ERDC/CERL TR-11-36

Construction Engineering
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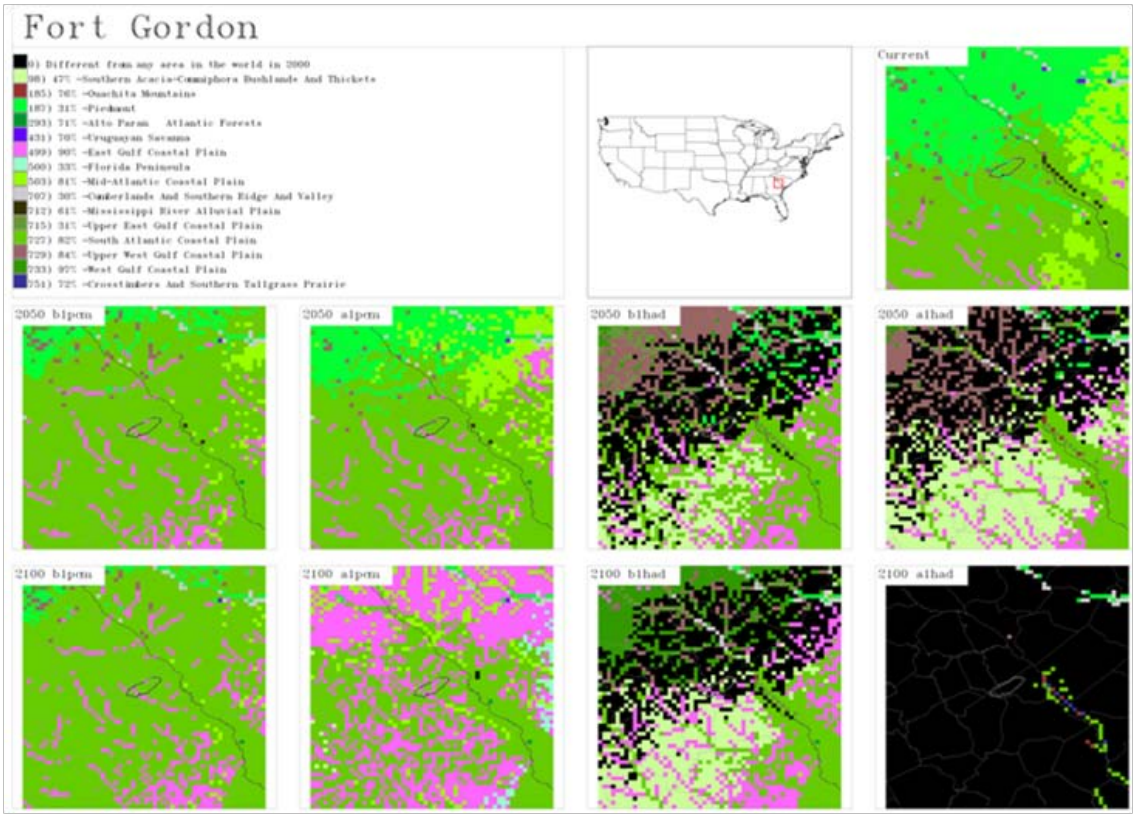
# Forecasting Climate-Induced Ecosystem Changes on Army Installations

James D. Westervelt and William W. Hargrove

October 2011



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Final Report



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Washington, DC 20314-1000

# Abstract

Military installation training lands must be managed to support species at risk as well as to be effective training environments for soldiers. Forecasts from various global climate change models suggest that the habitats associated with some military training installations will face pressures that induce biome-shifts, invasive species, loss of habitat, and changes in training opportunities. This study combined worldwide habitat forecast data with a current habitat map to identify major installations that appear to be most and least at-risk for habitat change.

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# Preface

This study was conducted for Dr. Jeffrey Holland, Director of the Engineer Research and Development Center under a project called, "Integrated Risk Management for Climate Change," via the Center Directed Research Program. The project Principal Investigator was Dr. Todd Bridges of the Environmental Laboratory.

The work was performed by the Environmental Processes Branch (CN-N) of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Dr. James Westervelt. William Meyer is Chief, CEERD-CN-N, and Dr. John Bandy is Chief, CEERD-CF. The Director of ERDC-CERL is Dr. Ilker R. Adiguzel.

CERL is an element of the US Army Engineer Research and Development Center (ERDC), US Army Corps of Engineers. The Commander and Executive Director of ERDC is COL Kevin J. Wilson, and the Director of ERDC is Dr. Jeffery P. Holland.

# 1 Introduction

## 1.1 Background

Military installations and ranges support military training and testing across the United States. That land must be managed in a manner that ensures that the military continues to have excellent conditions to support the training and testing missions. An emerging potential threat to those conditions comes in the form of forecasted climate change, which might directly affect training by changing erosion challenges or by compromising training realism. Climate change may also indirectly affect training by changing the suitability of on-installation important habitats – including areas that support threatened or endangered species.

## 1.2 Objective

This objective of this work was to address three questions regarding the anticipated implications of forecast climate change in the Continental United States (CONUS):

- Which Army installations are most at-risk with respect to ecosystem changes?
- What is the range of anticipated ecosystem shifts based on the forecasts of general circulation models (GCMs)?
- Where can one go today to find the ecosystem drivers (weather, climate, soil, and sun) anticipated in the future?

## 1.3 Approach

This study assumed that ecosystems are driven by conditions involving temperature, rainfall, solar insolation, and soil characteristics. By correlating these conditions with the ecosystems found across the United States (and the globe), it is possible to forecast ecosystem shifts based on forecast changes to these conditions. Note that identifying shifts in conditions that might favor a different ecosystem is only the first step in actually forecasting the timing or speed with which any given area will shift. Ecosystems can be associated with a significant level of persistence and it can take decades or even millennia for seeds to establish themselves in distant areas.

## 1.4 Scope

This study focused primarily on major CONUS Army installations.

## 1.5 Mode of technology transfer

This report will be made accessible through the World Wide Web (WWW) at URL: http://www.cecer.army.mil

# 2 Analysis Steps

This study developed future habitat maps for the Continental United States based on forecasts from global climate change models and habitat classifications developed by the Gap Analysis Program (GAP). Developing future habitat maps involves five steps (Figure 1). Three subsequent analyses use these maps: (1) installation biome shift analysis, (2) an analysis to find current areas that represent forecast installation conditions, and (3) an analysis to rank installations by degree of ecosystem driver shifts. The following sections describe each of the steps taken to develop these future habitat maps.

## 2.1 Steps 1 & 2: Climate Modeling

These efforts began with published data sets of current and future climate information created for the entire globe by the WorldClim group (http://www.worldclim.org). The climate modeling data development and analysis story begins with the running of General Circulations Models (GCM). The Intergovernmental Panel on Climate Change (IPCC), co-sponsored by the United Nations Environmental Programme (UNEP) and the World Meteorological Organization (WMO), is a focal point for coordinated global climate change analyses. In 2001, IPCC published the "Third Assessment Report" in four volumes. The first volume provides the scientific basis of the climate change analyses (IPCC 2001). From the IPCC 2001 analysis, results from two global climate models (GCMs, also known as general circulation models) were selected to represent forecast change extremes. The Hadley Centre model, HadCM3 (Wood et al. 1999), provides the conservative bookend. The National Center for Atmospheric Research (NCAR) Parallel Climate Model (PCM; Dai et al. 2001a; Hu et al. 2004) provides the more extreme forecasts.

These model the globe using grid cells that are roughly 3-degrees square. The Hadley model links an Ocean Model (HadOM3), which includes sea ice; with an atmospheric model (HadAM3). The PCM fully couples an 18-level atmospheric general circulation model (GCM), the 32 level Los Alamos National Laboratory Parallel Ocean Program (POP; Smith et al. 1992; Dukowicz and Smith 1994) ocean GCM, a land surface model, and a dynamic–thermodynamic sea ice model (Washington et al. 2000).

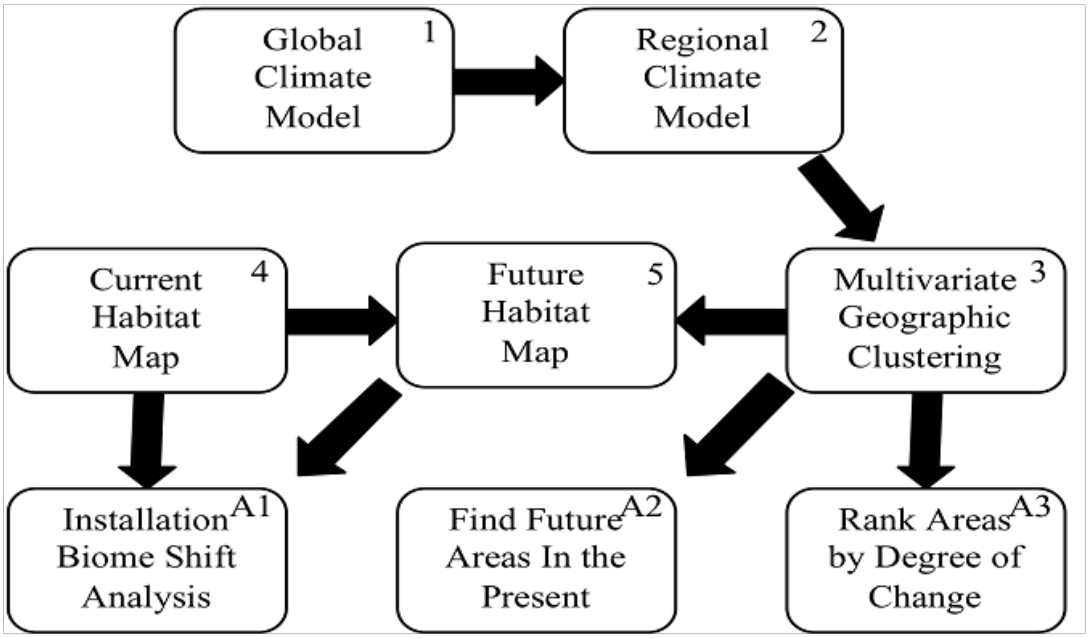



Figure 1. Overall approach.

These models were run using two internationally standardized gas-emission scenarios: Scenario A1, ("business-as-usual"), which corresponds with the highest emissions; and Scenario B1, which corresponds with the lowest emissions. Climate states for 2050 and 2080 were captured for downscaling.

The GCM data were processed into global climate layers by the WorldClim group posted at the WorldClim website (http://www.worldclim.org). The WorldClim group specializes in the development of ~1-km resolution climate maps for the world using thin-plate spline interpolations of world-wide weather station data (Hijmans et al. 2005). To create future maps at this resolution, GCM outputs (typically at resolutions of about 110 km) were compared with current conditions to create difference maps (of temperature and rainfall by season). These maps, in turn, were interpolated to the 1-km resolution and added to the equivalent WorldClim current weather maps (see: http://www.worldclim.org/downscaling). Using this approach, the WorldClim has processed 2020, 2050, and 2080 outputs from three GCM models that each ran A2A and B2B scenarios, for the third IPCC assessment report (TAR). For each model, scenario, and date combination, WorldClim generated monthly averages for maximum temperature, minimum temperature, and precipitation.

Using the WorldClim results, Chris Zganjar, of The Nature Conservancy, developed and ran geographic information processing scripts to generate nine maps that represent current conditions and future conditions (2050 and 2080) for two scenarios run by two GCMs. The resulting maps represent the current global system and the combinations of the two models, two scenarios, and 2 future years:

1. Precipitation during the locally hottest quarter
1. Precipitation during the locally coldest quarter
2. Precipitation during the locally driest quarter
3. Precipitation during the locally wettest quarter
4. Ratio of precipitation to potential evapotranspiration
5. Temperature during the coldest local quarter
6. Temperature during the hottest local quarter
7. Sum of local monthly Tavg where Tavg >=5 °C
8. Integer number of consecutive months where Tavg >= 5 °C (Length of potential growing season).

## 2.2 Step 3: Multivariate geographic clustering

Hargrove and Hoffman (2005) reviewed the history of statistical and geographic information system (GIS) based ecosystem map development and then described their Multivariate Geographic Clustering (MGC) empirical process for identifying habitats. They used nine characteristics captured as maps for the conterminous United States:

1. Plant-available water capacity
9. Soil organic matter
10. Total Kjeldahl soil nitrogen
11. Depth to a seasonally high water table
12. Mean precipitation during the growing season
13. Mean insolation during the growing season
14. Degree-day heat sum during the growing season
15. Degree-day cold sum during the non-growing season
16. Elevation.

Maps were at a resolution of 1-km. Each of the maps was converted to non-dimensional forms by assigning standard-deviation values from the means of each of the maps values. This resulted in each location being characterized by a coordinate point in the 9 dimensions. Hargrove and Hoffman used a two-step process using clustering and classification to

classify all locations. In the first step, the 9-dimensional space was divided in up to 3000 cluster centers that were then moved around the space until each cluster signature was associated with a similar number of locations (a subset of 1-km cells). With the established cluster means, each location was then assigned to the cluster that has the closest Euclidian distance in the 9-dimensions.

This study applied the MGC procedure simultaneously using nine sets of 16 map layers representing the current global state and the eight forecast future states:

1. Precipitation during the locally hottest quarter
17. Precipitation during the locally coldest quarter
18. Precipitation during the locally driest quarter
19. Precipitation during the locally wettest quarter
20. Ratio of precipitation to potential evapotranspiration
21. Temperature during the coldest locally quarter
22. Temperature during the hottest locally quarter
23. Sum of monthly Tavg where Tavg >=5 °C
24. Integer number of consecutive months where Tavg >= 5 °C (Length of potential growing season)
25. Available water holding capacity of soil
26. Bulk density of soil
27. Carbon content of soil
28. Nitrogen content of soil
29. Compound topographic index (relative wetness)
30. Solar interception
31. Day/night diurnal temperature difference.

To facilitate the combination and comparison of these maps through a cluster analysis, each was transformed by calculating the standard deviation of the maps' values. This resulted in a 16-value signature for every one of 48.6 million 2-minute square cells for the globe (including water areas) between 60 degrees south latitude and 90 degrees north latitude (10,800 columns and 4500 rows). The signatures for all land areas and for all maps were then clustered into 30,000 clusters. This large number of clusters allows for relatively fine separation of habitat types, yielding an average of about 500 cells per cluster. Figure 2 shows the resulting map for the area of the United States based on current (2000) conditions.

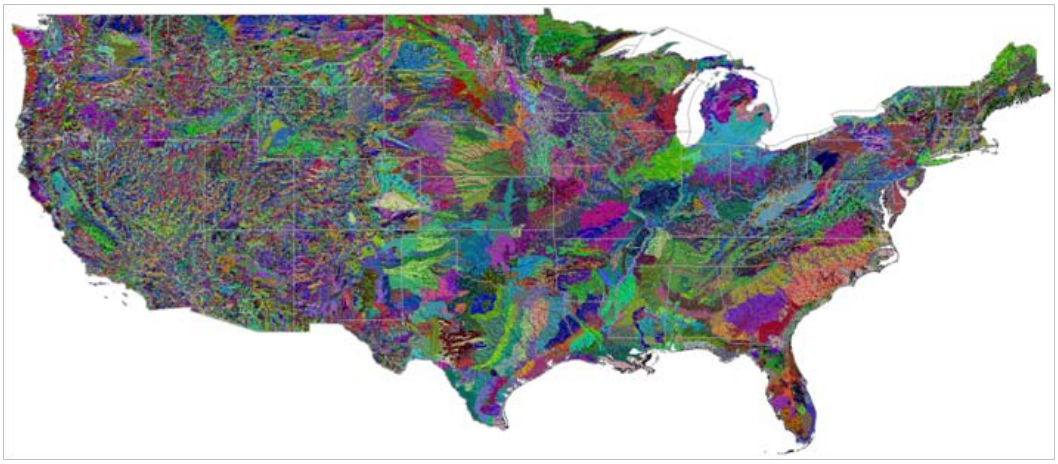


Figure 2. Global ecosystem map — random color table.

The color table is random and shows areas that are similar in the combination of the conditions represented in the 16 input maps. Note that analysis was done for the entire globe and for the eight future condition combinations. This means that areas with the same set of conditions anywhere in the world and/or any time in the future are assigned the same cluster number. The averages of the conditions for all locations associated with a cluster results in a signature for that cluster. This results in an extremely powerful set of maps that can be used for answering a wide variety of questions. Any naturally occurring thing on the earth can be located in the current map to identify the associated clusters and signatures, which can be located across the earth, currently and in the future.

For example, by identifying the location of oak-hickory assemblages, one can then identify the gridcells associated with those areas and find out what clusters they represent. By highlighting the gridcells across the country (or globe) across the future conditions, it is possible to identify where the conditions are forecast to be found that are currently associated with oak-hickory forests. This procedure can be used for locating the future locations of areas that share the ecosystem drivers currently associated with habitat, species, growing areas, cities, forests, or military installations.

## 2.3 Step 4: Current habitat maps

The 30,000 cluster categories generated for the globe across the current and nine future scenarios are simply statistically-similar areas based on standard-deviation values representing 16 distinct soil characteristics, solar interception, and climate values. Correlating these clusters with ac-

cepted habitat types is relevant to this work. This begins with selecting a habitat classification. Many habitat classification maps have been developed for the United States. Early examples include the Bailey (1983, 1995, 1996) and Omernick (1987) classification maps. Bailey generated maps at three levels of detail, identifying 52 ecoregions at the finest level. For studying water resources, Omernick identified 76 national ecoregions. These maps were created through a combination of computer-assisted classification of mapped data and subjective expert opinion.

This study selected two modern ecosystem classifications. The first, the GAP national land cover map, was developed by the GAP program (Davidson, 2010) and uses the Ecological System classification system developed by NatureServe to represent natural and semi-natural land cover, and covers the continental United States.

> Ecological systems were developed as a means of representing recurring groups of biological communities that are found in similar physical environments and that are influenced by similar dynamic ecological processes, such as fire or flooding. In addition, the national map contains 551 Ecological Systems and modified Ecological Systems containing 39 land use classes, which are depicted developed and disturbed land cover classes (GAP 2011).

Figure 3 shows the GAP map for the United States. Note that Appendix A to this report (Figure A1,p 34) contains the legend for this map (and all maps derived from this GAP map).

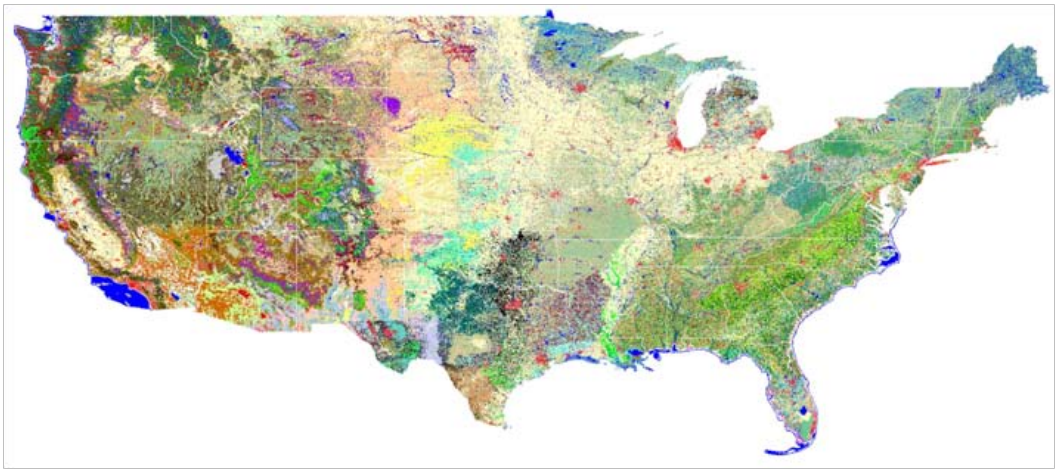


Figure 3. GAP national land cover map.

The second ecosystem map adopted covers the globe and was developed by the Nature Conservancy (TNC) as a unified global representation of ecosystems. Figure 4 shows the global TNC map* and Figure 5 shows the corresponding CONUS map. Figure A2 (p 35) contains the legend for the TNC maps. Note that the GAP ecosystem map is much more detailed than the TNC map (688 categories across the globe, but only 70 across CONUS).

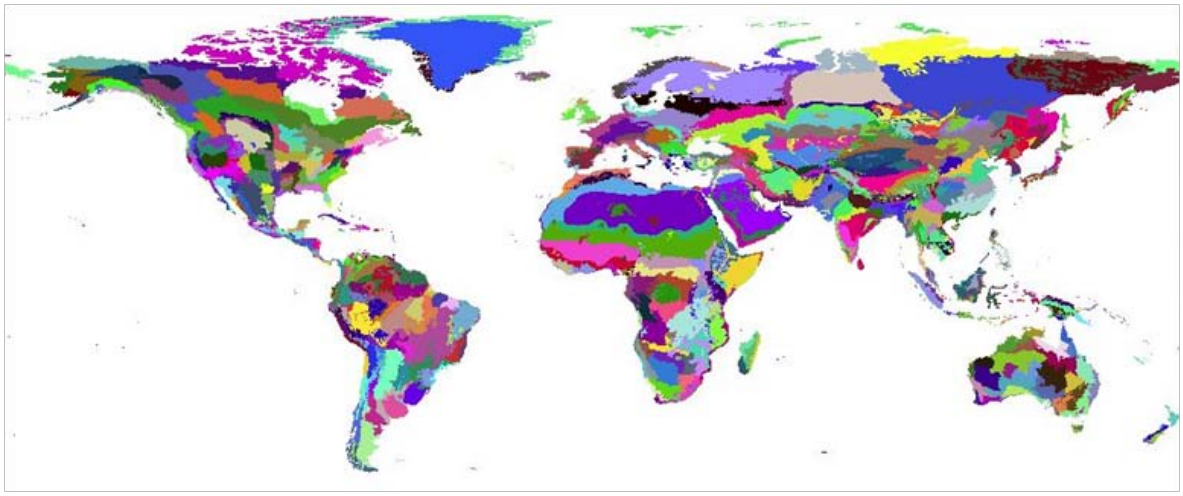


Figure 4. TNC ecosystems of the world.

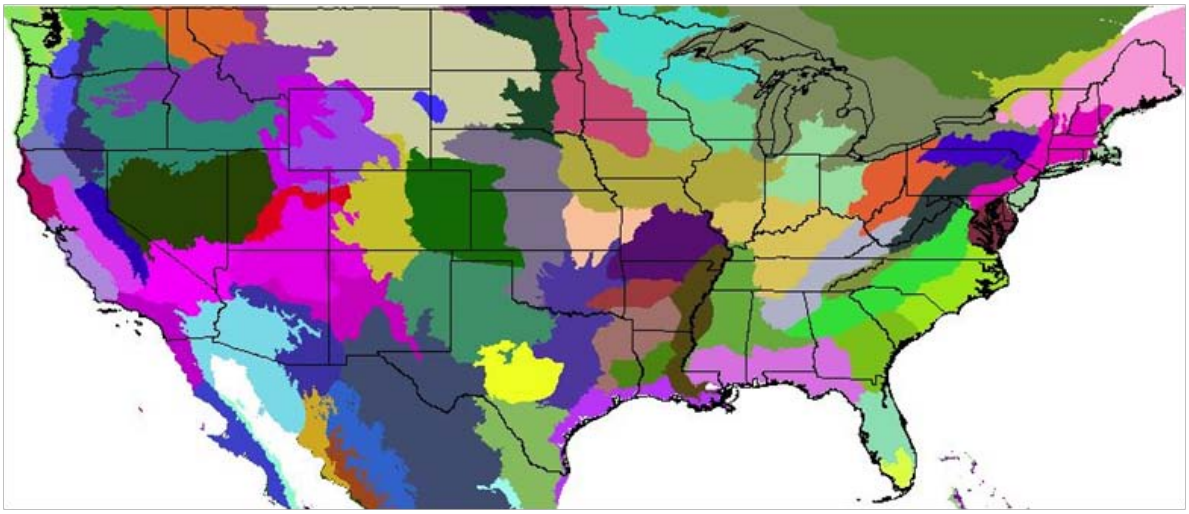


Figure 5. TNC ecosystems of the world — United States.

* Also available through URL: http://www.nature.org/multimedia/maps/

## 2.4 Step 5: Future habitat map

The goal of this step was to generate a consistent set of one current and eight future habitat maps based on the 551 GAP ecosystem and land use classes for CONUS and the 688 TNC ecosystem classes for the world. These are based on all combinations of two GCM models (Hadley and PCM), two scenarios (A1 and B1 emission levels), and two future times: 2050 and 2080. This step begins with eight future maps (and a current map) that have been collectively classified into 30,000 habitat clusters (Step 3). That is, each of the nine maps shares the same cluster values. Therefore, if the cluster categories in any one of the maps can be associated with ecosystems, then that same association can be shared with the other eight maps. This was done by cross-referencing the 551 GAP ecosystem and land use classes (Figure 3) with the cluster categories (Figure 2) (4284 categories of the 30,000 across the world, across the nine maps) found in the conterminous current map. Counts were made of the number of cells sharing each GAP category with the various cluster categories. For each cluster category, a count of the number of cells containing each shared GAP category was established and the most commonly shared GAP category was then assigned to each respective cluster category.

The reassignment relating Figure 2 to Figure 3 resulted in the map shown in Figure **6**. The 4284 cluster categories mapped into 243 (less than half) of the 551 GAP categories. Many GAP categories that represented small areas were washed out in the process – leaving only the more dominant ecosystem types. The cross-referencing established for the current map was then applied to all of the future maps – providing the basis for forecasting ecosystem change.

The same procedure was followed with the global TNC map. Each of the clusters was associated with the one TNC ecosystem type that most frequently correlated with the cluster. Unlike the GAP-based analysis, this was done with the global map. Figure 7 shows the result for CONUS.

There are two interesting differences between Figure 7 and Figure 5. First, the number of ecosystem categories across the United States increased from 70 to 287. This is because the entire globe was analyzed simultaneously and there are many cases where small areas in CONUS share the ecosystem driver conditions associated with broader areas elsewhere.

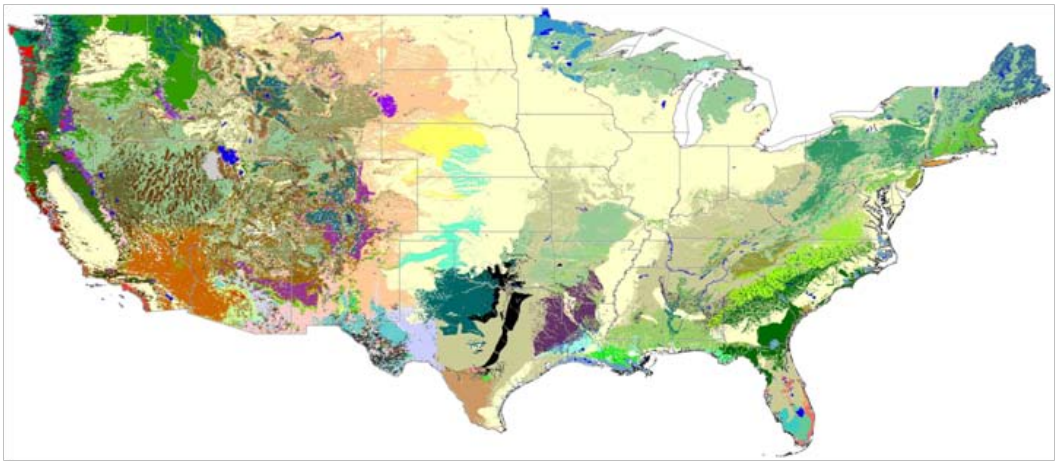


Figure 6. Global ecosystem map reclassified to GAP categories.

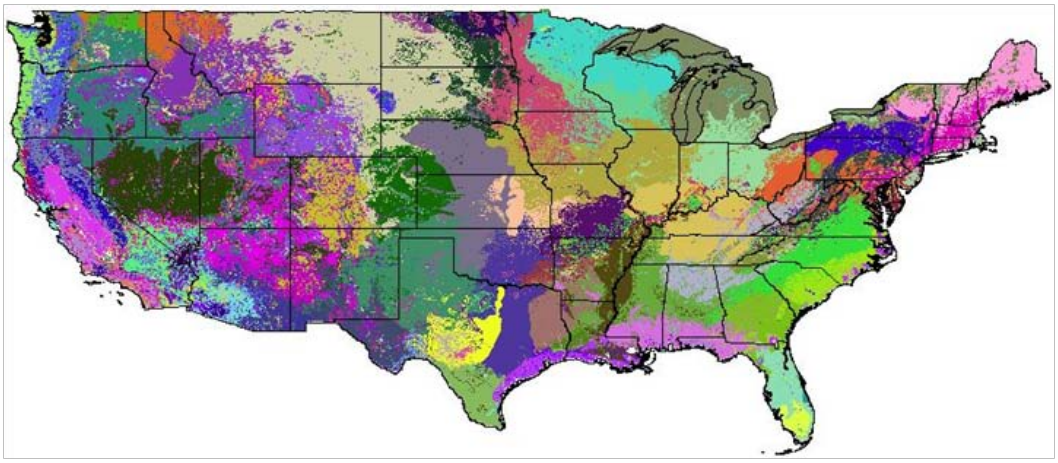


Figure 7. Global ecosystem map reclassified to TNC categories.

In many cases, these areas in CONUS can be very small. Second, while the ecosystem areas are grossly located similarly across the states, the edges of the ecosystem areas are much more jagged in the new map (Figure 7), more accurately representing reality in nature, and its lack of solid edges.

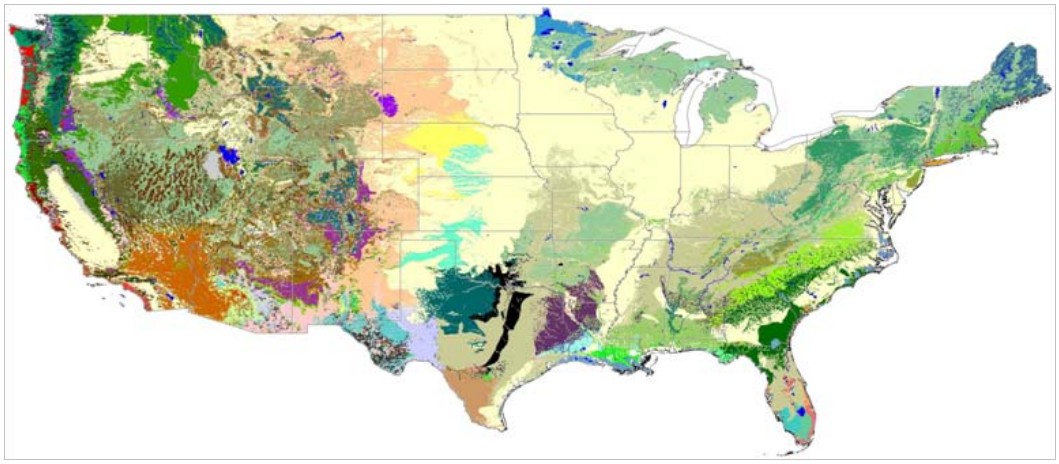
The new GAP and TNC maps were generated using lookup tables that associate each cluster to the associated ecosystem type. By applying these two lookup tables to the eight future maps, it is possible to generate sets of GAP and TNC-based ecosystem maps.

