Army should implement more buffering and other mitigation activities, including dedicated funding for ACUB. The Army should also conduct a study to identify which installations are most at risk for future biodiversity loss and species issues to help focus resources now, especially with respect to ACUB.

Sustainable Buildings

We identified a number of trends that will shape buildings of the future. First, state and local building codes, voluntary standards, and labeling programs will define higher and higher performance goals. Second, best practices for building management, including building commissioning, life-cycle analysis, and proper O&M, are becoming more important. Third, state and local governments are adopting policies to accelerate sustainable building practices, while Executive Orders and DoD policies continue to increase building sustainability requirements. Lastly, in the future there will be more emphasis on green procurement, life-cycle analysis, and designing buildings for reducing waste and deconstruction.

Given such trends, we have four main recommendations for the Army regarding sustainable buildings to help save the Army money, to help meet future requirements, and to improve operations and environmental quality:

First, the Army should have a policy to design buildings to exceed LEED Silver (where feasible given the proper implementation and cost-benefit analyses) and give attention to regional and local priorities. Investing now in energy and water efficiency improvements will provide years and even decades of savings at current prices.

Second, the Army needs to ensure that it is getting the cost savings from higher-performance buildings. To do this, the Army needs to require third-party certification for LEED building performance for both new construction and existing buildings and improve building operations and maintenance practices. The Army has issued a policy that new buildings will require third-party LEED certification starting in FY13, but not for renovations in existing buildings. The Army needs to ensure that this certification occurs and should include existing building renovations in such a certification requirement. The Army should also increase the use of continuous building commissioning to ensure that the benefits from capital investments are realized.

Third, the Army needs to ensure that appropriate life-cycle analysis is used to properly minimize total costs.

Fourth, in building designs and operations, the Army should place more emphasis on green procurement and designing buildings for reducing waste and deconstruction. Since green procurements, such as sustainable forest products, and designing buildings from the start to reduce waste and for ultimate deconstruction are trends that are likely to increase, both in industry operations and government requirements, the Army should be investing more in such activities now.

We also have two specific recommendations for ACSIM and IMCOM and other Commands that maintain buildings:

First, given the types of problems in Army sustainable building implementation that installations face, ACSIM and IMCOM and other Commands should conduct studies to assess the progress, barriers, and needed improvements in Army sustainable building implementation, green procurements in buildings, and designing buildings for reducing waste and deconstruction.

Second, ACSIM and IMCOM and other Commands should assist installations by helping to identify and evaluate the effectiveness of the many options for improving building performance and lowering costs (such as innovative efficiency technologies) to help the Army maximize the return on its investments. They should also support installation demonstrations of new technologies, such as green roofs, and evaluate their performance. Lastly, ACSIM and IMCOM and other Commands should help facilitate installation investment in technologies that are demonstrated to be successful because of the benefits of an enterprise approach and economies of scale.

Energy

We identified five main trends related to energy. First, energy demand and prices will continue to rise. Second, traditional energy sources will provide most U.S. energy, but the use of renewable energy and biofuels will grow. Third, renewable power generation capacity and use of natural gas are growing and expected to continue to grow. As their use and capacity grow, renewable energy technologies will become more cost competitive. Fourth, energy use and management will become smarter, more efficient, and more reliable. Lastly, federal, OSD, and Army policies are increasing energy efficiency and renewable energy requirements, which places more pressures on Army installations to invest in energy efficiency and renewables.

Given these energy trends and the Army context, we have six main categories of recommendations for the Army to save money over the long term and to be able to meet future requirements.

First, the Army should accelerate its efforts to improve energy efficiency and lay the foundation to aggressively implement more rigorous standards to save money over the long term. Installations will need to improve the energy efficiency of their buildings because of future likely stricter OSD, Army, and even state requirements. New construction energy standards should be more aggressive than for retrofits because new buildings are likely to be in place longer and changes are usually more expensive after construction. For new construction, the Army should set a goal to be at least 65 percent more efficient than ASHRAE 90.1-2004, which is projected to reduce building energy consumption by 50 percent compared to the Army's 2010 standard. ACSIM should do cost-benefit analysis to show the savings of such a standard over time to help in its justification and implementation.

Second, the Army should have a centralized headquarters organization of expertise that assists installations with technical, financial, legal, and contracting issues regarding large-scale energy investments. Such an assistance organization should provide technical and financial assistance on renewable energy as well as large-scale energy efficiency projects and help evaluate the cost-effectiveness of the many options for improving energy performance. This organization could be located in ASA(IE&E), at ACSIM, or at IMCOM or some combination of these organizations. The ASA(IE&E) Energy Initiatives Task Force, which helps installations implement large-scale installation renewable energy projects, is a good first start, though help is also needed for energy efficiency projects.

Third, ACSIM and IMCOM and other Commands should help installations by supporting demonstrations of new energy technologies and evaluating their performance. In the near term, such demonstrations should focus on innovative energy efficiency and renewable energy technologies. For the longer term, such demonstrations should focus on distributed generation, energy storage, and "smart grid" technologies or alternative grid architectures. Building on existing demonstration activities, ACSIM and IMCOM and other Commands should partner more with other organizations that help facilitate the development and implementation of energy technologies on such demonstrations, such as the Army RDT&E community, USACE, and DOE.

Fourth, ACSIM and IMCOM and other Commands should help installations collaborate more with utilities and industry to develop renewable and other energy resources or infrastructure when beneficial to installations.

Fifth, ACSIM and IMCOM and other Commands should also help installations identify low-cost opportunities to procure renewable power for sources inside and outside installations and move toward the energy monitoring and management systems standard as discussed in FY10 Defense Authorization, Subtitle D.

Lastly, ACSIM and IMCOM and other Commands should help installations promote competitive hiring and salaries for full-time energy managers and staff at installations to attract and retain qualified and skilled staff.

Sustainable Transportation

In terms of transportation, we identified four main trends relevant to Army installations that are likely to continue. First, there is increasing emphasis on compact land use and less personal vehicle travel because of the benefits to the environment, mobility, quality of life, and community livability. Second, more transportation system planning and operations improvements are being developed and implemented because of the benefits they provide. Third, increasingly many and increasingly diverse personal mobility options are becoming available and being implemented, such as car sharing. Fourth, more electric and other alternative energy vehicles are being developed and put into service.

We summarize our sustainable transportation recommendations in each of the four relevant trend areas.

First, installations should do more strategic transportation and land use growth planning and management that involves compact land use and efforts to decrease SOV travel. Specifically, ACSIM/IMCOM should encourage installations in master and transportation planning to do more compact land use and TND practices, and promote policies that encourage decreased personal vehicle travel.[723] Large installations should have free or low-cost and convenient post buses. More efforts should be made to partner with local governments and communities on providing transit. Designing bike lanes and bike racks for bike parking in key cantonment areas is another important activity.

Second, ACSIM/IMCOM should encourage installations in their transportation planning to do more transportation system planning and operations improvements to ensure efficient flow and management of traffic and other transportation infrastructure. Such planning is especially needed regarding issues with on and off post traffic access points.

Third, IMCOM should help implement more low-cost or even free car sharing pilot demonstrations at more installations, especially at those that are experiencing population growth and transportation problems. IMCOM should also explore doing a free or fee-based shared bicycle system or even a multi-model system installation pilot that involves bicycles and cars. Such personal mobility options are an opportunity for Army installations to provide alternative transportation options that could help with quality of life issues, post congestion and parking issues, air quality concerns, GHG emissions, and other environmental concerns.

Fourth, the Army should do several things to ensure the effective and efficient use of electric vehicles. The Army should compare costs and benefits of electric, hybrid, plug-in hybrid, and alternative fuel vehicles for different uses, and plan for electric charging infrastructure, including appropriate locations, metering, and voltage. Lastly, the Army should consider the costs and benefits of bundling renewable power and distributed generation with charging infrastructure.

To summarize, such strategic installation transportation planning and investments implemented now can help save costs; save valuable installation land space; improve installation quality of life; reduce traffic congestion, reduce air pollution, and address other environmental problems; help preserve installation operational flexibility that might

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[723] In 2012, draft Army master planning guidance was incorporating such items.

otherwise be constrained by air quality and other regulations; and help meet future federal, OSD, and Army energy requirements.

Water Scarcity

Water has become increasingly scarce in the world and the United States, and will likely continue in that direction because of increasing demand and problems with pollution, drought, and potential climate change impacts.

To ensure access to clean, safe water, Army installations will need to cooperate more with local communities to manage scarce water resources and develop more aggressive water conservation methods and policies. Army HQ will need to try to mitigate future impact by working with other federal agencies, regions, states, and local communities to protect water resources. ACSIM and IMCOM and other Commands need to better understand likely future water scarcity problems. To do this they should conduct a study to assess the potential implications of water trends by doing regional and individual installation analyses across the country and by examining evolving state and local government policies and actions.

The Army should place more emphasis, analysis, and visibility on water concerns now, and the net zero water activities present a good start. However, more needs to be done to ensure that garrison and installation commanders and other installation staff understand the significance of water issues. We recommend three key steps. First, the Army should conduct an analysis using installation and regional water case studies to examine likely installation implications and needs in the future given the likely water trends. Second, ACSIM/IMCOM in collaboration with the DASA(ESOH) within ASA(IE&E) should develop an integrated strategic action plan to address water concerns at installations that integrates future trends and scenarios and focuses on specific actions to address regional differences and needs. Lastly, individual installation sustainability and strategic plans should place more emphasis on long-term strategic approaches to water issues.

Sustainable Communities

In many ways the Army has a stronger sustainability program than most U.S. communities because it has invested more resources than most communities, including some dedicated staff. Some installations are leaders in key sustainability areas, such as ecosystem management; recycling and waste reuse and reduction; and energy efficiency and renewable energy investments. However, the Army can learn from U.S. sustainable community activities in four key areas: (1) eco-industrial parks, (2) traditional neighborhood development/new urbanism/compact land use, (3) diverse mobility and transportation planning, and (4) waste-to-energy plants.

To this end we provide a range of recommendations. Given the strengths of some Army installations' sustainability efforts, the Army should, first, publicize its installation sustainability efforts more. IMCOM should document in-depth case studies of installation sustainability practices, highlighting their successes and lessons learned. Second, ACSIM and IMCOM should ensure that installations collaborate more in regional and local sustainability community efforts. Third, the Army should also participate more in other public sustainability forums, such as activities with other federal agencies like EPA.

The Army should also ensure that installation sustainability staff and programs continue despite current budget cuts because of the cost savings and other benefits that they achieve.

In addition, ACSIM/IMCOM policies should require installations to include, wherever feasible, TND principles in installation master plans and transportation planning. They should also require installations to do sustainable transportation options in growth planning.

To take advantage of eco-industrial park trends, installations should try to develop and implement eco-industrial parks with neighboring industry. ASA(IE&E), ACSIM, and/or IMCOM should help sponsor some initial installation eco-industrial park pilots and provide information about such opportunities to installations.

Lastly, ASA(IE&E), ACSIM, and/or IMCOM should help installations develop some more waste-to-energy technology demonstration pilots and document and share information about such projects.

Relevant Societal Trends

We identified a number of likely U.S. societal trends that are relevant for Army installations. We should caution that many of these are speculative and urge anyone to be careful about generalizing for society at large. First, over the past few decades, there appears to be a changing sense of community for many, especially young people—a declining sense of local place-based neighborhood community and a growing importance of broader support networks and connections as part of one's sense of community. Second, there has been a significant growth in television and digital media use. Third, for many of today's youth compared to previous generations, there has been a decline in physical activity, unstructured, neighborhood, outdoor, and nature play; a significant increase in computer, cell phone, TV, video game, and other media use; and an increase in obesity and overweight children and young adults. Fourth, there appears to be a rise in problematic internet use (PIU), i.e., Internet addiction, with teenagers being especially vulnerable. There is mixed research about the implications of such trends, though some of it indicates that some young adults of the future may be more likely to have less social and coping skills, lower self-esteem, and more Internet addiction problems. Such trends might also mean that youth are also more likely to expect instantaneous access to information, want more constant communications with friends and family, engage regularly in multi-tasking, and have less patience with slow procedural processes. We heard anecdotes from Soldiers and their Families and installation support service providers in focus groups and interviews that such tentative implications are consistent with their Army experiences.

Given such possible societal trends and some of the insights about today's Army, we present some recommendations for the Army. First, for all the trends the Army should continue to track and monitor such changes as they evolve, especially among young people.

Second, Army Community Service (ACS), mental health, and other installation support and services will likely have to deal with more Soldiers and Families having potentially more needs related to less-developed social and coping skills, lower self-esteem, and Internet addiction problems. The Army should try to monitor and study both issues more to understand if this is really true, along with the extent of the need. Where needed, ACS and CYS Services staff and other service providers should do more to try to support and educate younger people who may not have as strong social and coping skills and other emotional issues.

MEDCOM should do clinical research about PIU in the Army to see how widespread a problem it is and develop appropriate interventions. Medical professionals, ACS staff, CYS Services staff, and other support staff should be educated more and on the lookout for signs of PIU so that appropriate interventions and support can be provided.

ACS and other installation support and service providers should strengthen community relationships, locally as well as regionally and nationally. Given how Soldiers and Families will likely depend more on their broader community and social networks, Army installation support staff relationships with broader support communities will become more important.

The Army will also need to place more emphasis on nutrition and physical exercise education and activities and take advantage of sustainable agriculture efforts like CSA and community gardens.

Lastly, the Army will need to adapt communication styles, approaches, and media technologies to better address youths' expectations. This includes more use of online communities, such as Facebook, as well as iPhone/iTouch apps.

Sustainable Agriculture

Key trends related to sustainable agriculture that are likely to continue include an increase in community supported agriculture (CSA), buying more locally grown and organic food, and more communities emphasizing and providing community garden plots. Concerns about obesity trends, health and nutrition, environmental impacts, and costs, as well as wanting to help local farmers, have helped motivate such trends.

Such sustainable agriculture activities are an opportunity to help improve Soldier and Family health given U.S. obesity trends as well as related diet and nutrition concerns. There are a number of steps that the Army and installations could take to take advantage of them. First, ACSIM/IMCOM should help installations participate in CSA and purchase more produce from local farmers. To this end, ACSIM/IMCOM would need to work with other military organizations, such as the Defense Commissary Agency (DeCA) regarding commissaries and the Army and Air Force Exchange Service (AAFES) regarding their fast food restaurants. A good way to start such a process is to have a few installations do demonstration projects in CSA or buying local produce and have them work with their local DeCA and AAFES staff. Another option is to have some of the local day care centers on posts begin to purchase local produce or participate in CSA. If day care centers participate in CSA the post could get the military families involved and also make it an educational experience which could have quality of life benefits.

Second, ACSIM/IMCOM should issue a policy encouraging installations to do on-post farmers markets, to offer CSA to military families and staff on post, and to provide community garden plots to Soldiers and military families on post. Again, ACSIM/IMCOM could begin by having a few installations do demonstration projects and then share the lessons learned with other installations about such activities.

Lastly, installations should compost most of their organic wastes. Composting is part of the net zero waste process, but to ensure wider implementation of compost projects, ACSIM/IMCOM should encourage installations to compost and to use the compost on post.

The types of recommendations suggested here could, with very minimal investment of installation resources, help improve the nutrition and health of Soldiers and their Families, help prevent encroachment, help to support the local community, local farmers, and the local economy, and help improve community relationships.

Online Communities

Online communities are groups of people who interact partly or primarily through the Internet for social, professional, and educational reasons. Online communities, such as Facebook and Twitter, are playing an increasingly integral part in the lives of many Americans, especially among young people. They offer important social benefits, especially with friends and relatives who live far away. They also pose risks, however: their users may reveal too much private information, or they may be detrimental to time management, taking away substantial amounts of their users' time from other activities.

Given the benefits, the Army should consider expanding its use of online communities to improve support for Soldiers and their Families. However, first the Army should conduct an analysis to see what current online communities it is sponsoring across all parts of the Army, as well as the unofficial ones that help support Soldiers and Families. The Army should also analyze how best to use online communities to support both Soldiers and Families and installation operations and how best to mitigate the security issues that arise from the use of these online communities, such as users revealing too much information.

More specifically for installations, ACSIM, IMCOM, and the rest of the installation management community should conduct an installation-specific analysis consisting of two different parts. One, the analysis should identify what online communities support Soldiers and Families, both officially and unofficially, and develop specific guidance and policy so that there is some consistency in their use across installations and ensures that security concerns are addressed. This assessment should also identify new opportunities for taking advantage of online communities. Two, the analysis should assess and identify areas where installation operations and staff could benefit from online communities. For example, Second Life, Facebook, or other social media could be used to help facilitate information sharing across installations for different staff professionals, such as Army Community Service (ACS), Financial Readiness Planners (FRPs), or energy management staff.

Then, based on these analyses, ACSIM and IMCOM should issue official policy and guidance on the use of online communities and officially support their development and use for MWR communities of interest; to help Families keep in touch with Soldiers when deployed or stationed at a different installation; to help Soldiers and Families prepare for relocation between installations; and for different functional areas of interest and professional staff where it seems beneficial to installation operations. Then, because of the dynamic nature of online communities, the Army installation community should frequently monitor how online communities are evolving and their own participation in them, and revise their programs accordingly.

Climate Change

Scientific evidence indicates that climate change is increasing and the United States is already seeing some of its effects. In the future, there are likely to be worldwide and U.S. policies and regulations to address greenhouse gas emissions as climate change pressures increase. Energy pressures are likely to rise, and there will be more requirements to invest in renewable energy technologies.

Some Army installations are also likely to experience physical changes in local environment, which could impact water supplies, habitat issues (such as more biodiversity loss and T&ES problems), and installation training environments. Installations also will likely have more uncertainty and wider fluctuations in temperatures, which could have potential impacts on a range of installation operations and infrastructure.

Since the impacts of climate change to installations are likely to vary by location and will affect the Army in other key trend areas, such as energy, many of our recommended actions are incorporated in these other trend discussions. However, given the threats associated with climate change, we recommend that the Army continue to track the trends, though no immediate actions are needed, since they are mentioned in other key areas. However, there are three strategic actions that the Army should consider conducting in the next few years. First, ACSIM and/or ASA(IE&E) staff should be discussing with DoD and Army research staff the possibility of one of these organizations conducting a study to assess which Army installations are most at risk from climate change impacts and how. Second, ACSIM and IMCOM should conduct periodic reviews of ongoing climate change research regarding military installations for lessons for Army installations. Lastly, IMCOM should make sure that its regional offices and local installations most at risk are tracking projected climate change impacts in their areas and what actions may be needed to address them.

Robotics

The field of robots is growing, but the growth differs by industry and application area. Potential future applications that are relevant for Army installations include perimeter robots that may help secure and protect installations; operations and maintenance robots that help clean and maintain facilities; and office robots that transport documents, sort mail, fetch coffee, and do other errands. However, such robots would likely be adopted by industry and the commercial sector before Army installations because of their high operational costs. In fact, system operational costs will likely limit widespread application of such robots for quite a while and thereby limit implementation at Army installations. Such robots will have ongoing high costs of acquisition, operation, maintenance, and energy usage. For example, buildings would require special infrastructure to facilitate robot activity. Pilot demonstrations would be needed first to see if the benefits outweigh the costs.