Future time series for each of the two models and the two emission time series are displayed for the GAP-based series in Figures 8 to 11; and for the TNC-based series in Figures 12 to 15. These are in order of apparent eco-

system impact severity. The PCM B1 scenario results are captured in Figures 8 and 12. The top image in each shows the current system state, the center image shows the scenario projected for 2050, and the bottom image, the scenario projected for 2080. This pattern is repeated in Figures 13 to 15. Significant shifts are evident in even the least dramatic forecast of change. Note, for example, the northern shifts in northern Texas and into Oklahoma. Northward shifts are also easily apparent in the Appalachian ecosystems.

The A1 scenario PCM model results (Figures 9 and 11) show similar, but more dramatic, changes. Note the changes throughout most of the country. Note the white areas throughout the 2080 map. Most of these areas represent changes that have no current United States ecosystem analogs. In some cases, these can be mapped to existing areas elsewhere in the world. In other cases there are no current world analogs.

The B1 and A1 Hadley results follow in Figures 10 and 11 (and Figures 14 and 15) respectively. The B1 forecast is more severe than the PCM A1 results. The A1 results suggest extremely dramatic changes throughout most of the country.



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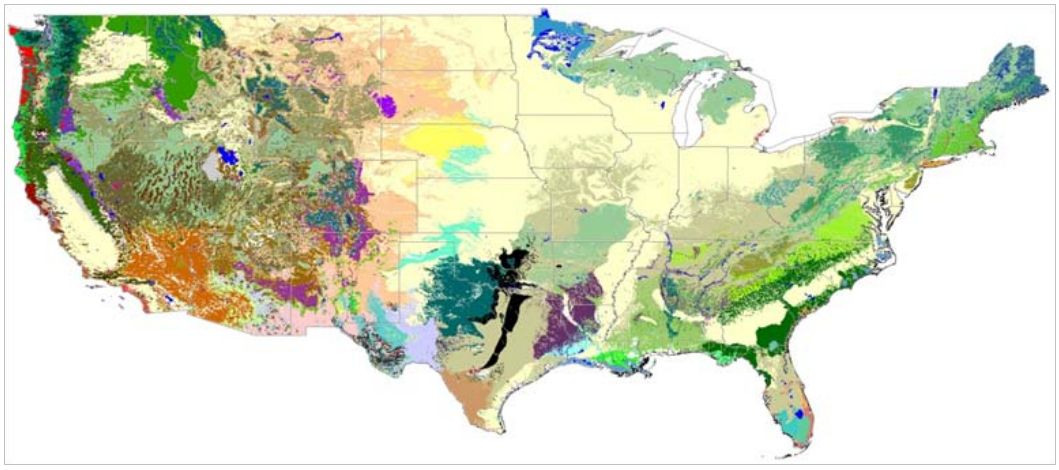
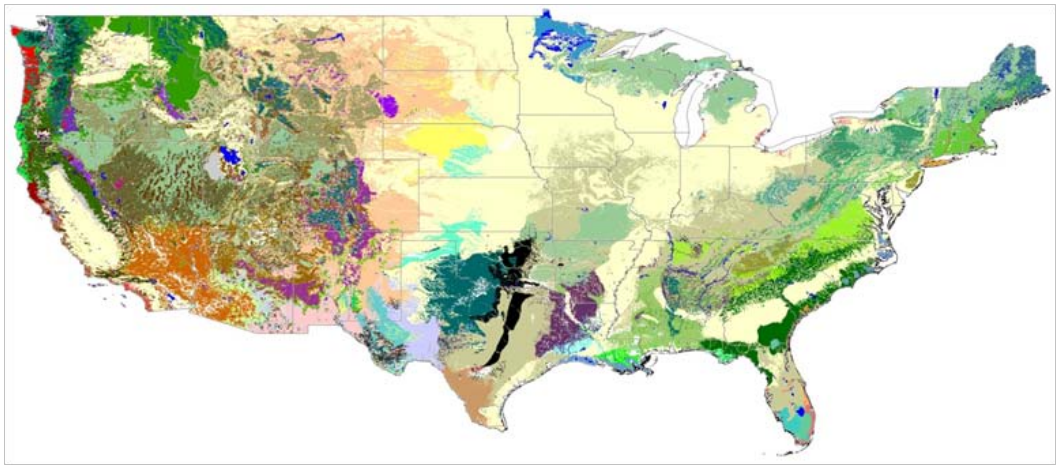
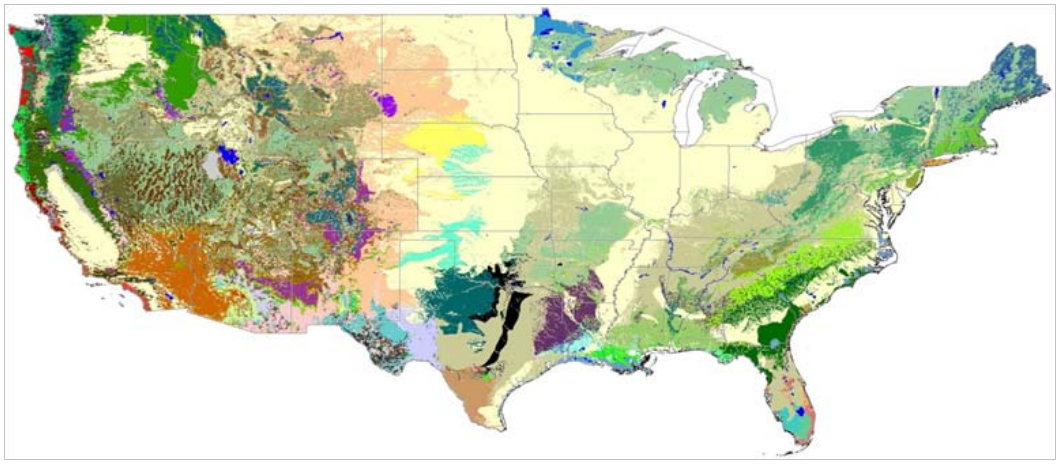


2050



2080

Figure 8. B1 Scenario, PCM Model; GAP Categories.



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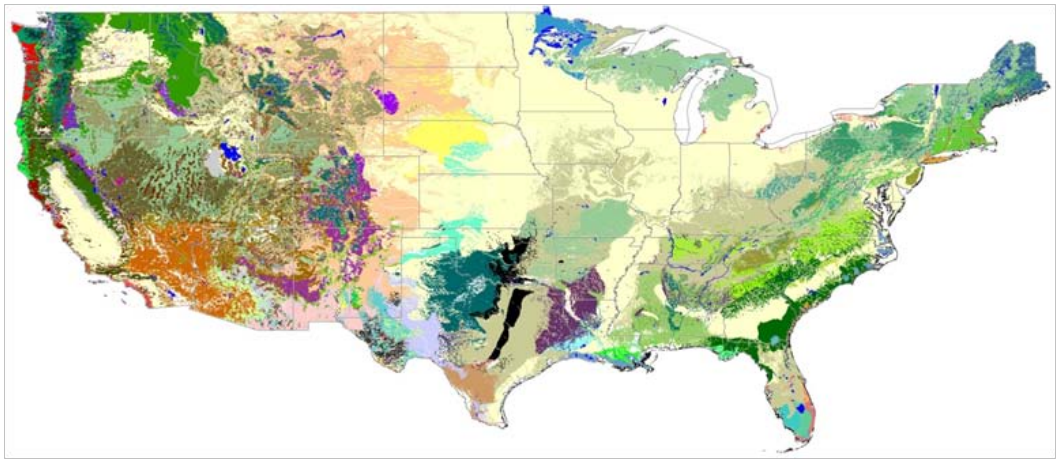
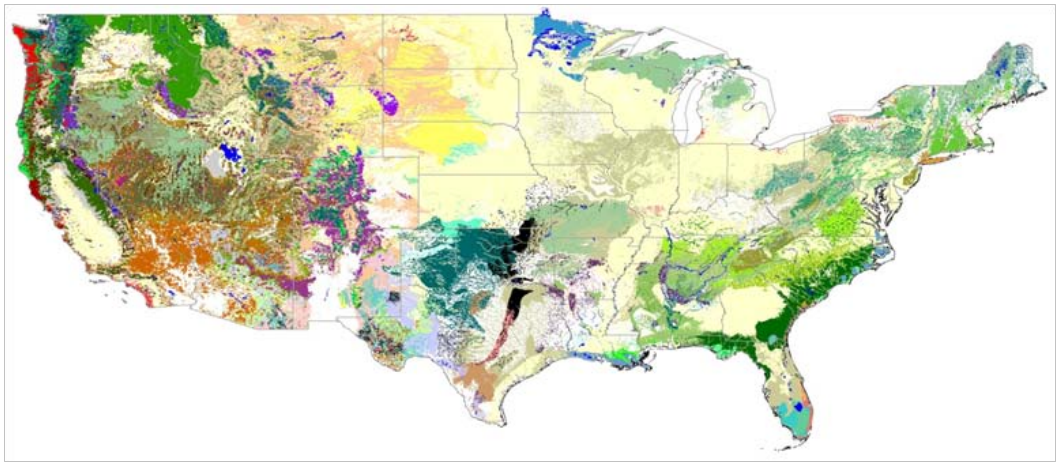
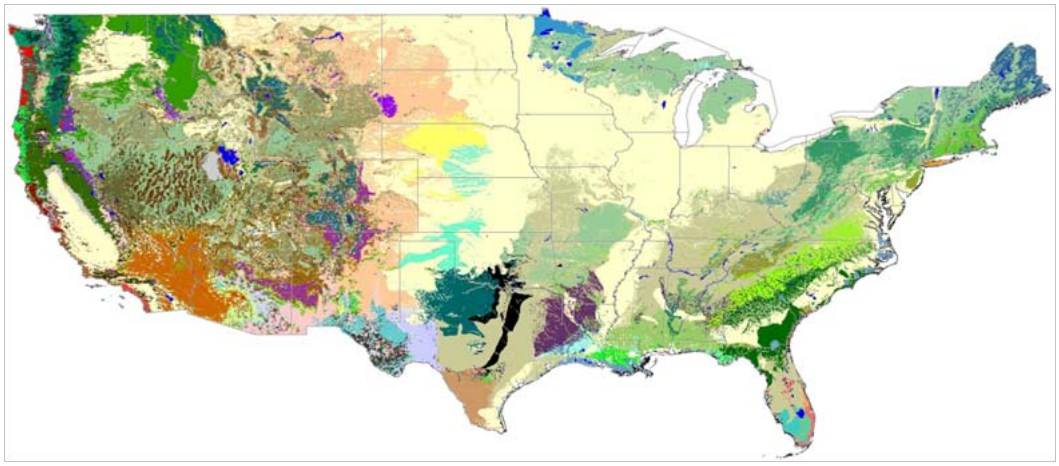


2050



2080

Figure 9. A1 Scenario, PCM Model; GAP categories.



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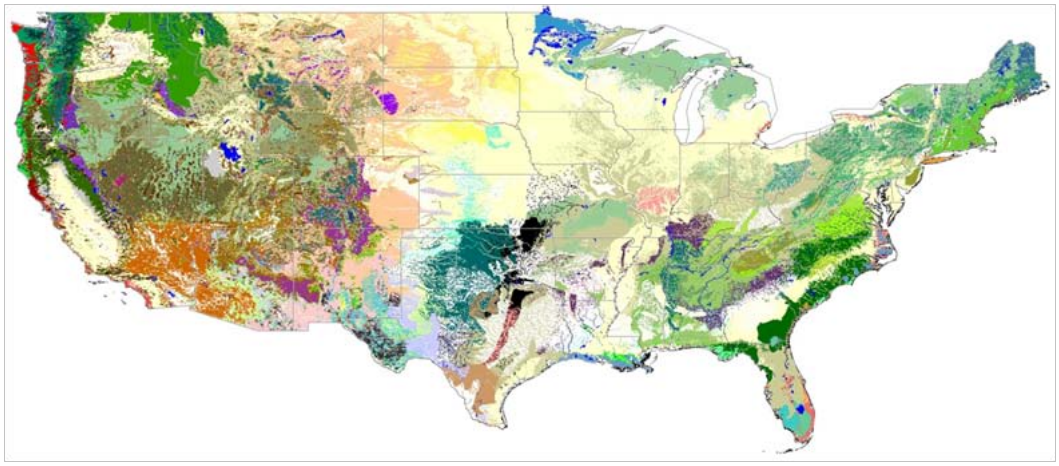

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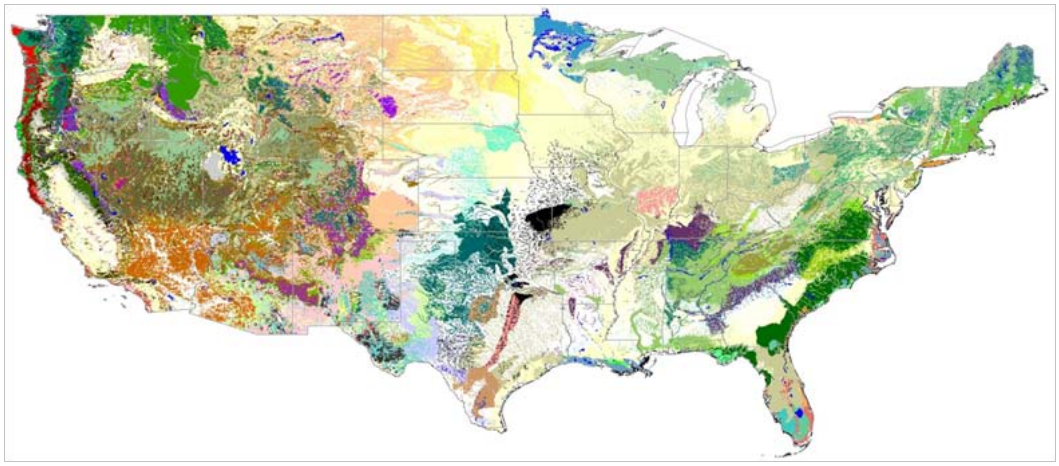
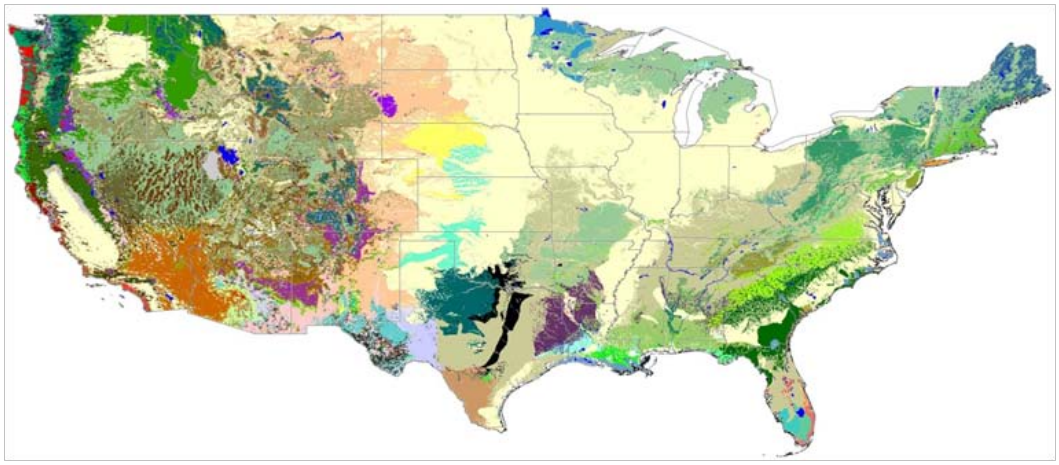
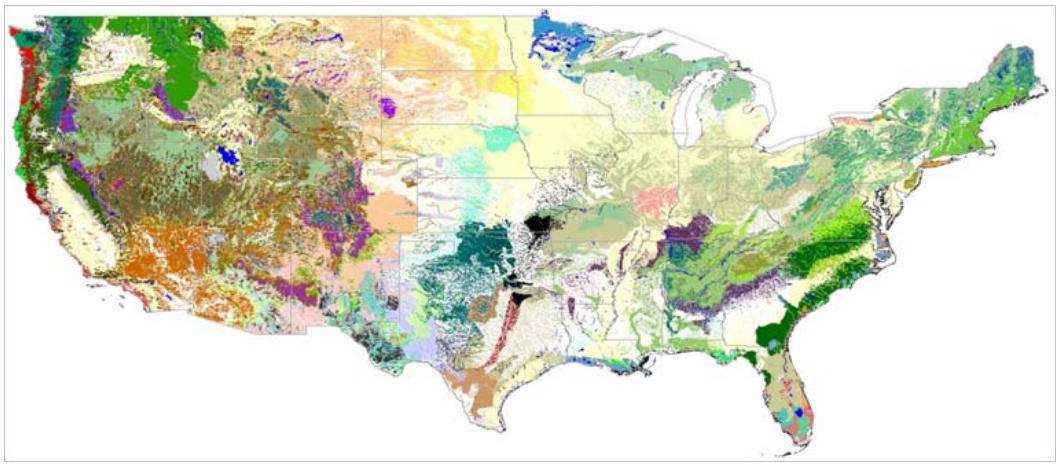


2080

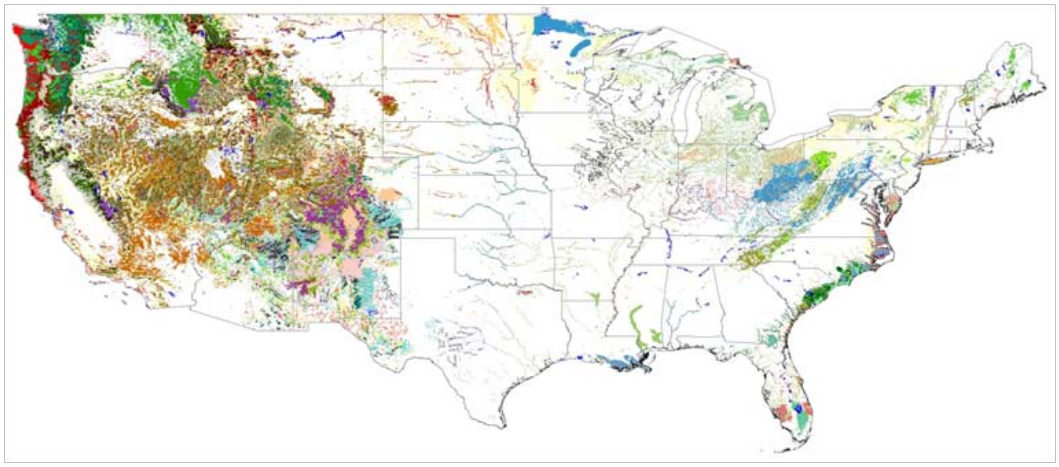
Figure 10. B1 Scenario, HAD Model; GAP categories.



Current

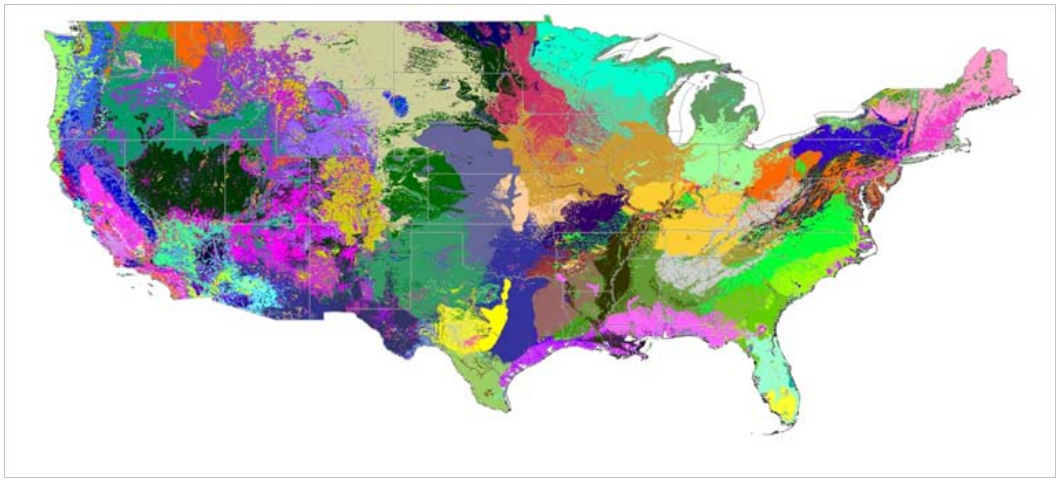


2050



2080

Figure 11. A1 Scenario, HAD Model; GAP categories.



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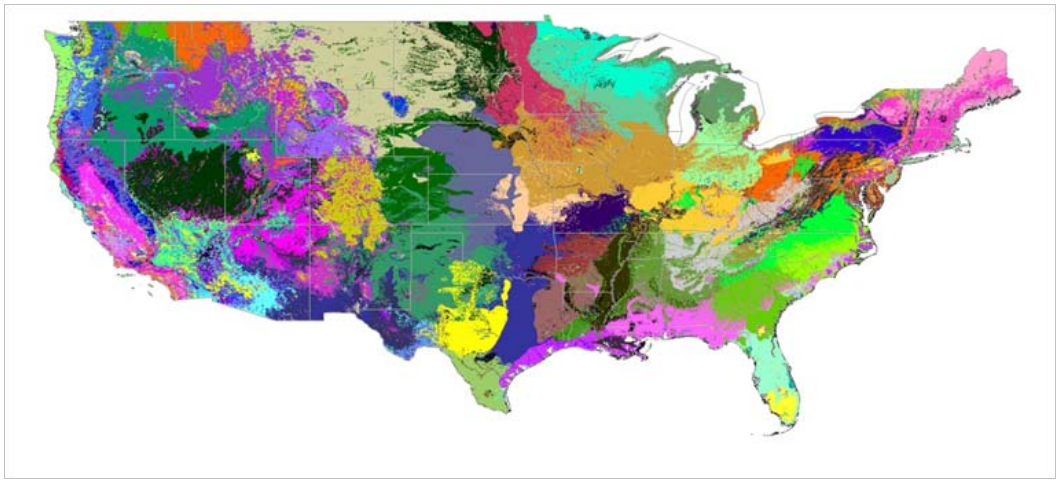

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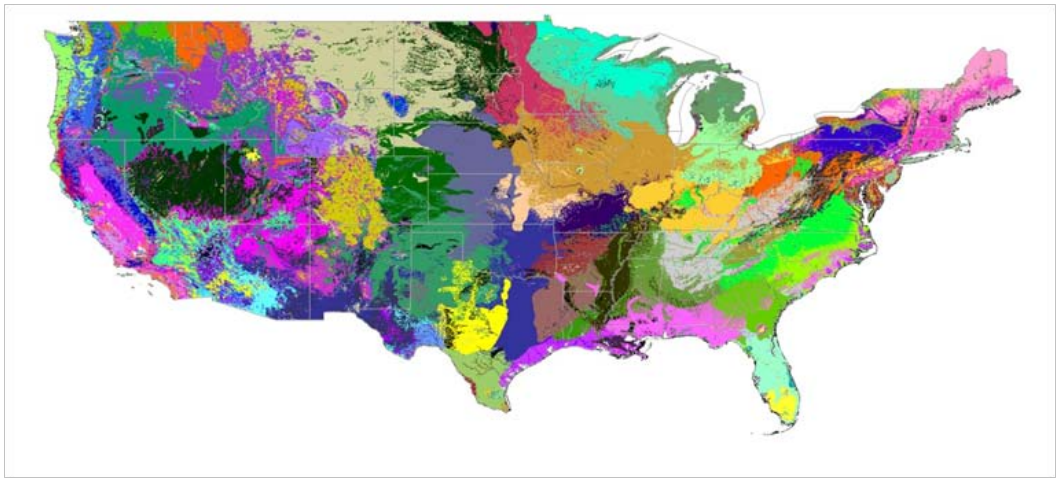
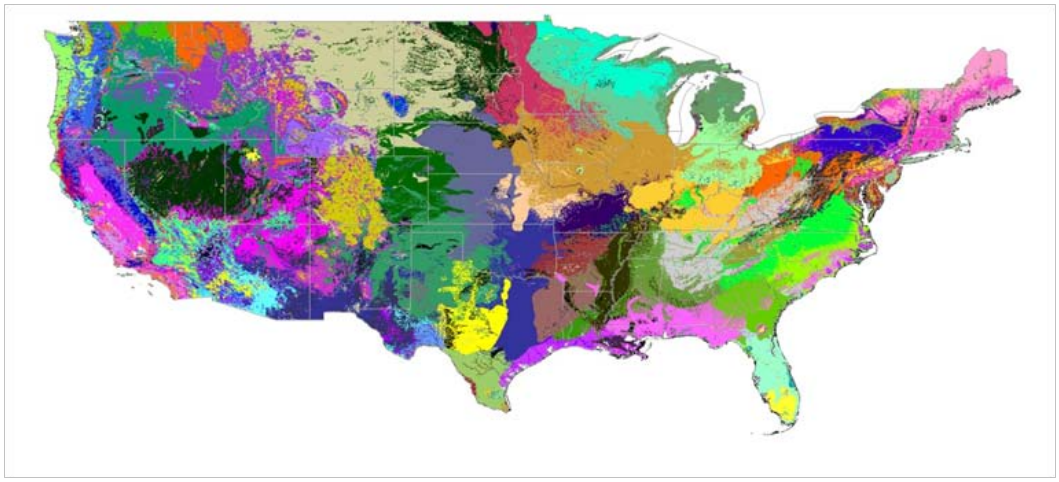


2080

Figure 12. B1 Scenario, PCM Model; TNC categories.



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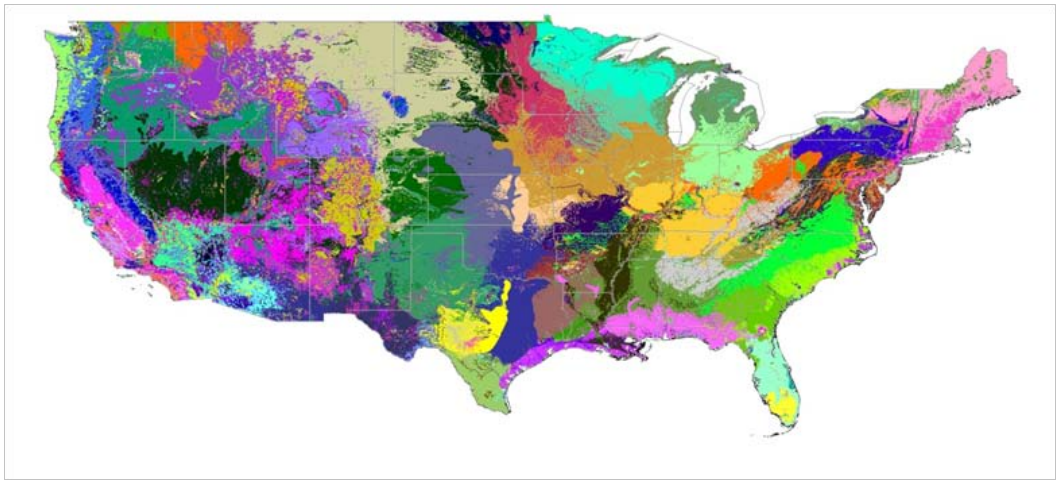
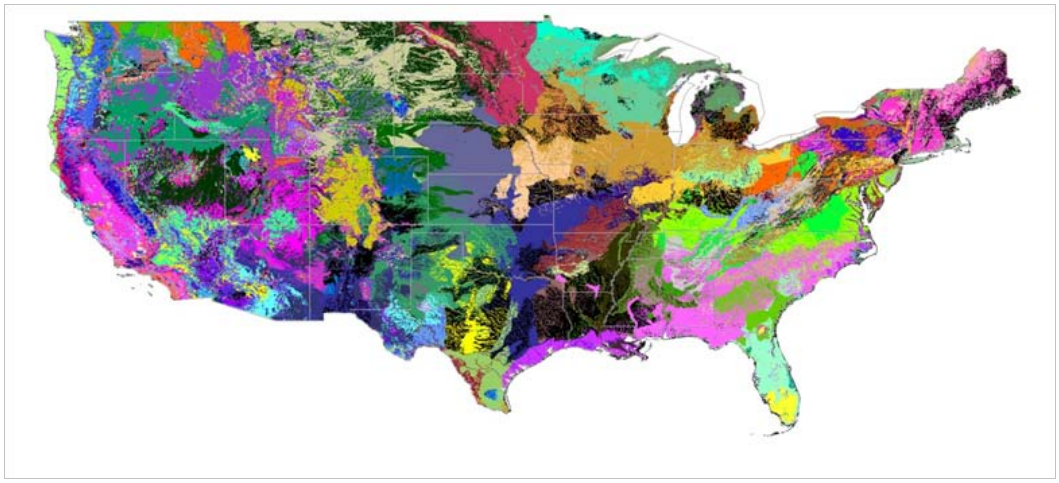
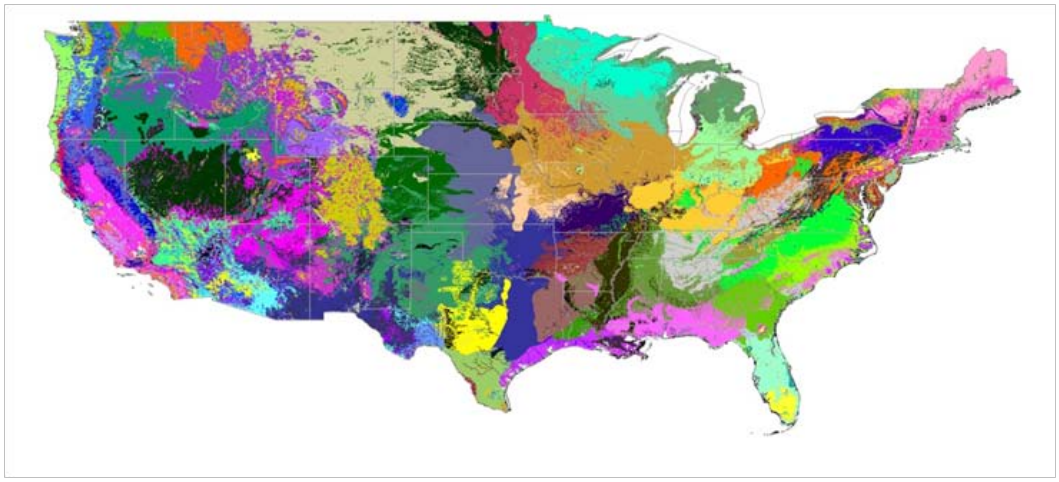


2050

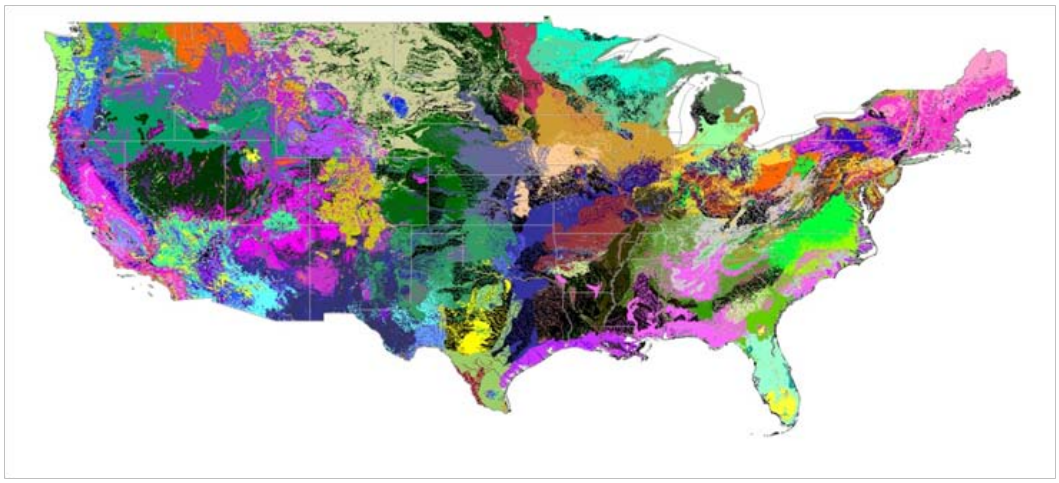


2080

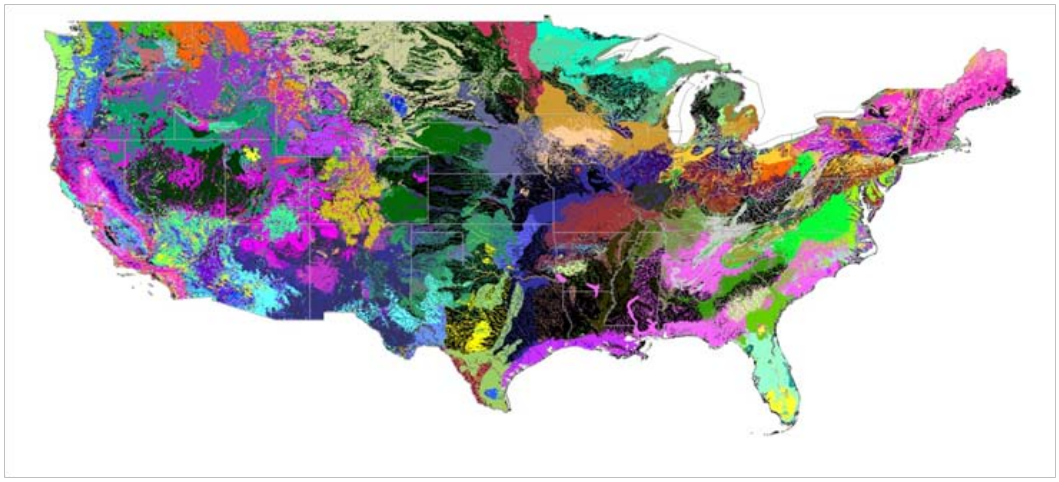
Figure 13. A1 Scenario, PCM Model; TNC categories.



Current

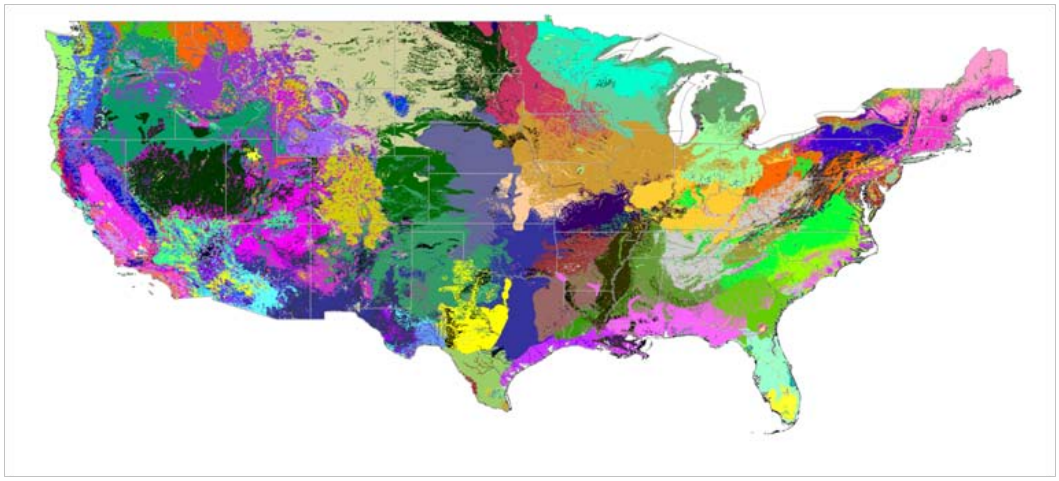


2050

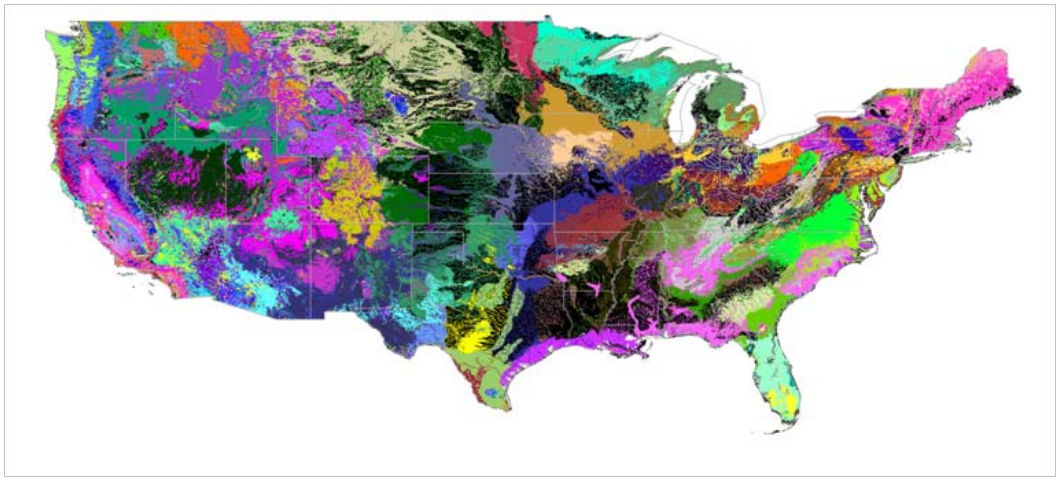


2080

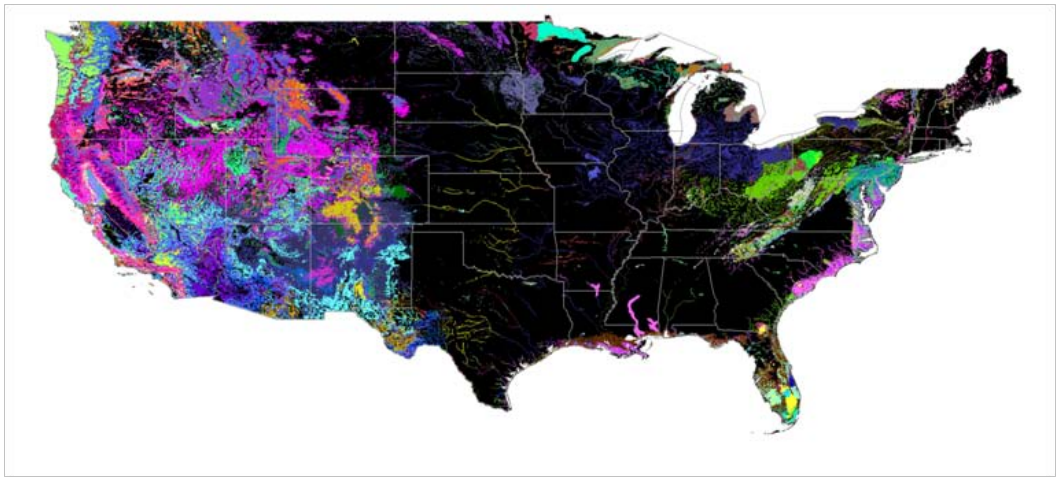
Figure 14. B1 Scenario, Hadley Model; TNC categories.



Current



2050



2080

Figure 15. A1 Scenario, Hadley Model; TNC categories.

# 3 Installation Analyses

## 3.1 Step A1: Forecasting installation biome shifts

In this step, one queries the future maps and asks how individual installations are likely to change, from an ecosystem perspective, over the 21st century. This was done by generating a page of images for each major installation that shows the area around each installation for each of the nine maps, and generating a rank-ordering of installations with respect to significance of change (discussed below). Appendix B (p 36) includes the results for select installations. (Figure 16 shows one example.) The location of an area around the installation is shown against the United States. The remaining maps "zoom into" this area. The map at the top-right shows the current ecosystem types. The middle row shows the images of the same area for the years 2050 and 2080. The columns represent the PCM model, B1 scenario; the PCM model, A1 scenario; the Hadley model, B1 scenario; and the Hadley A1, scenario. The top-left box provides an ecosystem/land-cover legend for the most commonly occurring categories across all of the maps on the page.

It is extremely important to read these maps with the following caveats. First, the Hadley and PCM models were chosen to represent relative extremes in GCM forecasts. Similarly, the A1 and B1 gas-emission scenarios provide relative extremes in greenhouse gas emission rates over the 21st century. Secondly, compared with the size of installations, the resolution of the national-scale study is relatively crude. Therefore, on-installation ecosystem details are not captured. Third, the classification of ecosystem type on the installations is likely to be crude – relative to the on-installation knowledge of local ecologists. Fourth, the forecast change identifies the very long-term steady state of an area. It does not take into account the rate of change to that system, which is mediated by seed dispersal rates, longevity of mature trees, human system management initiatives, susceptibility to disease, and inter-species competition.

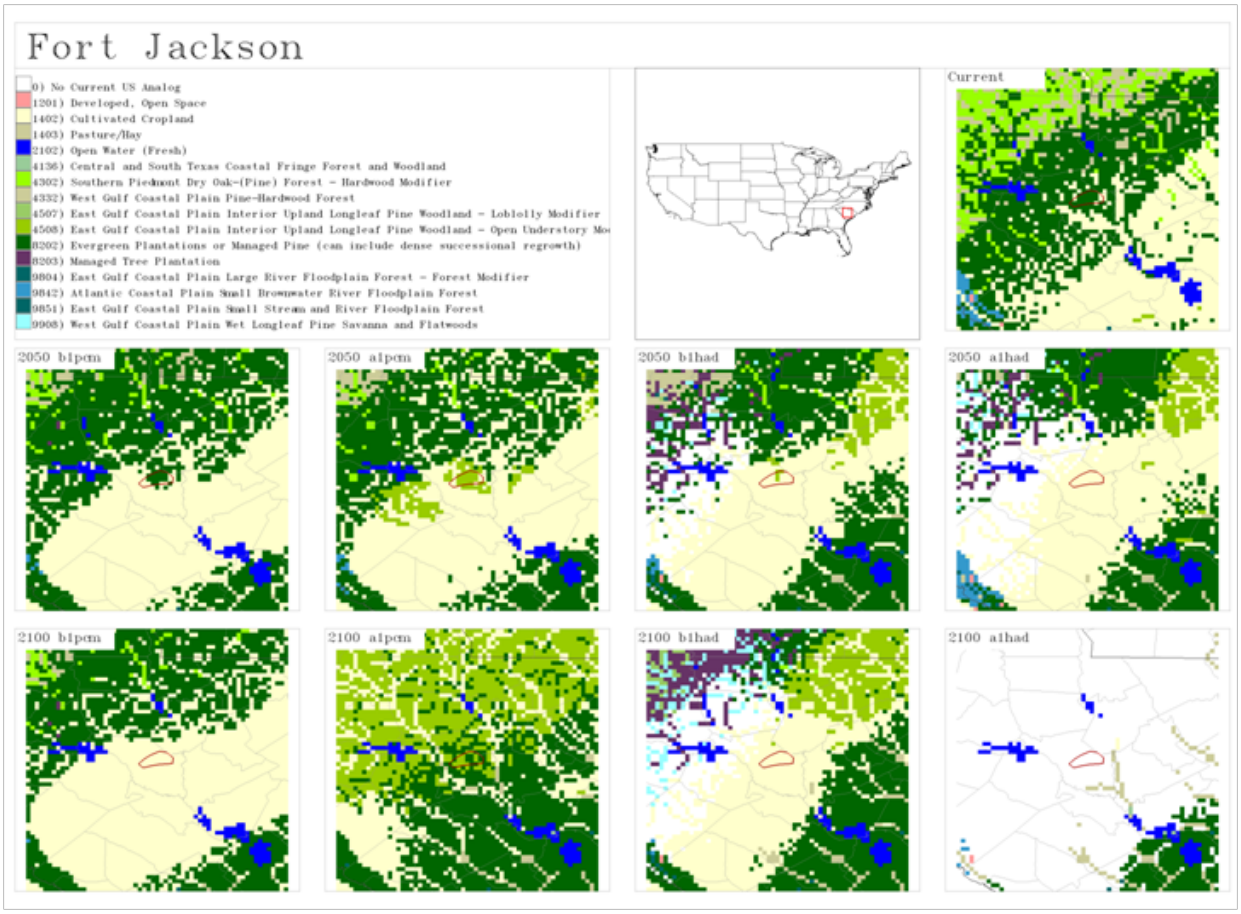



Figure 16. Sample installation report showing local biome shift potentials.

## 3.2 Step A2: Find future areas in the present

Another way to understand the potential for biome shift change and to visualize the relative amount of change is to display where one can go today to find the future ecosystem-driving conditions anticipated in the future. Consider Fort Jackson, SC (Figure 17). The images are arranged similarly to those in Figure 16: Current conditions are at top left, 2050 is the middle row, and 2080 is the bottom row. The first two columns are PCM model results, B1 scenario first and A1 scenario second. The last two columns are Hadley model results, again with B1 the first and A1 the second. The color table runs from dark green through bright green to white, with dark green being identical or very similar to the target.

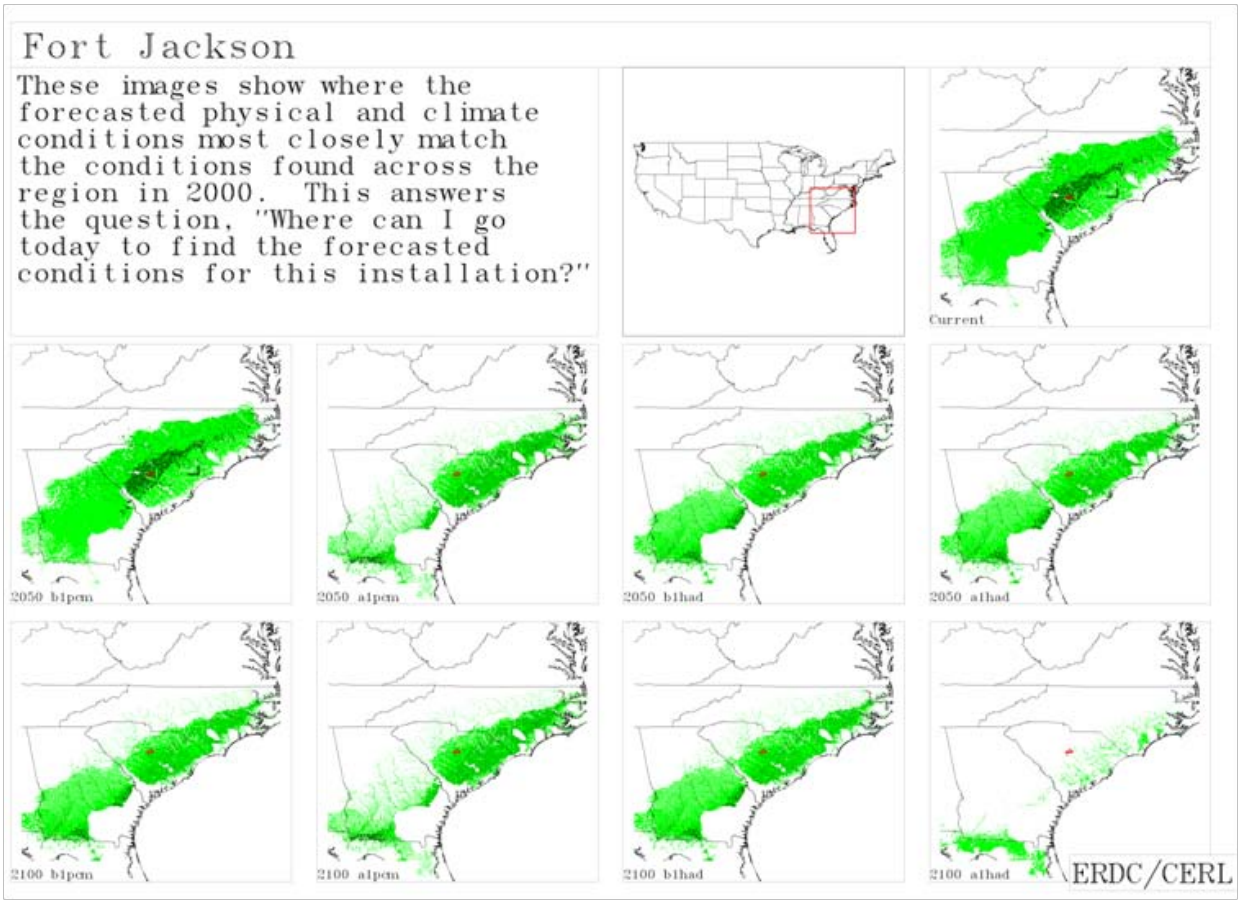



Figure 17. Current location of forecast ecosystem conditions.

The PCM B1 scenario suggests little change for this area by 2050. To find the best current example of conditions estimated for 2080 one needs to travel to the east area in Georgia. The Hadley A1 panel suggests that there are no areas that one can currently go today to find the conditions anticipated for Fort Jackson in 2080, but that the Florida panhandle offers the best analog. The gross graphical suggests that one need move further and further south to find areas that are similar to the modeled futures. Appendix B to this report (p 36) includes panels for selected installations.

## 3.3 Step A3: Rank areas by degree of change

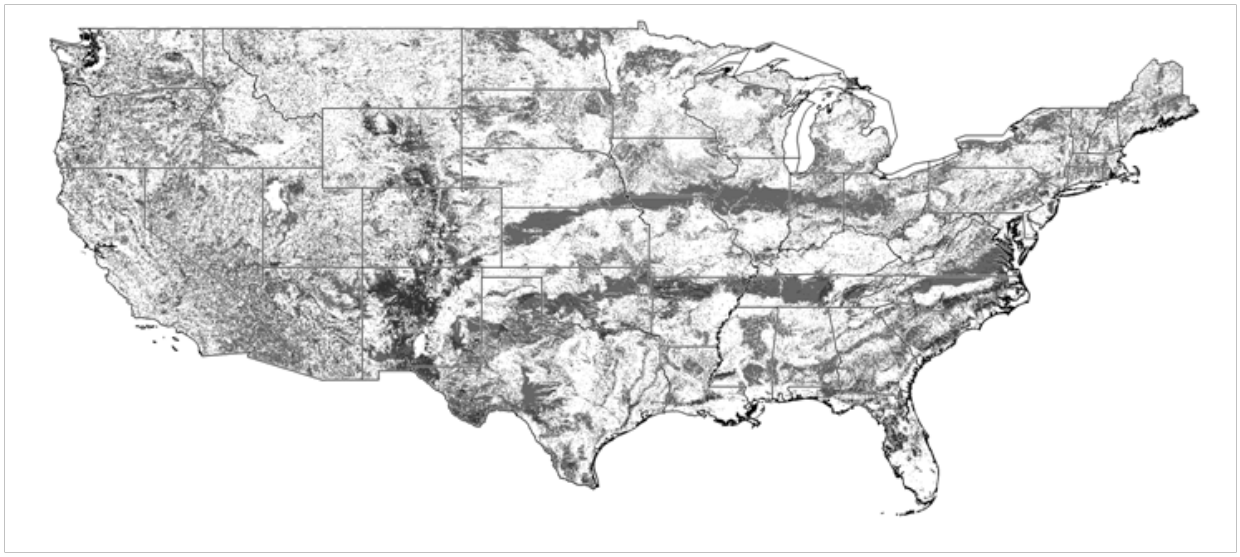
Which installations are most at-risk for change due to the consequences of potential ecosystem shift? To rank-order installations, the boundary of each installation was used to “cookie-cutter” into the current and future maps over the eight future GAP-based maps to tabulate the ecosystem type and amount of each type. For each future map, the percent of the installa-

tion that still held the current ecosystem types was calculated. The percentage across all eight future maps was then averaged and used to rank-order the installations. Appendix C (p 116) lists all of the Army installations beginning with the least changeable and ending with the installations likely to be most dramatically affected. The last column (on which the table is sorted) lists the average of the counts of changes for each model/scenario/time combination.

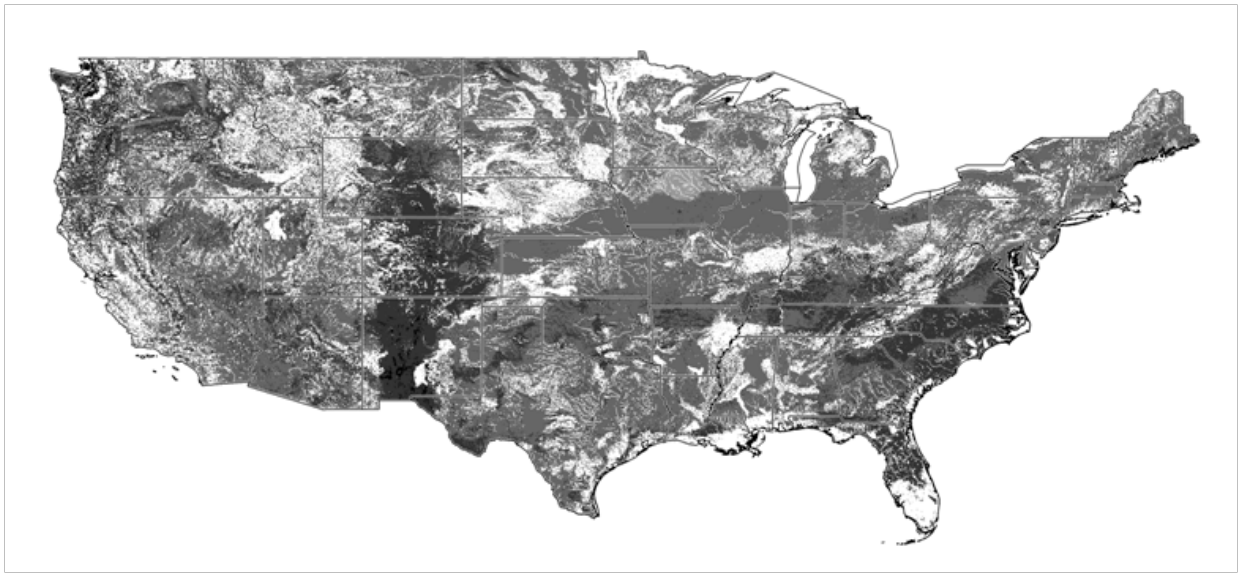
## 3.4 Step A4: Looking at raw change across CONUS

Another way to view the data is to simply look for degree of change over time across the 16 ecological drivers. Remember that each of the driver maps encodes the number of standard deviations from each map's average for each gridcell. Consider that these 16 values represent coordinates in a 16-dimensional space. One way to calculate overall change is to find the straight-line distance using the Pythagorean theorem between the 16-D coordinate for a space in 2000 and the 16-D coordinate representing a later time. This method assumes that one unit of change in one dimension is equivalent to one unit of change in every other dimension.

Figures 18 to 21 each show the two time steps (2050 and 2080) for each of the four model/scenario combinations. The images use a grey-scale color table with areas that change little in white and those that change a lot in black. Each image uses the same color table to allow for easy visual comparison. As expected, the Hadley model is consistently associated with greater change than the PCM model. Also, the higher emission scenario (A1) is associated with across the board greater change. In every map, the degree of change is quite variable across the nation, and the patterns of change are different across models and scenarios.

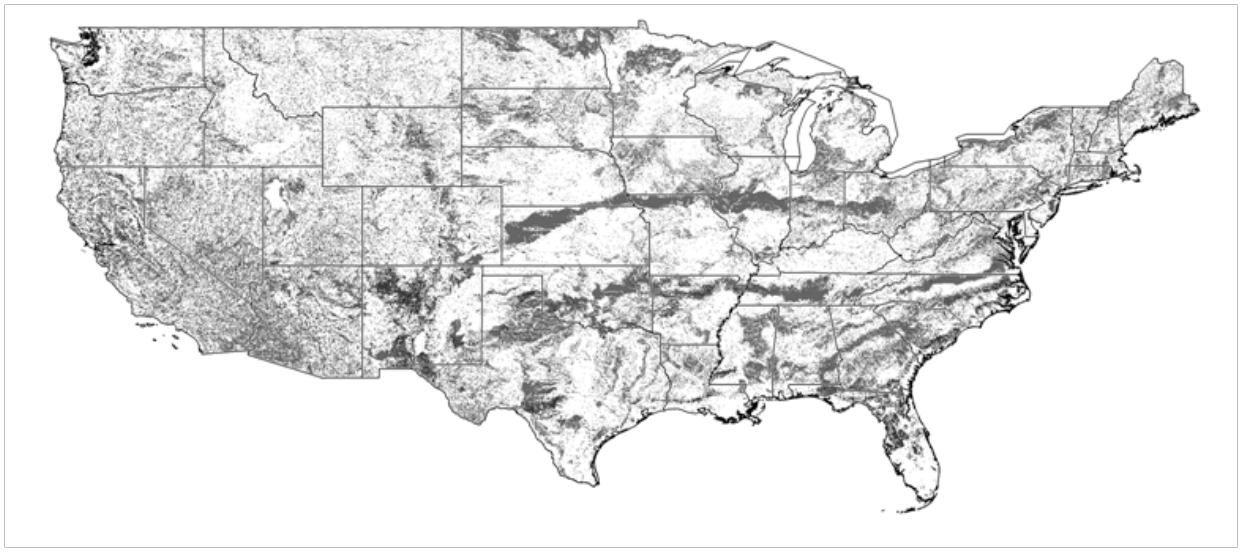


2005

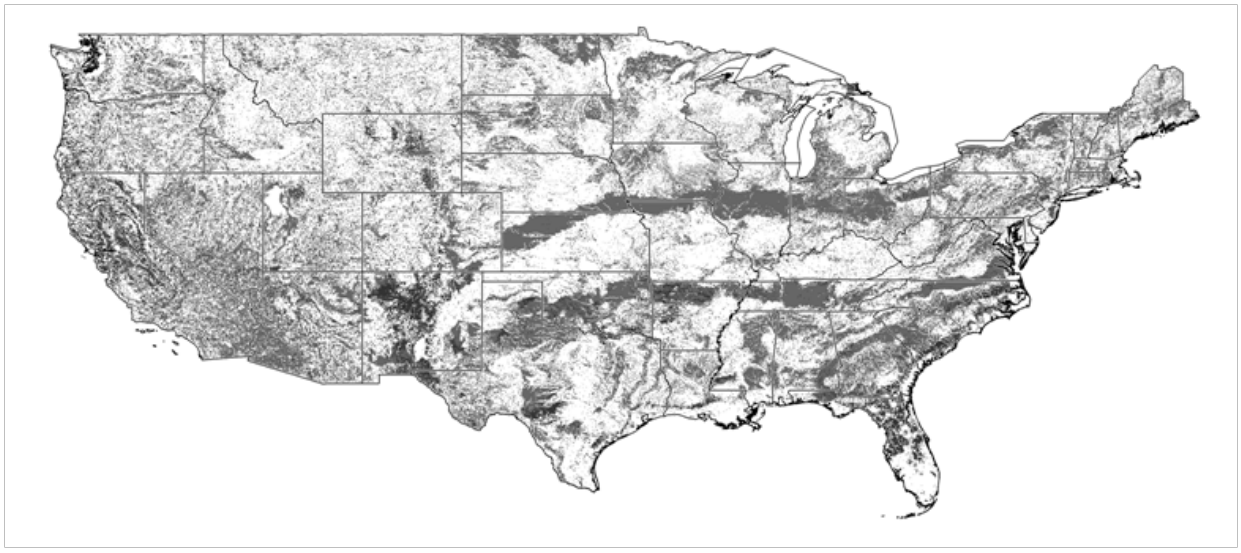


2080

Figure 18. Degree of change. Model: PCM, Scenario: A1.



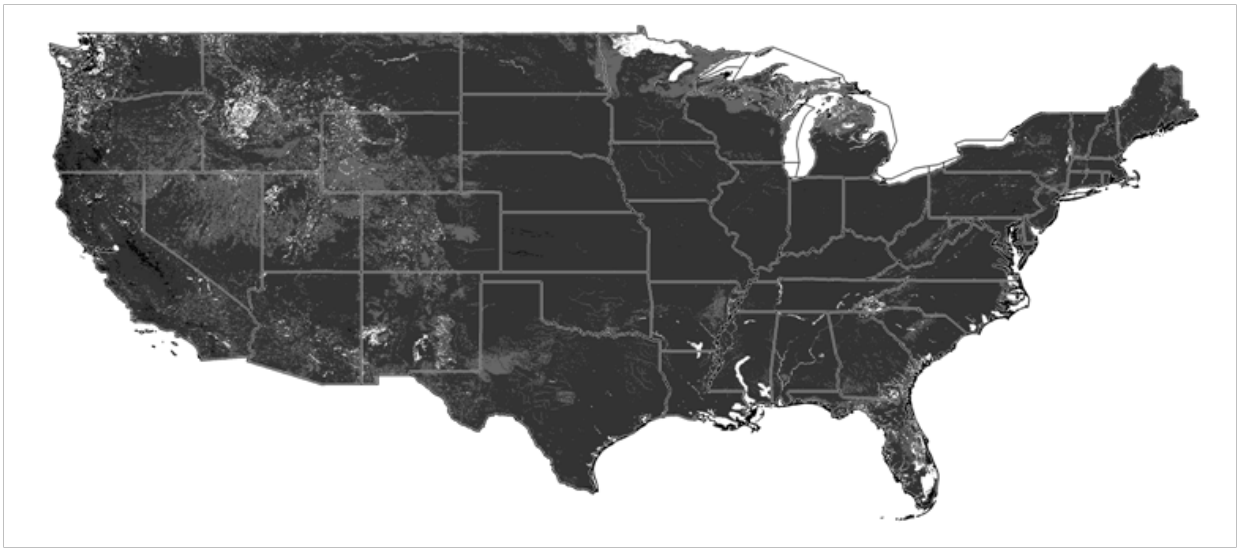
2005



2080

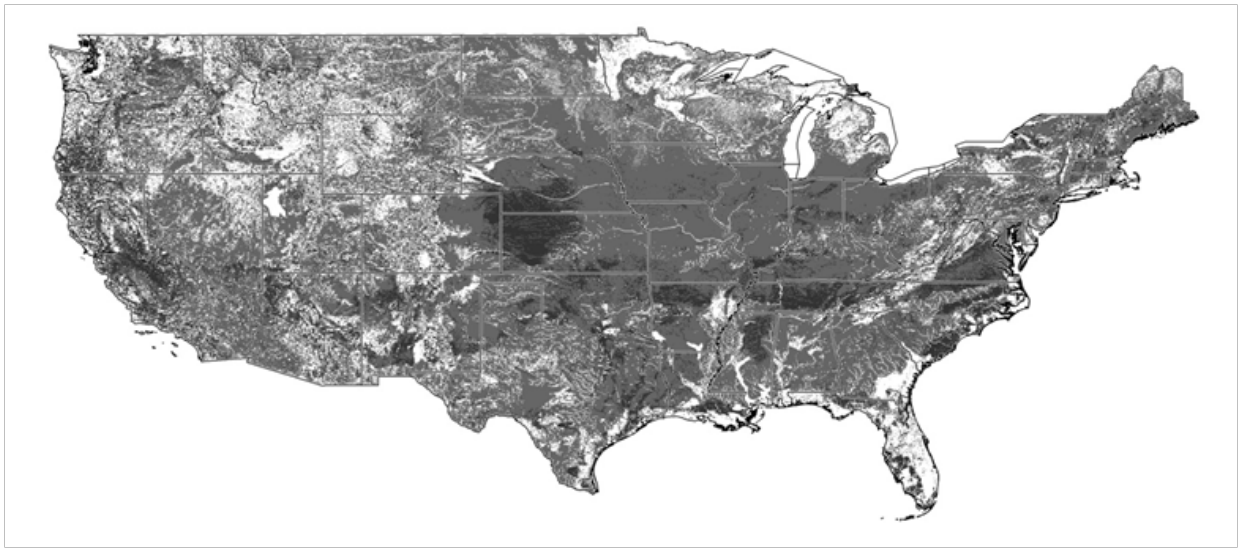
Figure 19. Degree of change. Model: PCM, Scenario: B1.