Given all these implications, ACSIM and the installation management community should continue to monitor robotic trends, but not address them in current installation planning. Robots are not likely to have much application at installations even by 2025, with the possible exception of security robots, and even there it would be longer than that before the Army would likely see any widespread application. One near-term action that the installation management community could pursue is to explore the potential with the Army R&D community of having some security robot research and demonstration pilots at installations.

Pervasive Computing

"Pervasive computing" refers to settings in which computing and communications capabilities are extensive and gracefully integrated with human users. Most homes and offices already have very basic examples of computing technology integrated into operational systems, such as thermostats, fire alarms, and security systems. Similarly, vehicles are increasingly drive-by-wire, relying on computers and electronics to control the vehicle's steering, acceleration, and braking, instead of the traditional mechanical systems. The vision of pervasive computing is that processing devices such as these will be present in all aspects of everyday life, and these devices will be integrated and networked together seamlessly and will also be unobtrusive to the user. Pervasive computing is a young field and many areas are still being researched, though basic applications in some fields are being developed, such as in medicine, energy, and smart homes.

Pervasive computing applications are most likely to be implemented in Army energy systems, buildings, and other infrastructure first. Such infrastructure would include barracks and other residential buildings, office buildings, and vehicles and transportation infrastructure. However, the supporting infrastructure would need to be built to enable networking. Energy applications are likely to emerge faster than some other areas, such as transportation, because of current private-sector systems in this area and the cost and energy consumption savings from implementation.

Other pervasive computing technology investments are likely to be slower because up-front and ongoing costs can be high and the benefits may not be as significant or as money-saving, or they may be harder to quantify. Different return on investment (ROI) estimation strategies may be needed to measure benefits and justify investments. In such areas, Army installations are likely to adopt these technologies when private industry and commercial sectors adopt them as they demonstrate their cost-effectiveness.

Given this situation, ACSIM and the installation management community should continue to monitor pervasive computing technology trends, but not address them in current installation planning. As just discussed, installations will naturally adopt these technologies in installation infrastructure systems as the broader U.S. society does.

Final Summary

We found that trends external to Army installations out to the year 2025 are likely to impact installations in a variety of ways and in many different areas. Key trend areas include sustainable buildings, energy, water scarcity, information technologies, loss of biodiversity, societal trends, sustainable communities, sustainable transportation, sustainable agriculture, urbanization and increased development, and climate change. These trends have the potential to cause harm to installation operations including testing, training, and constructing activities; to cost or save the Army significant amounts in the future; to hurt or improve Soldier and Family quality of life; to improve installation operations; to help meet future installation requirements; and to improve or hurt environmental conditions. In addition, a key cross-cutting issue is that community relationships are becoming more important to Army installations, especially in helping to mitigate potentially negative trends.

The Army has the ability with strategic actions in the near and long term to mitigate potentially negative consequences on Army installations from the trends and to take advantage of the potentially beneficial opportunities they present. It is important that the Army consider and implement the types of actions identified in this study for the different trends, both in the near term and in its strategic planning, to help save costs, to preserve installation operational flexibility, to improve Soldier and Family quality of life, and to help meet installation requirements. Since external trends will continue to change over time, the Army installation community should also implement a process (like the one outlined in this document) to continue to track them.

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APPENDIX A

Background on Political, Economic, and Demographic Trends

In this appendix we examine potential future global and domestic political, economic, and social trends; the potential future security environment that may result from the convergence of these trends; and how these trends may affect the Army. Analysis of these broad trends is important, as they set the context within which other, more specific trends examined in the body of this report play out. In addition, these broad trends offer insight into the types of security threats the United States may face in 2025 and the different demands that might be placed on the Army of the future.

The broad trends are also important because they give insight to future Army missions and composition that can impact Army installations. They inform how installations may be geographically distributed around the world (i.e., within the continental United States [CONUS] versus outside the continental United States [OCONUS]), the types of military operations that installations must be prepared to facilitate (thereby affecting installation operations), and the types of pressures installations may experience from their surrounding communities.

Political Trends

Specific future political trends are notoriously difficult to predict; however, our analysis does point to some broad trends that are likely to be part of the future global and domestic political environment.

Global Trends

Since the end of the Cold War, the United States has emerged as the dominant superpower in the global political environment. However, there are signs that this might be changing. For instance, China is quickly rising in military and economic power, and China is widely viewed as the most likely candidate to become a future peer-competitor of the United States. As G. John Ikenberry has predicted, "The rise of China will undoubtedly be one of the great dramas of the twenty-first century" and "China's rise will inevitably bring the United States' unipolar moment to an end."[724] Other countries, including Brazil, India, and Iran, are also

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[724] G. John Ikenberry, "The Rise of China as the Future of the West," *Foreign Affairs*, January/February, Vol. 87, Issue 1, 2008, p. 23.

growing in international stature and redefining the balance of power among countries in the international system.

The most comprehensive and reliable assessment of the future international system are the National Intelligence Council's recent report, *Global Trends 2025*, and the Department of Defense's *2010 Quadrennial Defense Review.* In its report, the National Intelligence Council (NIC) predicts that "the international system . . . will be almost unrecognizable by 2025" and that the most salient characteristics of the new international system will be "the shift from a unipolar world dominated by the United States to a relatively unstructured hierarchy of old powers and rising countries, and the diffusion of power from state to nonstate actors."[725] Such a shift is important to the United States, and in particular to the U.S. Army, because "emerging multipolar systems have historically been more unstable than bipolar or even unipolar ones; the greater diversity and growing power of more countries portends less cohesiveness and effectiveness for the international system."[726]

The NIC and others predict that in 2025, several emerging countries (including China, India, Japan, Brazil, Indonesia, Turkey, and Iran) will continue to increase their political and economic power, as well as their ability to challenge the United States.[727] In addition, the "*relative power* of nonstate actors (including businesses, tribes, religious organizations, and even criminal networks) will grow and these groups will influence decisions on a widening range of social, economic, and political issues."[728] Overall, these trends toward greater diffusion of power could lead to more instability and volatility in the international system.

In addition to these changing power dynamics in the international system, it is likely that future instability could also be triggered by the desire of some countries to acquire nuclear weapons; conflicts triggered by resource scarcities (including food and water scarcities); and increasing pressure on governments around the world to address social and economic issues related to population growth in the developing world and aging populations in the developed

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[725] See National Intelligence Council, *Global Trends 2025: A Transformed World*, Washington, D.C.: Government Printing Office, 2008, p. 1.

[726] National Intelligence Council, 2008, p. 29.

[727] See U.S. Department of Defense, *2010 Quadrennial Defense Review*, Washington, D.C.: Department of Defense, 2010, p. iii; National Intelligence Council, 2008, pp. 29–36; David J. Kay, "Emerging Global Trends and Potential Implications for National Security," National Security Watch 09-1, Arlington, VA: Association of the United States Army, May, 29, 2009, p. 2.

[728] National Intelligence Council, 2008, p. 81.

world.[729] Taken as a whole, these global trends point to a future political environment which is less predictable, more complex, more diffuse, and more volatile than today. At the end of this appendix we discuss the potential future security threats that could emerge from this future political environment.

U.S. Trends

Given the current volatility in the U.S. political system, it is especially difficult to make any meaningful predictions of what the political environment might look like in the United States in 2015–2025. The current trend in U.S. politics seems to be polarization and some fragmentation of the Republican and Democratic parties, but it remains to be seen how much staying power these current trends will have. If the current polarization in American politics continues, congressional gridlock and entrenched differences will continue to make it difficult for the Army to plan and budget for a longer time horizon.

Given the expected demographic changes over the next 15 years, it can be expected that Hispanics and those over 65 will become key political constituencies due to their sheer numbers (see section below on demographic trends). What is also safe to say is that political trends in the United States will largely be influenced by future economic trends, just as they are today. It is to these future economic trends that we turn next.

Economic Trends

Like political trends, future economic trends are also difficult to predict. This is especially true today because it remains to be seen how the recent global recession will impact the future global economy over the next 15 years. However, some general projections about economic trends can be made by looking at current trends.

Global Trends

The current global shift in relative wealth and economic power from West to East has created such fundamental shifts in supply and demand that these current trends are likely to endure into the future.[730] For instance, China is likely to remain an economic powerhouse. The National Intelligence Council estimates that in 2025, the eight largest economies will be,

[729] U.S. Joint Forces Command, *The Joint Operating Environment*, 2010; Kay, 2009, pp. 1–2; National Intelligence Council, 2008, pp. 51–56; Department of Defense, 2010, pp. iv, 85.

[730] Michael Geoghegan, "The Future of Finance Shifts from West to East," *Forbes*, April 29, 2010.

in descending order, the United States, China, India, Japan, Germany, the United Kingdom, France, and Russia. Growth projections for Brazil, Russia, India, and China (the BRICs) indicate that they will collectively match the original G-7's share of global gross domestic product (GDP) by 2040–2050.[731]

There are also expected to be major shifts in the distribution of wealth across the globe. For instance, the World Bank estimates that over the next several decades, the number of people considered to be in the "global middle class" is projected to swell from 440 million to 1.2 billion or from 7.6 percent of the world's population to 16.1 percent, with most of those new entrants coming from China and India. By 2025–2030, the portion of the world considered poor will shrink by about 23 percent, but the world's poor—still 63 percent of the globe's population—stand to become relatively poorer.

U.S. Trends

Given the current volatility in the U.S. economy, it is very difficult to predict future domestic economic trends. The most comprehensive source for future economic trends is the Congressional Budget Office's report entitled *The Budget and Economic Outlook: Fiscal Years 2010–2020*. However, in the near-term this report predicts that "spending by households is likely to be constrained by slow growth of income, lost wealth, and limits on their ability to borrow, and investment spending will be slowed by the large number of vacant homes and offices."[732] This restriction of spending could continue to be a drag on the domestic economy as well as the global economy.

The report predicts that the United States economy will continue to grow and recover. From 2012 through 2014, real GDP is expected to increase by an average of 4.4 percent per year,[733] and then decrease to an average of 2.4 percent per year in 2015-2020.Unemployment in the United States is predicted to continue to hover at 9.5 percent until 2011, then decrease to 6.5 percent in 2012–2014 and then decrease again to 5 percent in 2015–2020.[734] Most importantly, CBO expects that throughout the coming decade, "spending on the government's health care and retirement programs will increasingly strain the federal budget."[735] This strain on the federal budget could severely impact the Army in the coming decade.

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[731] National Intelligence Council, 2008, p. 7.

[732] Congressional Budget Office, *The Budget and Economic Outlook: Fiscal Years 2010–2020,* Washington, D.C.: Congressional Budget Office, 2010, p. xi.

[733] Congressional Budget Office, 2010, p. 23.

[734] Congressional Budget Office, 2010, p. 24.

[735] Congressional Budget Office, 2010, p. 2.

Demographic Trends

Unlike political and economic trends, it is much easier to predict demographic trends.

Global Trends

Between 2009 and 2025, the global population is projected to grow by about 1.2 billion—from 6.8 billion to around 8 billion people. The largest increase (240 million people) will occur in India, representing about one-fifth of all growth. China is projected to add more than 100 million to its current population of over 1.3 billion, the countries of sub-Saharan Africa are projected to add about 350 million people, and those in Latin America and the Caribbean will increase by about 100 million (see Figure A.1). According to UN projections, between 2004 and 2015, 52 countries in the world will still have a population growth rate of more than 2 percent—31 of them in the least developed regions.[736]

The populations of the United States, Canada, Australia, and a few other industrial states with relatively high immigration rates will continue to grow—the United States by more than 40 million. Due to low fertility, increased longevity, and limited immigration, the populations of most European countries and many other developed countries are becoming smaller, and many are experiencing labor force shortages.[737] Between now and 2025, Russia, Ukraine, almost all countries in Western and Eastern Europe, and Japan are expected to see their populations decline by several percent.[738]

U.S. Trends

The U.S. Census Bureau estimates that the U.S. population will grow to 420 million persons by 2050.[739] The country's population will continue to age, with the nation's elderly population estimated to double in size from 2005 to 2050.[740] Those aged 80 and above will become the most populous age group—33.7 million people or 8 percent of the entire U.S. population (see Figure A.2). [741]

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[736] International Organization for Migration, *Demographic Trends and Realities*, 2009.

[737] International Organization for Migration, *Demographic Trends and Realities*, 2009.

[738] National Intelligence Council, 2008.

[739] Laura R. Shrestha, *The Changing Demographic Profile of the United States*, Washington, D.C.: Congressional Research Service, May 2006.

[740] Pew Hispanic Research Center, *U.S. Population Projections: 2005–2050*, February 2008, p. i.

[741] Laura R. Shrestha, *The Changing Demographic Profile of the United States*, Washington, D.C.: Congressional Research Service, May 2006.

Figure A.1
World Age Structure, 2005 and Projected 2025

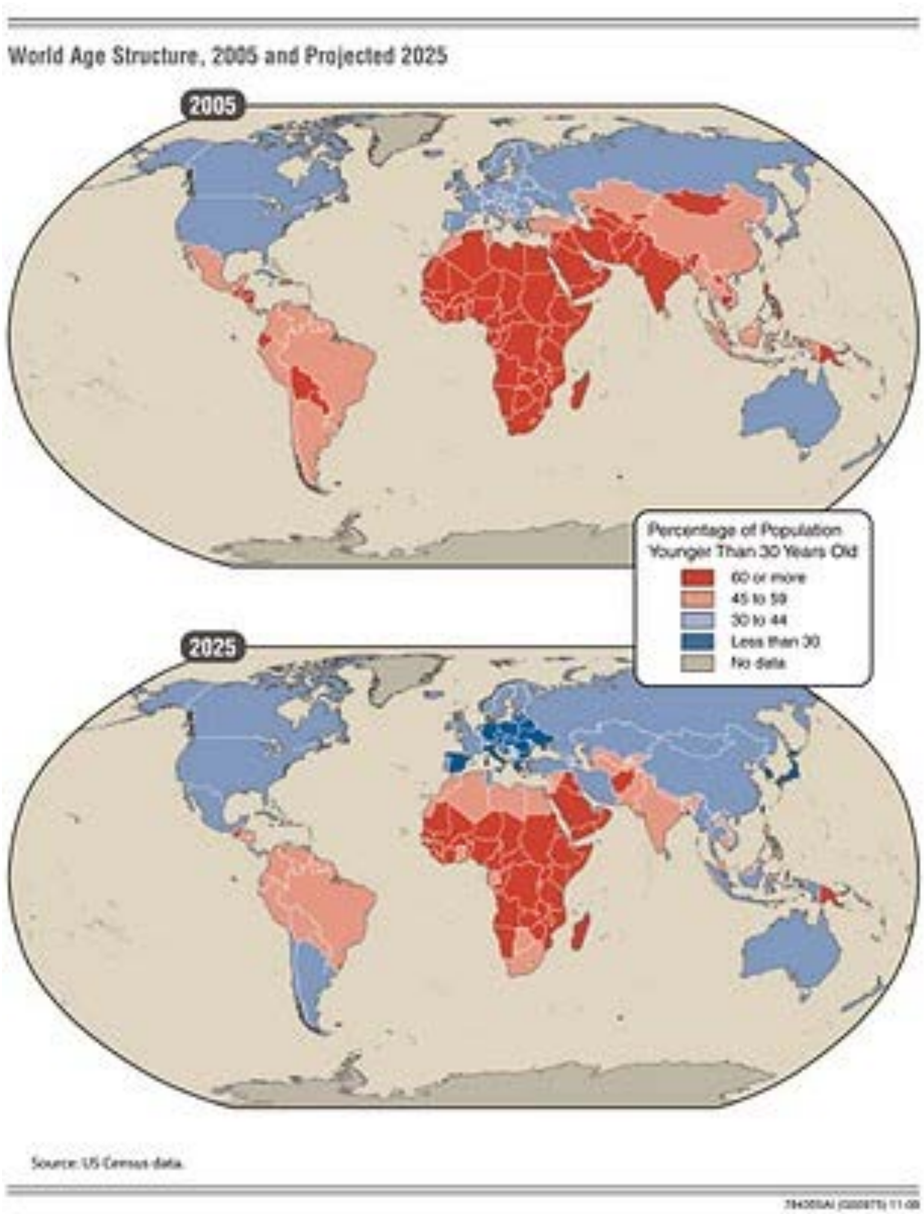
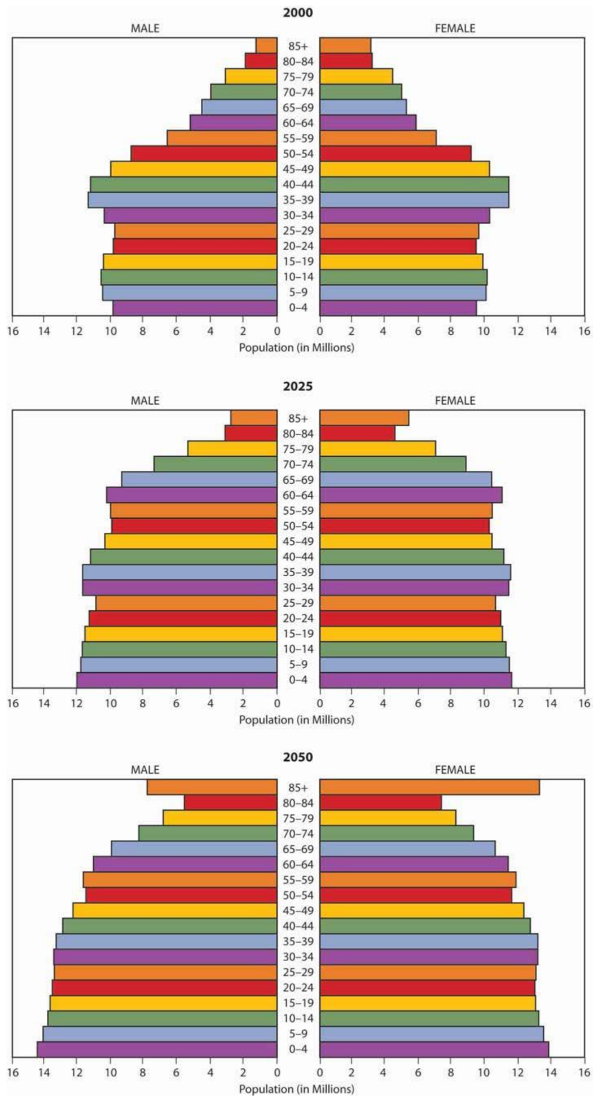


Figure A.2
Changing Demographics of the United States



SOURCE U.S. Census Bureau, International Population Data Base.