2005

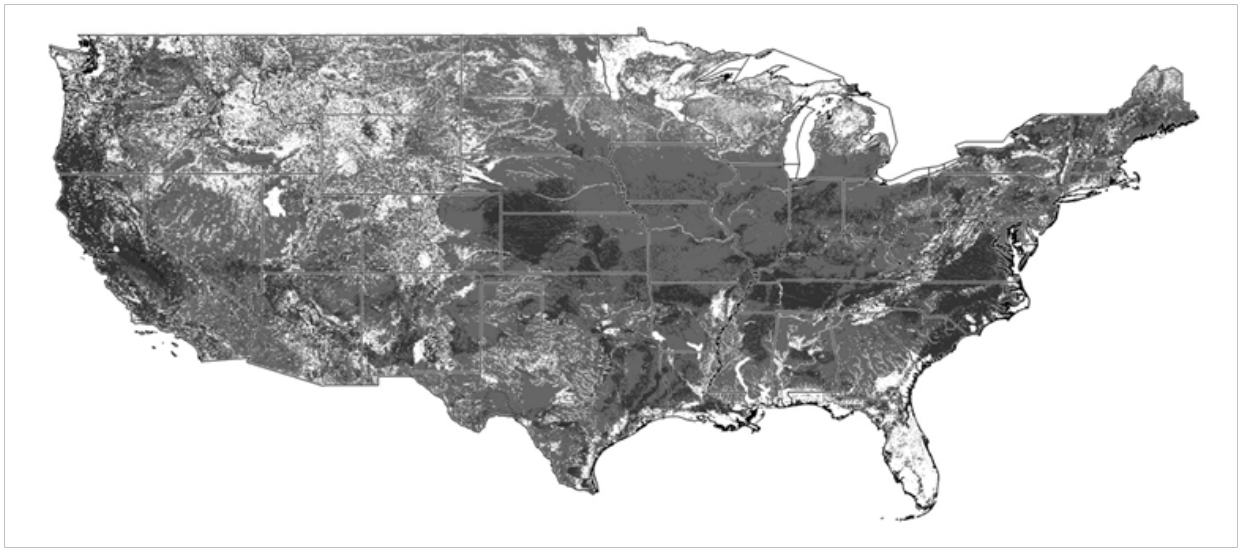


2080

Figure 20. Degree of change. Model: Hadley, Scenario: A1.



2005



2080

Figure 21. Degree of change. Model: Hadley, Scenario: B1.

# 4 Conclusions

This work has addressed three questions regarding the anticipated implications of forecast climate change in the CONUS for US Army installations.

## 4.1 "Which installations are most at-risk with respect to ecosystem changes?"

This work investigated the potential for ecosystem shifts on 134 military installations and tabulated the percent of anticipated shift in Appendix C (p 116). That potential was estimated for all eight combinations of two GCMs (Hadley, a model that tends to predict significant change; and PCM, a model that predicts less severe change), two scenarios (A1, higher carbon emissions, and B1, lower emissions), and two time periods. This work concludes that the major training/testing installations that appear to be most at risk include:

- Yakima
- Fort Huachuca
- Fort Drum
- Fort Hunter-Liggett
- Fort Jackson
- Fort Knox
- Fort Bliss
- Fort Sill
- Fort Campbell
- Fort Gordon
- Fort Benning.

## 4.2 What is the range of anticipated ecosystem shifts based on the forecasts of general circulation models (GCMs)?

The two GCMs chosen represent a reasonable range of climate condition change forecasts. The models generally agreed in the direction of system changes, varying only in degree. Based on this analysis, 66–88 percent of installations are expected to see ecosystem driver conditions (weather, soils, and insolation) change enough by 2050 to support a different system than now exists. By 2080 that range shifts to 68–99 percent. By this anal-

ysis, this work concludes that over the coming decades, most installations are expected to see clear evidence of climate change impact on the types of plants and animals that naturally thrive on their lands.

## 4.3 Where can one go today to find the ecosystem drivers (weather, climate, soil, and sun) anticipated in the future?

Appendix B to this report (p 36) includes three panels of analysis results for some of the largest Army training and testing installations. The third panel in each set maps where one might go today to find the ecosystem driver conditions that most closely match the anticipated future conditions for the installation. In general one must travel south, or down-slope, to find the anticipated future conditions today. However, in the long term, it becomes increasingly likely that there is no nearby location that is like the anticipated future.

As noted earlier, this analysis looks only at the anticipated changing conditions that support ecosystems and that matches future conditions to current conditions to see what ecosystems are currently supported by specific combinations of conditions. While this analysis might predict what ecosystems might emerge in the future if conditions were to stabilize, it absolutely does not forecast when the new system will replace the current system. However, this analysis does suggest that across CONUS there will be a long-term mismatch between extant systems and the conditions upon which those systems depend. Ecological models may become useful for forecasting change rate and process, but the consequences of these changes will be the subject of study for many decades to come.

# Acronyms and Abbreviations

| Term | Definition |
|---|---|
| BRD | Biological Resources Discipline |
| CEERD | U.S. Army Corps of Engineers, Engineer Research and Development Center |
| CERL | Construction Engineering Research Laboratory |
| CONUS | Continental United States |
| DC | District of Columbia |
| ERDC | Engineer Research and Development Center |
| GAP | Gap Analysis Program |
| GCM | general circulation model |
| GIS | geographic information system |
| MGC | Multivariate Geographic Clustering |
| NCAR | National Center for Atmospheric Research |
| PCM | Parallel Climate Model |
| POP | Parallel Ocean Program |
| TNC | The Nature Conservancy |
| TR | Technical Report |
| URL | Universal Resource Locator |
| US | United States |
| USGS | U.S. Geological Survey |
| WWW | World Wide Web |

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# Appendix A: Legends


Figure A1. Legend for GAP maps.


Figure A2. Legend for TNC maps.

# Appendix B: Installation Biome Shift Forecasts

Installations are alphabetically ordered on the following pages:

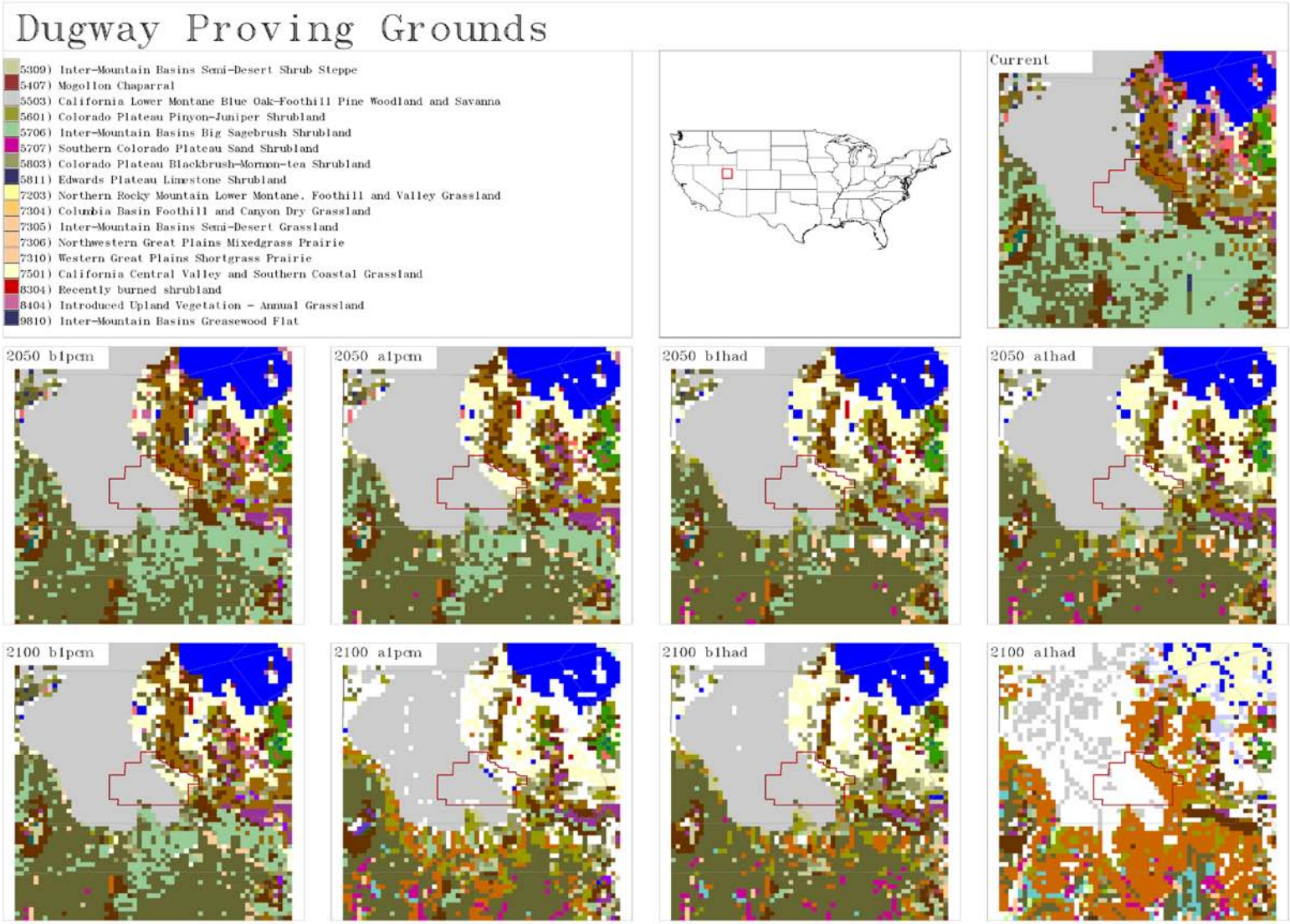


Each installation is illustrated with three panels:

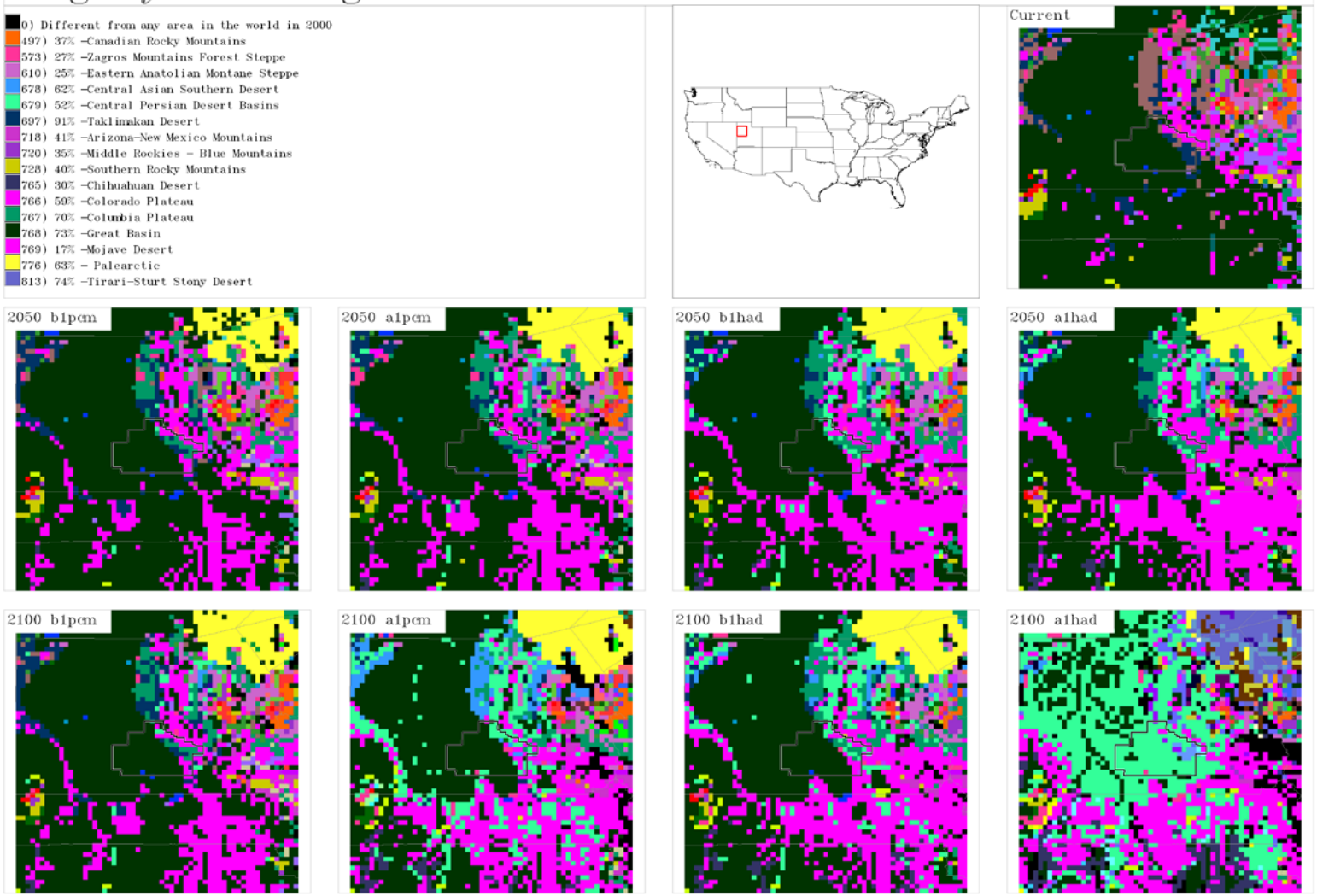
1. A series of current and future GAP-analysis maps.
2. A series of current and future TNC-analysis maps.
3. A series of maps showing where, today, one might go to find the future forecast conditions.

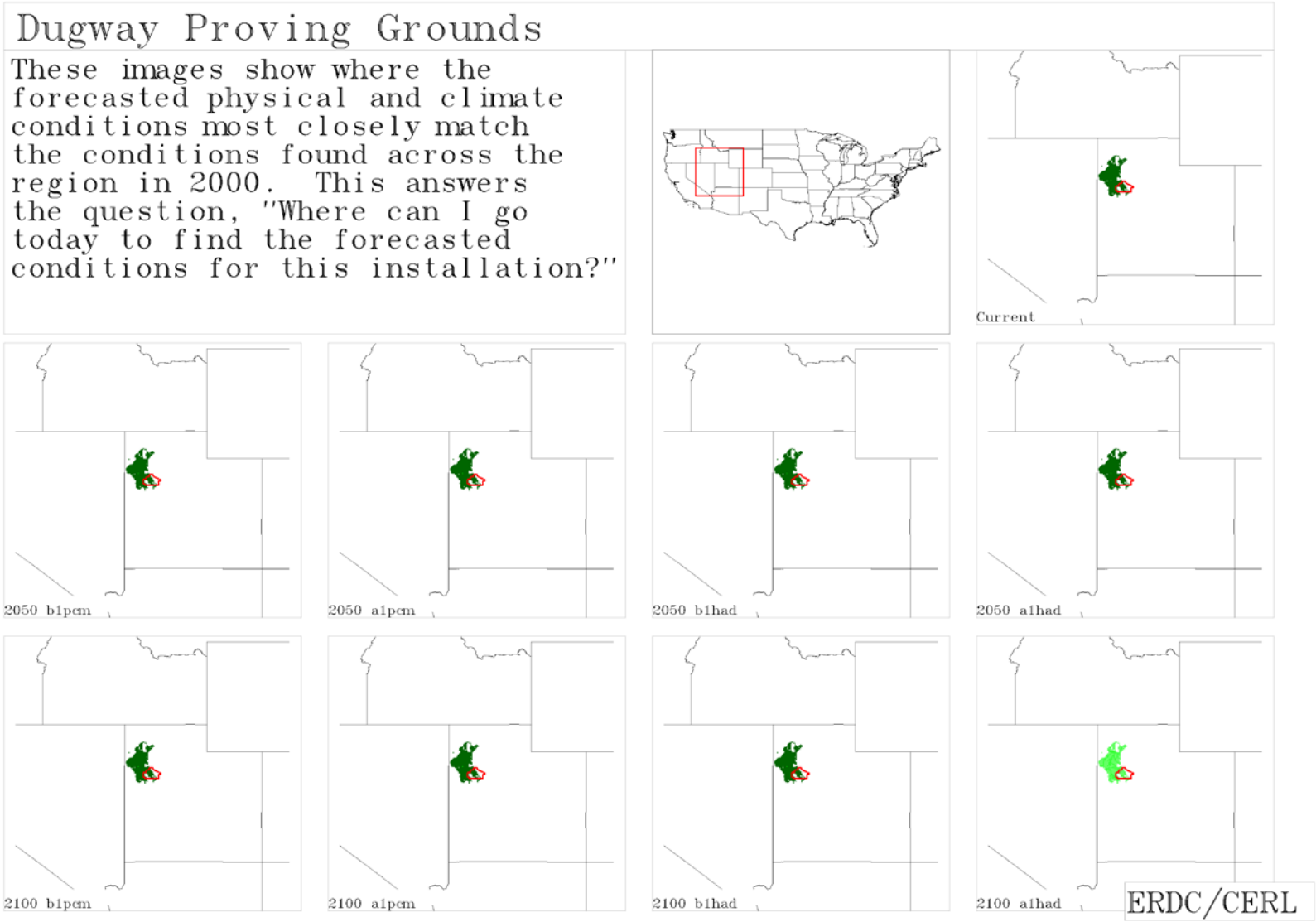
For each page, the location of an area around the installation is shown against the United States. The remaining maps "zoom into" this area. The map at the top-right shows the current ecosystem types. The middle row shows the images of the same area for 2050 and 2080. The columns represent the PCM model, B1 scenario; the PCM model, A1 scenario; the Hadley model, B1 scenario; and the Hadley A1, scenario. The top-left box for the GAP and TNC images provides an ecosystem/land-cover legend for the most commonly occurring categories across all of the maps on the page.

## Dugway Proving Grounds

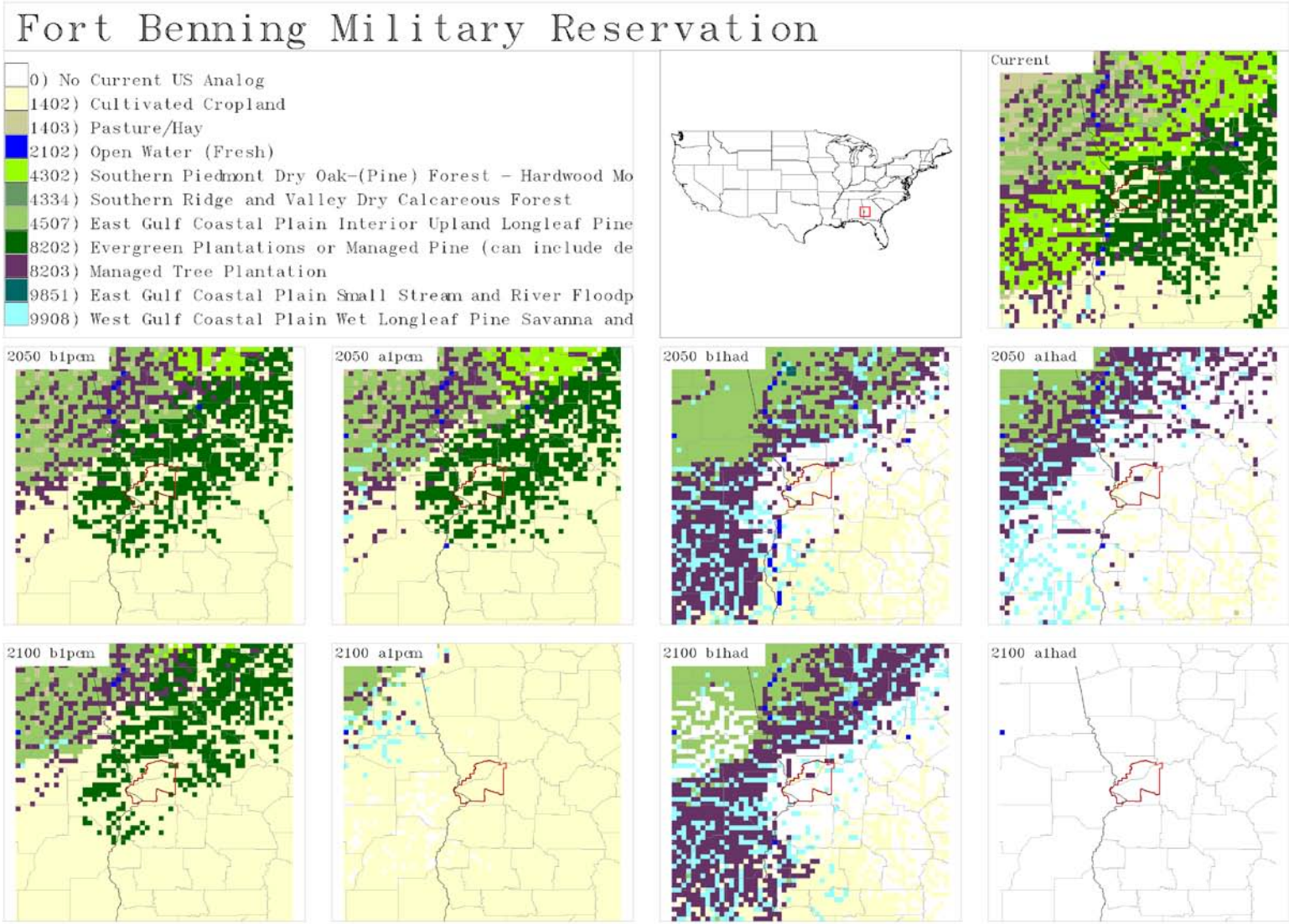


# Dugway Proving Grounds

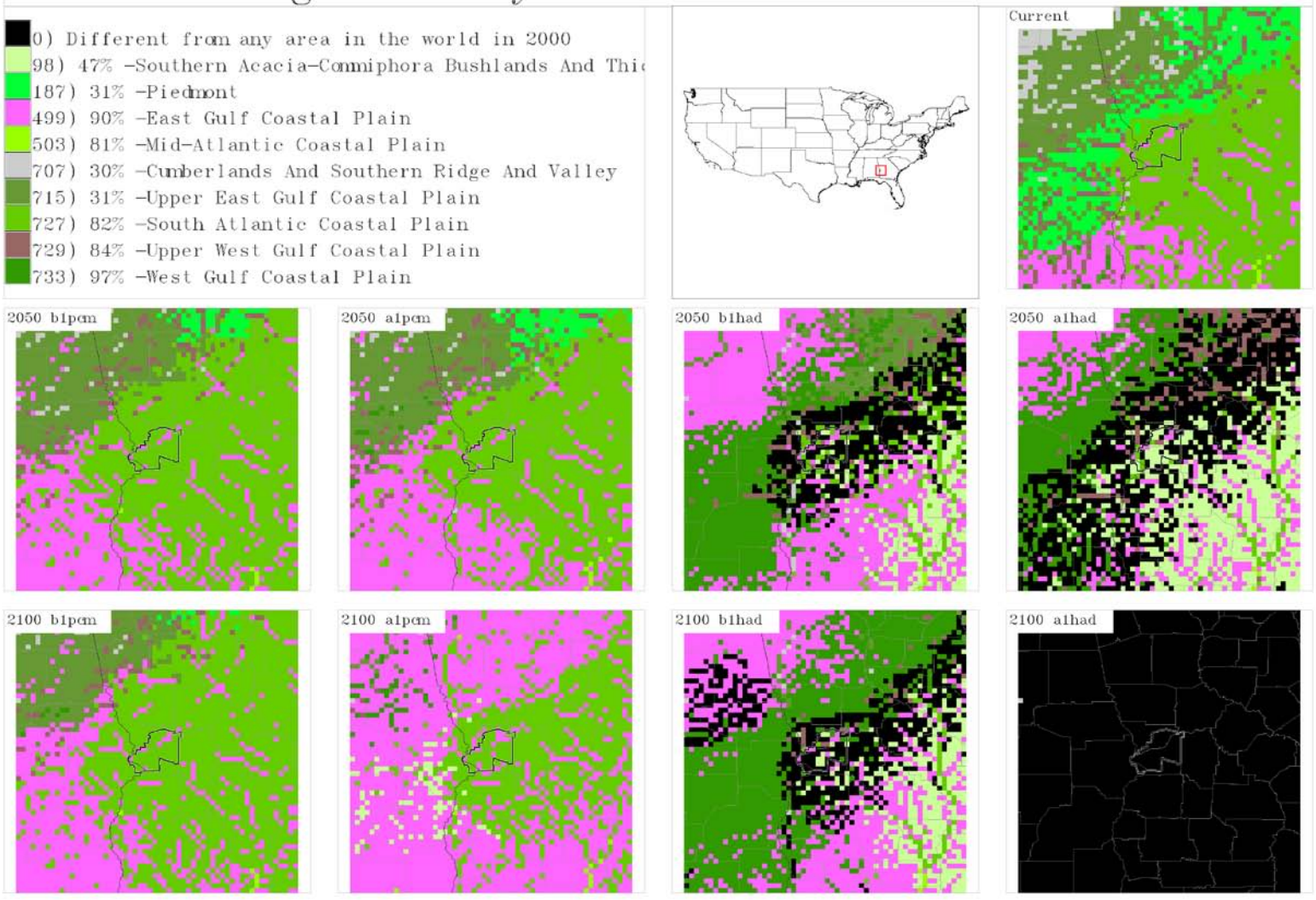


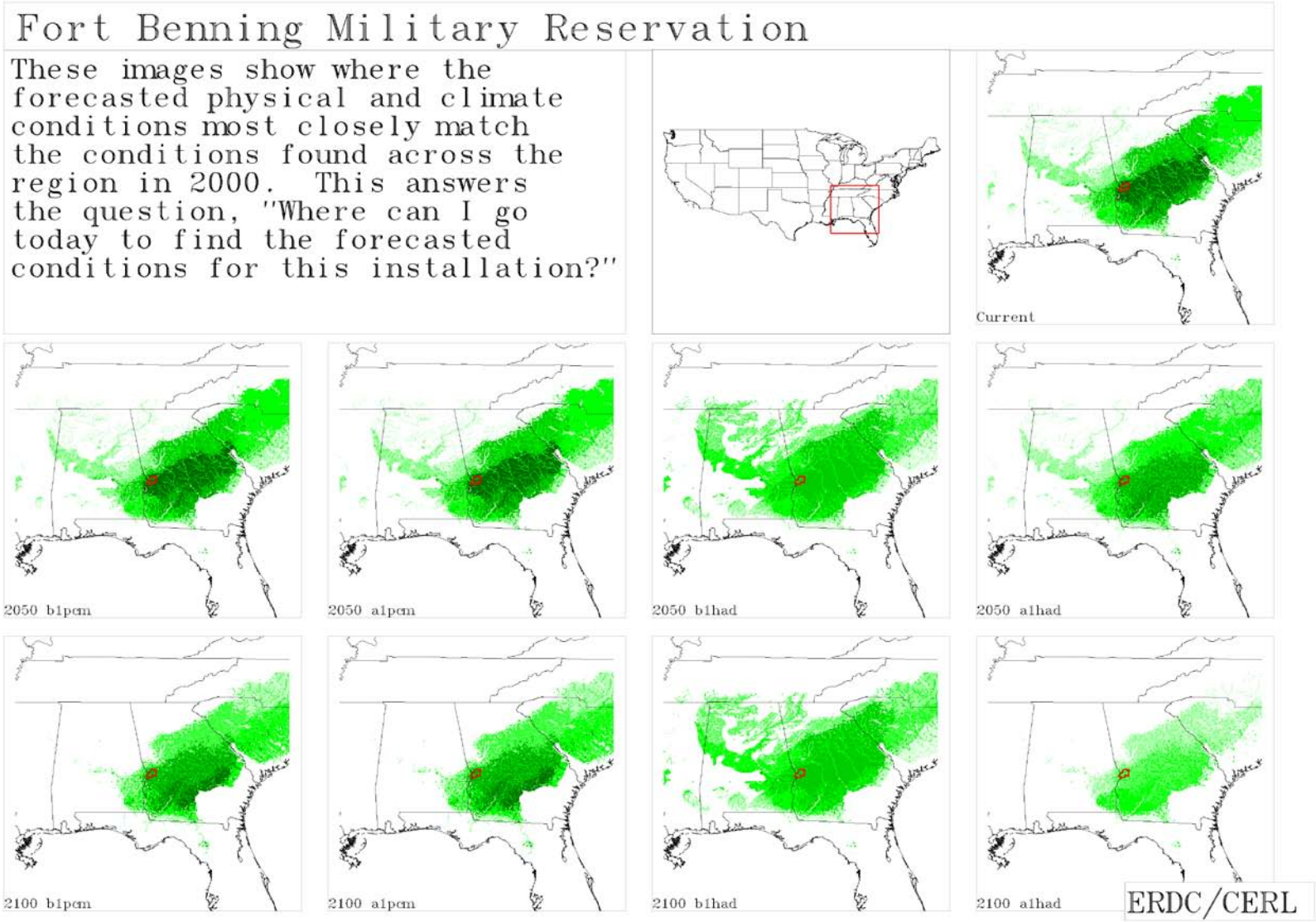



## Fort Benning


Fort Benning Military Reservation
0) No Current US Analog
1402) Cultivated Cropland
1403) Pasture/Hay
2102) Open Water (Fresh)
4302) Southern Piedmont Dry Oak-(Pine) Forest - Hardwood Mo
4334) Southern Ridge and Valley Dry Calcareous Forest
4507) East Gulf Coastal Plain Interior Upland Longleaf Pine
8202) Evergreen Plantations or Managed Pine (can include de
8203) Managed Tree Plantation
9851) East Gulf Coastal Plain Small Stream and River Floodp
9908) West Gulf Coastal Plain Wet Longleaf Pine Savanna and
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