Immigration will be a major driver of demographic changes in the United States over the next forty years. For instance, from 2005 to 2050, new immigrants and their descendants will account for 82 percent of population increase. In 2050, nearly 1 in 5 Americans (19 percent) will be an immigrant, compared with 1 in 8 (12 percent) in 2005. Whites are expected to become a minority (47 percent) by 2050 and Hispanics are estimated to make up 29 percent of the U.S. population in 2050 compared with 14 percent in 2005.[742]

The Active Duty Force Has Undergone Several Demographic Changes in the Last 30 Years

With the advent of the All-Volunteer Force (AVF), the U.S. military has become older and better educated, and it has experienced increases in the representation of minority and female service members. In FY08, women represented 13.6 percent of the active Army, 17 percent of the Army's commissioned officers (compared with 11 percent in FY85), and 9 percent of the warrant officers (compared with 2 percent in FY85). There have been significant increases in the percentage of Hispanic Soldiers serving in the Army, although the percentage of Hispanics in the Army continues to be less than the percentage of Hispanics in the U.S. population.[743] There has been a decline in the percentage of African American Soldiers. The overall percentage of African American enlisted personnel in the Army declined from 30 percent in FY95 to today's rate of 21 percent.[744]

A greater proportion of service members now are married and have children.[745] Although the marriage rate in the Army has decreased since the mid-1990s, the percentage of Soldiers who are single parents has increased slightly. In 2005, 7 percent of active-duty Soldiers were single parents with a child enrolled in the Defense Enrollment Eligibility Reporting System (DEERS), compared to less than 6 percent in 1995.[746]

Potential Security Threats in 2025

Taken together, the trends above have the potential to create an extremely complex future security environment. The NIC identifies a number of potential security threats that the United States may face in 2025. For instance, terrorism, proliferation, and conflict will remain key concerns.[747] "For those terrorist groups active in 2025, the diffusion of

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[742] For data used in this paragraph, see Pew Hispanic Research Center, *U.S. Population Projections: 2005–2050*, 2008.

[743] U.S. General Accounting Office, *Military Personnel: Active Duty Benefits Reflect Changing Demographics, but Opportunities Exist to Improve*, Washington, D.C.: Government Printing Office, September 2002.

[744] Department of the Army Deputy Chief of Staff, Headquarters, Army G-1, Office of Army Demographics, *The Changing Profile of the Army*, 2008.

[745] U.S. General Accounting Office, *Military Personnel: Active Duty Benefits Reflect Changing Demographics, but Opportunities Exist to Improve*, Washington, D.C.: Government Printing Office, September 2002.

[746] Booth, Segal, and Bell, *What We Know About Army Families: 2007 Update*, 2007.

[747] National Intelligence Council, 2008, p. ix.

technologies and scientific knowledge will place some of the world's most dangerous capabilities within their reach." The United States could face new challenges if China becomes a peer competitor. In addition, over the next 15–20 years, a number of regional states could consider actively pursuing nuclear weapons. In particular, the prospect of a nuclear arms race in the Middle East and possible interstate conflicts over resources appears to be growing.

The NIC also acknowledges the potential for a number of nontraditional security threats. For instance, the NIC predicts that "the breadth of transnational issues requiring attention also is increasing to include issues connected with resource constraints in energy, food, and water; and worries about climate change."[748] New conflicts over resources may also rise. For instance, the NIC estimates that "access to relatively secure and clean energy sources and management of chronic food and water shortages will assume increasing importance for a growing number of countries during the next 15–20 years." The World Bank estimates that demand for food will rise by 50 percent by 2030, as a result of growing world population and rising affluence. Owing to continuing population growth, 36 countries, home to about 1.4 billion people, are projected to have scarcities in cropland or access to freshwater by 2025. Unprecedented global economic growth—positive in so many other regards—will continue to put pressure on a number of highly strategic resources, including energy, food, and water, and demand is projected to outstrip easily available supplies over the next decade or so.

How These Future Trends Might Impact the Army

DoD and the Army are already planning for the type of future envisioned by the NIC and others. For instance, the *2010 Quadrennial Defense Review* acknowledges that "the distribution of global political, economic, and military power is shifting and becoming more diffuse." The Army's new Capstone Concept's vision of 2016–2028 echoes much of the NIC's predictions. The Army Capstone Concept (ACC) cites the following important trends that will influence the global security situation:[749]

- changing demographics
- emerging patterns of globalization
- shifting economic patterns

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[748] National Intelligence Council, 2008, p. 1.

[749] U.S. Army, TRADOC Pam 525-3-0, *The Army Capstone Concept Operational Adaptability—Operating Under Conditions of Uncertainty and Complexity in an Era of Persistent Conflict*, 2009.

- emerging energy technologies and demands
- scarcity of food and water
- emerging effects of climate change
- natural disasters
- pandemics

Taken as a whole, the ACC envisions that 2016–2028 will be an era of "uncertainty," "complexity," and "persistent conflict." In order to respond to this type of security environment, the ACC cautions that the Army must remain ready to conduct full spectrum operations (i.e. simultaneous offensive, defensive, and stability or support operations). Therefore, Army units must be both an expeditionary and campaign quality force to respond to a broad range of threats and challenges anywhere in the world, on short notice, for long periods of time.

These types of operations will have a direct impact on installations. For example, because of the lack of advanced strategic lift and adversary employment of strategic preclusion, operational exclusion (anti-access), and tactical access denial capabilities, Army units must be able to conduct and sustain full spectrum operations from and across extended distances. Therefore, support and sustain operations will occur from and across extended distances. Some Reserve Component installations may need to sustain the mission of serving as steady-state mobilization posts for extended periods of time rather than just episodically.

Since operations will be increasingly dispersed, this will increase the support challenge faced by logistics force elements. The whole of the logistics chain, from the United States and forward bases to the deployed forward operating bases, will require protection, and this requires joint solutions and encompasses civilian actors. Sustainment will need to be delivered by an increasingly diverse logistics force comprising regular military personnel, reservists, civil servants, and contractors—who may be locally recruited, deployed U.S. nationals, or third-country nationals.

APPENDIX B

Background on RAND Study of Soldier and Family Problems and Installation Support Needs

RAND conducted a study for ACSIM to examine demands for individual and family support and how these are changing in the face of lengthy, repeated deployments, availability and sufficiency of support services, and alternatives and resource requirements for improving installation services. To understand the effects of the current deployment tempo and ARFORGEN on Soldiers and Families, RAND researchers conducted focus groups and interviews with Soldiers, spouses, parents of Soldiers, and service providers at multiple installations, reviewed the literature about problems that Soldiers and Families face, and reviewed information and data obtained as part of the Army Family Action Plan process. RAND researchers held 60 focus groups and talked to over 730 people in the groups and interviews at nine different Army installations and six Reserve Component (RC) events. See Table B.1 for the details on who RAND staff talked with in focus groups compared with the interviews.

Table B.1
Composition of Focus Groups and Interviews

Component	Soldiers	Spouses and Other Family Members	Service Providers	Total People
AC	209	117	162	488
RC	136	88	20	244
Total people	345	205	182	732

The focus groups and interviews allowed researchers to capture emerging issues and to understand first hand what Soldiers, Families, and service providers are experiencing. These discussions focused on identifying problems and needs from the current deployment pace and how best to improve installation support and services to better address such problems and needs. Focus groups and interviews with Active Component members were held at Fort Hood, Fort Belvoir, Fort Sill, Fort Carson, Fort Campbell, and Joint Base Lewis-McChord. At these installations, focus groups were 90-minute sessions and there were separate groups with service providers, Soldiers (grouped by rank), and spouses (grouped by officer and enlisted spouses), while interviews were with one to five people and lasted half an hour to two hours. Most of the interviews were with service providers to really understand their support services, Soldier and Family problems they had seen, and what they thought worked best to help Soldiers and Families.

Focus groups and interviews with Reserve Component members were initially held in Anaheim, California (Army Reserve) and in Burlingame, California (Army National Guard) at respective Yellow Ribbon Reunion and Reintegration Events. Then we also did focus groups and interviews at a Utah National Guard and a Vermont National Guard Yellow Ribbon event. At these RC Yellow Ribbon events, focus groups consisted of Soldiers and spouses participating together (grouped by enlisted/officer and by grade), single Soldiers, and spouses and parents together. RAND also held focus groups and did interviews at an Army Reserve Family Readiness Training event in Maryland and with another in Missouri. These focus groups tended to be a mix of Soldiers, spouses, parents, and even a few girlfriends. At Fort Carson, one of the six focus groups was a Reserve Soldier group.

RAND researchers also benefited from another RAND study in this research. Several of the RAND research team members were working on a G-1 and G-3/5/7 sponsored study focused on Deployment Cycle support which also conducted focus groups with Soldiers, spouses, and service providers about deployment related problems and needs. Since this information was directly relevant we incorporated these focus groups findings at Forts Benning, Drum, Hood, and Riley into this analysis. These focus group numbers are included in the totals in table B.1.

The focus groups, interviews, and literature indicate that Soldiers and Families experience a range of problems. We heard consistently from over 730 people in the numerous interviews and in 60 focus groups and at installations across the country from Soldiers, spouses, parents of Soldiers, and service providers that the main deployment Soldier and Family problems are in the areas of Soldier and spouse well-being, relationships, children, and financial problems. These findings were consistent with the literature. We also found that many of these problems are interrelated and may cause or make other problems worse. Problems also tend to feed back onto one another. Not everyone experiences problems in the same ways or experiences the same range of feelings and behaviors, which vary across demographic groups. They often have different needs for support, i.e., some need more than others.

We also found that many factors contribute to the types and severity of problems that Soldiers and their Families develop and to the resulting needs for programs and services. Some of these factors are inherent to the characteristics of Soldiers and their Families—such as maturity level or amount of family support. Other factors are driven by Army policy, including the ARFORGEN cycle and permanent change of station (PCS) moves, and still other factors are changes in the external environment, such as U.S. societal trends.[750]

[750] For more details on this study see Beth E. Lachman et al., *Helping Soldiers and Families Cope with the Stress of War*, Santa Monica, CA: RAND Corporation, forthcoming.

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Bibliography

16 U.S.C. Section 1531(b).

ABI Research, "Personal Robotics 2009: Task, Security and Surveillance/Telepresence, Entertainment and Education Robots, and Robotic Components Markets Through 2015," 2009. As of September 9, 2010: http://www.abiresearch.com/research/1003675-Personal+Robotics+2009

Acohido, Byron, "Sex Predators Target Children Using Social Media," *USA Today*, March 1, 2011. As of August 25, 2011: http://abcnews.go.com/Technology/sex-predators-target-children-social-media/story?id=13024943

Adams, John, and Bob Heile, "Busy as a ZigBee," *IEEE Spectrum*, 2006. As of September 3, 2010: http://spectrum.ieee.org/computing/networks/busy-as-a-zigbee

Allen, Patricia, Debra Van Dusen, Jackelyn Lundy, and Stephen Gliessman, "Integrating Social, Environmental, and Economic Issues in Sustainable Agriculture," *American Journal of Alternative Agriculture,* Vol. 6, 1991, pp. 34–39.

Alliance to Save Energy, website, 2011. As of April 1, 2011: http://ase.org/

Allison, S.E., et al., "The Development of the Self in the Era of Internet and Role-Playing Fantasy Games," *American Journal of Psychiatry*, Vol. 163, 2006, , pp. 381–385.

American Association of State Highway and Transportation Officials, *Transportation Invest in our Future: Future Needs of the U.S. Surface Transportation System*, Washington, D.C., 2007.

American Community Gardens Association, "What Is a Community Garden," website, no date. As of December 2012: http://www.communitygarden.org/learn/

American Council for an Energy-Efficient Economy, website, 2011. As of April 1, 2011: http://www.aceee.org/

American Institute of Architects, website, 2011. As of April 1, 2011: http://www.aia.org/index.htm

American Planning Association, *Planning and Urban Design Standards*, Hoboken, NJ: John Wiley & Sons, 2006.

American Public Health Association, "Policy Statement No. 200712: Toward a Healthy, Sustainable Food System," November 6, 2007.

American Society of Civil Engineers, website, 2011. As of April 1, 2011: http://www.asce.org/

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), website, 2010. As of April 1, 2011: http://www.ashrae.org/

Amin, Massoud, and John Stringer, "The Electric Power Grid: Today and Tomorrow," *MRS Bulletin*, Vol. 33, April 2008, pp. 399–407. As of September 14, 2010: http://www.mrs.org/s_mrs/bin.asp?CID=12527&DID=206424

Arlington County, Virginia, *Arlington County Community Energy & Sustainability Task Force Report: FINAL DRAFT*, March 4, 2011.

Army Chief of Staff, "Army Communities Excellence Awards 2011," U.S. Army, 2011.

Army Energy Program, "Appropriated Funds-ECIP," updated January 4, 2010. As of March 14, 2010: http://army-energy.hqda.pentagon.mil/funding/ecip.asp.

Army Energy Program, "Army Vision for Net Zero," no date. As of August 21, 2011: http://army-energy.hqda.pentagon.mil/netzero/

Army Regulation 420-1, "Army Facilities Management," draft, August 2012.

Army Wife Network, Message Board, August 2, 20210. As of September 7, 2010: http://www.armywifenetwork.com/forum/

Arnold, Matthew B., and Robert M. Day, *The Next Bottom Line: Making Sustainable Development Tangible*, Washington, D.C.: World Resources Institute, 1998.

Assistant Secretary of the Army for Installations, Energy, and Environment, "Net Zero: A Force Multiplier," no date. As of August 29, 2011: http://www.asaie.army.mil/Public/IE/netzero_info.html

Baillie, Jonathan, Craig Hilton-Taylor, and Simon N. Stuart (eds.), *A Global Species Assessment*, Cambridge, UK: IUCN, 2004.

Balepur, Prashant N., Krishna V. Varma, and Patricia L. Mokhtarian, "The Transportation Impacts of Center-Based Telecommuting: Interim Findings from the Neighborhood Telecenters Project," *Transportation*, Vol. 25, No. 3., 1998, p. 1. As of November 1, 2010: http://www.springerlink.com/content/w83287v254264u52/fulltext.pdf

Barnes, Kassandra, Raymond C. Marateo, and S. Pixy Ferris, "Teaching and Learning with the Net Generation." As of February 10, 2011: http://innovateonline.info/pdf/vol3_issue4/Teaching_and_Learning_with_the_Net_Generation.pdf.

Barnett, Emma, "200m Facebook Users Play Games Every Month," *The Telegraph*, September 22, 2010. As of April 12, 2011: http://www.telegraph.co.uk/technology/facebook/8018515/200m-Facebook-users-play-games-every-month.html

Barno, David, Assistant Chief of Staff for Installation Management, "Sustainable Management of Waste in Military Construction, Renovation and Demolition Activities," February 6, 2006.

Barrow, Mary Reid, "Community Gardens a Growing Trend," *The Virginian-Pilot*, July 12, 2009.

Bayractar, F., and Z. Gun, "Incidence and Correlates of Internet Usage Among Adolescents in North Cyprus," *CyberPsychology & Behavior*, Vol. 10, 2007.

BBC Mobile News UK, "Twitter, Facebook and Blackberry to Attend Riot Summit," August 25, 2011. As of August 25, 2011:
http://www.bbc.co.uk/news/uk-14657456

BCC Research, "Medical Robotics and Computer-Assisted Surgery," June 1, 2009. As of September 9, 2010:
http://www.marketresearch.com/product/display.asp?productid=2290056

Beck, Eckardt C., "The Love Canal Tragedy," *EPA Journal*, January 1979. As of December 2011:
http://www.epa.gov/history/topics/lovecanal/01.html

Beckert, Elizabeth, and Anne Jakle, *Renewable Energy Data Book*, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, September 2008. As of April 1, 2011:
http://www.emnrd.state.nm.us/ECMD/Multimedia/documents/eere_databook_091208.pdf

Bike Share Nashville, website, 2009. As of November 2, 2010:
http://www.nashvillebikeshare.org/home.aspx

Blizzard Entertainment, "World of Warcraft Subscriber Base Reaches 11.5 Million Worldwide," November 21, 2008. As of September 7, 2010:
http://us.blizzard.com/en-us/company/press/pressreleases.html?081121

Boase, Jeffrey, John B. Horrigan, and Barry Wellman, *The Strength of Internet Ties: The Internet and Email Aid Users in Maintaining Their Social Networks and Provide Pathways to Help When People Face Big Decisions*, Washington, D.C.: Pew Internet and American Life Project, January 25, 2006.

Boddy, Chet, "Rural Sprawl," *Mendocino Coast Real Estate Magazine*, January 1995.

Booth, Bradford, Mady Wechsler Segal, and D. Bruce Bell*, What We Know About Army Families: 2007 Update,* Fremont, CA: Caliber Consulting, 2007. As of December 2012:
http://www.mwrbrandcentral.com/HOMEPAGE/Graphics/Research/whatweknow2007.pdf

Boyce, Paul, "Army Announces Historic Electric Vehicle Lease," United States Army Press Release, January 12, 2009. As of November 1, 2010:
http://www.army.mil/-newsreleases/2009/01/12/15707-army-announces-historic-electric-vehicle-lease/

Boyd, Danah, "Why Youth (Heart) Social Network Sites: The Role of Networked Publics in Teenage Social Life," in David Buckingham (ed.), *Youth, Identity, and Digital Media*, Cambridge, MA: The MIT Press, 2008, pp. 119–142.

The Brattle Group; Freeman, Sullivan & Company; Global Energy Partners, LLC, *A National Assessment of Demand Response Potential*, U.S. Department of Energy, 2009. As of April 1, 2011:
http://www.brattle.com/_documents/uploadlibrary/upload775.pdf

Brunekreef, Burt, and Stephen T. Holgate, "Air Pollution and Health," *The Lancet*, Vol. 360, No. 9341, 2002, pp. 1233–1242.

Budiman, Adrian M., *Virtual Online Communities: A Study of Internet Based Community Interactions*, dissertation, Athens, OH: Scripps College of Communications of Ohio University, 2008. As of September 8, 2010:
http://etd.ohiolink.edu/etd/send-pdf.cgi/Budiman%20Adrian%20M.pdf?acc_num=ohiou1215559506

Building Codes Assistance Project, *About Us*, undated. As of April 1, 2011:
http://bcap-energy.org/node/147

Built Green Washington, website, 2011. As of April 1, 2011:
http://www.builtgreenwashington.org/

Buntrock, Gerrit, "Food Prices: Cheap No More," *The Economist*, December 6, 2007.

Burdette, Hillary, and Robert C. Whitaker, "Resurrecting Free Play in Young Children Looking Beyond Fitness and Fatness to Attention, Affiliation, and Affect," *Archives of Pediatrics and Adolescent Medicine*, Vol. 159, No. 1, January 2005, pp. 46–50.

Bureau of Labor Statistics, "American Time Use Survey," 2010 data. As of January 17, 2011:
http://www.bls.gov/tus/charts/leisure.htm

Bureau of Labor Statistics, "Women in the Labor Force, 2010," December 23, 2011. As of December 2012:
http://www.bls.gov/opub/ted/2011/ted_20111223.htm

C40 Cities, Climate Leadership Group, Clinton Climate Initiative, *Transport: Portland, United States of America*, 2009. As of November 1, 2010:
http://www.c40cities.org/bestpractices/transport/portland_traffic.jsp

California Building Standards Commission, *2010 California Green Building Standards Code, California Code of Regulations, Title 24, Part 11,* January 1, 2011. As of March 31, 2011:
http://www.documents.dgs.ca.gov/bsc/CALGreen/2010_CA_Green_Bldg.pdf

California Energy Commission, "Fuel-Efficient Traffic Signal Management: Results from the 1983 Program," 1984.

Californians Against Waste, "E-waste Laws in Other States." As of December 2012:
http://www.cawrecycles.org/issues/ca_e-waste/other_states.

Callaghan, Vic, Graham Clarke, and Jeannette Chin, "Some Socio-Technical Aspects of Intelligent Buildings and Pervasive Computing Research," *Intelligent Buildings International Journal*, Vol. 1, No. 1, 2008, pp. 56–74.

Campbell, Roy, Jalal Al-Muhtadi, Prasad Naldurg, Geetanjali Sampemanel, and M. Dennis Mickunas, "Towards Security and Privacy for Pervasive Computing," *Lecture Notes in Computer Science,* Vol. 2609, 2003, pp. 77–82.

Capriola, Jennifer, "Water Resources Management at Fort Huachuca Continues 15 Years Later." As of September 30, 2010: http://www.army.mil/-news/2010/07/26/42850-water-resources-management-at-fort-huachuca-continues-15-years-later/.

Carnegie Mellon University, *The TriPOD House*, undated a. As of March 31, 2011: http://www.andrew.cmu.edu/org/SD2007/house/index.html

———, School of Architecture, *Facilities*, undated b. As of April 1, 2011: http://www.cmu.edu/architecture/facilities/index.html

———, School of Architecture, *Research*, undated c. As of April 1, 2011: http://www.cmu.edu/architecture/research/cbpd/absic-cbpd.html

Carswell, W., et al., "The NOCTURNAL Ambient Assisted Living System," *Pervasive Computing Technologies for Healthcare (PervasiveHealth)*, 2011 5th International Conference on Pervasive Computing Technologies for Healthcare and Workshops, May 23–26 2011, pp. 208–209. As of August 23, 2012: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6038795&isnumber=6038756

Cao, F., L. Su, T. Liu, and X. Gao, "The Relationship Between Impulsivity and Internet Addiction in a Sample of Chinese Adolescents," *European Psychiatry*, Vol. 22, pp. 466–471, 2007.

Celizic, Mike "Chrysler's Peapod: 2 Cents Per Mile Plus a Smile," *Today*, April 22, 2009. As of November 2, 2010: http://today.msnbc.msn.com/id/30344587.

Centers for Disease Control and Prevention, "Behavioral Risk Factor Surveillance System, 2009." As of September 16, 2010: http://apps.nccd.cdc.gov/brfss/

Centers for Disease Control and Prevention, "Calorie Consumption on the Rise in United States, Particularly Among Women," February 5, 2004. As of January 20, 2011: http://www.cdc.gov/nchs/pressroom/04news/calorie.htm.

Centers for Disease Control and Prevention, "U.S. Obesity Trends," no date. As of September 17, 2010: http://www.cdc.gov/obesity/data/trends.html#County.

Centers for Neighborhood Technology, website. As of October 21, 2010: http://www.cnt.org/.

Chen, Allan, "Working Toward the Very Low Energy Consumption Building of the Future," Berkeley Lab and U.S. Department of Energy, 2009. As of April 1, 2011: http://newscenter.lbl.gov/feature-stories/2009/06/02/working-toward-the-very-low-energy-consumption-building-of-the-future/

Circeo, Louis, *Plasma Arc Generation of Municipal Solid Waste*, Georgia Tech Electro-Optical Systems Laboratory, 2010.

City of Chicago, "City Hall's Rooftop Garden," no date. As of December 2012: http://www.cityofchicago.org/city/en/depts/dgs/supp_info/city_hall_green_roof.html

City of Palo Alto, Title 18, Zoning Code, September 11, 2007. As of November 4, 2010: http://www.amlegal.com/nxt/gateway.dll/California/paloalto_ca/paloaltomunicipalcode?f=templates$fn=default.htm$3.0$vid=amlegal:paloalto_ca

Claridge, J., and D. Haberl, "Can You Achieve 150% of Predicted Retrofit Savings? Is It Time for Recommissioning?" American Council for an Energy Efficiency Economy (ACEEE), Summer Study on Energy Efficiency in Buildings, *Volume 5, Commissioning, Operation and Maintenance*, ACEEE, Washington, D.C., 1994. Cited by Federal Energy Management Program, *Operations and Maintenance Best Practices: A Guide to Achieving Operational Efficiency*, 2002.

Clements, R., "An Investigation of the State of Outdoor Play," *Contemporary Issues in Early Childhood*, Vol. 5, No. 1, 2004, pp. 68–80.

Colorado Office of Economic Development and International Trade, *Colorado Data Book*, Denver: COED&IT, 2006. As of September 28, 2010: http://www.state.co.us/oed/business-development/colorado-data-book.cfm

Colorado State University, "Institute for the Built Environment," website, 2010. As of April 1, 2011: http://www.ibe.colostate.edu/

Committee for the Study on the Relationships Among Development Patterns, Vehicle Miles Traveled, and Energy Consumption, *Driving and the Built Environment: The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions*, Washington, D.C.: Transportation Research Board, TRB Special Report 298, 2009. As of October 29, 2010: http://onlinepubs.trb.org/Onlinepubs/sr/sr298.pdf

Comstock, George, *The Evolution of American Television*, Newbury Park, CA: Sage, 1989.

Congress for the New Urbanism, "Charter of the New Urbanism," 1996.

Congressional Budget Office, *The Budget and Economic Outlook: Fiscal Years 2010–2020*, Washington, D.C.: Congressional Budget Office, 2010.

Cook, Diane J., Juan C. Augusto, and Vikramaditya R. Jakkula, "Ambient Intelligence: Technologies, Applications, and Opportunities," *Pervasive Mobile Computing*, Vol. 5, No. 4, 2009, pp. 277–298.

Costanza, R., et al., "The Value of the World's Ecosystem Services and Natural Capital," *Nature*, Vol. 387, 1997, pp. 253–260.

Coste-Manière, È., D. Olender, W. Kilby, and R.A. Schultz, "Robotic Whole Body Stereotactic Radiosurgery: Clinical Advantages of the CyberKnife® Integrated System," *International Journal of Medical Robotics Computer Assisted Surgery*, Vol. 1, No. 2, 2005, pp. 28–39.

"Couple Let Baby Starve to Death While Raising Virtual Baby Online," *The Huffington Post*, May 5, 2010, As of February 16, 2011: http://www.huffingtonpost.com/2010/03/05/couple-let-baby-starve-to_n_487287.html

Czincz, Jennifer, and Regina Hechanova, "Internet Addiction: Debating the Diagnosis," *Journal of Technology in Human Services*, Vol. 27, No. 4, October 2009, pp. 257–272.

Daily, Gretchen C., et al., "Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystems," *Issues in Ecology*, Number 2, Ecological Society of America, 1997.

Davis Langdon Management Consulting, *Life Cycle Costing (LCC) as a Contribution to Sustainable Construction: A Common Methodology—Draft Methodology: Key Issues and Outline Framework*, 2006. As of March 31, 2011: http://www.tmb.org.tr/arastirma_yayinlar/LCC_draft-methodology.pdf

Defense Science Board, *More Fight—Less Fuel*, Defense Science Board Task Force on DoD Energy Security, Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, Washington, D.C., February 2008.

Department of the Army, "Army Regulation 200–1. Environmental Protection and Enhancement," December 13, 2007.

Department of the Army, *Army Energy Security Implementation Strategy*, January 13, 2009.

Department of the Army Deputy Chief of Staff, Headquarters, Army G-1, Office of Army Demographics, *The Changing Profile of the Army,* 2008.

Despommier, Dickson D., "A Farm on Every Floor," *New York Times*, August 23, 2009.

"Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives," *Official Journal of the European Union*, November 22, 2008. As of March 31, 2011: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0003:EN:PDF

"Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings," *Official Journal of the European Union*, June 18, 2010. As of March 31, 2011: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF

Dobb, Anthony N., and Glenn F. MacDonald, "Television Viewing and Fear of Victimization: Is the Relationship Causal?" *Journal of Personality and Social Psychology*, Vol. 37, February 1979, pp. 170–179.

Dollman, J., K. Norton, and L. Norton, "Evidence for Secular Trends in Children's Physical Activity Behaviour," *British Journal of Sports Medicine*, Vol. 39, 2005, pp. 892–897.

Dowling, R., D. Feltham, and W. Wycko, "Factors Affecting Transportation Demand Management Program Effectiveness at Six San Francisco Medical Institutions," Transportation Research Board, Record 1321, 1991, pp. 109–117.

Duany, Andres, Elizabeth Plater-Zyberck, and Jeff Speck., *Suburban Nation: The Rise of Sprawl and Decline of the American Dream*, New York: North Point Press, 2001.

Duany, Andres, Elizabeth Plater-Zyberck, et al., *Town and Town-Making Principles*, New York: Rizzoli, 1991.

Ducatel, K., M. Bogdanowicz, F. Scapolo, J. Leijten, and J.C. Burgelman, *ISTAG, Scenarios for Ambient Intelligence in 2010*, Seville, Spain: IPTS, 2001.

Ellison, N.B., C. Steinfield, and C. Lampe, "The Benefits of Facebook 'Friends:' Social Capital and College Students' Use of Online Social Network Sites," *Journal of Computer-Mediated Communication*, Vol. 12, No. 4, Article 1. As of September 7, 2010: http://jcmc.indiana.edu/vol12/issue4/ellison.html

Energy Star, website, undated a. As of March 31, 2011: https//www.energystar.gov/

———, "Buildings and Plants," undated b. As of April 1, 2011: http://www.energystar.gov/index.cfm?c=business.bus_index

England, Gordon, Deputy Secretary of Defense, memorandum, "Strengthening America's Security and Improving the Environment," February 16, 2007. As of December 2012: http://army-energy.hqda.pentagon.mil/docs/keyDirectives/Energy%20EO%20 SecDef-signed%20memo%202-16-07.pdf

Enns, Cecilia Wikinson, Sharon J. Mickle, and Joseph D. Goldman, "Trends in Food and Nutrient Intakes by Children in the United States," *Family Economics and Nutrition Review*, Vol. 14, No. 2, 2002, pp. 56–68.

Environmental Defense Fund, "Protect 10 Million Acres from Sprawl," July 2007. As of September 9, 2010: http://www.edf.org/page.cfm?tagID=4581

Environmental Protection Agency, "Bucks County Eco-Industrial Park and Two Tenants Join EPA Sustainability Initiative, Push Green Commitment Higher," 2009.

Environmental Protection Agency, "Exotic Species," last updated April 6, 2011. As of April 11, 2010: http://water.epa.gov/type/oceb/habitat/invasive_species_index.cfm

Environmental Protection Agency, "HUD-DOT-EPA Interagency Partnership for Sustainable Communities," June 16, 2009.

Environmental Protection Agency, *Report on the Environment: Highlights of National Trends*, Washington, D.C.: EPA, June 2008.

European Commission Environment Directorate-General, "Overview of the EU Legislation with Reference to Green Public Procurement," 2009.

Evan, Mark B., "Tucson Water Continues Successful Rebate Programs," *Tucson Citizen.com*, July 2, 2010. As of August 12, 2010: http://tucsoncitizen.com/hot-off-the-press-release/2010/07/02/tucson-water-continues-successful-rebate-programs/

Ewing, R., J. Kostyak, D. Chen, B. Stein, and M. Ernst, *Endangered by Sprawl: How Runaway Development Threatens America's Wildlife*, Washington, D.C.: National Wildlife Federation, Smart Growth America, NatureServe, 2005.

Ewing, Reid, Keith Bartholomew, Steve Winkelman, Jerry Walters, and Don Chen, *Growing Cooler: The Evidence on Urban Development and Climate Change*, Washington, D.C.: Urban Land Institute, 2008. As of October 29, 2010: https://www.commuterconnections.org/uploads/committee-documents/u1ZbXlk20070921140031.pdf

Executive Order (EO) 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," applicability October 5, 2009.

Facebook, statistics, 2010. As of September 7, 2010: http://www.facebook.com/press/info.php?statistics

Farley, Scott M., and Scott C. Belfit, "Addressing Encroachment with Cooperative Agreements and Conservation," *Federal Facilities Environmental Journal*, Vol. 12, No. 2, Summer 2001.

Farmland Information Center, website. As of October 9, 2010: http://www.farmlandinfo.org

Farr, Douglas, *Sustainable Urbanism: Urban Design with Nature*, Hoboken, NJ: Wiley, 2008.

Federal Office for Information Security, *Pervasive Computing: Trends and Impacts*, 2006. As of September 8, 2010: https://www.bsi.bund.de/cae/servlet/contentblob/486908/publicationFile/30670/Percenta_elay_pdf.pdf

Federation of Canadian Municipalities, "Solid Waste as a Resource: Guide for Sustainable Communities," 2004.

Fisk, William, "Health and Productivity Gains from Better Indoor Environments and Their Implications for the U.S. Department of Energy," in *E-Vision 2000: Key Issues That Will Shape Our Energy Future: Analyses and Papers Prepared for the E-Vision 2000 Conference*, Santa Monica, CA: RAND Corporation, CF-170/1-1-DOE, 2001, pp. 165–201. As of March 31, 2011: http://www.rand.org/pubs/conf_proceedings/CF170z1-1

Fjørtoft, Ingunn, "The Natural Environment as a Playground for Children: The Impact of Outdoor Play Activities in Pre-Primary School Children," *Early Childhood Education Journal*, Vol. 29, No. 2, Winter 2001, pp. 111–117.

Fletcher, R.R., et al., "Mobile Application and Wearable Sensors for Use in Cognitive Behavioral Therapy for Drug Addiction and PTSD," *Pervasive Computing Technologies for Healthcare (PervasiveHealth)*, 2011 5th International Conference on Pervasive Computing Technologies for Healthcare and Workshops, May 23–26 2011, pp. 202–203. As of August 23, 2011:
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6038792&isnumber=6038756

Florance, Andy, "The Economics of Green," presented at the EPA Conference on The Power of Information to Motivate Change: Communicating the Energy Efficiency of Today's Commercial Buildings, Washington, D.C.: December 2008.

Florida Green Building Coalition (FGBC), website, 2011. As of April 1, 2011:
http://floridagreenbuilding.org/

Forest Stewardship Council, website, 1996. As of March 31, 2011:
http://www.fscus.org/

Forest Stewardship Council, United States, "Mission and Vision," undated. As of December 2012:
https://us.fsc.org/mission-and-vision.187.htm

Fort Campbell, "Army Installation Success Stories: Demolition Concrete Waste Diversion," fact sheet, undated.

Fort Carson, *Fort Carson 2006 Sustainability Report*, Fort Carson, CO, 2006.

Fort Hood, "Solid Waste Annual Report for FY06," Fort Hood, Texas, 2006.

Friedewald, Michael, Elena Vildjiounaite, Yves Punie, and David Wright, "Privacy, Identity and Security in Ambient Intelligence: A Scenario Analysis," *Telematics and Informatics*, Vol. 24, No. 1, 2006, pp. 15– 29.

Fry, Emory A., and Leslie A. Lenert, "MASCAL: RFID Tracking of Patients, Staff and Equipment to Enhance Hospital Response to Mass Casualty Events," *AMIA Annu Symp Proceedings*, 2005, pp. 261–265. As of September 3, 2010:
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1560691/

Fujioka, Chisa, "World Needs Urgent Action to Stop Species Loss: UN," Reuters, October 18, 2010. As of October 26, 2010:
http://www.reuters.com/article/idUSTRE69E0BF20101018?pageNumber=2

Fuller, Sieglinde, *Life-Cycle Cost Analysis (LCCA),* National Institute of Standards and Technology, 2010. As of April 1, 2011:
http://www.wbdg.org/resources/lcca.php

Fullerton, Howard N., "Labor Force Participation: 75 Years of Change, 1950–98 and 1998–2025," *Monthly Labor Review*, December 1999, pp. 3–12.

Gaddam, A., S.C. Mukhopadhyay, and G.S. Gupta, "Smart Home for Elderly Care Using Optimized Number of Wireless Sensors," *Lecture Notes in Electrical Engineering*, Vol. 64, 2010, pp. 307–328.

Gao, G., and L. Su, "Internet Addiction Among Chinese Adolescents: Prevalence and Psychological Features," *Child Care Health and Development*, No. 33, 2007.

Gartner, "Gartner Says 80 Percent of Active Internet Users Will Have a 'Second Life' in the Virtual World by the End of 2011," April 24, 2007. As of September 7, 2010: http://www.gartner.com/it/page.jsp?id=503861

Gasteyer, Stephen, and Jason Gray, "Rural Sprawl: How Is Infrastructure Development Impacting the Quality of Life in Rural Communities," *Rural Matters*, Summer 2005.

Gates, Bill, "A Robot in Every Home," *Scientific American*, January 2007. As of September 10, 2010: http://www.scientificamerican.com/article.cfm?id=a-robot-in-every-home

Gelman, Rachel, *2009 Renewable Energy Data Book*, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, August 2010. As of April 1, 2011: http://www1.eere.energy.gov/analysis/pdfs/48178.pdf

Gelman, Rachel, and Steve Hockett, *2008 Renewable Energy Data Book*, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, July 2009. As of April 1, 2011: http://www1.eere.energy.gov/analysis/pdfs/45654.pdf

Geoghegan, Michael, "The Future of Finance Shifts from West to East," *Forbes*, April 29, 2010. As of October 23, 2010: http://www.forbes.com/2010/04/29/hsbc-ceo-asia-china-india-markets-economy-michael-geoghegan.html

Gerbner, George, Larry Gross, Michael Morgan, and Nancy Signorelli, "The 'Mainstreaming' of America: Violence Profile No. 11," *Journal of Communication*, Vol. 30, Summer 1980, pp. 10–29.

Gerlak, Andrea, and Tanya Heikkila, "Comparing Collaborative Mechanisms in Large-Scale Ecosystem Governance," *Natural Resources Journal*, Vol. 46, Summer 2006, pp. 657–707.

Glascock, Anthony P., and David M. Kutzik, "The Impact of Behavioral Monitoring Technology on the Provision of Health Care in the Home," *Journal of Universal Computer Science*, Vol. 12, No. 1, 2006, pp. 59–79.

Global Biodiversity Outlook 3, Montreal: Secreatariat of the Convention on Biological Diversity, 2010, As of September 8, 2010: http://www.cbd.int/doc/publications/gbo/gbo3-final-en.pdf

Goodman, Christy, "Arlington County Board Forms Energy Task Force to Advise on Emissions," *Washington Post*, January 2, 2010. As of March 31, 2011: http://www.washingtonpost.com/wp-dyn/content/article/2010/01/01/AR2010010101862.html

Gortmaker, Steven, et al., "Television Viewing as a Cause of Increasing Obesity Among Children in the United States, 1986–1990," *Arch Pediatr Adolesc Med.*, Vol. 150, No. 4, 1996, pp. 356–362.

Governor of Hawaii, "Protecting Our Food Security," fact sheet. As of December 2012: http://hawaii.gov/gov/leg/2008-session/fact-sheets/text-documents/protecting-our-food-security

Granade, Hannah Choi, Jon Creyts, Anton Derkach, Philip Farese, and Scott Nyquist, *Unlocking Energy Efficiency in the U.S. Economy*, McKinsey & Company, 2009. As of March 31, 2011: http://www.mckinsey.com/clientservice/electricpowernaturalgas/downloads/US_energy_efficiency_full_report.pdf

Grant, Michael, et al., *Assessing Mechanisms for Integrating Transportation-Related Greenhouse Gas Reduction Objectives into Transportation Decision Making*, Transportation Research Board, National Cooperative Highway Research Program, Web-Only Document 152, January 2010. As of December 2012: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w152.pdf

Green Home NYC, *About Us,* 2011. As of April 1, 2011: http://greenhomenyc.org/about-us

Greene, D.L., and A. Schafer, *Reducing Greenhouse Gas Emissions from U.S. Transportation*, Pew Center on Global Climate Change, Arlington, VA, May 2003.