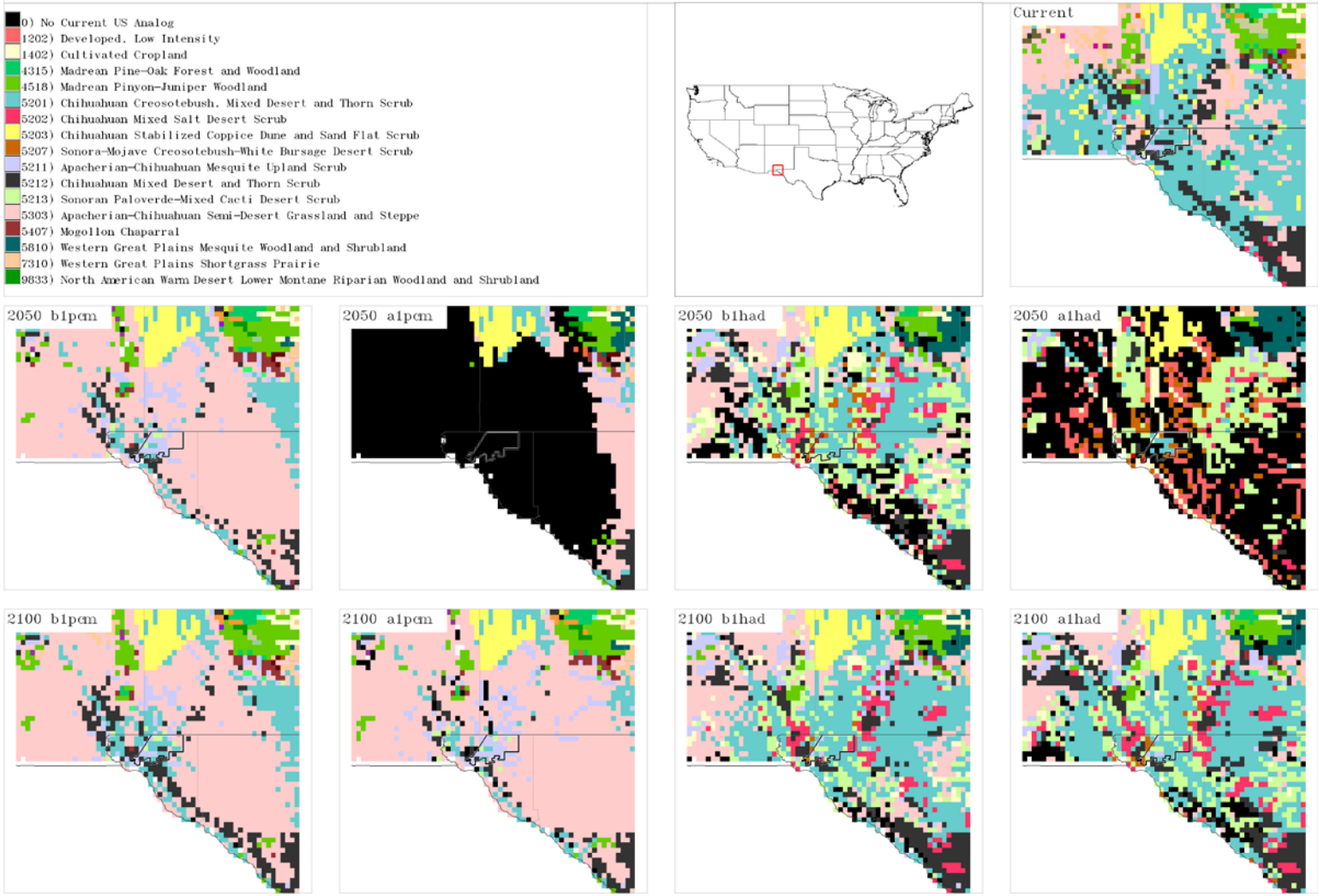
# Fort Benning Military Reservation




Fort Benning Military Reservation
These images show where the forecasted physical and climate conditions most closely match the conditions found across the region in 2000. This answers the question, "Where can I go today to find the forecasted conditions for this installation?"
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had
ERDC/CERL

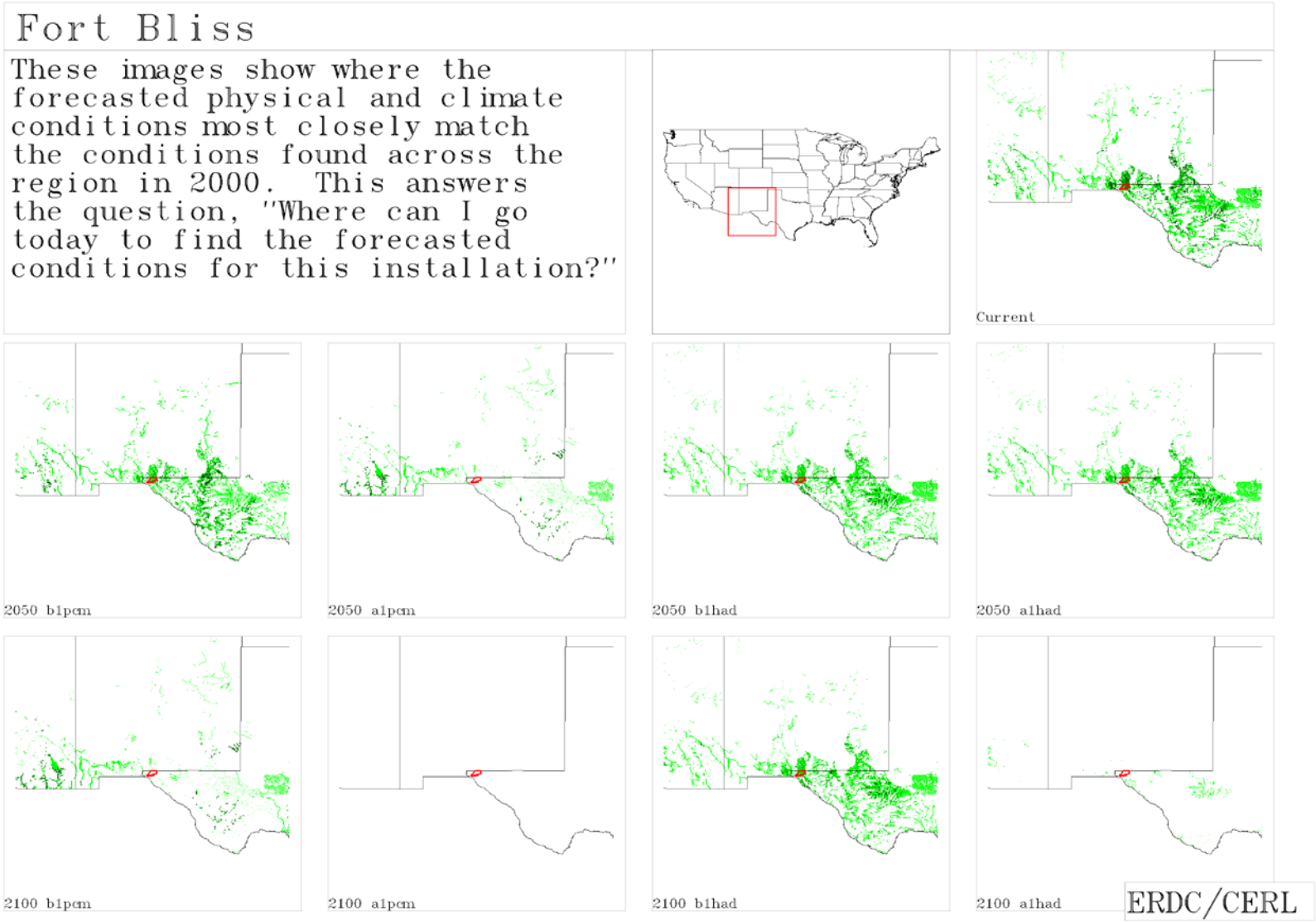
## Fort Bliss

# Fort Bliss

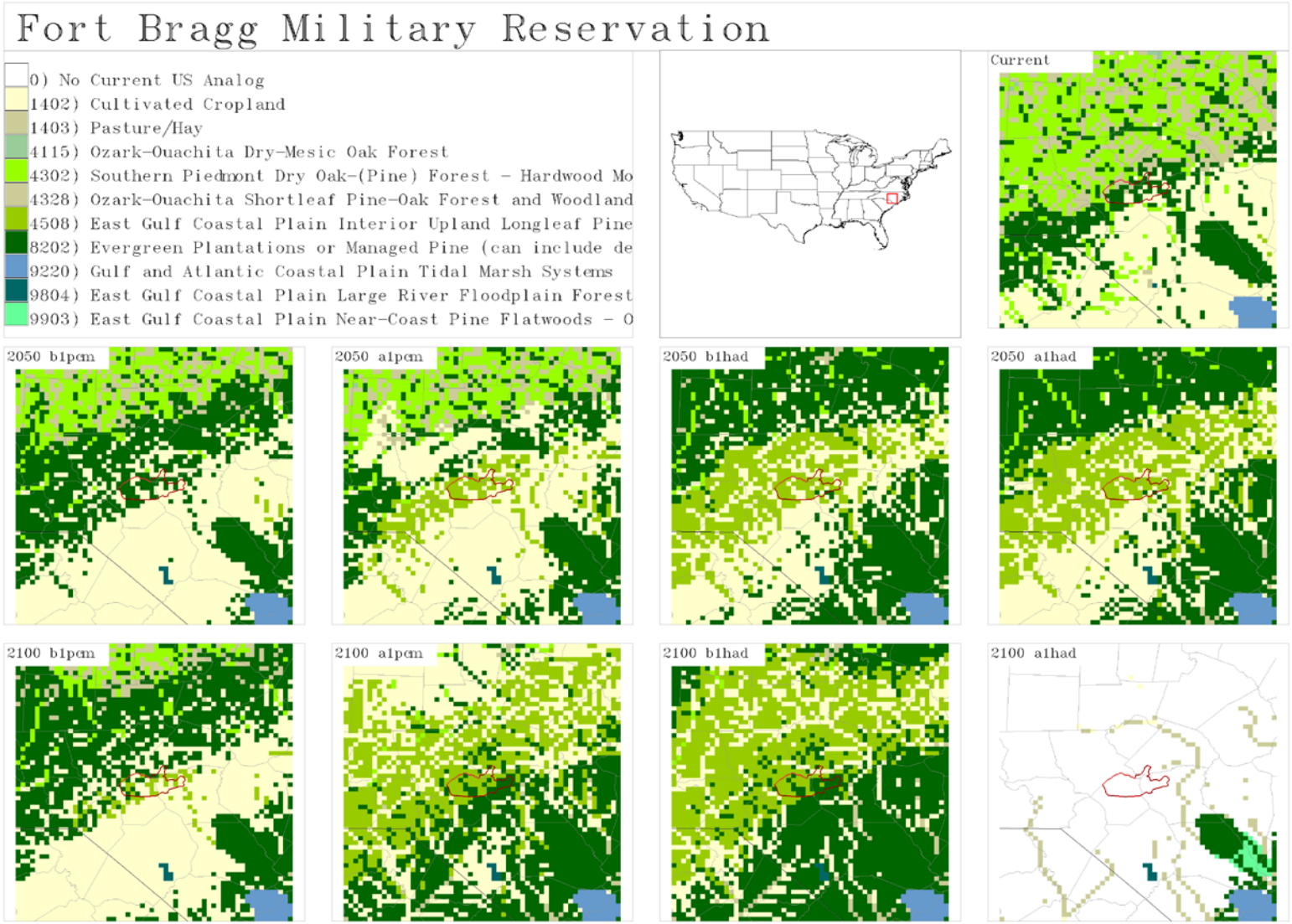

0) No Current US Analog
1202) Developed, Low Intensity
1402) Cultivated Cropland
4315) Madrean Pine-Oak Forest and Woodland
4518) Madrean Pinyon-Juniper Woodland
5201) Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub
5202) Chihuahuan Mixed Salt Desert Scrub
5203) Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub
5207) Sonora-Mojave Creosotebush-White Bursage Desert Scrub
5211) Apacherian-Chihuahuan Mesquite Upland Scrub
5212) Chihuahuan Mixed Desert and Thorn Scrub
5213) Sonoran Paloverde-Mixed Cacti Desert Scrub
5303) Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5407) Mogollon Chaparral
5810) Western Great Plains Mesquite Woodland and Shrubland
7310) Western Great Plains Shortgrass Prairie
9833) North American Warm Desert Lower Montane Riparian Woodland and Shrubland
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

# Fort Bliss

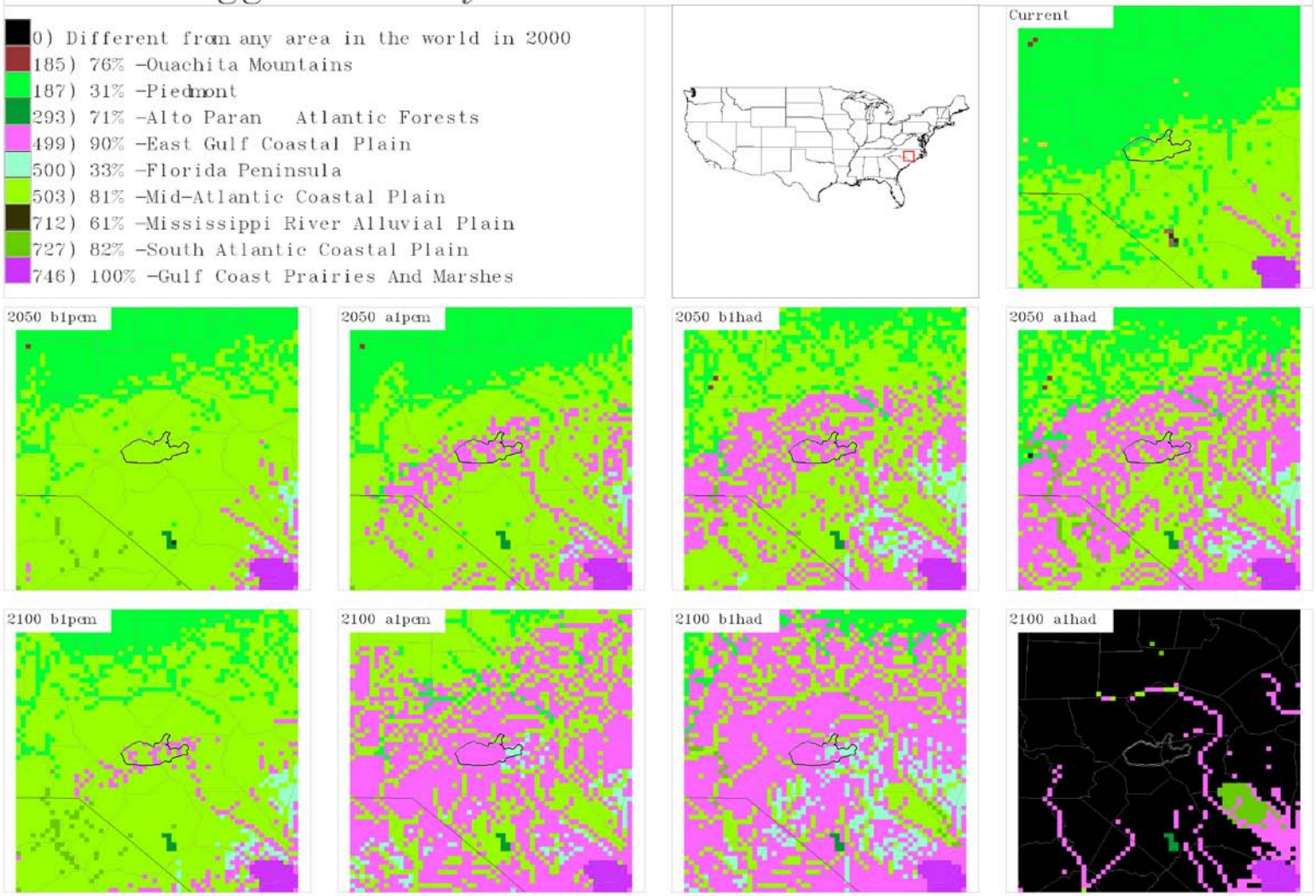

0) Different from any area in the world in 2000
93) 43% -Northern Acacia-Commiphora Bushlands And Thickets
145) 96% -Kalahari Xeric Savanna
269) 54% -Southern Shortgrass Prairie
419) 28% -Trans-Mexican Volcanic Belt Pine-Oak Forests
432) 56% -Espinal
434) 37% -Low Monte
448) 37% -High Monte
538) 49% -Central China Loess Plateau Mixed Forests
673) 85% -Baluchistan Xeric Woodlands
693) 64% -Registan-North Pakistan Sandy Desert
703) 55% -Sonoran-Sinaloan Transition Subtropical Dry Forest
704) 49% -Sierra Madre Occidental Pine-Oak Forests
718) 41% -Arizona-New Mexico Mountains
763) 71% -Apache Highlands
765) 30% -Chihuahuan Desert
770) 45% -Sonoran Desert
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

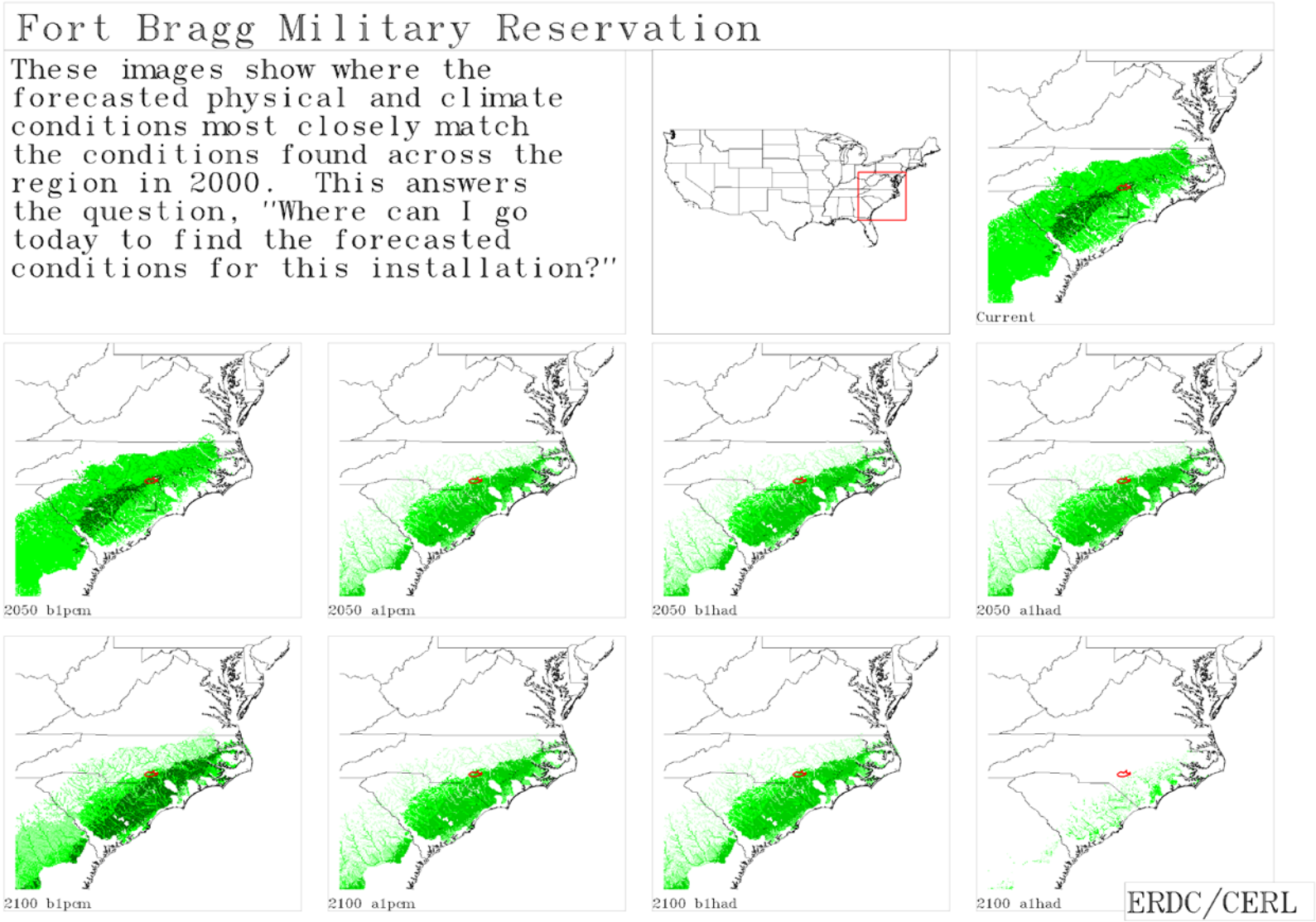



**Fort Bragg Military Reservation**


Fort Bragg Military Reservation
0) No Current US Analog
1402) Cultivated Cropland
1403) Pasture/Hay
4115) Ozark-Ouachita Dry-Mesic Oak Forest
4302) Southern Piedmont Dry Oak-(Pine) Forest - Hardwood Mo
4328) Ozark-Ouachita Shortleaf Pine-Oak Forest and Woodland
4508) East Gulf Coastal Plain Interior Upland Longleaf Pine
8202) Evergreen Plantations or Managed Pine (can include de
9220) Gulf and Atlantic Coastal Plain Tidal Marsh Systems
9804) East Gulf Coastal Plain Large River Floodplain Forest
9903) East Gulf Coastal Plain Near-Coast Pine Flatwoods - O
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

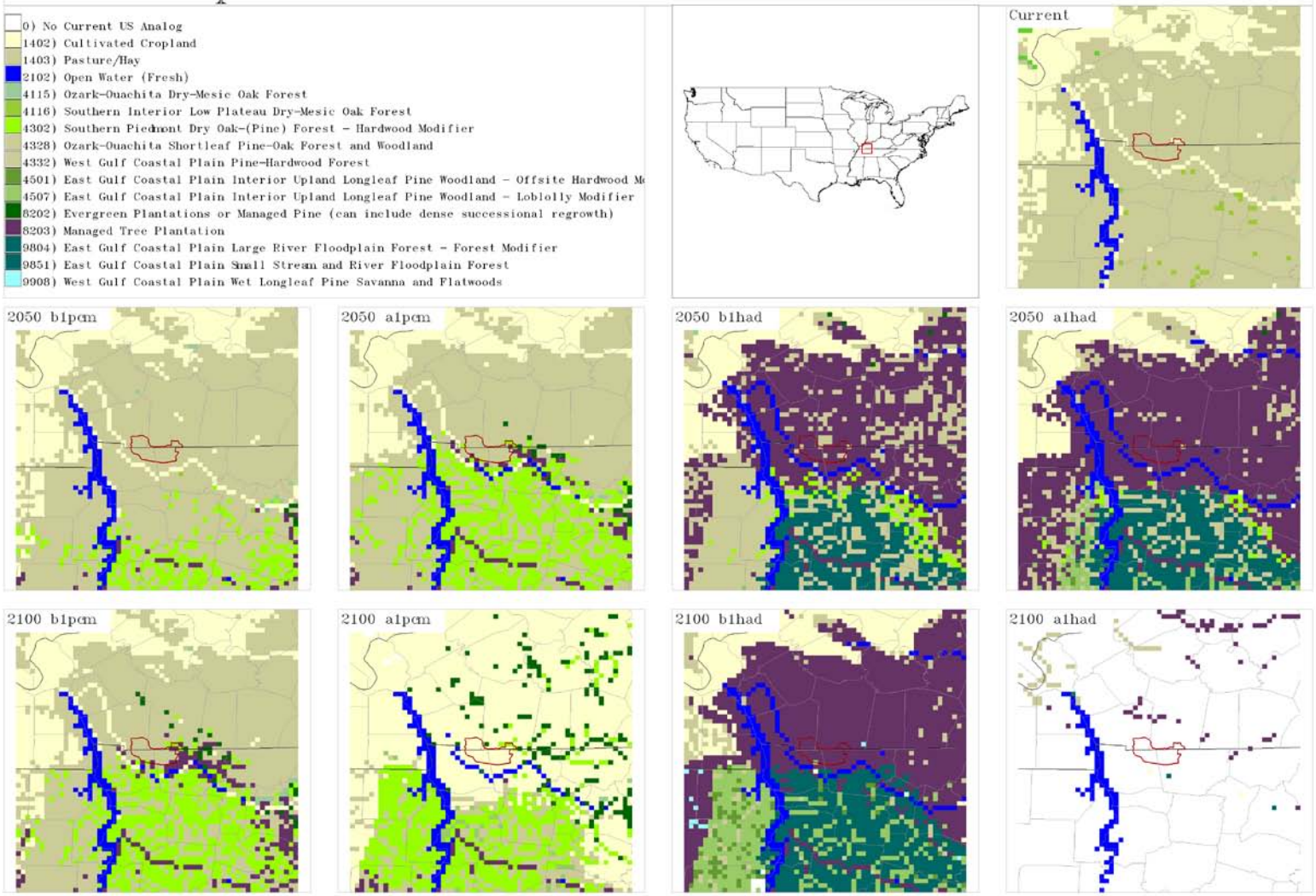
# Fort Bragg Military Reservation





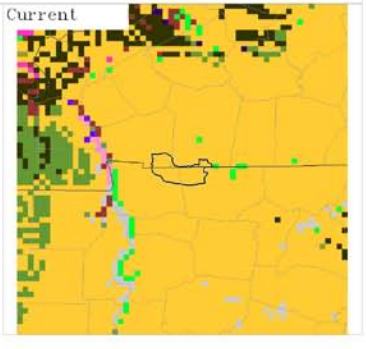

## Fort Campbell

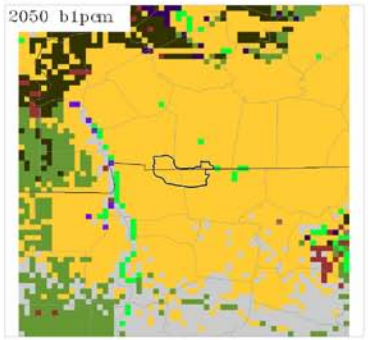
# Fort Campbell

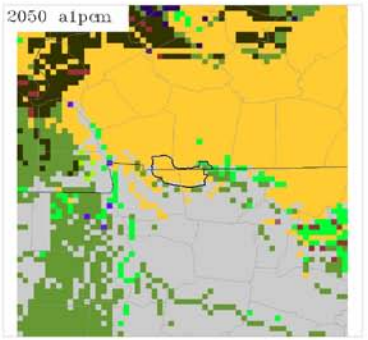


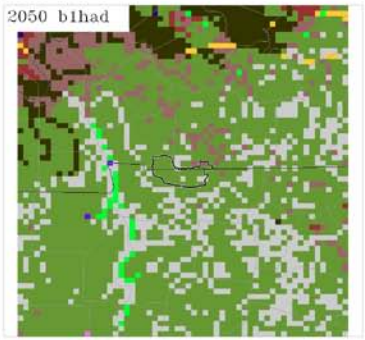
# Fort Campbell

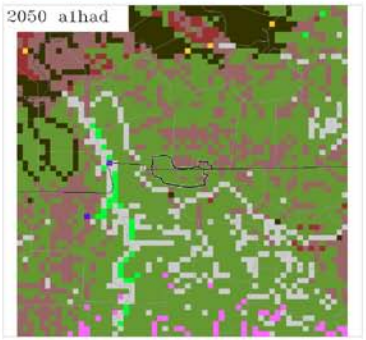
0) Different from any area in the world in 2000
185) 76% -Ouachita Mountains
186) 94% -Ozarks
187) 31% -Piedmont
189) 94% -Southern Blue Ridge
293) 71% -Alto Paran  Atlantic Forests
431) 70% -Uruguayan Savanna
499) 90% -East Gulf Coastal Plain
503) 81% -Mid-Atlantic Coastal Plain
706) 56% -Chesapeake Bay Lowlands
707) 30% -Cumberlands And Southern Ridge And Valley
710) 38% -Interior Low Plateau
712) 61% -Mississippi River Alluvial Plain
715) 31% -Upper East Gulf Coastal Plain
729) 84% -Upper West Gulf Coastal Plain
733) 97% -West Gulf Coastal Plain
751) 72% -Crosstimbers And Southern Tallgrass Prairie