Greenguard, "Greenguard Certification Programs," 2010. As of March 31, 2011: http://www.greenguard.org/en/CertificationPrograms.aspx

Grone, Philip W., Deputy Under Secretary of Defense (Installations and Environment), memorandum, "Installation Energy Policy Goals," November 18, 2005. As of December 2012: http://army-energy.hqda.pentagon.mil/docs/keyDirectives/18%20Nov%202005%20policy%20-%20Grone.pdf

Hamblem, Matt, "Survey Shows Mobility Is Mainstream at Work," *Computerworld*, October 19, 2010. As of October 29, 2010: http://www.computerworld.com/s/article/9191431/Survey_shows_mobility_is_mainstream_at_work

Hammack, Katherine, Assistant Secretary of the Army, IE&E, "Energy and Sustainability Priorities and Opportunities," *U.S. Army Journal of Installation Management*, Spring 2011.

Hamner, Bradley, Sanjiv Singh, Stephan Roth, and Takeshi Takahashi, "An Efficient System for Combined Route Traversal and Collision Avoidance," *Autonomous Robots*, Vol. 24, No. 4, May, 2008, pp. 365–385.

Hampton, Keith, and Barry Wellman, "Neighboring in Netville: How the Internet Supports Community and Social Capital in a Wired Suburb," *City & Community*, Vol. 2, No. 4, December 2003, pp. 277–311.

Hanak, Ellen, and Matthew Davis, "Lawns and Water Demands in California," *California Economic Policy*, Vol. 2, No. 2, July 2006, p. 3.

Hansen, Andrew J., et al. (eds.), "Land-Use Change in Rural America: Rates, Drivers, and Consequences," *Ecological Applications*, Vol. 15, No. 6, 2005.

Hansmann, Uwe, Lothar Merk, Martin S. Nicklous, and Thomas Stober, *Pervasive Computing : The Mobile World*, Springer, August 2003.

Hassan, Rashid, Robert Scholes, and Neville Ash (eds.), *Ecosystems and Human Well-Being: Current State and Trends, Volume 1*, Washington, D.C.: Island Press, 2005. As of December 2012:
http://www.unep.org/maweb/en/Condition.aspx

Hay, L.E., "Educating the Net Generation," *The Social Administrator,* Vol. 57, No. 54, 2000, pp. 6–10.

Hayghe, Howard V., "Family Members in the Work Force," *Monthly Labor Review*, March 1990, pp. 14–29.

Hayhoe, K., C.P. Wake, T.G. Huntington, L. Luo, M.D. Schwartz, J. Sheffield, E. Wood, B. Anderson, J. Bradbury, A. DeGaetano, T.J. Troy, and D. Wolfe, "Past and Future Changes in Climate and Hydrological Indicators in the U.S. Northeast," *Climate Dynamics*, Vol. 28, No. 4, 2007, pp. 381–407.

Heerwagen, Judith, "Sustainable Design Can Be an Asset to the Bottom Line," *Environmental Design and Construction*, 2002.

Heerwagen, Judith, and Betty Hase, "Building Biophilia: Connecting People to Nature in Building Design," *Environmental Design and Construction*, 2001, pp. 30–36.

Helft, Michael, "Google's Buses Help Its Workers Beat the Rush," *New York Times*, March 10, 2007. As of October 29, 2010:
http://www.nytimes.com/2007/03/10/technology/10google.html

Hertz Car Rental, website, 2010. As of November 1, 2010:
http://www.hertz.com/

Hicks, Thomas, and Bill Von Neida, *U.S. National Energy Performance Rating System and ENERGY STAR Building Certification Program*, American Council for an Energy-Efficient Economy, 2003.

Hirsch, Paul M., "The 'Scary World' of the Nonviewer and Other Anomalies: A Reanalysis of Gerbner et al.'s Findings on Cultivation Analysis, Part 1," *Communication Research*, Vol. 7, October 1980, pp. 403–457.

Hoegh-Guldberg, O., et al., "Coral Reefs Under Rapid Climate Change and Ocean Acidification," *Science*, Vol. 318, No. 5857, 2007, pp. 1737–1742.

Holden, Erling, *Achieving Sustainable Mobility*, Burlington, VT: Ashgate Publishing, 2007.

Honda, *The 2011 Civic Hybrid*, 2010. As of November 1, 2010:
http://automobiles.honda.com/civic-hybrid/

"How Will Climate Change Affect India's Monsoon Season?" *ScienceDaily*, March 12, 2007.

Hsu, Jeremy, "Who Killed the Electric Car? Not the Army," *Popular Science*, January 15, 2009. As of November 1, 2010: http://www.popsci.com/cars/article/2009-01/who-killed-electric-car-not-army

Hsu, Lucy L., et al., "Trends in Overweight and Obesity Among 18-Year-Old Applicants to the United States Military, 1993–2006," *Journal of Adolescent Health*, Vol. 41, Issue 6, December 2007.

Huang, Andrew C., Benjamin C. Ling, Shankar Ponnekanti, and Armondo Fox, "Pervasive Computing: What Is It Good For?" *Proceedings of the ACM International Workshop on Data Engineering for Wireless and Mobile Access*, 1999, pp. 84–91.

Hughes, Michael, "The Fruits of Cultivation Analysis: A Re-examination of the Effects of Television Watching on Fear of Victimization, Alienation, and the Approval of Violence," *Public Opinion Quarterly*, Vol. 44, Autumn 1980, pp. 287–303.

Hunt, David, "Jacksonville Mom Shakes Baby for Interrupting Farmville, Pleads Guilty to Murder," *The Florida Times-Union*, October 27, 2010. As of February 16, 2011: http://jacksonville.com/news/crime/2010-10-27/story/jacksonville-mom-shakes-baby-interrupting-farmville-pleads-guilty-murder

Hunter, P.R., "Climate Change and Waterborne and Vector-Borne Disease," *Journal of Applied Microbiology*, Vol. 94, 2003, pp. 37S–46S.

IBM Corporation, "IBM's Vision of a Smarter Home Enabled by Cloud Technology," *Insights from IBM Global Electronics Industry*, 2009.

Ikenberry, G. John, "The Rise of China as the Future of the West," *Foreign Affairs,* Vol. 87, Issue 1, January/February 2008, p. 23.

Institute of Transportation Studies, Berkeley, "UC Berkeley Center for Future Urban Transport," 2009. As of November 3, 2010: http://www.its.berkeley.edu/volvocenter/

Institute of Transportation Studies, Berkeley, website, 2010. As of November 3, 2010: http://its.berkeley.edu/

Intergovernmental Panel on Climate Change, "Chapter 3: Linking Climate Change and Water Resources: Impacts and Responses," in *Climate Change and Water,* IPCC Technical Paper VI, 2007. As of December 2012: http://www.ipcc.ch/pdf/technical-papers/ccw/chapter3.pdf

Intergovernmental Panel on Climate Change, *Climate Change 2007: Synthesis Report*, 2007. As of December 2012: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

International Code Council, website, 2010. As of April 1, 2011: http://www.iccsafe.org/

International Energy Agency, *World Energy Outlook 2011*, 2011. As of April 1, 2011: http://www.worldenergyoutlook.org/

International Federation of Robotics, "2007 World Robot Market: Executive Summary," *World Robotics 2008*, 2008. As of April 12, 2011: www.worldrobotics.org/downloads/2008_executive_summary.pdf

International Federation of Robotics, *World Robotics 2008*, June 2008. As of April 12, 2011: www.worldrobotics.org/downloads/Charts_PC_11_June_2008.pdf

International Federation of Robotics, *Executive Summary of 1. World Robotics 2009 Industrial Robots and 2. World Robotics 2009 Service Robots,* 2009. As of April 12, 2011: www.worldrobotics.org/downloads/2009_executive_summary.pdf

International Institute for Sustainable Development, "Kalundborg," no date. As of September 25, 2010: http://www.iisd.org/business/viewcasestudy.aspx?id=77

International Union for Conservation of Nature, *IUCN Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species*, Prepared by the Species Survival Commission Invasive Species Specialist Group, and approved by the 51st Meeting of the IUCN Council, Gland, Switzerland: Island Press, 2000.

International Union for Conservation of Nature, "Nature's Backbone at Risk," October 26, 2010. As of October 27, 2010: http://www.iucnredlist.org/news/vertebrate-story

International Union for Conservation of Nature, website. As of September 9, 2010: http://www.iucn.org/about/

Intuitive Research & Technology Corporation, *Department of Defense Energy Manager's Handbook*, Prepared for the Office of Deputy Under Secretary of Defense, Installations and Environment, August 25, 2005.

Jackson, Nancy Mann, "Fort Carson," *WasteAge*, Penton Media, Inc., September 23, 2010. As of April 6, 2011: http://wasteage.com/Landfill_Management/landfill-solar-energy-20100923/index1.html.

Jacobsen, Noel Brings, "Industrial Symbiosis in Kalundborg, Denmark: A Quantitative Assessment of Economic and Environmental Aspects," *Journal of Industrial Ecology*, Vol. 10, Issue 1, 2006, pp. 239–255.

Janetos, A., L. Hansen, D. Inouye, B.P. Kelly, L. Meyerson, B. Peterson, and R. Shaw, "Biodiversity," in P. Backlund et al., *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States*, Synthesis and Assessment Product 4.3, Washington, D.C.: U.S. Department of Agriculture, 2008, p. 151–181.

Jarmon, Leslie, Tomoko Traphagan, Michael Mayrath, and Avani Trivedi, "Virtual World Teaching, Experiential Learning, and Assessment: An Interdisciplinary Communication Course in Second Life," *Computers & Education*, Vol. 53, No. 1, 2009, pp. 169–182. As of September 7, 2010: http://www.sciencedirect.com/science/article/B6VCJ-4VR1T4G-1/2/1a178b60ea11fcdb0bf28e6f363d1d3a.

Jarnagin, Ronald, "ASHRAE Standard 90.1-2007: Setting a New Bar," briefing to GovEnergy Conference, August 7, 2007.

Jenicek, Elisabeth M., Natalie R.D. Myers, Brad Boesdorfer, and Donald F. Fournier, *Strategic Sustainability Assessment Pilot Study: Fall Line Region of the Southeast*, USACE, ERDC/CERL TR-06-32, November 2006.

Jian, Leiwen, Malea Hoepf Young, and Karen Hardee, "Population, Urbanization and Environment," *World Watch Magazine*, September/October, Vol. 21, No. 5, 2008.

Johansson, A., et al., "Internet Addiction: Characteristics of a Questionnaire and Prevalence in Norwegian Youth (12–18 years)," *Scandinavian Journal of Psychology*, 2004.

Juster, F. Thomas, Hiromi Ono, and Frank Stafford, *Changing Times of American Youth: 1981–2003*, Ann Arbor, MI: University of Michigan Institute for Social Research, November 2004.

Kargbo, D.M., R.G. Wilhelm, and D.J. Campbell, "Natural Gas Plays in the Marcellus Shale: Challenges and Potential Opportunities," *Environmental Science & Technology*, Vol. 44, No. 15, 2010, pp. 5679–5684.

Karpinski, A.C., and A. Duberstein, "A Description of Facebook Use and Academic Performance Among Undergraduate and Graduate Students," poster presented at American Educational Research Association Annual Meeting, 2009.

Kats, Greg H., *The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force*, Sacramento, CA: Sustainable Building Task Force, 2003.

Katz, Peter, *The New Urbansim: Toward an Architecture of Community*, New York: McGraw-Hill, 1993.

Kay, David J., "Emerging Global Trends and Potential Implications for National Security," National Security Watch 09-1, Arlington, VA: Association of the United States Army, May 29, 2009.

Kellert, Steven, and ,Edward O. Wilson (eds.), *The Biophilia Hypothesis*, Washington, D.C.: Island Press, 1993.

KHOU.com, Houston, Texas, "Police: San Antonio Sex Offender Targeted Victims on Facebook, Myspace," July 16, 2011. As of August 25, 2011: http://www.khou.com/news/texas-news/125692538.html

Kim, Hyung Chul, Gregory A. Keoleian, Darby E. Grande, and James C. Bean, "Life Cycle Optimization of Automobile Replacement: Model and Application," *Environmental Science and Technology*, Vol. 27, 2003, pp. 5407–5413. As of October 29, 2010: http://pubs.acs.org/doi/pdf/10.1021/es0345221

Kim, Kyunghee, Eunjung Ryu, Mi-Young Chon, Eun-Ja Yeun, So-Young Choi, Jeong-Seok Seo, and Bum-Woo Nam, "Internet Addiction in Korean Adolescents and Its Relation to Depression and Suicidal Ideation: A Questionnaire Survey," *International Journal of Nursing Studies*, Vol. 43, Issue 2, February 2006, pp. 185–192.

Kjellström, Barbro, David Ingel, JoAnn Abraham, Tom Bennett, and Robert Bourge, "Trans-telephonic Monitoring of Continuous Haemodyncamic Measurements in Heart Failure Patients," *Journal of Telemedicine and Telecare*, Vol. 11, No. 5, 2005, pp. 240–244.

Kneebone, Elizabeth, and Emily Garr, *The Landscape of Recession*, Washington, D.C.: Brookings Institution, 2009.

Ko, Chih-Hung, Ju-Yu Yen, Shu-Chun Liua, Chi-Fen Huanga, and Cheng-Fang Yen, "The Associations Between Aggressive Behaviors and Internet Addiction and Online Activities in Adolescents," *Journal of Adolescent Health*, Vol. 44, Issue 6, June 2009, pp. 598–605.

Koren, H.S., "Associations Between Criteria Air Pollutants and Asthma," *Environmental Health Perspectives*, Vol. 103, No. Suppl 6, 1995, pp. 235–242.

Korkeilaa, J., S. Kaarlasa, M. Jääskeläinenc, T. Vahlbergd, and T. Taiminene, "Attached to the Web—Harmful Use of the Internet and Its Correlates," *European Psychiatry*, Vol. 25, Issue 4, May 2010, pp. 236–241.

Kumagai, Jean, "A Robotic Sentry for Korea's Demilitarized Zone," *IEEE Spectrum*, 2007. As of April 12, 2011:
http://spectrum.ieee.org/robotics/military-robots/a-robotic-sentry-for-koreas-demilitarized-zone

Kuo, Frances E., and Andrea Faber Taylor, "A Potential Natural Treatment for Attention-Deficit/Hyperactivity Disorder: Evidence from a National Study," *American Journal of Public Health*, Vol. 94, No. 9, September 2004, pp. 1580–1586.

Lachman, Beth E., *Linking Sustainable Community Activities to Pollution Prevention: A Sourcebook*, Santa Monica, CA: RAND Corporation, MR-855-OSTP, 1997.
http://www.rand.org/pubs/monograph_reports/MR855.html

Lachman, Beth E., et al., *Developing Headquarters Guidance for Army Installation Sustainability Plans in 2007*, Santa Monica, CA: RAND Corporation, MG-837-A, 2010.
http://www.rand.org/pubs/monographs/MG837.html

Lachman, Beth E., et al., *Integrated Facility Environmental Management Approaches: Lessons from Industry for Department of Defense Facilities*, Santa Monica, CA: RAND Corporation, MR-1343-OSD, 2001.
http://www.rand.org/pubs/monograph_reports/MR1343.html

Lachman, Beth E., et al., *The Thin Green Line: An Assessment of DoD's Readiness and Environmental Protection Initiative to Buffer Installation Encroachment*, Santa Monica, CA: RAND Corporation, MG-612-OSD, 2007.
http://www.rand.org/pubs/monographs/MG612.html

Lachman, Beth E., Kimberly Curry Hall, Aimee E. Curtright, and Kimberly M. Colloton, *Making the Connection: Beneficial Collaboration Between Army Installations and Energy Utility Companies*, Santa Monica, CA: RAND Corporation, MG-1126-A, 2011.
http://www.rand.org/pubs/monographs/MG1126.html

Lal, M., "Implications of Climate Change on Agricultural Productivity and Food Security in South Asia," in *Key Vulnerable Regions and Climate Change—Identifying Thresholds for Impacts and Adaptation in Relation to Article 2 of the UNFCCC*, Dordrecht: Springer, 2005.

Land Trust Alliance, *National Land Trust Census*, Washington, D.C., September 12, 2001.

Land Trust Alliance, *2005 National Land Trust Census*, Washington, D.C., November 30, 2006.

Land Trust Alliance, website. As of October 9, 2010: http://www.lta.org/

———, "Talking Points on 2005 National Land Trust Census and Related Trends with Land Trusts." As of September 24, 2010: http://www.landtrustalliance.org/land-trusts/copy_of_land-trust-census/census-talking-points.doc

Lau, Sabrina M., *Investigating Eco-Industrial Park Development: Final Report & Recommendations for Future Consideration*, The Green Institute, October 1996.

LDA Consulting, CIC Research Inc., ESTC, Elham Shirazi, and Cheryl Collier, *Transportation Emission Reduction Measure (Term) Analysis Report, FY 2003–2005*, Washington, D.C.: Metropolitan Washington Council of Governments Commuter Connections Program, 2005.

Le Bohec, Celine et al., "King Penguin Population Threatened by Southern Ocean Warming," *Proceedings of the National Academy of Sciences of the United States*, Vol. 105, No. 7, 2008, pp. 2493–2497.

Leatherman, D.A., I. Aguayo, and T.M. Mehall, "Mountain Pine Beetle," Colorado State University Extension, fact sheet 5.528, April 3, 2012, As of December 2012: http://www.ext.colostate.edu/pubs/Insect/05528.html

Lee, Kai, "World Is Soon Half Urban," Worldwatch Institute, May 6, 2008.

Lee, Moon-Soo, et al., "Characteristics of Internet Use in Relation to Game Genre in Korean Adolescents, *CyberPsychology & Behavior*, Vol. 10, No. 2, 2007.

Leeming, J.J. , *Road Accidents: Prevent or Punish,* Cassell, 1969.

Lenhart, Amanda, "Adults and Social Network Websites," *Pew Internet and American Life Project*, January 14, 2009a.

Lenhart, Amanda, "It's Personal: Similarities and Differences in Online Social Network Use Between Teens and Adults," *Pew Internet and American Life Project*, May 23, 2009b.

Lenhart, Amanda, "Teens, Privacy and Online Social Networks," *Pew Internet and American Life Project,* 2007. As of April 12, 2011: http://www.pewinternet.org/Reports/2007/Teens-Privacy-and-Online-Social-Networks.aspx

Lenhart, Amanda, Mary Madden, and Paul Hitl, *Teens and Technology Youth Are Leading the Transition to a Fully Wired and Mobile Nation*, Pew Research Center, July 27, 2005.

Lenhart, Amanda, Kristen Purcell, Aaron Smith, and Kathryn Zickuhr, *Social Media and Mobile Internet Use Among Teens and Young Adults*, Pew Research Center, February 3, 2010.

Leonard, Abby, "Architect Frank Gehry Talks LEED and the Future of Green Building," PBS, June 14, 2010. As of December 2012: http://www.pbs.org/wnet/need-to-know/culture/architect-frank-gehry-talks-leed-and-the-future-of-green-building/

Lew, Michael, Erwin M. Bakker, Nicu Sebe, and Thomas S. Huang, "Human-Computer Interaction: A Survey," *Lecture Notes in Computer Science*, Vol. 4796, 2007, pp. 1–5.

Lifecycle Building Challenge, "2009 Lifecycle Building Challenge 3," 2012. As of December 2012: http://www.epa.gov/greenbuilding/pubs/lbc3.html#winners

Linkov, Igor, "Military Installations and Climate Change: Decisions, Decisions, Decisions, …" U.S. Army Engineer Research and Development Center, Concord, MA, April 20–21, 2011.

Liska, Kathy J., Michael A. Mackin, Michael J. Lichter, David W. York, Dilip Pillai, and David S. Rosenbaum, "Keeping a Beat on the Heart," *IEEE Pervasive Computing*, Vol. 3, No. 4, 2004, pp. 42–49.

Litman, Todd, *Smart Transportation Investments: Reevaluating the Role of Highway Expansion for Improving Urban Transportation*, Victoria, BC, Canada: Victoria Transport Policy Institute, October 1, 2006.

Louv, Richard, *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder*, Chapel Hill, NC: Algonquin Books, 2008.

Luciano, Christine, "Going Lean, Clean, and (Army) Green: DPW Tackles Environmental Issues," Fort Hood Department of Public Works Environmental News Release, Fort Hood, TX, July 2007. As of September 19, 2010: http://www.dpw.hood.army.mil/Files/Engineers%20go%20green.pdf

Luthcke, S.B., H.J. Zwally, W. Abdalati, D.D. Rowlands, R.D. Ray, R.S. Nerem, F.G. Lemoine, J.J. McCarthy, and D.S. Chinn, "Recent Greenland Ice Mass Loss by Drainage System from Satellite Gravity Observations," *Science*, Vol. 314, No. 5803, 2006, pp. 1286–1289.

Mandel, Jenny, "Federal Purchasing Should Be Guided by Emission Disclosures—GSA," *E&E News PM*, July 19, 2010.

Manzo, Lynne C., and Douglas D. Perkins, "Finding Common Ground: The Importance of Place Attachment to Community Participation and Planning," *Journal of Planning Literature*, Vol. 20, 2006, pp. 335–350.

Mascareñas, David, Eric Flynn, Michael Todd, Gyuhae Park, and Charles Farrar, "Wireless Sensor Technologies for Monitoring Civil Structures," *Sound and Vibration*, Vol. 42, No. 4, 2008, pp. 16–20.

McDonald, Robert I., Peter Kareiva, and Richard T.T. Forman, "The Implications of Current and Future Urbanization for Global Protected Areas and Biodiversity Conservation," *Biological Conservation*, Vol. 141, Issue 6, June 2008, pp. 1695–1703.

McLaughlin, John F., et al., "Climate Change Hastens Population Extinctions," *Proceedings of the National Academy of Sciences*, Vol. 9, 2002, pp. 6070–6074.

McKeown, Alice, "Organic Agriculture More Than Doubled Since 2000," *Vital Signs*, Washington, D.C.: Worldwatch Institute, 2010. As of September 16, 2010: http://www.groupedebruges.eu/pdf/Vital_Signs_2010.pdf

McMenamin, Sarah K., Elizabeth A. Hadly, and Christopher K. Wright, "Climatic Change and Wetland Desiccation Cause Amphibian Decline in Yellowstone National Park," *Proceedings of the National Academy of Sciences*, Vol. 105, No. 44, 2008, pp. 16988–16993.

McMichael, A.J., D.H. Campbell-Lendrum, C.F. Corvalan, K.L. Ebi, A.K. Githeko, J.D. Scheraga, and A. Woodward (eds.), *Climate Change and Human Health—Risks and Responses*, Geneva: World Health Organization, 2003.

Meetup, "About Meetup," 2010. As of September 7, 2010: http://www.meetup.com/about/

MetroTRansit, website, 2010. As of October 29, 2010: http://www.metrotransit.org/

Mettler, Diane, "Making Compost Military Style," *WHEN, Waste Handling Equipment News*, September 2011.

Meyrowitz, Joshua, *No Sense of Place: The Impact of Electronic Media on Social Behavior*, Oxford University Press, 1985.

Military Pathways, "Welcome to the Screening Program," 2009. As of September 7, 2010: http://www.militarymentalhealth.org/Welcome.aspx

Millard-Ball, Adam, Gail Murray, Jessica Ter Schure, Christine Fox, and Jon Burkhardt, "Car-Sharing: Where and How It Succeeds," in *Transit Cooperative Research Program Report 108*, Washington, D.C.: Transportation Research Board, 2005.

Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being: Biodiversity Synthesis*, Washington, D.C.: World Resources Institute, 2005. As of August 16, 2010: http://www.millenniumassessment.org/documents/document.354.aspx.pdf

Miller, D., "Deconstruction Projects Reduce Waste, Create Jobs," *County News*, August 17, 2009.

Mills, Evan, *Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions*, Sacramento, CA: California Energy Commissions Public Interest Energy Research (PIER), 2009. As of March 31, 2011: http://cx.lbl.gov/documents/2009-assessment/LBNL-Cx-Cost-Benefit.pdf

Mills, Evan, and Paul Matthews, *Monitoring-Based Commissioning: Benchmarking Analysis of 24 UC/CSU/IOU Projects*, California Energy Commission Public Interest Energy Research (PIER) Technology Demonstration Program, LBNL-1972E, 2009. As of March 31, 2011:
http://eetd.lbl.gov/emills/pubs/pdf/MBCx-LBNL.pdf

MIT, "Intelligent Transportation Research Center," website. As of September 12, 2011:
http://mtlweb.mit.edu/researchgroups/itrc/itrc.html

Mitchell, William J., Christopher E. Borroni-Bird, and Lawrence D. Burns, *Reinventing the Automobile: Personal Urban Mobility for the 21st Century*, Cambridge, MA: MIT Press, 2009.

Moore, Gordon E., "Cramming More Components onto Integrated Circuits," *Electronics*, Vol. 38, No. 8, 1965. As of September 3, 2010:
ftp://download.intel.com/research/silicon/moorespaper.pdf

Morris, Frank, "Army Boot Camp Embraces New-Age Fitness," National Public Radio from KCUR, December 28, 2010.

Myerowicz, Joshua, *No Sense of Place: The Impact of Electronic Media on Social Behavior*, New York: Oxford University Press, 1985.

Myers, N., "Environmental Refugees: An Emergent Security Issue," 13th Economic Forum, Prague, May 2005.

The National Academies, "Federal Facilities Council," 2012. As of August 24, 2012:
http://sites.nationalacademies.org/DEPS/FFC/

National Defense Authorization Act 2010, "To Authorize Appropriations for Fiscal Year 2010 for Military Activities of the Department of Defense, to Prescribe Military Personnel Strengths for Fiscal Year 2010, and for Other Purposes," H.R. 2647, 2010.

National Institute of Building Sciences, website, 2011. As of April 1, 2011:
http://www.nibs.org/

National Institute of Standards and Technology (NIST), "Building and Fire Research Laboratory Home," August 18, 2010. As of April 1, 2011:
http://www.nist.gov/bfrl/

National Intelligence Council, *Global Trends 2025: A Transformed World*, Washington, D.C.: Government Printing Office, 2008. As of August 13, 2010:
http://www.dni.gov/nic/NIC_2025_project.html

National Oceanic and Atmospheric Administration, National Climatic Data Center, "State of the Climate in 2011," *Special Supplemental to the Bulletin of the American Meteorological Society*, Vol. 93, No. 7, July 2012.

National Resources Conservation Service, website. As of October 20, 2010:
http://www.nrcs.usda.gov

National Science and Technology Council, Committee on Environment and Natural Resources, *Scientific Assessment of the Effects of Global Change on the United States*, Washington, D.C., 2008.

National Sustainable Agriculture Information Service, "Reducing Food Miles," April 26, 2012. As of December 2012: http://attra.ncat.org/attra-pub/farm_energy/food_miles.html

Natural Resources Defense Council, "Smart Growth in Uniform: Fort Belvoir's Example," *Natural Resources Defense Council Switchboard Staff Blog*, July 15, 2008. As of December 2012: http://switchboard.nrdc.org/blogs/kbenfield/smart_growth_in_uniform.html

NatureServe, website. As of August 13, 2010: http://www.natureserve.org/

Nature Conservancy, website. As of August 13, 2010: http://www.nature.org/.

Navarro, Mireya, "Some Buildings Not Living Up to Green Label," *New York Times*, August 30, 2009. As of March 31, 2011: http://www.nytimes.com/2009/08/31/science/earth/31leed.html

Nebel, Bernard J., and Richard T. Wright, *Environmental Science: The Way the World Works*, Englewood Cliffs, NJ: Prentice Hall, 1993.

Neely, B., S. Kettler, J. Horsman, C. Pague, R. Rondeau, R. Smith, L. Grunau, P. Comer, G.Belew, F. Pusateri, B. Rosenlund, D. Runner, K. Sochi, J. Sovell, D. Anderson, T. Jackson, and M. Klavetter, *Central Shortgrass Prairie Ecoregional Assessment and Partnership Initiative: Final Report*, The Nature Conservancy of Colorado and the Shortgrass Prairie Partnership, November 2006. As of August 10, 2010: http://www.cnhp.colostate.edu/download/documents/2006/CSP_Final_Report_2006.pdf

New York City Department of City Planning, "Bike Share Opportunities in New York City 2009," 2010. As of November 2, 2010: http://www.nyc.gov/html/dcp/html/transportation/td_bike_share.shtml

Ng, Brian D., and Peter Weimer-Hastings, "Addiction to the Internet and Online Gaming," *CyberPsychology & Behavior*, Vol. 8, No. 2, 2005, pp. 110–113.

Nilles, Jack M., *City of Los Angeles Telecommuting Project: Final Report*, Los Angeles, CA: JALA International, Inc., 1993.

North American Bird Conservation Initiative, U.S. Committee, *The State of the Birds, United States of America,* Washington, D.C.: U.S. Department of Interior, 2009. As of August 16, 2010: http://www.stateofthebirds.org/pdf_files/State_of_the_Birds_2009.pdf

Nucleus Research, "Facebook: Measuring the Cost to Business of Social Networking," 2009. As of April 12, 2011: http://nucleusresearch.com/research/notes-and-reports/facebook-measuring-the-cost-to-business-of-social-notworking/

Oblinger, Diana, and James L. Oblinger (eds.), *Educating the Net Generation,* EDUCAUSE, 2005.

Ofcom, *Social Networking: A Quantitative and Qualitative Research Report into Attitudes, Behaviours and Use*, April 2, 2008.

Office of the Assistant Chief of Staff for Installation Management, "Interim Army Implementation Guidance for Encroachment Authorities," DAIM-ISE Memo, February 24, 2012.

Office of the Assistant Secretary of the Army (OASA (IE&E)), "Net Zero Installations Identified." As of May 9, 2011:
http://www.asaie.army.mil/Public/IE/

Office of the Assistant Secretary of the Army (OASA (IE&E)), "Sustainable Design and Development Policy Update (Environmental and Energy Performance)," Washington, D.C., 2010.

Office of the Assistant Secretary of the Army (OASA (IE&E)), "Sustainable Design and Development Policy Update—Life Cycle Costs," memorandum on Installations and Environment, April 27, 2007.

Ogden, Cynthia, and Margaret Carroll, "Prevalence of Obesity Among Children and Adolescents: United States, Trends 1963–1965 Through 2007–2008." June 2010. As of September 17, 2010:
http://www.cdc.gov/nchs/data/hestat/obesity_child_07_08/obesity_child_07_08.htm

Organic Foods Production Act of 1990 [as amended through Public Law 109-97, November 10, 2005]. As of September 16, 2010:
http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5060370&acct=nopgeninfo

Organic Monitor, "Organic Monitor Gives 2009 Predictions." As of September 16, 2010:
www.organicmonitor.com/r3001.htm

Organic Trade Association (OTA), *2009 Organic Industry Survey, Executive Summary*, Greenfield, MA: OTA, May 2009.

Organization for Economic Cooperation and Development, *OECD Environmental Outlook to 2030*, Paris: OECD, 2008.

Orwat, Carsten, Andreas Graefe, and Timm Faulwasser, "Towards Pervasive Computing in Health Care: A Literature Review," *BMC Medical Informatics and Decision Making*, Vol. 8, No. 26, 2008. As of September 3, 2010:
http://www.biomedcentral.com/1472-6947/8/26

Otarian, website. As of October 21, 2010:
http://www.otarian.com/love-the-planet/environmental.html

Padel, Susanne, Diana Schaack, and Helga Willer, "Development of the Organic Market in Europe," in Helga Willer and Lukas Kilcher (eds.), *The World of Organic Agriculture Statistics and Emerging Trends 2009*, Bonn: Research Institute of Organic Agriculture (FiBL), International Federation of Organic Agriculture Movements (IFOAM), and International Trade Centre (ITC), 2009.

Pandya, Shawna, Jason W. Motkoski, Cesar Serrano-Almeida, Alexander D. Greer, Isabelle Latour, and Garnette R. Sutherland, "Advancing Neurosurgery with Image-Guided Robotics," *Journal of Neurosurgery*, Vol. 111, No. 6, 2009, pp. 1141–1149.

Parker, Larry, and Brent D. Yacobucci, *Climate Change: Costs and Benefits of the Cap-and-Trade Provisions of H.R. 2454*, Congressional Research Service, 2009. As of April 1, 2011: http://energy.senate.gov/public/_files/R40809.pdf

Pavey, Rob, "Fort Gordon Contract Awarded for New Modular Barracks," *The Augusta Chronicle*, May 12, 2009. As of March 31, 2011: http://chronicle.augusta.com/stories/latest/lat_519030.shtml

Peace, Johanna, "Facebook Eases Freshmen Fears, Fosters Friendship," CNN, September 7, 2007. As of September 7, 2010: http://edition.cnn.com/2007/TECH/ptech/09/07/cnnu.facebook/index.html

Pearle, Andrew D., Daniel Kendoff, Volker Stueber, Volker Musahl, and John A. Repicci, "Perioperative Management of Unicompartmental Knee Arthroplasty Using the MAKO Robotic Arm System (MAKOplasty)," *American Journal of Orthopedics*, Vol. 38, No. 25, 2009, pp. 16–19.

Petrich, Marisa, "Soldiers Leave Legacy of Sustainability," *Northwest Guardian*, August 18, 2011.

Petrina, A.M., "Robotics: Present and Future," *Scientific and Technical Information Processing*, Vol. 35, No. 2, 2008, pp. 73–79.

Pew Hispanic Research Center, *U.S. Population Projections: 2005–2050*, Washington, D.C.: Pew Research Center, February 2008.

Pew Research Center, *Millennials: A Portrait of Generation Next: Confident, Connected, Open to Change*, Washington, D.C.: February 24, 2010. As of September 7, 2010: http://pewresearch.org/pubs/1501/millennials-new-survey-generational-personality-upbeat-opennew-ideas-technology-bound

Pierce, D.W., T.P. Barnett, K.M. AchutaRao, P.J. Gleckler, J.M. Gregory, and W.M. Washington, "Anthropogenic Warming of the Oceans: Observations and Model Results," *Journal of Climate*, Vol. 19, No. 10, 2006, pp. 1873–1900.

Pimentel, David, et al., "Economic and Environmental Benefits of Biodiversity," *BioScience*, Vol. 47, No. 11, December, 1997.

Pimentel, D., S. McNair, J. Janecka, J. Wightman, C. Simmonds, C. O'Connell, E. Wong, L. Russel, J. Zern, T. Aquino, and T. Tsomondo, "Economic and Environmental Threats of Alien Plant, Animal, and Microbe Invasions," *Agriculture, Ecosystems and Environment*, Vol. 84, 2001, pp. 1–20.

Piotrowski, J. "Pro-Active Maintenance for Pumps, Archives," Pump-Zone.com, 2001. Cited by Federal Energy Management Program, *Operations and Maintenance Best Practices: A Guide to Achieving Operational Efficiency*, 2002, p. 2.3.

Pisarski, Alan E., "Commuting in America III: The Third National Report on Commuting Patterns and Trends," *TR News* 247, 2006. pp. 26–29.

Plattsburgh Airbase Redevelopment Corporation, undated. As of December 2012: http://www.nysmpos.org/sci/Quality_Communities/PARC.pdf

Pongsiri, Montira J., Joe Roman, Vanessa O. Ezenwa, Tony L. Goldberg, Hillel S. Koren, Stephen C. Newbold, Richard S. Ostfeld, Subhrendu K. Pattanayak, and Daniel J. Salkeld, "Biodiversity Loss and the New Global Disease Ecology," *BioScience,* Vol. 59, No. 11, December 2009, pp. 945–954.

Porter, Douglas R., *Managing Growth in America's Communities*, Washington, D.C.: Island Press, 1997.

Portland Bureau of Planning and Sustainability, website. As of December 2012: http://www.portlandoregon.gov/bps/

Portland Bureau of Transportation, "Welcome to the City's Bicycle Sharing Page," 2010. As of November 2, 2010: http://www.portlandonline.com/Transportation/index.cfm?c=50814#Bike%20Sharing%20Types

Portland Energy Conservation, Inc. (PECI), website, 2010. As of April 1, 2011: http://www.peci.org/

Posnick-Goodwin, Sherry, "Meet Generation Z," California Teachers Association, February 2010. As of December 2012: http://www.cta.org/Professional-Development/Publications/Educator-Feb-10/Meet-Generation-Z.aspx

Postman, Neil. *Amusing Ourselves to Death: Discourse in the Age of Show Business*, New York: Viking-Penguin Books, 1985.

Pounds, J. Alan, et al., "Widespread Amphibian Extinctions from Epidemic Disease Driven by Global Warming," *Nature*, Vol. 439, January 2006, pp. 161–167.

Prensky, Marc, "Digital Natives, Digital Immigrants, Part II: Do They Really Think Differently?" *On the Horizon*, Vol. 9, No. 6, December 2001, pp. 1–9.

Public Law 88-206, Stat. 401, Clean Air Act, 1963.

Public Law 91-604, Stat. 1676, 1970 Clean Air Act Amendment, 1970.

Public Law 101-549, Stat. 1630, 1990 Clean Air Act Amendment, 1990.

Public Law 101-624, Title XVI, Subtitle A, Section 1603.

Pugh, Tom, "Man Charged for Riot Incitement Using Facebook," *The Independent*, August 11, 2011. As of December 2012: http://www.independent.co.uk/news/uk/crime/man-charged-for-riot-incitement-using-facebook-2335821.html

Putnam, Robert D., "Bowling Alone: America's Declining Social Capital," *Journal of Democracy*, Vol. 6, No. 1, January 1995, pp. 65–78.

Putnam, Robert D., *Bowling Alone: The Collapse and Revival of American Community*, New York: Simon and Schuster, 2000.

Putnam, Robert D., "The Strange Disappearance of Civic America," *The American Prospect*, Vol. 24, Winter 1996, pp. 34–48.

Putnam, Robert D., "Tuning In, Tuning Out: The Strange Disappearance of Social Capital in America," *PS: Political Science and Politics*, Vol. 28, No. 4, December 1995, pp. 664–665.

Raibert, Marc, Kevin Blankespoor, Gabriel Nelson, Rob Playter, and the BigDog Team, "BigDog, the Rough-Terrain Quadruped Robot," *Proceedings of the 17th World Congress, The International Federation of Automatic Control*, 2008. As of September 10, 2010: http://www.df.unibo.it/divulgazione/attualita/bigdog.pdf

Rainie, Lee, "Digital 'Natives' Invade the Workplace: Young People May Be Newcomers to the World of Work, But It's Their Bosses Who Are Immigrants into the Digital World," Pew Research Center, September 27, 2006.