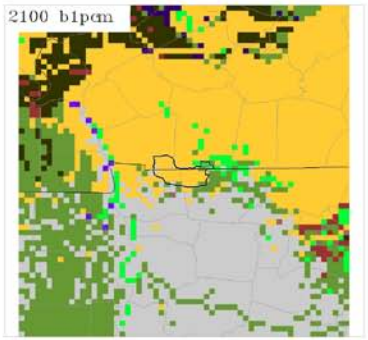


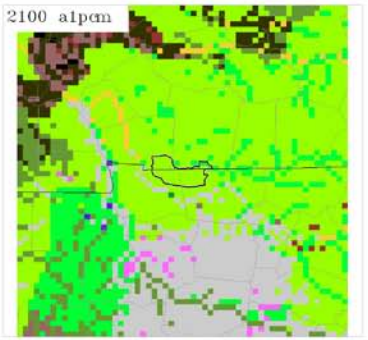



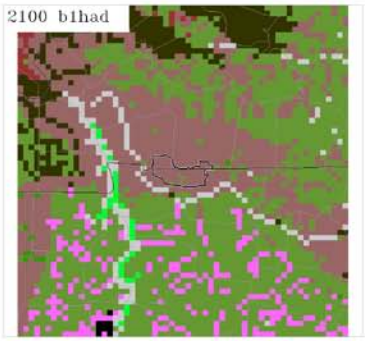



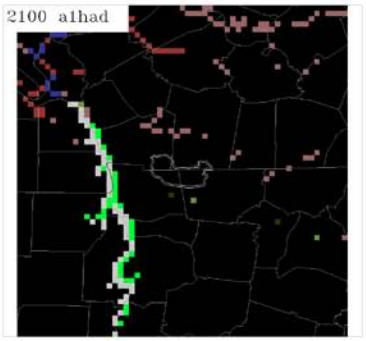



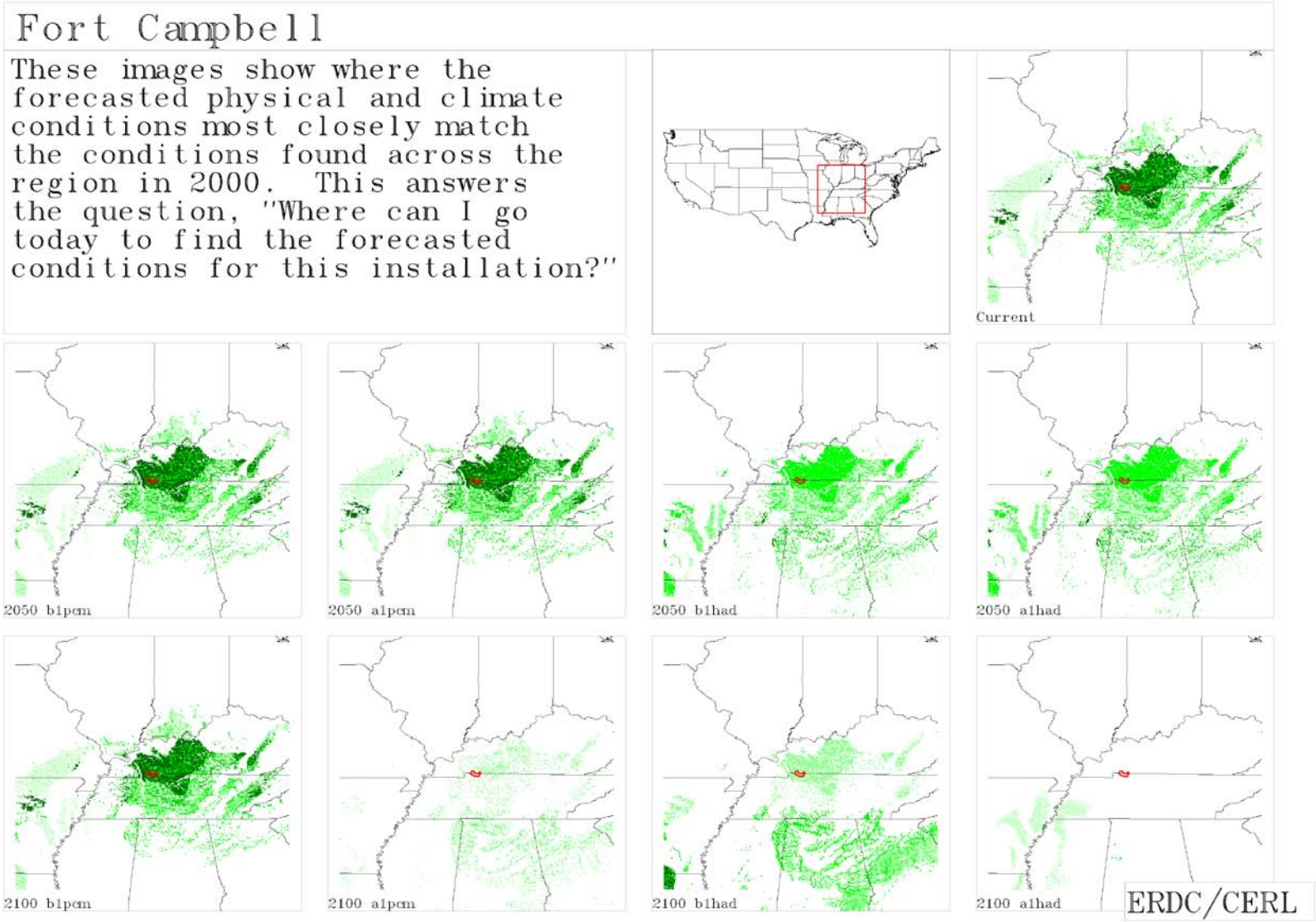



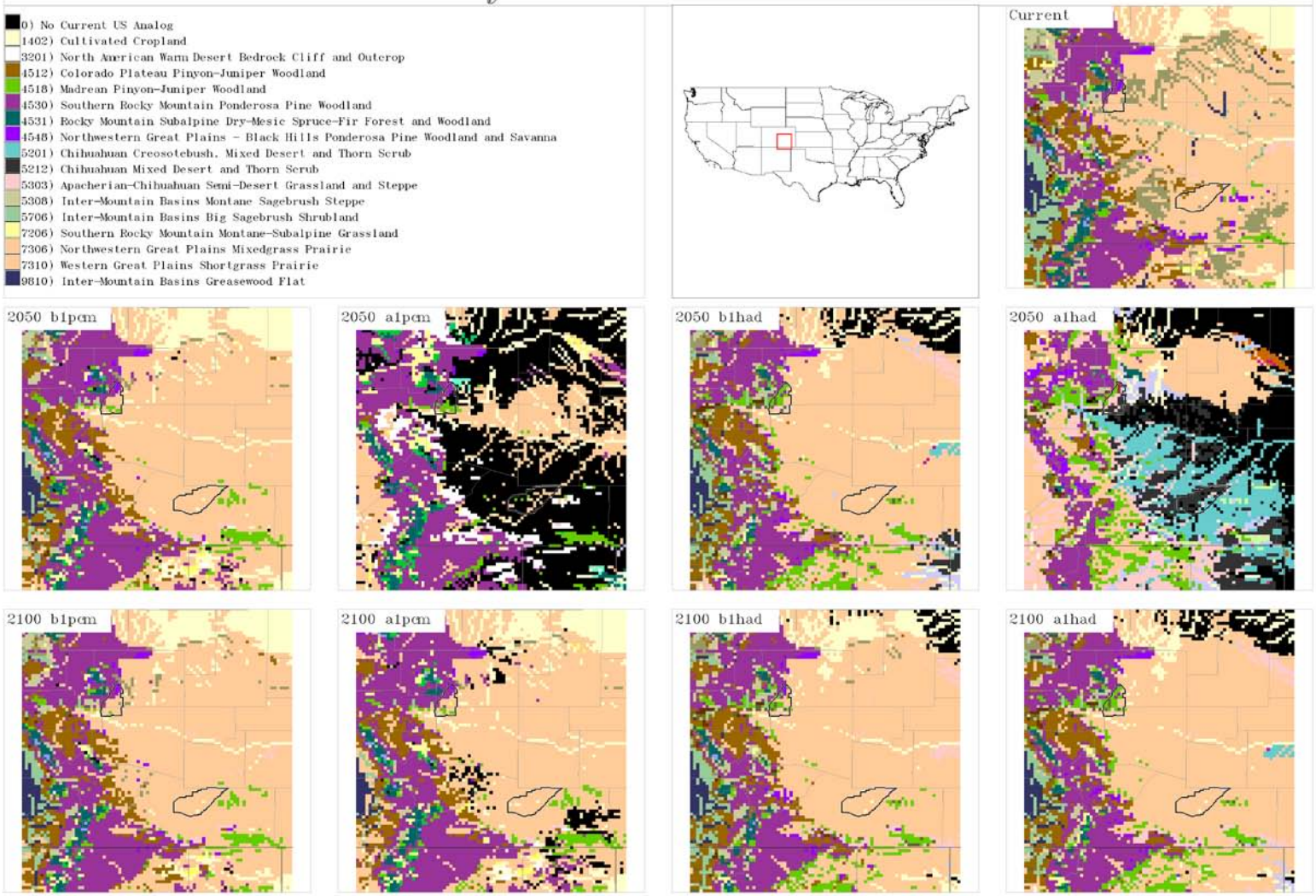



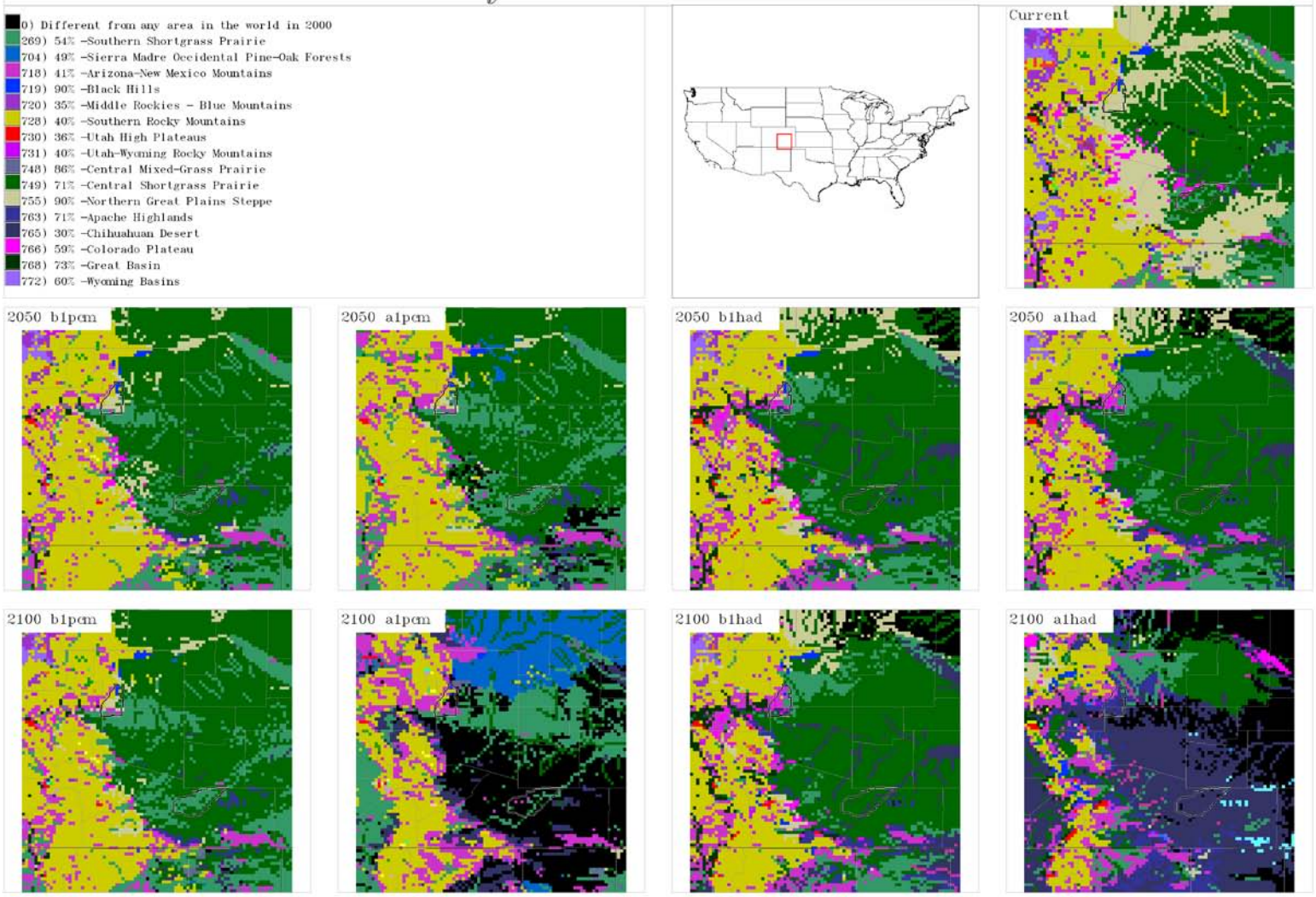


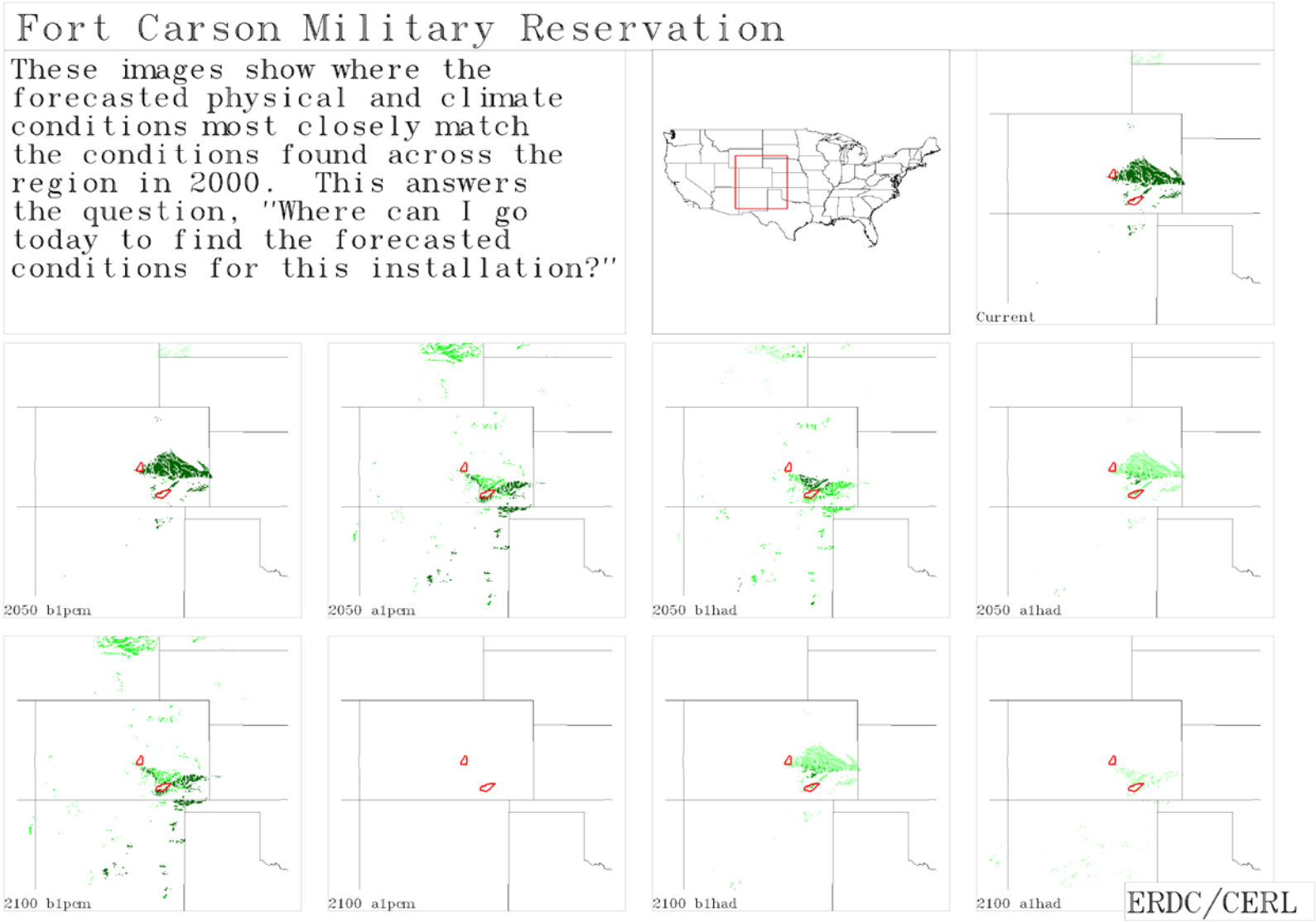

## Fort Carson Military Reservation

# Fort Carson Military Reservation



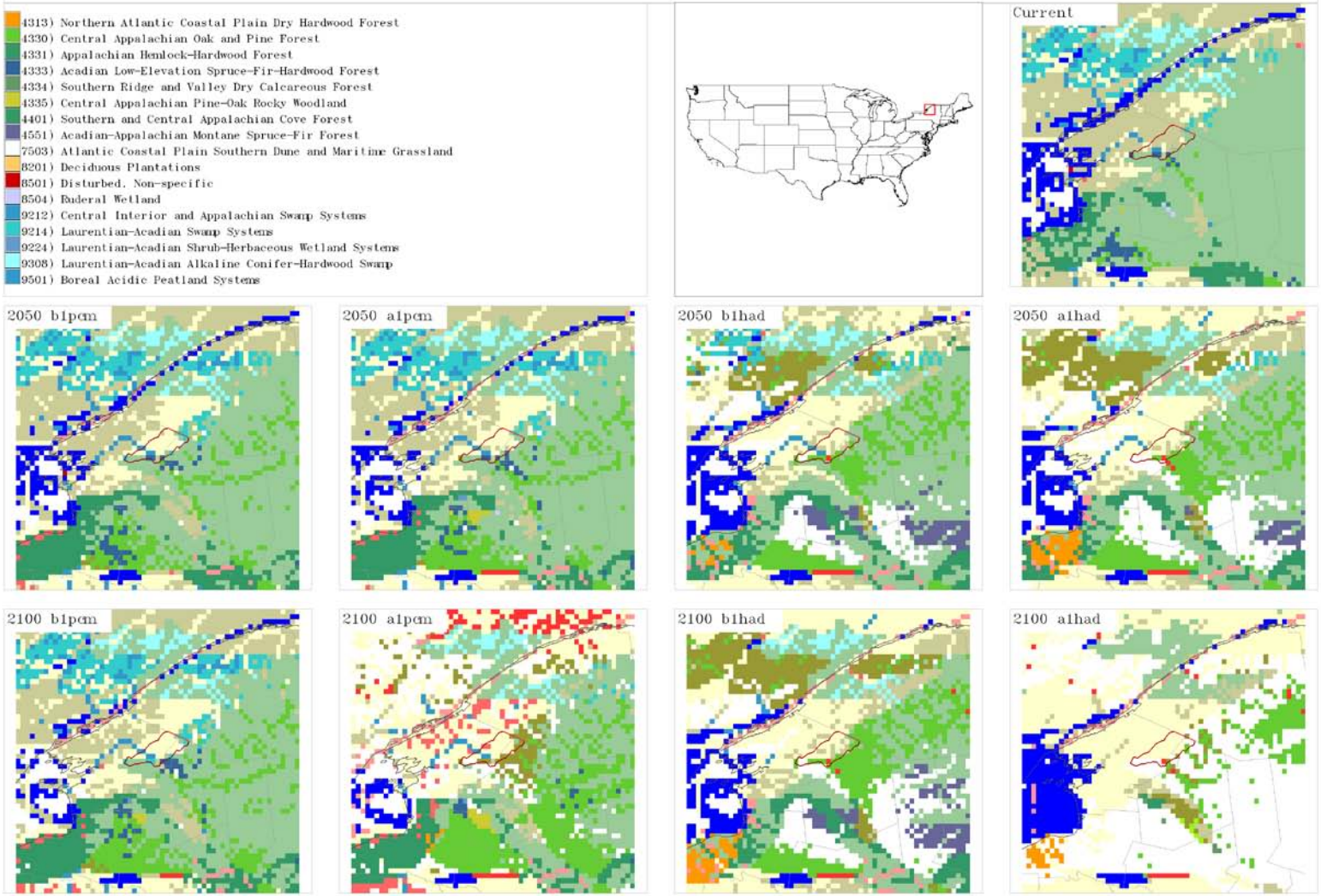
# Fort Carson Military Reservation




Fort Carson Military Reservation
These images show where the forecasted physical and climate conditions most closely match the conditions found across the region in 2000. This answers the question, "Where can I go today to find the forecasted conditions for this installation?"
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had
ERDC/CERL

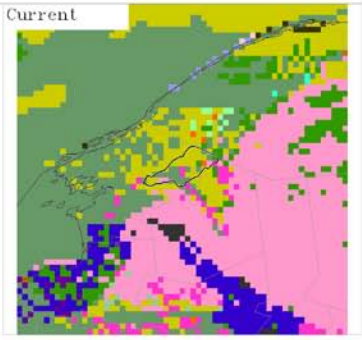
## Fort Drum

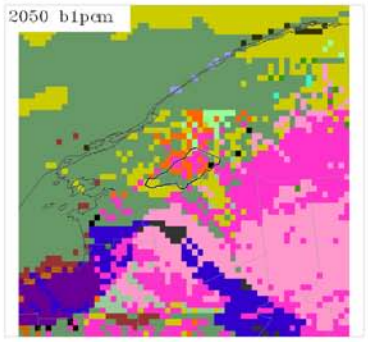
# Fort Drum

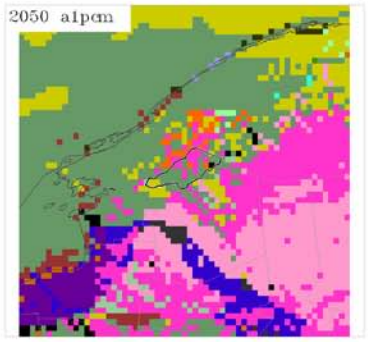

4313) Northern Atlantic Coastal Plain Dry Hardwood Forest
4330) Central Appalachian Oak and Pine Forest
4331) Appalachian Hemlock-Hardwood Forest
4333) Acadian Low-Elevation Spruce-Fir-Hardwood Forest
4334) Southern Ridge and Valley Dry Calcareous Forest
4335) Central Appalachian Pine-Oak Rocky Woodland
4401) Southern and Central Appalachian Cove Forest
4551) Acadian-Appalachian Montane Spruce-Fir Forest
7503) Atlantic Coastal Plain Southern Dune and Maritime Grassland
8201) Deciduous Plantations
8501) Disturbed, Non-specific
8504) Ruderal Wetland
9212) Central Interior and Appalachian Swamp Systems
9214) Laurentian-Acadian Swamp Systems
9224) Laurentian-Acadian Shrub-Herbaceous Wetland Systems
9308) Laurentian-Acadian Alkaline Conifer-Hardwood Swamp
9501) Boreal Acidic Peatland Systems
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

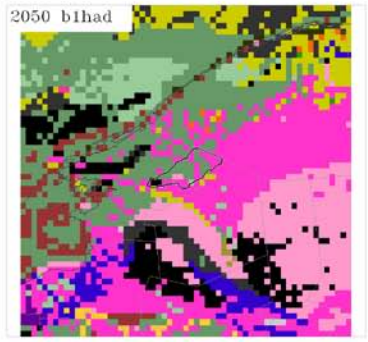
# Fort Drum

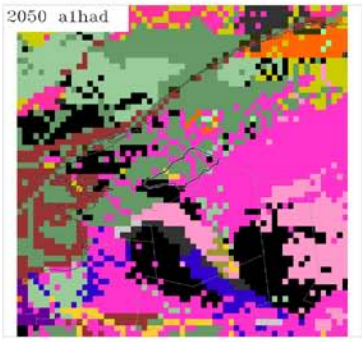

0) Different from any area in the world in 2000
182) 47% -North Atlantic Coast
184) 53% -Northern Appalachian / Acadian
558) 100% -Pannonian Mixed Forests
559) 67% -Po Basin Mixed Forests
571) 39% -Western European Broadleaf Forests
705) 56% -Central Appalachian Forest
706) 56% -Chesapeake Bay Lowlands
708) 78% -Great Lakes
709) 58% -High Allegheny Plateau
710) 38% -Interior Low Plateau
711) 73% -Lower New England / Northern Piedmont
712) 61% -Mississippi River Alluvial Plain
713) 100% -St. Lawrence - Champlain Valley
715) 31% -Upper East Gulf Coastal Plain
716) 44% -Western Allegheny Plateau
729) 84% -Upper West Gulf Coastal Plain

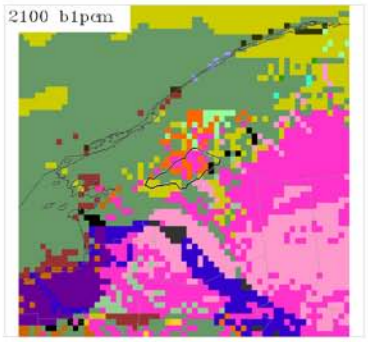

Current

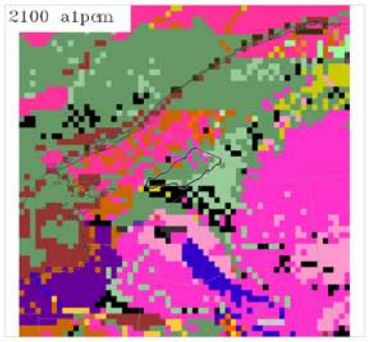

2050 b1pcm

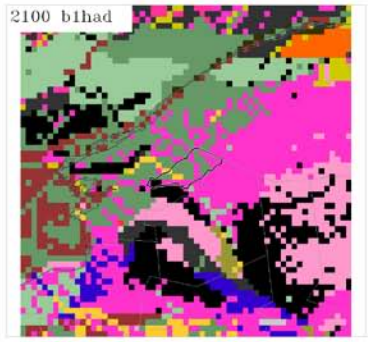

2050 a1pcm

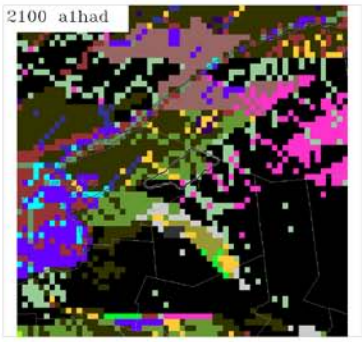

2050 b1had

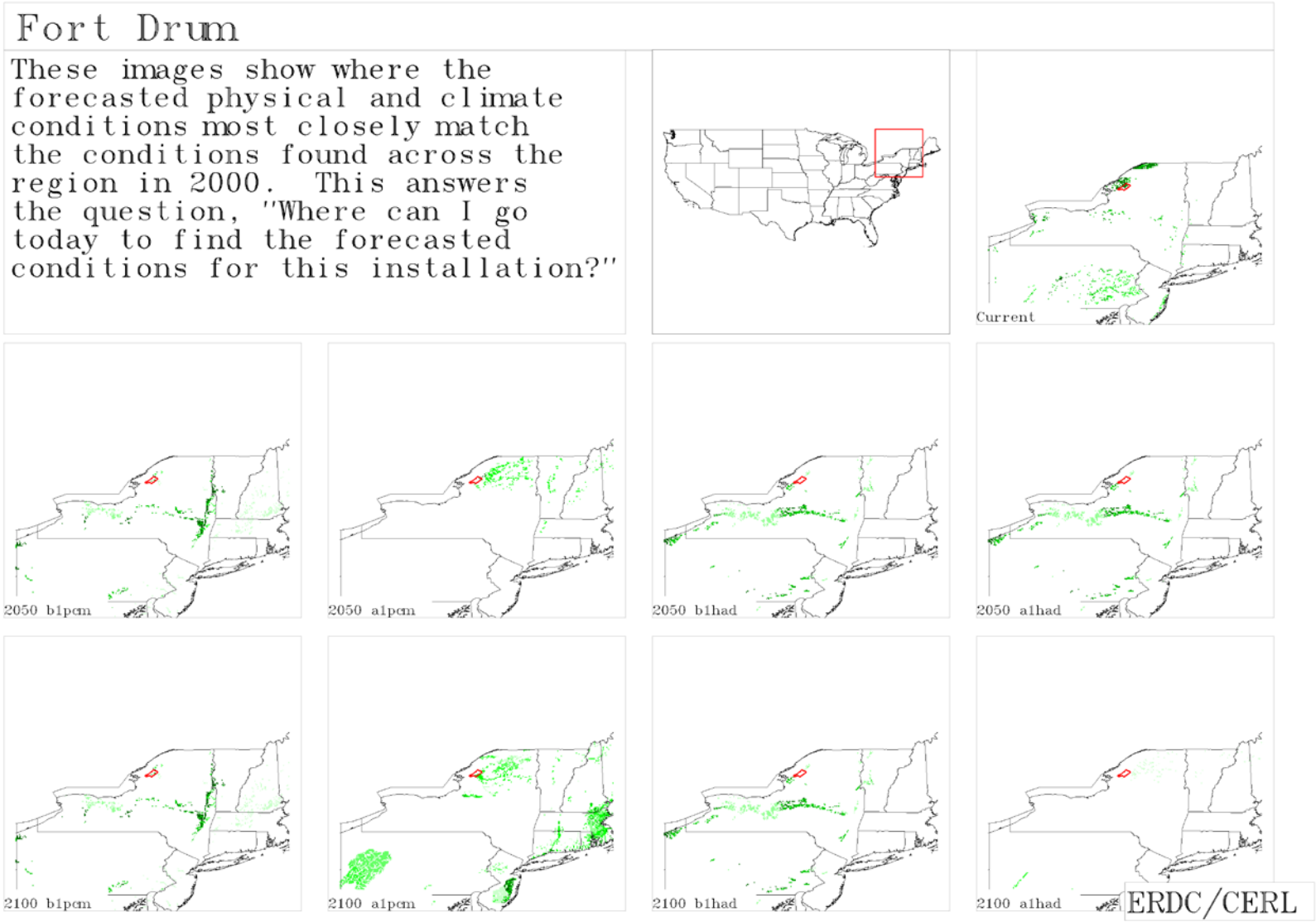

2050 a1had


2100 b1pcm


2100 a1pcm

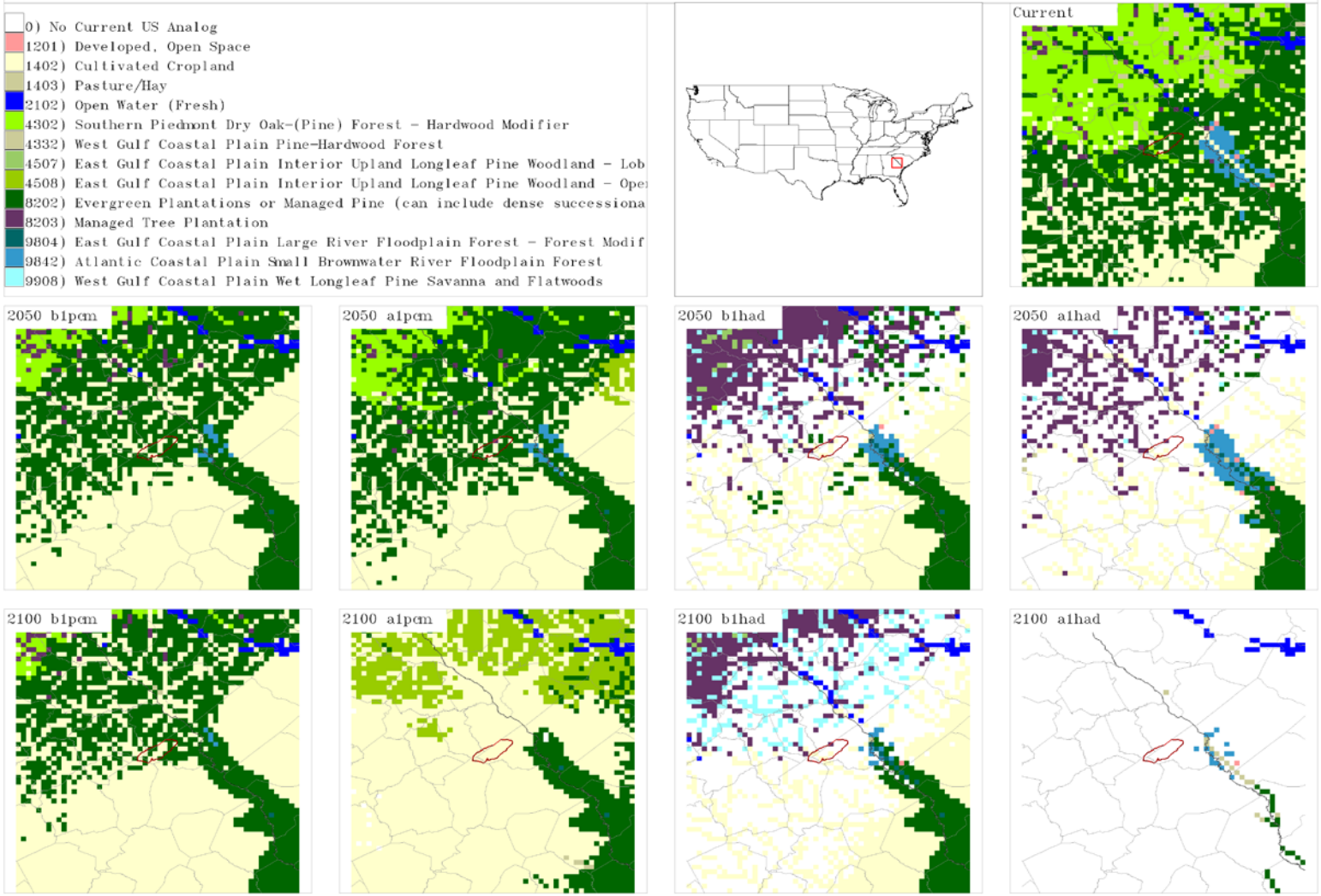

2100 b1had


2100 a1had

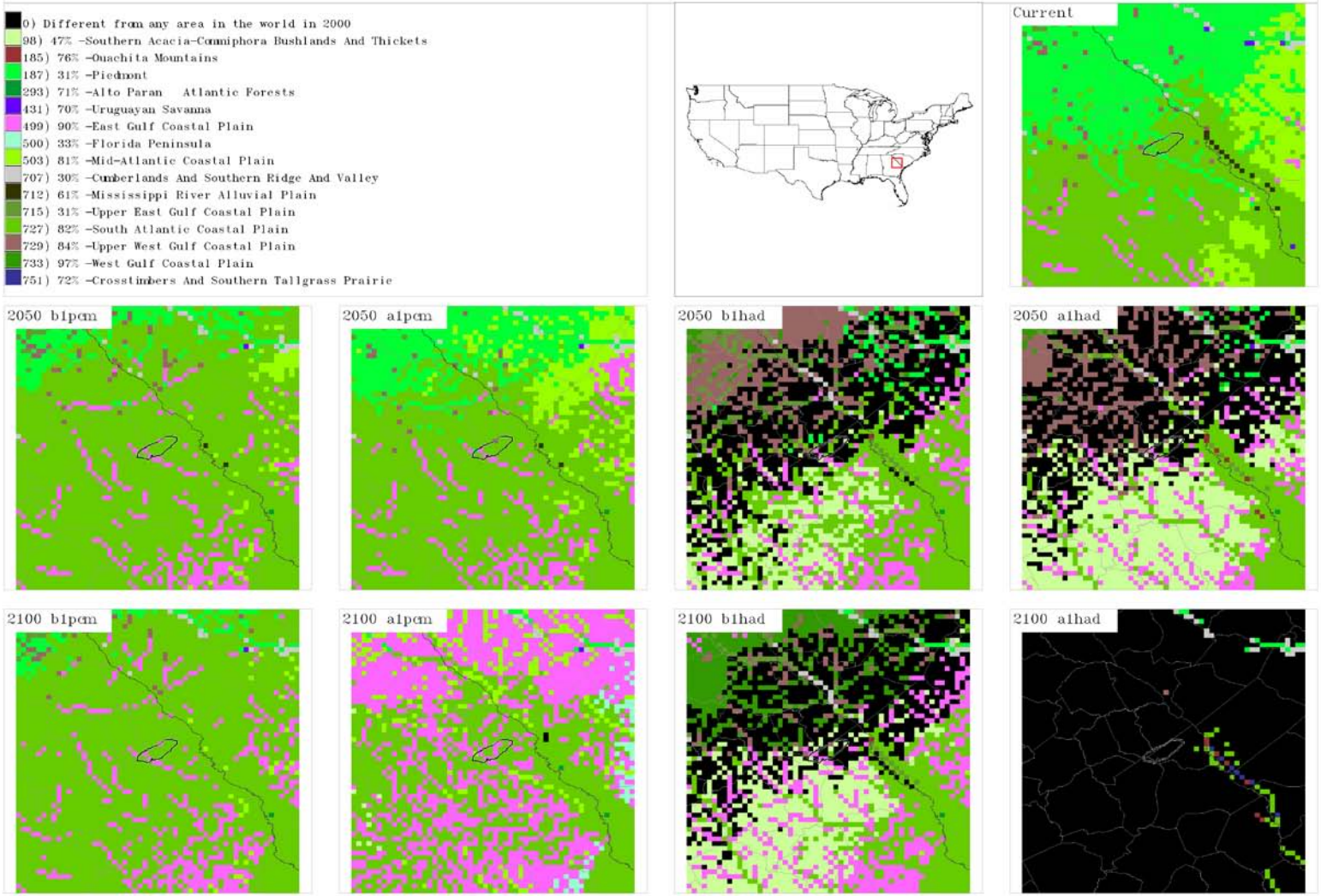

Fort Drum
These images show where the forecasted physical and climate conditions most closely match the conditions found across the region in 2000. This answers the question, "Where can I go today to find the forecasted conditions for this installation?"
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had
ERDC/CERL