Rahim, Saqib, "Energy Efficiency: Your Building May Soon Be Tested," *ClimateWire*, December 22, 2009.

Rawson, Jean M., *Sustainable Agriculture*, Washington, D.C.: Congressional Research Service, October 25, 1995.

Ray, Tina, "Fort Bragg Focuses on Energy, Water Conservation," September 16, 2010. As of June 29, 2010: http://www.army.mil/article/45274/fort-bragg-focuses-on-energy-water-conservation/

Readiness and Environmental Protection Initiative: Conservation and Compatible Land Use Partnering, Fourth Annual Report to Congress, Washington, D.C.: Department of Defense, March 2010.

Regional Transportation Authority, website, 2010. As of October 29, 2010: http://www.rta-ride.org/carpoolrideshare.html

Reilly, J.J., D.M. Jackson, C. Montgomery, L.A. Kelly, C. Slater, S. Grant, and J.Y. Paton, "Total Energy Expenditure and Physical Activity in Young Scottish Children: Mixed Longitudinal Study," *The Lancet*, Vol. 363, Issue 9404, January 17, 2004, pp. 211–212.

Research and Innovative Technology Administration, "Achieving the Vision: From VII to IntelliDrive," U.S. Department of Transportation Policy White Paper, 2010.

Research and Innovation Technology Administration, Bureau of Transportation Statistics, *National Household Transportation Survey 2001, National Data and Analysis Tool*. As of November 4, 2010: http://www.bts.gov/publications/national_household_travel_survey_2001_cd/

Ribeiro, Suzana Kahn, Shigeki Kobayashi, Michel Beuthe, Jorge Gasca, David Greene, David S. Lee, Yasunori Muromachi, Peter J. Newton, Steven Plotkin, Daniel Sperling, Ron Wit, and Peter J. Zhou, "Transport and Its Infrastructure," in B. Metz, O.R. Davidson, P.R. Bosch, R. David, and L.A. Meyer (eds.), *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, New York: Cambridge University Press, 2007.

Rideout, Victoria, Donald F. Roberts, and Ulla G. Foehr, *Generation M: Media in the Lives of 8–18 Year Olds,* Kaiser Family Foundation, March 2005.

Rideout, Victoria, Ulla G. Foehr, and Donald F. Roberts, *Generation M^2: Media in the Lives of 8–18 Year Olds*, Kaiser Family Foundation, January 2010.

Robert Half Technology, "Whistle—But Don't Tweet—While You Work," 2011. As of April 12, 2011:
http://rht.mediaroom.com/index.php?s=131&item=790

Roberts, Donald F., Ulla G. Foehr, Victoria Rideout, and Mollyann Brodie, *Kids & Media @the New Millennium*, Kaiser Family Foundation, November, 1999.

Roosevelt, Margot, "Environmental Groups Try to Block Parts of California's Green Building Code," *Los Angeles Times*, January 11, 2010. As of March 31, 2011:
http://articles.latimes.com/2010/jan/11/business/la-fi-green-building11-2010jan11

Saha, Devashree, and Robert G. Paterson, "Local Government Efforts to Promote the 'Three Es' of Sustainable Development: Survey in Medium to Large Cities in the United States," *Journal of Planning Education and Research*, Vol. 28, 2008, pp. 21–37.

Sahota, Amarjit, "The Global Market for Organic Food and Drink," in Helga Willer and Lukas Kilcher (eds.), *The World of Organic Agriculture, Statistics and Emerging Trends 2009*, Bonn: Research Institute of Organic Agriculture (FiBL), International Federation of Organic Agriculture Movements (IFOAM), and International Trade Centre (ITC), 2009, pp. 59–60.

Salant, Katherine, "Deconstructing an Old Home Can Give You Building Blocks for a New One," *Washington Post*, December 13, 2008. As of March 31, 2011:
http://www.washingtonpost.com/wp-dyn/content/article/2008/12/12/
AR2008121201893.html.

Samet, Jonathan M., Scott L. Zeger, Francesca Dominici, Frank Curriero, Ivan Coursac, Douglas W. Dockery, Joel Schwartz, and Antonella Zanobetti, *The National Morbidity, Mortality, and Air Pollution Study Part II: Morbidity and Mortality from Air Pollution in the United States*, Cambridge, MA: Health Effects Institute Report 94, 2000. As of October 29, 2010:
http://www.cabq.gov/airquality/pdf/samet2.pdf

Satyanarayanan, M., "Pervasive Computing: Vision and Challenges," *Personal Communications IEEE*, Vol. 8, No. 4, 2001, pp. 10–17.

Savkar, Rasika, "Life-Cycle Cost Assessment as a Tool for Retrofits," *buildings.com*, August 26, 2009. As of March 31, 2011: http://www.buildings.com/Magazine/ArticleDetails/tabid/3413/ArticleID/9924/Default.aspx

Scanlon, Bill, "Award-Winning Reflector to Cut Solar Cost," National Renewable Energy Laboratory, August 3, 2009.

Schafer, Susan M., "Top Army Recruiter Weighs Fat Camp for Recruits," *Army Times*, January 12, 2009.

Schlarb, Mary, *Eco-Industrial Development: A Strategy for Building Sustainable Communities*, Washington, D.C.: U.S. Economic Development Administration, 2001.

Schneider, Jo Ann, *The Role of Social Capital in Building Healthy Communities*, The Ann E. Casey Foundation, November 2004.

Schrank, David, and Tim Lomax, *The 2007 Urban Mobility Report*, College Station, TX: Texas Transportation Institute, 2007. As of October 28, 2010: http://tti.tamu.edu/documents/ums/mobility_report_2007_wappx.pdf

Schulz, William, "The Cost of Biofuels," *Chemical & Engineering News*, December 17, 2007.

Seager, Richard, et al., "Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America," *Science*, Vol. 316, No. 5828, 2007, pp. 1181–1184.

Segway, website, 2010. As of November 2, 2010: http://www.segway.com/

SERDP and ESTCP, "Addressing the Impacts of Climate Change on U.S. Army Alaska with Decision Support Tools Developed Through Field Work and Modeling," no date. As of December 2012: http://www.serdp.org/Program-Areas/Resource-Conservation-and-Climate-Change/Climate-Change/Vulnerability-and-Impact-Assessment/RC-2110

SERDP and ESTCP, "Climate Change and Impacts of Sea Level Rise," no date. As of December 2012: http://www.serdp.org/Featured-Initiatives/Climate-Change-and-Impacts-of-Sea-Level-Rise

SERDP and ESTCP, "Integrated Water Planning Through Building Level Cascade of Water Use," no date. As of December 2012: http://www.serdp.org/Program-Areas/Energy-and-Water/Water-Conservation/EW-201155

SERDP and ESTCP, "Resource Conservation and Climate Change," no date. As of December 2012: http://www.serdp.org/Program-Areas/Resource-Conservation-and-Climate-Change/(list)/1/

Shaheen, Susan A., Adam P. Cohen, and J. Darius Roberts, "Carsharing in North America: Market Growth, Current Developments, and Future Potential," *Transportation Research Record: Journal of the Transportation Research Board*, Issue 1986, 2006, pp. 116–124.

Shaw, Martha, and Donald W. Black, "Internet Addiction: Definition, Assessment, Epidemiology and Clinical Management," *CNS Drugs*, Vol. 22, No. 5, 2008, pp. 353–365.

Shoup, Donald C., *Evaluating the Effects of Parking Cash Out: Eight Case Studies*, Sacramento, CA: California Air Resources Board, 1997.

Shrestha, Laura R., *The Changing Demographic Profile of the United States*, Washington, D.C.: Congressional Research Service: May 2006.

Siciliano, Bruno, and Oussama Khatib (eds.), *Springer Handbook of Robotics*, Berlin: Springer-Verlag, 2008.

Siegel, Kassie, Climate, Air, and Energy Program Director, Center for Biological Diversity, Testimony to the U.S. House of Representatives Select Committee on Energy Independence and Global Warming, January 17, 2008, "On Thin Ice: The Future of the Polar Bear." As of August 11, 2010:
http://globalwarming.house.gov/tools/assets/files/0302.pdf

Silberglitt, Richard, Anny Wong, S. R. Bohandy, Brian G. Chow, Noreen Clancy, Scott Hassell, David R. Howell, Gregory S. Jones, Eric Landree, and Parry Norling, *The Global Technology Revolution China, Executive Summary: Emerging Technology Opportunities for the Tianjin Binhai New Area (TBNA) and the Tianjin Economic-Technological Development Area (TEDA)*, Santa Monica, CA: RAND Corporation, MG-776-TBNA/TEDA, 2009. As of April 1, 2011:
http://www.rand.org/pubs/monographs/MG776/

Silberglitt, Richard, Philip S. Anton, David R. Howell, Anny Wong, Natalie Gassman, Brian A. Jackson, Eric Landree, Shari Lawrence Pfleeger, Elaine M. Newton, and Felicia Wu, *The Global Technology Revolution 2020, In-Depth Analyses: Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications*, Santa Monica, CA: RAND Corporation, TR-303-NIC, 2006. As of September 10, 2010:
http://www.rand.org/pubs/technical_reports/TR303.html

Sinclair Knight Merz, *Review of Perth Parking Policy*, Perth, WA, Australia, 2007. As of October 29, 2010: http://www.transport.wa.gov.au/mediafiles/regional_parkingpolicy.pdf

Sinervo, Barry, et al., "Erosion of Lizard Diversity by Climate Change and Altered Thermal Niches," *Science*, Vol. 328. No. 5980, 2010, pp. 894–899.

Siomos, Konstantinos E., et al., "Internet Addiction Among Greek Adolescent Students," *CyberPsychology & Behavior*, Vol. 11, No. 6, 2008.

Sky News, "Second Life Visit to Mecca for the Hajj," December 19, 2007. As of September 7, 2010:
http://news.sky.com/skynews/Home/Sky-News-Archive/Article/20080641297721

SmartBike, website, 2008. As of November 2, 2010:
http://www.smartbike.com

Smart Cities, *Mobility on Demand: Future of Transportation in Cities*, Cambridge, MA: MIT Media Laboratory, 2008. As of November 2, 2010:
http://cities.media.mit.edu/pdf/Mobility_on_Demand_Introduction.pdf

Smart Growth Resource Library, "Smart Growth in Action: Rosslyn-Ballston Metro Corridor, Arlington County, Virginia," 2010. As of October 29, 2010:
http://www.smartgrowth.org/library/articles.asp?art=1824

Smart Growth Resource Library, "Smart Growth in Action: Village of Hyannis, Barnstable, Massachusetts," 2010. As of October 29, 2010:
http://www.smartgrowth.org/library/articles.asp?art=3313

Smart Soldier, website. As of September 7, 2010:
http://www.smartsoldier.com/

Smart USA, "Pure Coupe Technical Specs," 2010. As of November 2, 2010:
http://www.smartusa.com/pure-coupe-specs.aspx?model=pure_coupe

Smith, Dewayne, "Lessons Learned: Utility Energy Services Contracts," briefing, IMCOM/Southeast Region Energy Managers Forum, Atlanta, GA, February 13, 2008.

Smith, Robert Leo, and Thomas M. Smith, *Ecology & Field Biology*, Sixth Edition, New York: Benjamin Cummings, 2001..

Sofge, Erik, "With Electric Scooter, MIT Hopes to Rev Up Practical Transport," *Popular Mechanics*, October 1, 2009. As of November 2, 2010:
http://www.popularmechanics.com/science/4252300

"Soldiers to Watch Family Members' Graduations Online," MSNBC, May 18, 2006. As of September 7, 2010:
http://www.msnbc.msn.com/id/12861456/

Sony Electronics Inc., "The Sony Take Back Recycling Program," undated. As of July 15, 2010:
http://green.sel.sony.com/pages/recycle.html

"South Korean Dies After Game Sessions," *BBC News*, August 10, 2005. As of February 16, 2011:
http://news.bbc.co.uk/2/hi/technology/4137782.stm

Stanchak, Jesse, "Making a Military-Grade Case for Social Media," *SmartBlog on Social Media*, April 23, 2010. As of August 25, 2011:
http://smartblogs.com/socialmedia/2010/04/23/making-a-military-grade-case-for-social-media/

Stanford Global Climate Change and Energy Project, website. As of August 14, 2010:
http://gcep.stanford.edu/

State of Washington Department of Ecology, "Reduced Snowpack and Earlier Runoff." As of August 15, 2010: http://www.ecy.wa.gov/climatechange/reducedsnow_more.htm

"Statement of Dr. James Hansen, Director, NASA Goddard Institute for Space Studies." As of December 2012: http://image.guardian.co.uk/sys-files/Environment/documents/2008/06/23/ClimateChangeHearing1988.pdf

Stein, Bruce, Lynn S. Kutner, and Jonathan S. Adams (eds.), *Precious Heritage: The Status of Biodiversity in the United States*, Oxford: Oxford University Press, 2000.

Stern, N. (ed.), *The Economics of Climate Change: The Stern Review*, Cambridge: Cambridge University Press, 2006.

Stewart, I.T., D.R. Cayan, and M.D. Dettinger, "Changes in Snowmelt Runoff Timing in Western North America Under a 'Business as Usual' Climate Change Scenario," *Climatic Change*, Vol. 62, No. 1-3, 2004, pp. 217–232.

Stewart, Nikita, "Zipcar to Manage System for Employee Vehicle Fleet," *The Washington Post*, April 28, 2009. As of November 1, 2010: http://www.washingtonpost.com/wp-dyn/content/article/2009/04/27/AR2009042703376.html?hpid=sec-metro

Strasburger, Victor C., Amy B. Jordan, and Ed Donnerstein, "Health Effects of Media on Children and Adolescents," *Pediatrics*, Vol. 125, No. 2, April 2010, pp. 756–767.

Sullivan, G.P., R. Pugh, A.P. Melendez, and W.D. Hunt, *Operations and Maintenance Best Practices: A Guide to Achieving Operational Efficiency*, Release 2.0, Washington, D.C.: U.S. Department of Energy, Federal Energy Management Program, 2004. As of March 31, 2011: http://www.mass.gov/Eoaf/docs/dcam/mafma/manuals/o_and_m_guide_to_achieving_operational_efficiency.pdf

Sustainable Communities, Washington, D.C.: U.S. Economic Development Administration, 2001.

Tang, Didi, "Bike-Sharing Programs Spin Across U.S. Campuses," *USA Today*, September 22, 2010. As of November 2, 2010: http://www.usatoday.com/news/education/2010-09-21-college-bike-sharing_N.htm

Tapscott, Don, *Grown Up Digital: How the Net Generation Is Changing Your World*, McGraw-Hill, 2008.

Tarng, Pin-Yun, Kuan-Ta Chen, and Polly Huang, "An Analysis of WoW Players' Game Hours," NetGames '08, Worchester, MA: 7th ACM SIGCOMM Workshop on Network and System Support for Games, October 21–22, 2008, pp. 40–45. As of April 12, 2011: http://portal.acm.org/citation.cfm?id=1517504&CFID=17658183&CFTOKEN=44554795.

Taylor, Andrea Faber, Frances E. Kuo, and William C. Sullivan, "Views of Nature and Self-Discipline: Evidence from Inner City Children," *Journal of Environmental Psychology*, Vol. 22, No. 1–2, March 2002, pp. 49–63.

Texas Transportation Institute, "Urban Mobility Information," 2009. As of November 2, 2010:
http://mobility.tamu.edu/

Texas Water Matters, "Municipal Water Use: Success Story." As of September 10, 2010:
http://www.texaswatermatters.org/conservation_users.htm

The President's Council on Sustainable Development, *Eco-Efficiency Task Force Report*, Washington, D.C., 1996a.

———, *Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future*, Washington, D.C., February 1996b.

———, *Materials: A Report of the Interagency Workgroup on Industrial Ecology, Material and Energy Flows*, Washington, D.C., July 1998.

Theobald, David M., *Defining and Mapping Rural Sprawl: Examples from the Northwest US*," Fort Collins, CO: Colorado State University, September 16, 2003.

Thomas, C.D., A. Cameron, R.E. Green, M. Bakkenes, L.J. Beaumont, Y.C. Collingham, B.F.N. Erasmus, M.F.D. Siqueira, A. Grainger, and L. Hannah, "Extinction Risk from Climate Change," *Nature*, Vol. 427, No. 6970, 2004, pp. 145–148.

Thompson, J. Michael T., and Brian Launder, *Geo-engineering Climate Change: Environmental Necessity or Pandora's Box?* Cambridge, U.K.: Cambridge University Press, 2010.

"TND Neighborhoods by State and Country," *The Town Paper*, no date. As of December 2012:
http://www.tndtownpaper.com/neighborhoods.htm

Toyota, *Prius 10*, specifications, 2010. As of November 1, 2010:
http://www.toyota.com/prius-hybrid/specs.html

Transportation Research Board of the National Academies, website, 2010. As of November 2, 2010:
http://www.trb.org/

Trebilcock, Bob, "The Robots Are Coming: Robotic Materials Handling Technology Is Changing the Way We Move Products in the Plant and the Distribution Center," *Modern Materials Handling*, August 19, 2010. As of September 10, 2010:
http://www.mmh.com/article/the_robots_are_coming

Trzesniewski, Kali H., M. Brent Donnellan, and Richard W. Robins, "Is 'Generation Me' Really More Narcissistic Than Previous Generations?" *Journal of Personality*, Vol. 76, No. 4, August 2008, pp. 903–918.

Turner, Cathy, and Mark Frankel, *Energy Performance of LEED for New Construction Buildings*, White Salmon, WA: New Buildings Institute, 2008. As of March 31, 2011:
http://www.usgbc.org/ShowFile.aspx?DocumentID=3930

Twenge, Jean, *Generation Me: Why Today's Youth Are More Confident, Assertive, Entitled—and More Miserable Than Ever Before*, Free Press, 2006.

Twenge, Jean M., "Generational Changes and Their Impact in the Classroom: Teaching Generation Me," *Medical Education*, Vol. 43, May 2009, pp. 398–405.

Twitter, "Army Wife Network," August 2, 2010. As of September 7, 2010: http://www.armywifenetwork.com/forum/

U Car Share, website, 2010. As of November 1, 2010: https://www.ucarshare.com/secure/Home.aspx

U-Haul, website, 2010. As of November 1, 2010: http://www.uhaul.com/

United Nations, Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2006 Revision, Highlights*, Working Paper No. ESA/P/WP.202, 2007.

United Nations Environment Programme (UNEP) and the Secretariat for the Conservation of Migratory Species of Wild Animals, *Migratory Species and Climate Change: Impact of a Changing Environment on Wild Animals*, 2006.

United Nations World Urbanization Prospects database. As of October 10, 2010: http://esa.un.org/unup/

U.S. Air Force, *RQ-4 Global Hawk*, factsheet. As of September 10, 2010: http://www.af.mil/information/factsheets/factsheet.asp?id=13225

U.S. Army, "Army Compatible Use Buffer Program (ACUB),", website, undated. As of September 20, 2010: http://www.sustainability.army.mil/tools/programtools_acub.cfm

U.S. Army, "The Army Strategy for the Environment: Sustain the Mission—Secure the Future." Washington, D.C., U.S. Army Environmental Policy Institute, 2004.

U.S. Army, "Army Environmental Programs Awarded for Making a Difference," *States News Service*, Washington, D.C., June 13, 2007.

U.S. Army, "Comprehensive Soldier Fitness," undated. As of October 2, 2011: csf.army.mil

U.S. Army, TRADOC Pam 525-3-0, *The Army Capstone Concept Operational Adaptability—Operating Under Conditions of Uncertainty and Complexity in an Era of Persistent Conflict*, 2009.

U.S. Army Corps of Engineers, *CER Mission*, 2011. As of April 1, 2011: http://www.cecer.army.mil/td/tips/product/details.cfm?ID=458

U.S. Army, Office of Assistant Chief of Staff for Installation Management, "Real Property Summary Installation and Site Statistics for Fiscal Year 2009 Quarter 4," September 30, 2009.

U.S. Army, Office of the Deputy Assistant Secretary for Energy and Partnerships, *Energy Security Tiger Team Assessment—Fort Bliss, Final Report*, Washington, D.C., April 14, 2009.

U.S. Census Bureau, "America's Families and Living Arrangements: 2009," Table FG-1: Married Couple Family Groups, by Labor Force Status of Both Spouses, and Race and Hispanic Origin/1 of the Reference Person: 2009, As of January 15, 2011: http://www.census.gov/population/www/socdemo/hh-fam/cps2009.html

U.S. Census Bureau, "Florida, California and Texas to Dominate Future Population Growth, Census Bureau Reports," April 21, 2005.

U.S. Council on Science and Public Health, *Emotional and Behavioral Effects, Including Addictive Potential, of Video Games*, CSAPH Report 12-A-07, 2007.

U.S. Department of Agriculture, "National Organic Program," website. As of October 21, 2010:
http://www.ams.usda.gov/AMSv1.0/nop

U.S. Department of Agriculture, National Agricultural Statistics Bureau, *USDA Census of Agriculture-State Data*, 2007.

U.S. Department of Agriculture, Natural Resources Conservation Service, *Summary Report: 1997 National Resources Inventory* (revised December 2001), Washington, D.C., 2001.

U.S. Department of Commerce, Census Bureau, *2001 Statistical Abstract of the United States*, 2001.

U.S. Department of Defense, *2010 Quadrennial Defense Review*, Washington, D.C.: Department of Defense, 2010. As of August 12, 2010:
http://www.defense.gov/qdr/images/QDR_as_of_12Feb10_1000.pdf

U.S. Department of Defense, *United Facilities Criteria (UFC): Installation Master Planning*, UFC 2-100-01, May 15, 2012. As of December 2012:
http://www.wbdg.org/ccb/DOD/UFC/ufc_2_100_01.pdf

U.S. Department of Defense Instruction 4170.11, "Installation Energy Management," November 22, 2005. As of April 1, 2011:
http://www.energytracking.com/download/DOD_417011p.pdf

U.S. Department of Defense Instruction 4170.11, "Installation Energy Management," 2009. As of April 1, 2011:
http://www.dtic.mil/whs/directives/corres/pdf/417011p.pdf

U.S. Department of Energy, *Building Technologies Program*, undated. As of April 1, 2011:
http://www.eere.energy.gov/buildings/

U.S. Department of Energy, *Buildings Energy Data Book*, 2011. As of April 1, 2011:
http://buildingsdatabook.eren.doe.gov/

U.S. Department of Energy, *Energy Efficiency Trends in Residential and Commercial Buildings*, October 2009. As of April 1, 2011:
http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/bt_stateindustry.pdf

U.S. Department of Energy, "Fort Lewis Army Base," *Building America Best Practices Series: Volume 5—Builders and Buyers Handbook for Improving New Home Efficiency, Comfort, and Durability in the Marine Climate*, February 2006.

U.S. Department of Energy, *Guidelines for Selecting Cool Roofs*, 2010. As of December 2012: http://www1.eere.energy.gov/femp/pdfs/coolroofguide.pdf

U.S. Department of Energy, *The Smart Grid: An Introduction*, undated. As of April 1, 2011: http://www.oe.energy.gov/SmartGridIntroduction.htm

U.S. Department of Energy, *Solar Decathlon*, 2011. As of April 1, 2011: http://www.solardecathlon.gov/

U.S. Department of Energy, Federal Management Program, *U.S. Army Charges Ahead in Using Electric Vehicles,* 2009. As of November 1, 2010: http://www1.eere.energy.gov/femp/pdfs/fedfleet_army_ss.pdf.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Buildings Energy Codes 101: An Introduction*, PNNL-SA-70586, 2010. As of March 31, 2011: https://www.energycodes.gov/training/pdfs/codes_101.pdf

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Codes Program, "Status of State Energy Codes: District of Columbia," 2010. As of March 31, 2011: http://www.energycodes.gov/states/state_info.php?stateAB=DC

U.S. Department of Health and Human Services, *Childhood Obesity*. As of February 2, 2011: http://aspe.hhs.gov/health/reports/child_obesity/

U.S. Department of Transportation, website, 2010. As of November 2, 2010: http://www.dot.gov

U.S. Department of Transportation, Office of Operations, "Travel Demand Management," 2008. As of October 29, 2010: http://ops.fhwa.dot.gov/tdm/index.htm

U.S. Department of Transportation, Research and Innovative Technology Administration (RITA), "Intelligent Transportation Systems: Applications Overview," February 27, 2009. As of September 3, 2010: http://www.itsoverview.its.dot.gov/DAS.asp

U.S. Energy Information Administration, "Glossary," undated. As of September 3, 2010: http://www.eia.doe.gov/glossary/index.cfm

U.S. Energy Information Administration, *Commercial Buildings Energy Consumption Survey, 2007*. As of April 1, 2011: http://www.eia.doe.gov/emeu/cbecs/

U.S. Energy Information Administration, *Electric Power Annual 2008*, DOE/EIA-0348(2008), 2010, Table 1.1. As of September 14, 2010: http://www.eia.doe.gov/cneaf/electricity/epa/epa.pdf

U.S. Energy Information Administration, *Annual Energy Outlook 2009*, DOE/EIA-0383(2009), 2009a. As of April 1, 2011:
http://www.eia.doe.gov/oiaf/archive/aeo09/index.html

U.S. Energy Information Administration, *International Energy Outlook 2009*, DOE/EIA-0484(2009), 2009b. April 1, 2011:
http://www.eia.doe.gov/oiaf/archive/ieo09/index.html

U.S. Energy Information Administration, *An Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook*, SR-OIAF/2009-03, 2009c. As of April 1, 2011:
http://www.eia.doe.gov/oiaf/servicerpt/stimulus/index.html

U.S. Energy Information Administration, *International Energy Outlook, 2010*. As of April 1, 2011:
http://www.eia.doe.gov/oiaf/ieo/index.html

U.S. Energy Information Administration, website, 2011a. As of April 1, 2011:
http://www.eia.doe.gov/

U.S. Energy Information Administration, *Annual Energy Outlook 2011 Early Release Overview*, 2011b. As of April 1, 2011:
http://www.eia.doe.gov/oiaf/aeo/index.html

U.S. Energy Information Administration, *Short-Term Energy Outlook*, 2011c. As of April 1, 2011:
http://www.eia.doe.gov/emeu/steo/pub/contents.html

U.S. Environmental Protection Agency, *Climate Change Indicators in the United States*, April 2010.

U.S. Environmental Protection Agency, *Design for Deconstruction*, undated. As of May 12, 2013:
http://www.epa.gov/region9/greenbuilding/pdfs/DesignForDeconstrManual.pdf

U.S. Environmental Protection Agency, Energy Star, *Life Cycle Cost Estimate for 1 Energy Star Qualified Compact Florescent Lamp(s)*, undated. As of April 1, 2011:
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorCFLs.xls

U.S. Environmental Protection Agency, *Partnership Programs: List of Programs*, undated a. As of April 1, 2011:
http://www.epa.gov/partners/programs/

U.S. Environmental Protection Agency, *Water Sense*, undated b. As of March 31, 2011:
http://www.epa.gov/WaterSense/

U.S. Environmental Protection Agency, *Using Coal Ash in Highway Construction: A Guide to Benefits and Impacts*, Report EPA-530-K-05-002, 2005. As of November 1, 2010:
http://agremax.com/Downloads/coal-ash.pdf

U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2006*, Washington, D.C., 2008. As of October 29, 2010: http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf

U.S. Environmental Protection Agency, *U.S. EPA's 2008 Report on the Environment (Final Report)*, 2008. As of October 28, 2010: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=190806#Download

U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2008*, Washington, D.C., 2010. As of October 29, 2010: http://www.epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010_Report.pdf

U.S. Environmental Protection Agency, *Environmentally Preferable Purchasing (EPP)*, 2010a. As of April 1, 2011: http://www.epa.gov/epp/

U.S. Environmental Protection Agency, *Green Building*, 2010b. As of April 1, 2011: http://www.epa.gov/greenbuilding/

U.S. Environmental Protection Agency, *Energy Star, State and Local Governments Leveraging Energy Star,* 2010b. As of March 31, 2011: http://www.energystar.gov/ia/business/government/State_Local_Govts_Leveraging_ES.pdf

U.S. Environmental Protection Agency, *Green Building: Basic Information*, 2010c. As of March 31, 2011: http://www.epa.gov/greenbuilding/pubs/about.htm

U.S. Environmental Protection Agency, *Wastes—Resourse Conservation—Reduce, Reuse, Recycle—Industrial Materials Recycling*, 2010e. As of April 1, 2011: http://www.epa.gov/epawaste/conserve/rrr/imr/index.htm

U.S. Environmental Protection Agency, *Indoor Air Quality*, 2011. As of April 1, 2011: http://www.epa.gov/iaq/index.html

U.S. Fish and Wildlife Service, website. As of August 13, 2010: http://www.fws.gov/

U.S. General Accounting Office, *Freshwater Supply: States' Views on How the Federal Government Can Help Them Meet the Challenges of Expected Shortages,* Washington, D.C.: Government Printing Office, June 2003.

U.S. General Accounting Office, *Military Personnel: Active Duty Benefits Reflect Changing Demographics, but Opportunities Exist to Improve*, Washington, D.C.: Government Printing Office, September 2002.

U.S. General Accounting Office, *Military Training: DOD Lacks a Comprehensive Plan to Manage Encroachment on Training Ranges*, GAO-02-614, Washington, D.C., June 2002.

U.S. General Services Administration, *GSA-Sponsored Telework Centers,* 2010. As of October 31, 2010:
http://www.gsa.gov/portal/category/26435

U.S. General Services Administration, *High Performance Buildings*, 2011a. As of April 1, 2011:
http://www.gsa.gov/portal/content/105331

U.S. General Services Administration, *Sustainable Design Program*, 2011b. As of April 1, 2011:
http://www.gsa.gov/portal/content/104462

U.S. Green Building Council, *LEED 2009 for New Construction and Major Renovations,* 2008.

U.S. Green Building Council, website, 2011a. As of April 1, 2011:
http://www.usgbc.org/

U.S. Green Building Council, *LEED*, 2011b. As of March 31, 2011:
http://www.usgbc.org/DisplayPage.aspx?CMSPageID=51

U.S. Green Building Council, *LEED 2009: Technical Advancements to the LEED Rating System*, 2011c. As of March 31, 2011:
http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1971

U.S. Geologic Survey, *Changes in Streamflow Timing in the Western United States in Recent Decades*, Fact Sheet 2005-3015, March 2005. As of August 15, 2010:
http://pubs.usgs.gov/fs/2005/3018/.

U.S. Government Accountability Office, *DOD Report on Training Ranges Does Not Fully Address Congressional Reporting Requirements*, GAO-04-608, Washington, D.C.: Government Printing Office, June 2004.

U.S. Joint Forces Command, *The Joint Operating Environment*, 2010.

U.S. Library of Congress (U.S. LOC), "H.R.6 Energy Independence and Security Act of 2007," 2007. As of March 13, 2010:
http://thomas.loc.gov/cgi-bin/bdquery/z?d110:h.r.00006:

United States Global Change Research Program, *Global Climate Change Impacts in the United States*, New York: Cambridge University Press, 2009. As of August 12, 2010:
www.globalchange.gov/usimpacts

University of California Berkeley, "Green Buildings Research Center," 2009. April 1, 2011:
greenbuildings.berkeley.edu/

University of California, Berkeley, "Transportation Sustainability Research Center," 2010. As of November 3, 2010: http://tsrc.berkeley.edu/

University of California, Santa Barbara, Institute for Energy Efficiency, "Research," undated. As of April 1, 2011:
http://iee.ucsb.edu/research

University of Maryland Medical Center, "Robot Delivers Medication at University of Maryland Shock Trauma Center: Advanced Technology Allows Robot to Steer Around Obstacles and Call for Elevators," Baltimore, MD, May 10, 2004. As of September 10, 2010:
http://www.umm.edu/news/releases/robot.htm

University of Michigan, "Transportation Research Institute," 2010. As of November 3, 2010:
http://www.umtri.umich.edu/

Urban Land Institute, website, 2011. As of April 1, 2011:
http://www.uli.org/

Van Rooij, Antonius J., et al., "Compulsive Internet Use: The Role of Online Gaming and Other Internet Applications," *Journal of Adolescent Health*, Vol. 47, 2010, pp. 51–57.

Wan, Chin-Sheng, and Wen-Bin Chiou, "Why Are Adolescents Addicted to Online Gaming? An Interview Study in Taiwan," *CyberPsychology & Behavior*, Vol. 9, No. 6, 2006.

Wang, X., F. Chen, and Z. Dong, "The Relative Role of Climatic and Human Factors in Desertification in Semiarid China," *Global Environmental Change*, Vol. 16, 2006, pp. 48–57.

Wang, Youfa, and May A. Beydoun, "The Obesity Epidemic in the United States—Gender, Age, Socioeconomic, Racial/Ethnic, and Geographic Characteristics: A Systematic Review and Meta-Regression Analysis," *Epidemiological Reviews*, May 17, 2007.

Washington Forest Law Center, "Complaints Filed Against SFI," 2009a. As of April 1, 2011:
http://wflc.org/cases/credibleforestcert/SFIcomplaints

Washington Forest Law Center, "Sierra Club Files Complaint Against Weyerhaeuser for Logging on Steep and Unstable Slopes," 2009b. As of April 1, 2011:
http://wflc.org/cases/credibleforestcert/SFI%20Complaint

Weber, S., and T.C. Lueth, "Concept and Realisation of an Implantable EMG and Motion Measuring Device," *Pervasive Computing Technologies for Healthcare*, January 30, 2008–February 1, 2008, pp. 165–168. As of August 23, 2012:
http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4571060&isnumber=4571002

Wells, Nancy M., and Gary W. Evans, "Nearby Nature: A Buffer of Life Stress Among Rural Children," *Environment and Behavior*, Vol. 35, No. 5, May 2003, pp. 311–330.

Whaley, Monte, "Community Gardens a Hot Trend in Recession," *Denver Post*, May 4, 2009.

White House Office of Science and Technology Policy, Environmental Technology Strategy Staff, *Technology for a Sustainable Future: A Framework for Action*, Washington, D.C.: U.S. Government Printing Office, July 1994.

Wildlife Habitat Council, "Registry of Certified Programs," 2011. As of March 31, 2011:
http://www.wildlifehc.org/certification/registry-of-existing-programs/

Willer, Helga, "Organic Agriculture Worldwide," FiBL, March 10, 2009. As of October 3, 2011: http://www.organic-world.net/fileadmin/images/yearbook/2009-graphs/fibl-ifoamgraphs-yearbook-2009.pdf

Williams, Dmitri, Nicolas Ducheneaut, Li Xiong, Nich Yee, and Eric Nickell, "From Tree House to Barracks: The Social Life of Guilds in World of Warcraft," *Games and Culture*, Vol. 1, No. 4, 2006, pp. 338–361.

Wilson, D.H., and C. Atkeson, "Simultaneous Tracking & Activity Recognition (STAR) Using Many Anonymous, Binary Sensors," *Lecture Notes in Computer Science*, Vol. 3468, 2005, pp. 62–79.

Wisconsin Department of Military Affairs, "Adjutant General Holds E-town Hall," *Wisconsin National Guard News*, June 25, 2009. As of September 7, 2010: http://dma.wi.gov/dma/news/2009news/09058.asp

Wiser, Ryan, and Mark Bolinger, *2008 Wind Technologies Market Report*, U.S. Department of Energy, DOE/EERE-LBNL, 2009. As of April 1, 2011: http://eetd.lbl.gov/ea/ems/reports/2008-wind-technologies.pdf

Wondolleck, Julia M., and Steven L. Yaffee, *Making Collaboration Work: Lessons from Innovation in Resource Management*, Washington, D.C.: Island Press, 2000.

World Commission on Environment and Development, *Our Common Future*, 1987.

World Meteorological Organization, *Report of the International Conference on the Assessment of the Role of Carbon Dioxide and of Other Greenhouse Gases in Climate Variations and Associated Impacts*, Villach, Austria, 1986. As of August 12, 2010: http://www.icsu-scope.org/downloadpubs/scope29/statement.html

World Resources Institute, website. As of July 22, 2010: http://www.wri.org/

World Wildlife Fund, "Tiger Facts and Future." As of October 17, 2010: http://wwf.panda.org/what_we_do/endangered_species/tigers/

Wowwiki, "Guild," undated. As of April 12, 2011: http://www.wowwiki.com/Guild

Wu, Chin-Shan, and Fei-Fei Cheng, "Internet Café Addiction of Taiwanese Adolescents," *CyberPsychology & Behavior*, Vol. 10, No. 2, 2007.

Wyon, David, "Enhancing Productivity While Reducing Energy Use in Buildings," in *E-Vision 2000: Key Issues That Will Shape Our Energy Future: Analyses and Papers Prepared for the E-Vision 2000 Conference*, Santa Monica, CA: RAND Corporation, CF-170/1-1-DOE, 2001, pp. 233–254. As of March 31, 2011: http://www.rand.org/content/dam/rand/pubs/conf_proceedings/CF170z1-1/CF170.1.wyon.pdf.

Yen, Ju-Yu, et al., "The Comorbid Psychiatric Symptoms of Internet Addiction: Attention Deficit and Hyperactivity Disorder (ADHD), Depression, Social Phobia, and Hostility," *Journal of Adolescent Health*, Vol. 41, Issue 1, July 2007, pp. 93–98.

Yoney, Domenick, "MIT GreenWheel: Simply an Electric Bicycle Revolution," *Autobloggreen*, February 19, 2009. As of November 2, 2010: http://green.autoblog.com/2009/02/19/mit-greenwheel-simply-an-electric-bicycle-revolution/

Young, B., "Diffusion and Usage Patterns of the Internet in Korea and Japan: A Comparison of Policy and Cultural Factors," *Development and Society*, Vol. 33, 2004, pp. 229–250.

Yoshikawa, K., and L.D. Hinzman, "Shrinking Thermokarst Ponds and Groundwater Dynamics in Discontinuous Permafrost," *Permafrost Periglac.*, Vol. 14, No. 2, 2003, pp. 151–160.

Zipcar, website, 2010. As of November 1, 2010: http://www.zipcar.com/

Zipcar, "Green Benefits," 2010. As of November 1, 2010: http://www.zipcar.com/business/is-it/greenbenefits