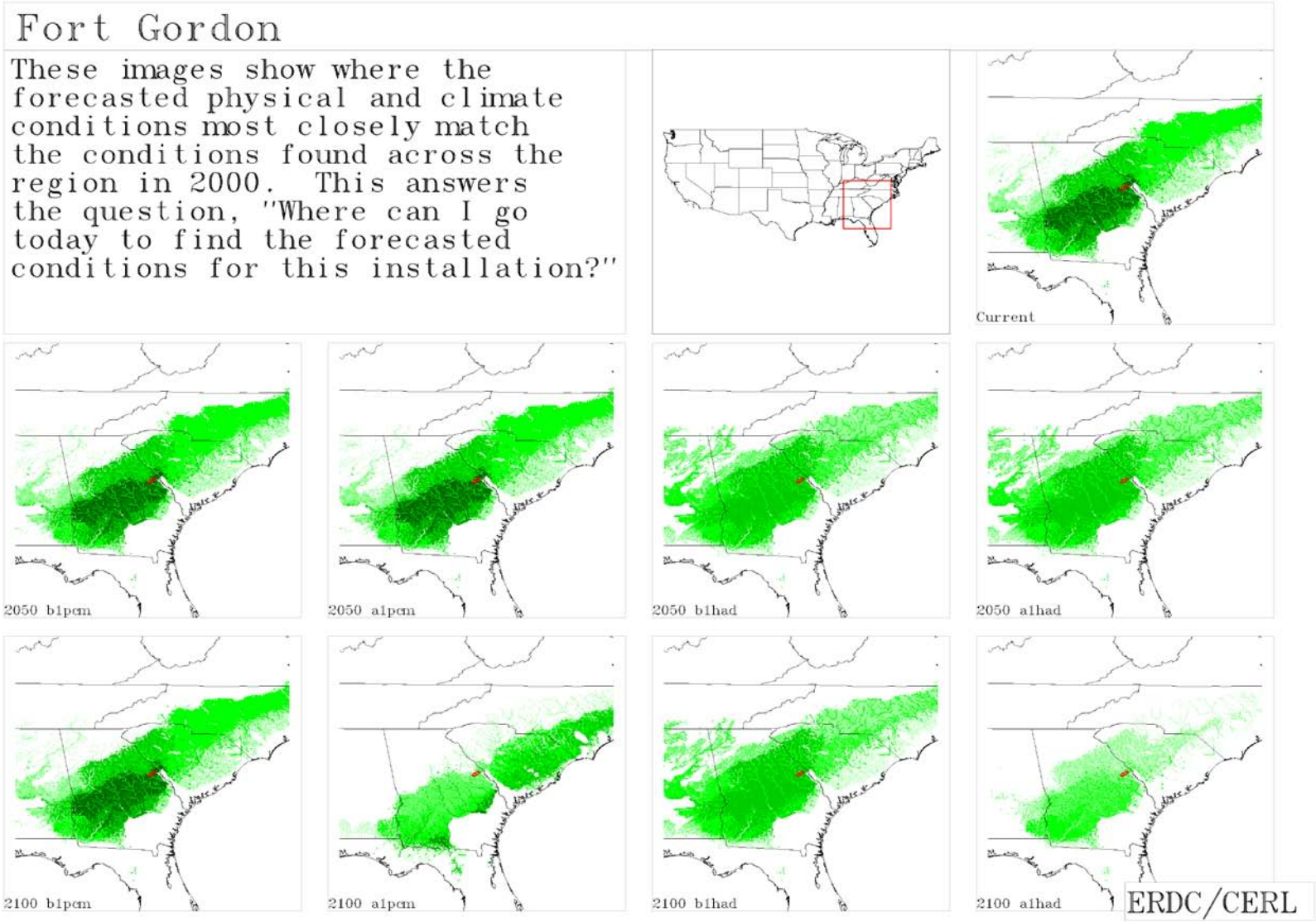
## Fort Gordon

# Fort Gordon


0) No Current US Analog
1201) Developed, Open Space
1402) Cultivated Cropland
1403) Pasture/Hay
2102) Open Water (Fresh)
4302) Southern Piedmont Dry Oak-(Pine) Forest - Hardwood Modifier
4332) West Gulf Coastal Plain Pine-Hardwood Forest
4507) East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland - Lob
4508) East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland - Ope
8202) Evergreen Plantations or Managed Pine (can include dense successiona
8203) Managed Tree Plantation
9804) East Gulf Coastal Plain Large River Floodplain Forest - Forest Modif
9842) Atlantic Coastal Plain Small Brownwater River Floodplain Forest
9908) West Gulf Coastal Plain Wet Longleaf Pine Savanna and Flatwoods
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

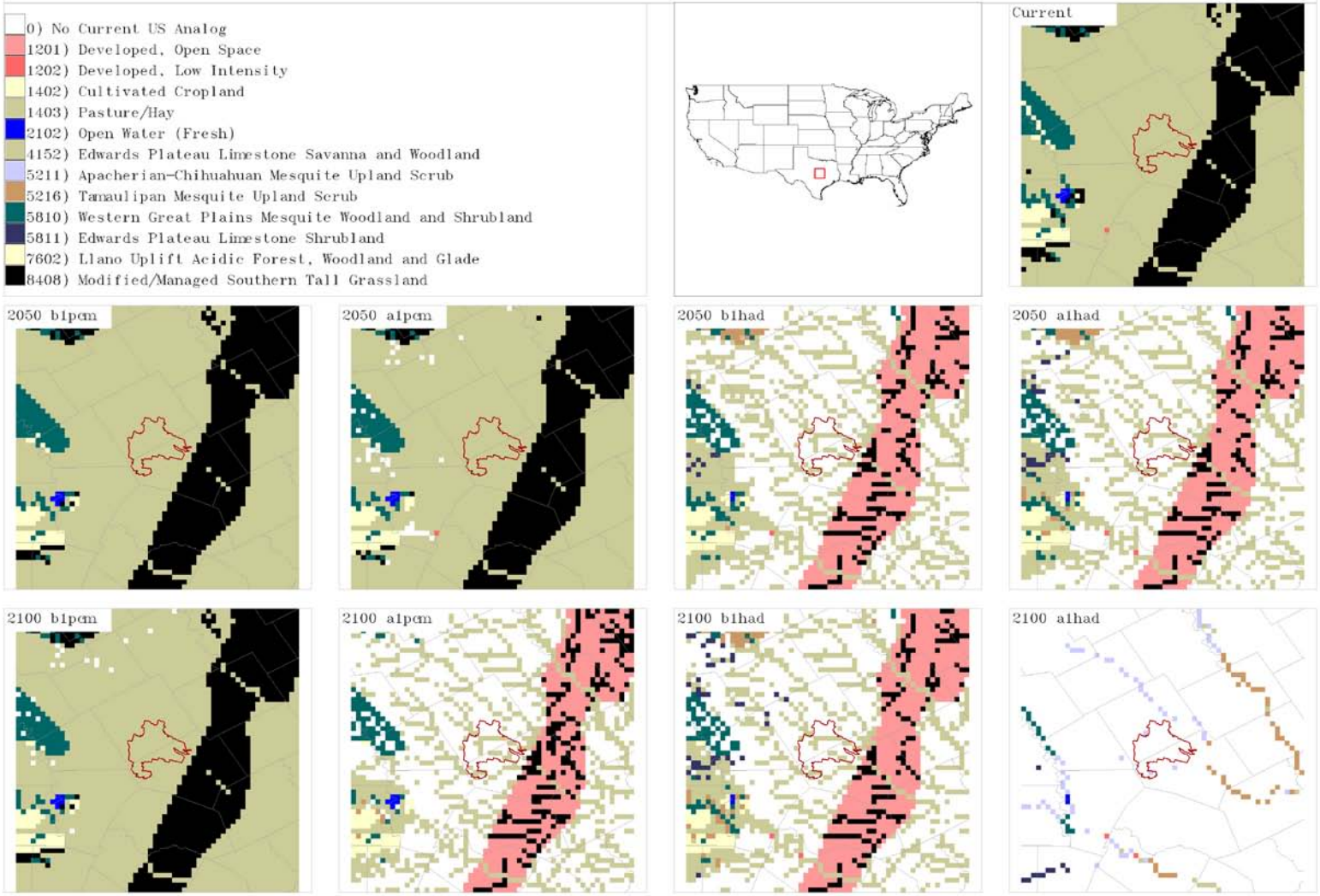
# Fort Gordon


0) Different from any area in the world in 2000
98) 47% -Southern Acacia-Commiphora Bushlands And Thickets
185) 76% -Ouachita Mountains
187) 31% -Piedmont
293) 71% -Alto Paran  Atlantic Forests
431) 70% -Uruguayan Savanna
499) 90% -East Gulf Coastal Plain
500) 33% -Florida Peninsula
503) 81% -Mid-Atlantic Coastal Plain
707) 30% -Cumberlands And Southern Ridge And Valley
712) 61% -Mississippi River Alluvial Plain
715) 31% -Upper East Gulf Coastal Plain
727) 82% -South Atlantic Coastal Plain
729) 84% -Upper West Gulf Coastal Plain
733) 97% -West Gulf Coastal Plain
751) 72% -Crosstimbers And Southern Tallgrass Prairie
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had


Fort Gordon
These images show where the forecasted physical and climate conditions most closely match the conditions found across the region in 2000. This answers the question, "Where can I go today to find the forecasted conditions for this installation?"
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had
ERDC/CERL

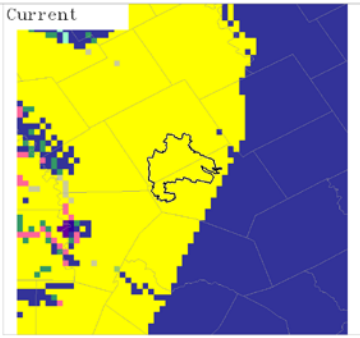
## Fort Hood

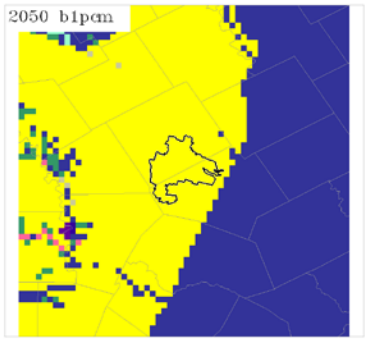
# Fort Hood

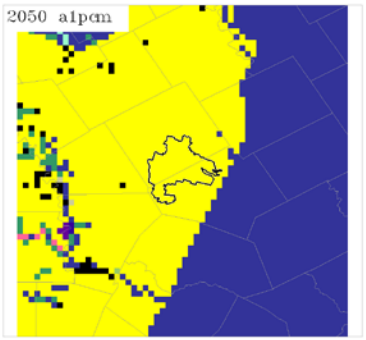

0) No Current US Analog
1201) Developed, Open Space
1202) Developed, Low Intensity
1402) Cultivated Cropland
1403) Pasture/Hay
2102) Open Water (Fresh)
4152) Edwards Plateau Limestone Savanna and Woodland
5211) Apacherian-Chihuahuan Mesquite Upland Scrub
5216) Tamaulipan Mesquite Upland Scrub
5810) Western Great Plains Mesquite Woodland and Shrubland
5811) Edwards Plateau Limestone Shrubland
7602) Llano Uplift Acidic Forest, Woodland and Glade
8408) Modified/Managed Southern Tall Grassland
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

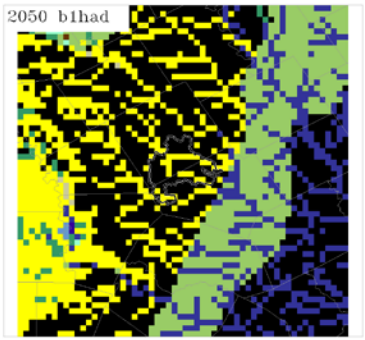
# Fort Hood

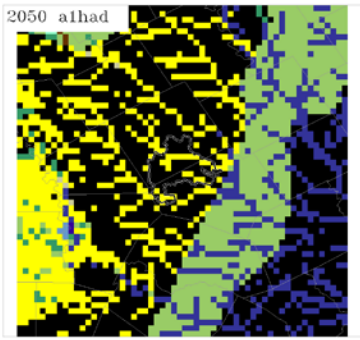

0) Different from any area in the world in 2000
50) 37% -Albertine Rift Montane Forests
97) 100% -Somali Acacia-Commiphora Bushlands And Thickets
155) 51% -Southwestern Arabian Foothills Savanna
269) 54% -Southern Shortgrass Prairie
432) 56% -Espinal
433) 36% -Humid Pampas
751) 72% -Crosstimbers And Southern Tallgrass Prairie
753) 53% -Edwards Plateau
765) 30% -Chihuahuan Desert
771) 53% -Tamaulipan Thorn Scrub
785) 62% -Brigalow Tropical Savanna
790) 76% -Mitchell Grass Downs
793) 50% -Southeast Australia Temperate Savanna
795) 77% -Coolgardie Woodlands
808) 100% -Great Sandy-Tanami Desert
814) 34% -# 814 categories

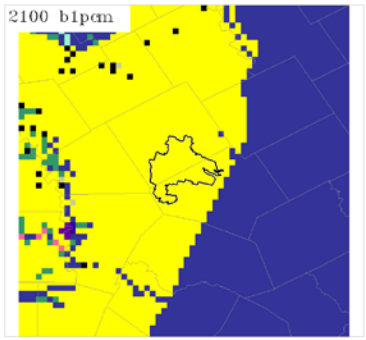

Current

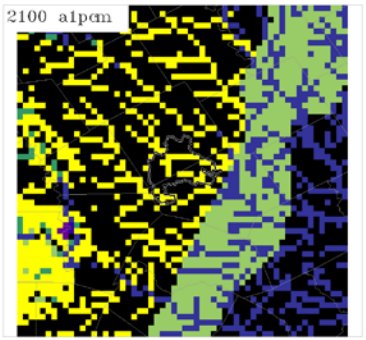

2050 b1pcm

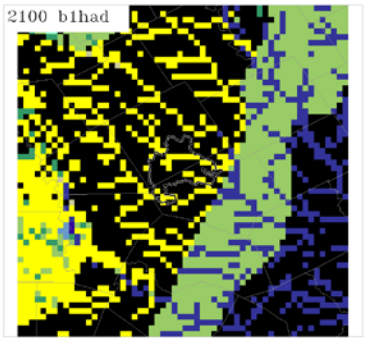

2050 a1pcm

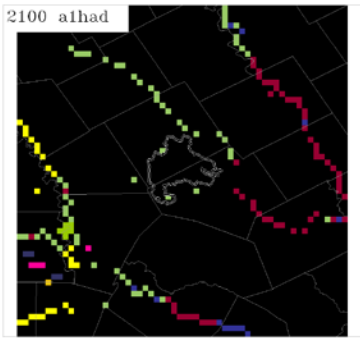

2050 b1had

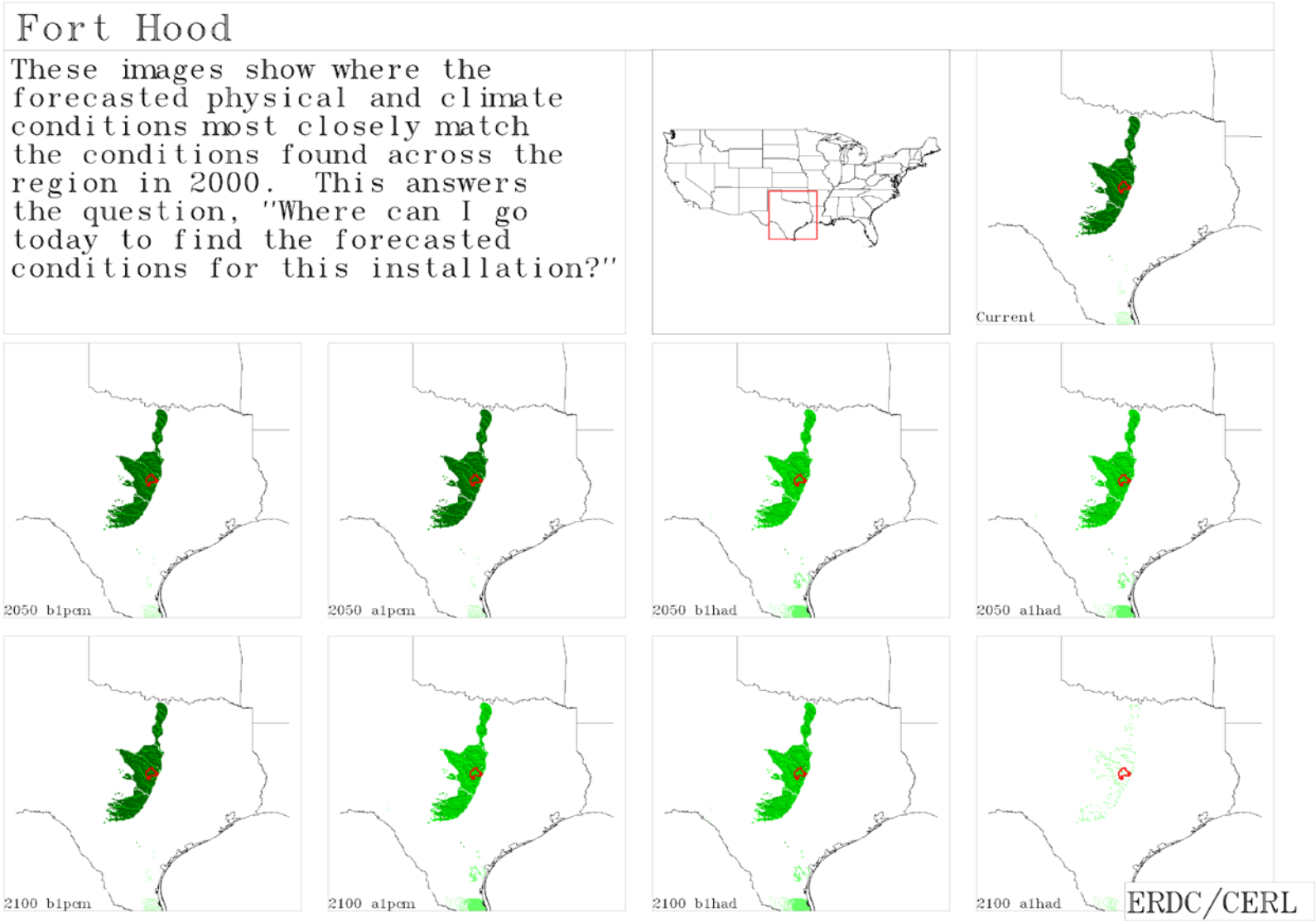

2050 a1had


2100 b1pcm


2100 a1pcm

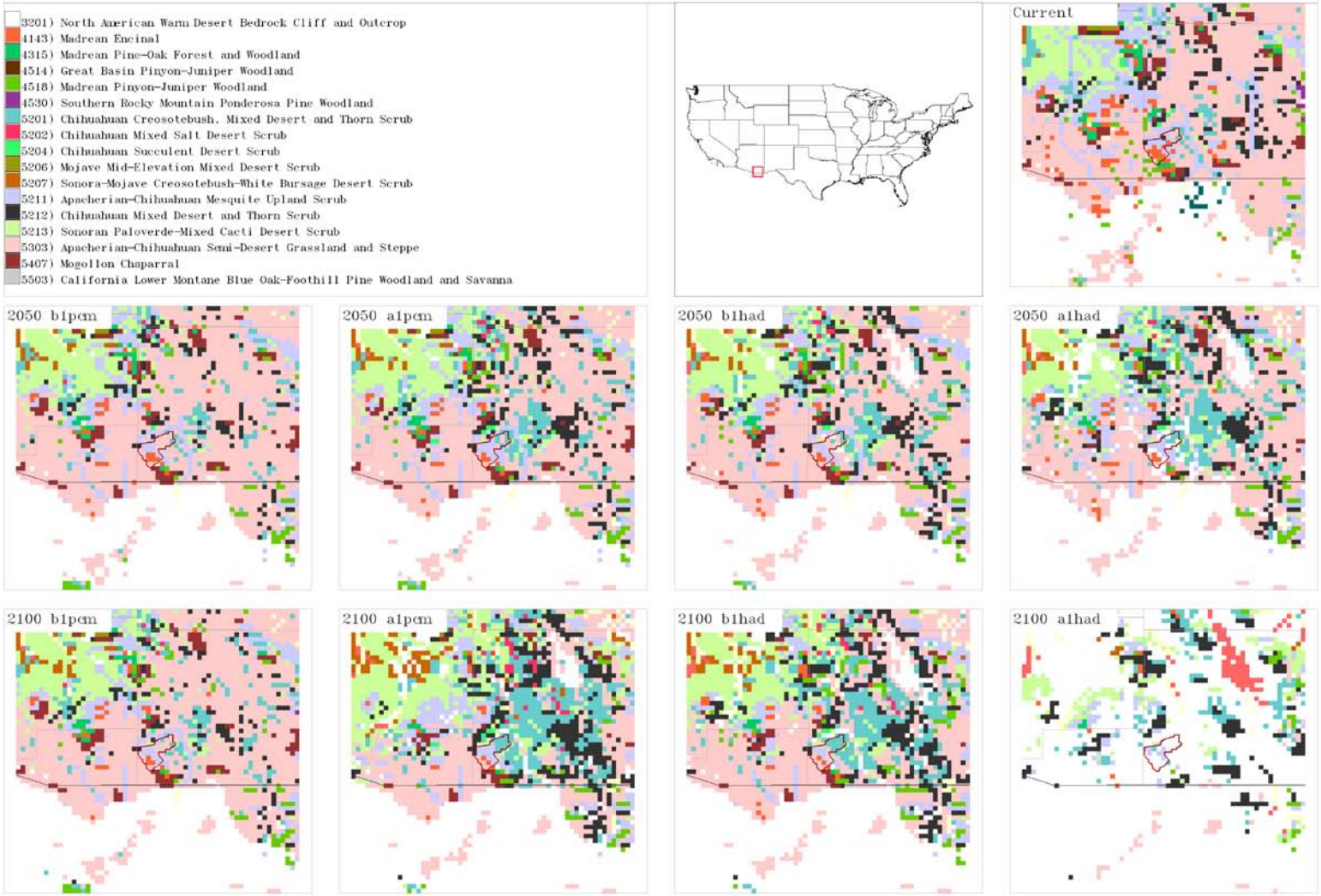

2100 b1had


2100 a1had

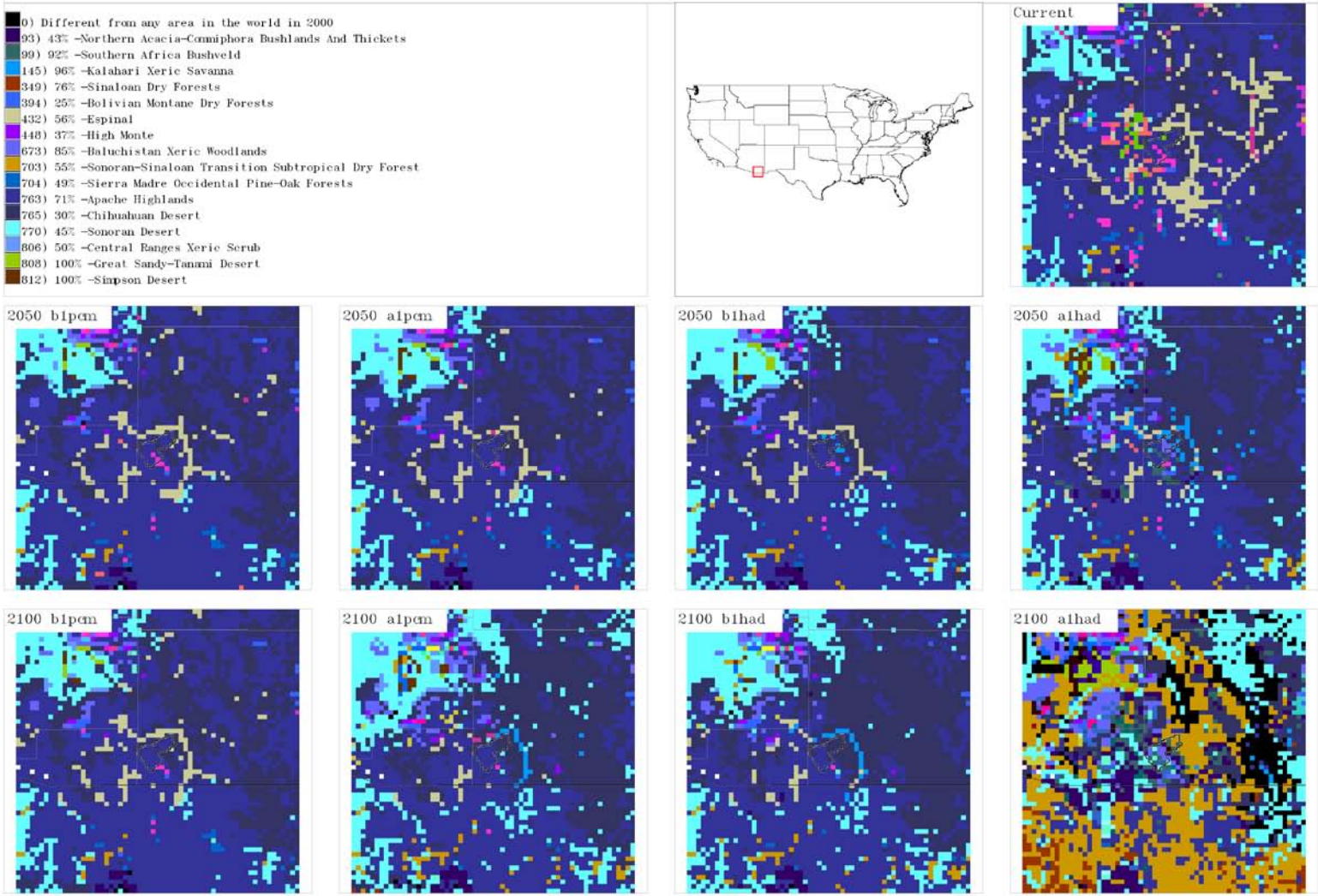


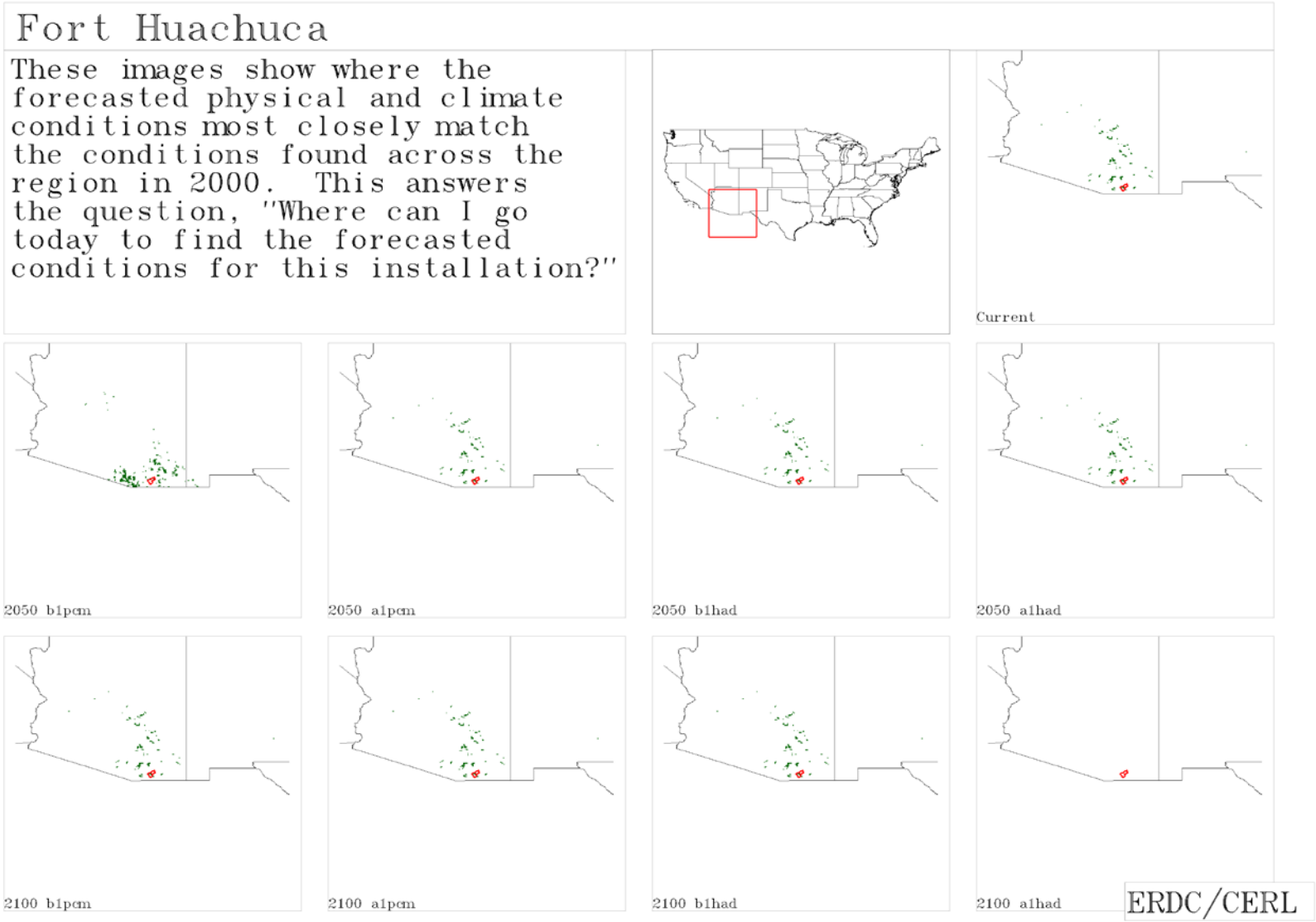

## Fort Huachuca

# Fort Huachuca



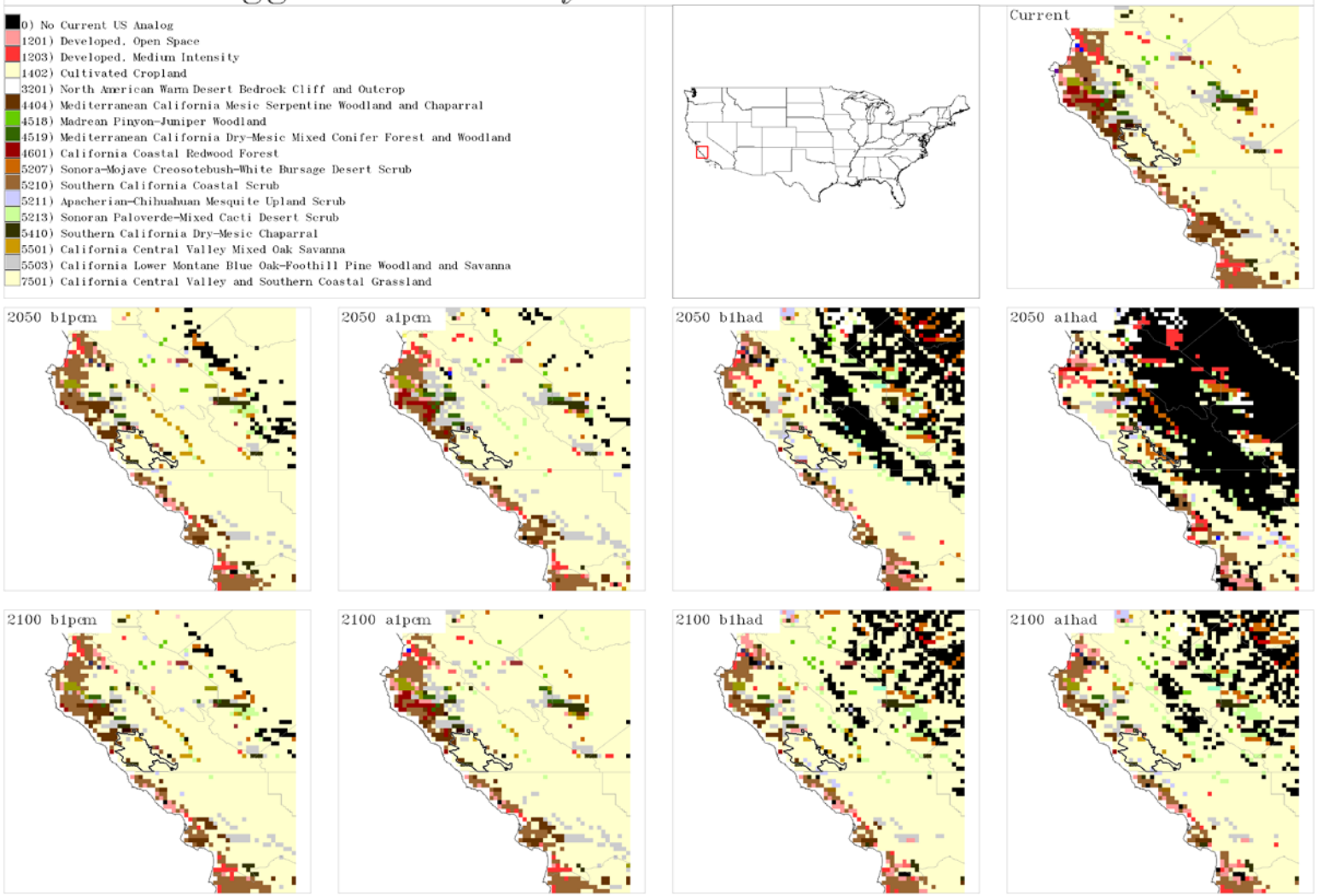
# Fort Huachuca



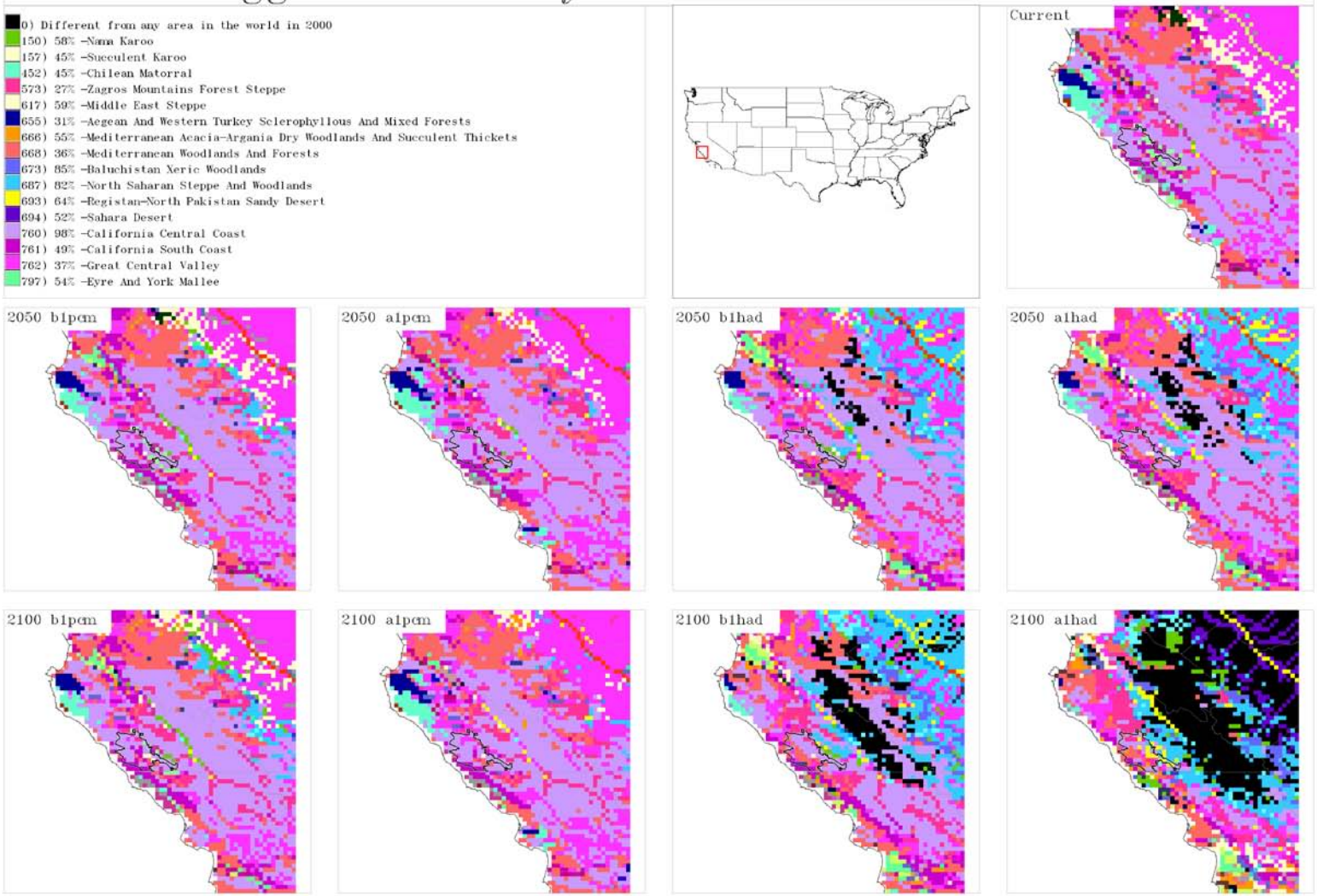


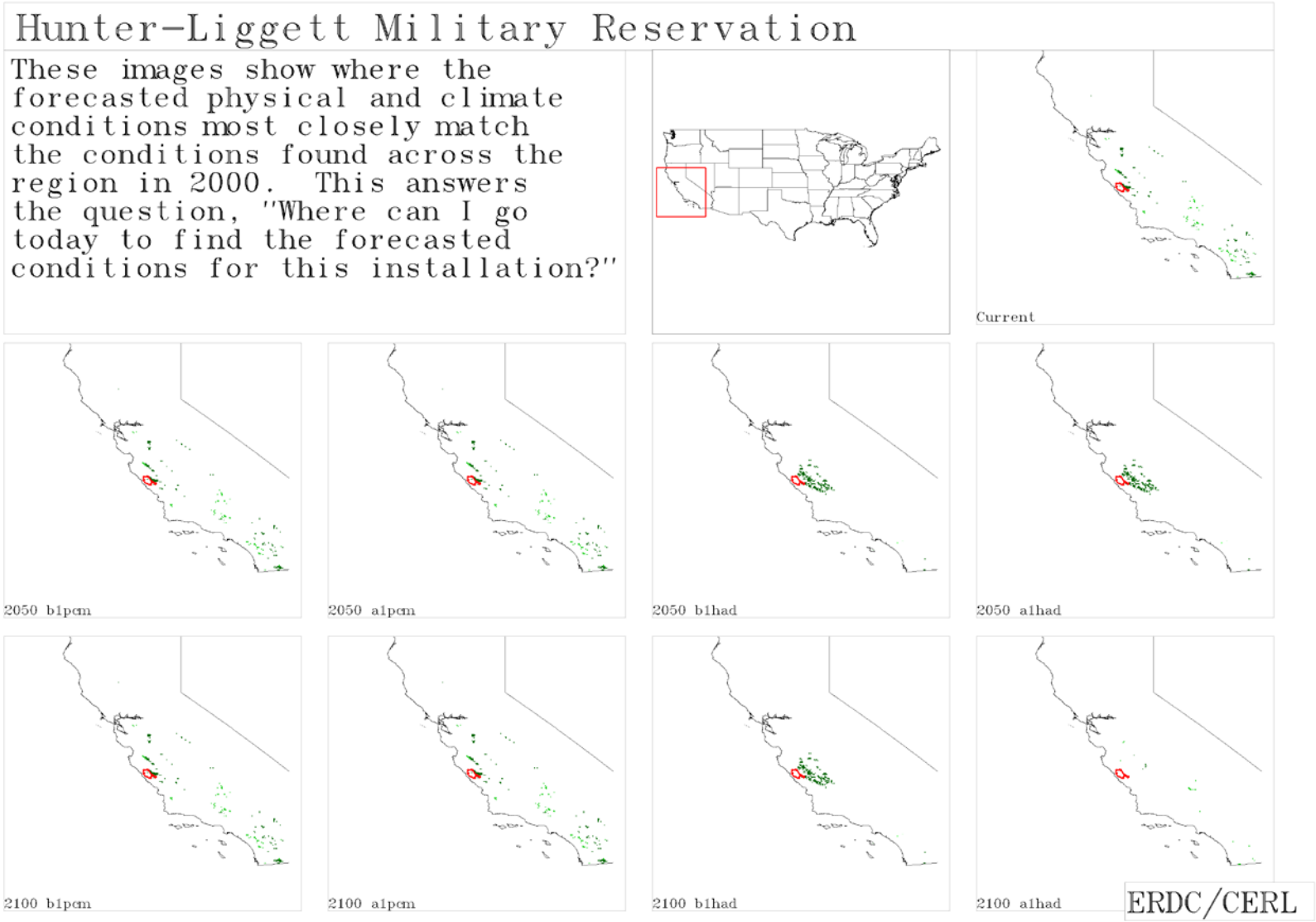

**Hunter-Liggett Military Reservation**

# Hunter–Liggett Military Reservation

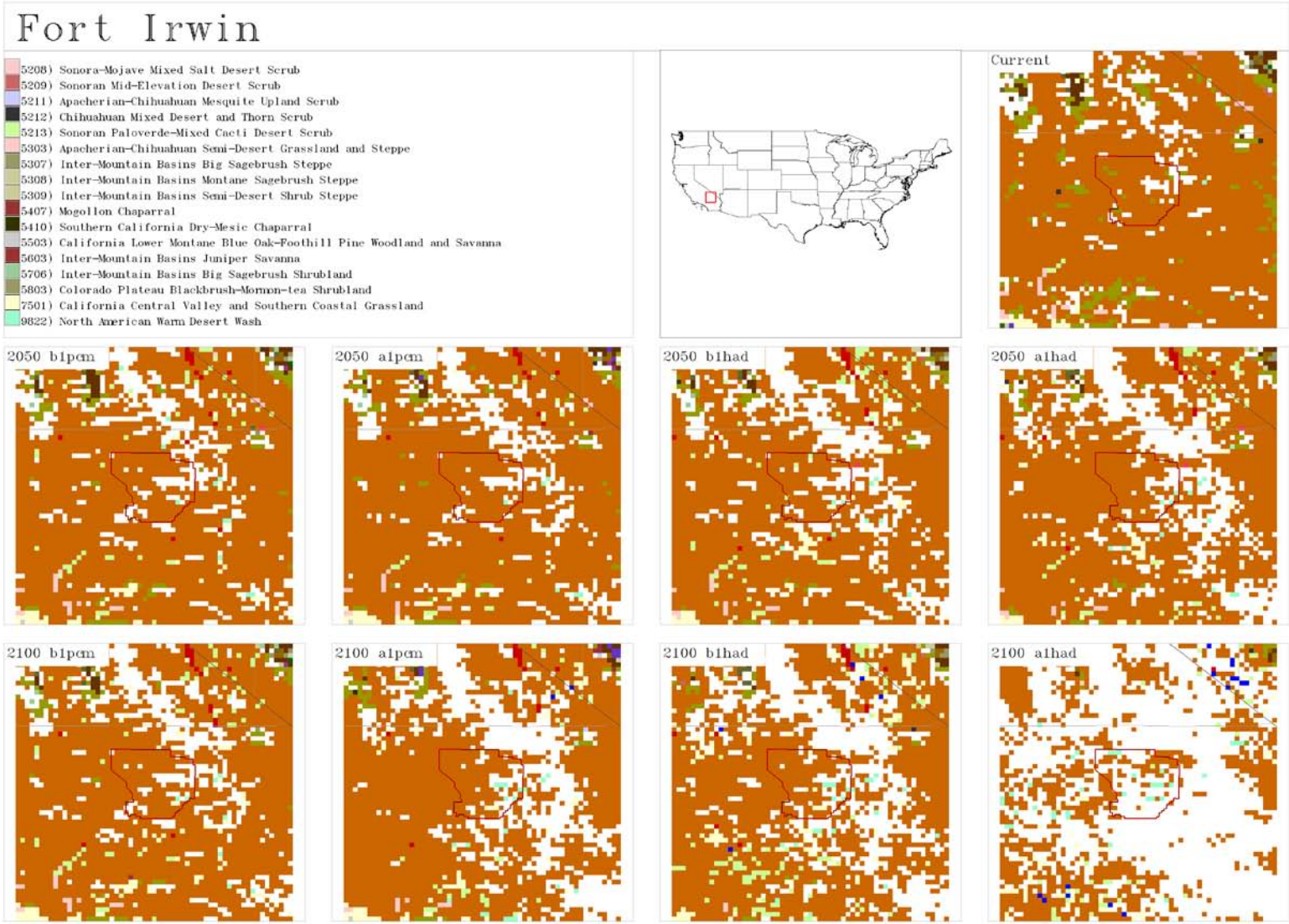


# Hunter–Liggett Military Reservation

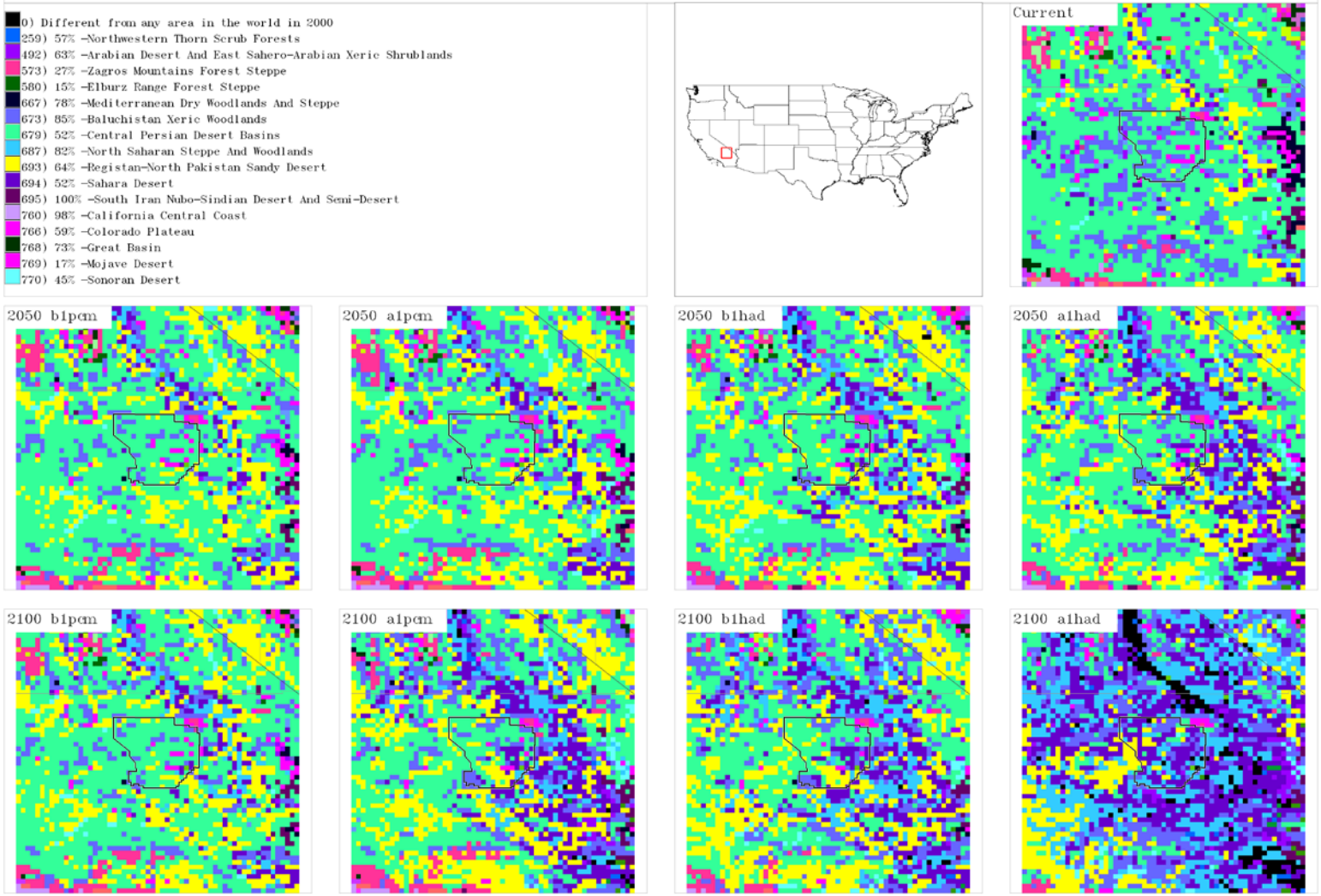


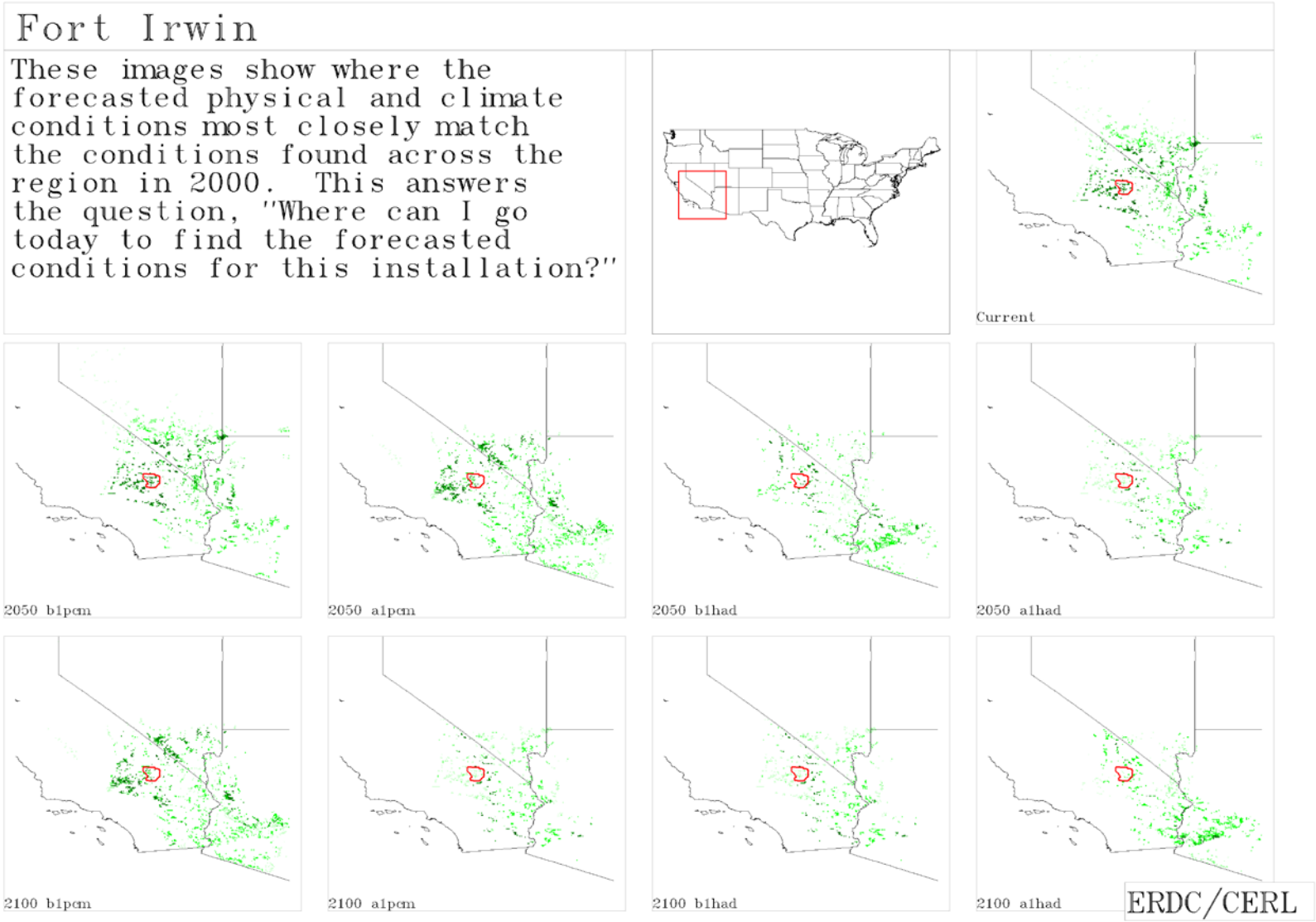

Hunter-Liggett Military Reservation
These images show where the forecasted physical and climate conditions most closely match the conditions found across the region in 2000. This answers the question, "Where can I go today to find the forecasted conditions for this installation?"
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had
ERDC/CERL

## Fort Irwin


Fort Irwin
5208) Sonora-Mojave Mixed Salt Desert Scrub
5209) Sonoran Mid-Elevation Desert Scrub
5211) Apacherian-Chihuahuan Mesquite Upland Scrub
5212) Chihuahuan Mixed Desert and Thorn Scrub
5213) Sonoran Paloverde-Mixed Cacti Desert Scrub
5303) Apacherian-Chihuahuan Semi-Desert Grassland and Steppe
5307) Inter-Mountain Basins Big Sagebrush Steppe
5308) Inter-Mountain Basins Montane Sagebrush Steppe
5309) Inter-Mountain Basins Semi-Desert Shrub Steppe
5407) Mogollon Chaparral
5410) Southern California Dry-Mesic Chaparral
5503) California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna
5603) Inter-Mountain Basins Juniper Savanna
5706) Inter-Mountain Basins Big Sagebrush Shrubland
5803) Colorado Plateau Blackbrush-Mormon-tea Shrubland
7501) California Central Valley and Southern Coastal Grassland
9822) North American Warm Desert Wash
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

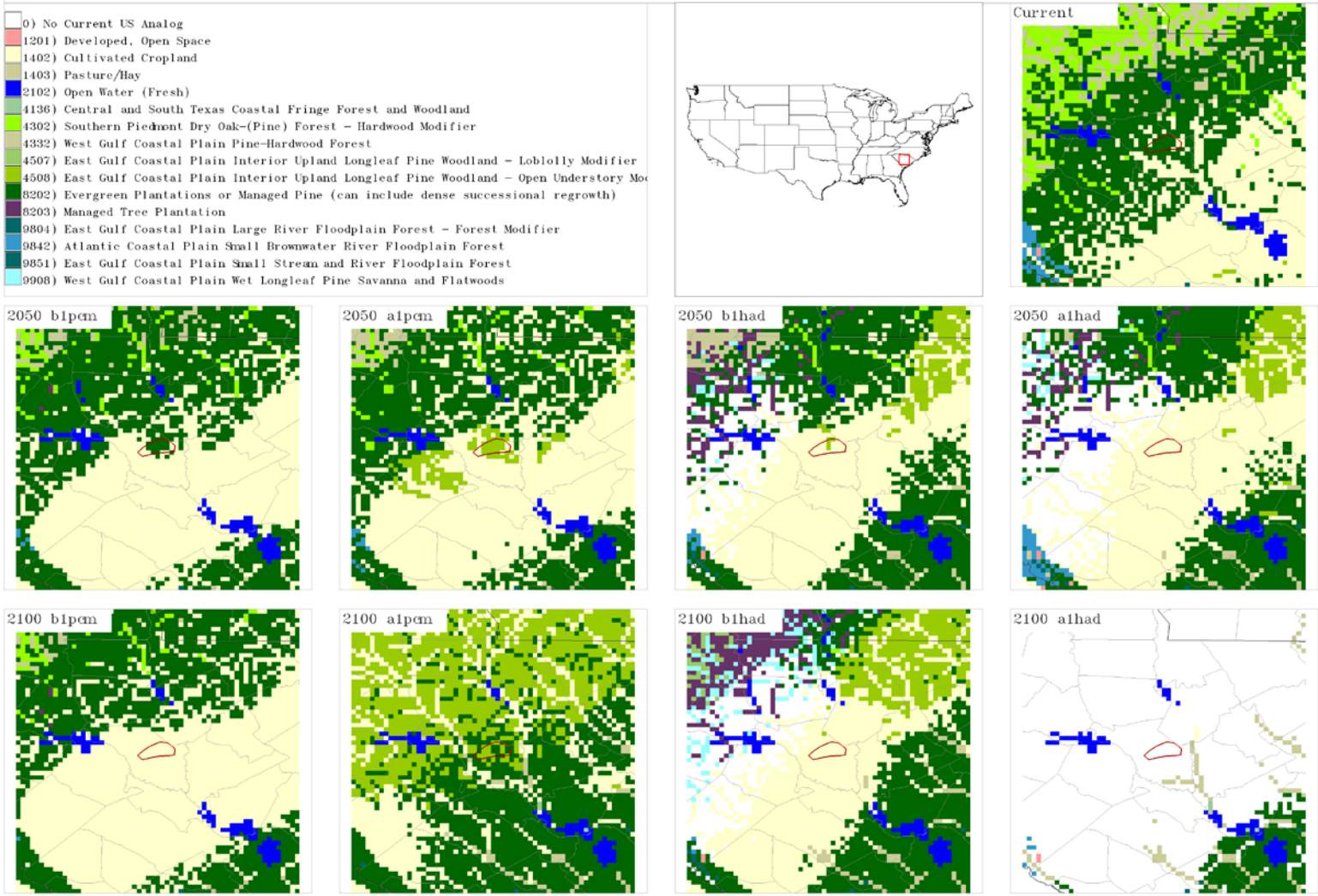
# Fort Irwin


0) Different from any area in the world in 2000
259) 57% -Northwestern Thorn Scrub Forests
492) 63% -Arabian Desert And East Sahero-Arabian Xeric Shrublands
573) 27% -Zagros Mountains Forest Steppe
580) 15% -Elburz Range Forest Steppe
667) 78% -Mediterranean Dry Woodlands And Steppe
673) 85% -Baluchistan Xeric Woodlands
679) 52% -Central Persian Desert Basins
687) 82% -North Saharan Steppe And Woodlands
693) 64% -Registan-North Pakistan Sandy Desert
694) 52% -Sahara Desert
695) 100% -South Iran Nubo-Sindian Desert And Semi-Desert
760) 98% -California Central Coast
766) 59% -Colorado Plateau
768) 73% -Great Basin
769) 17% -Mojave Desert
770) 45% -Sonoran Desert
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

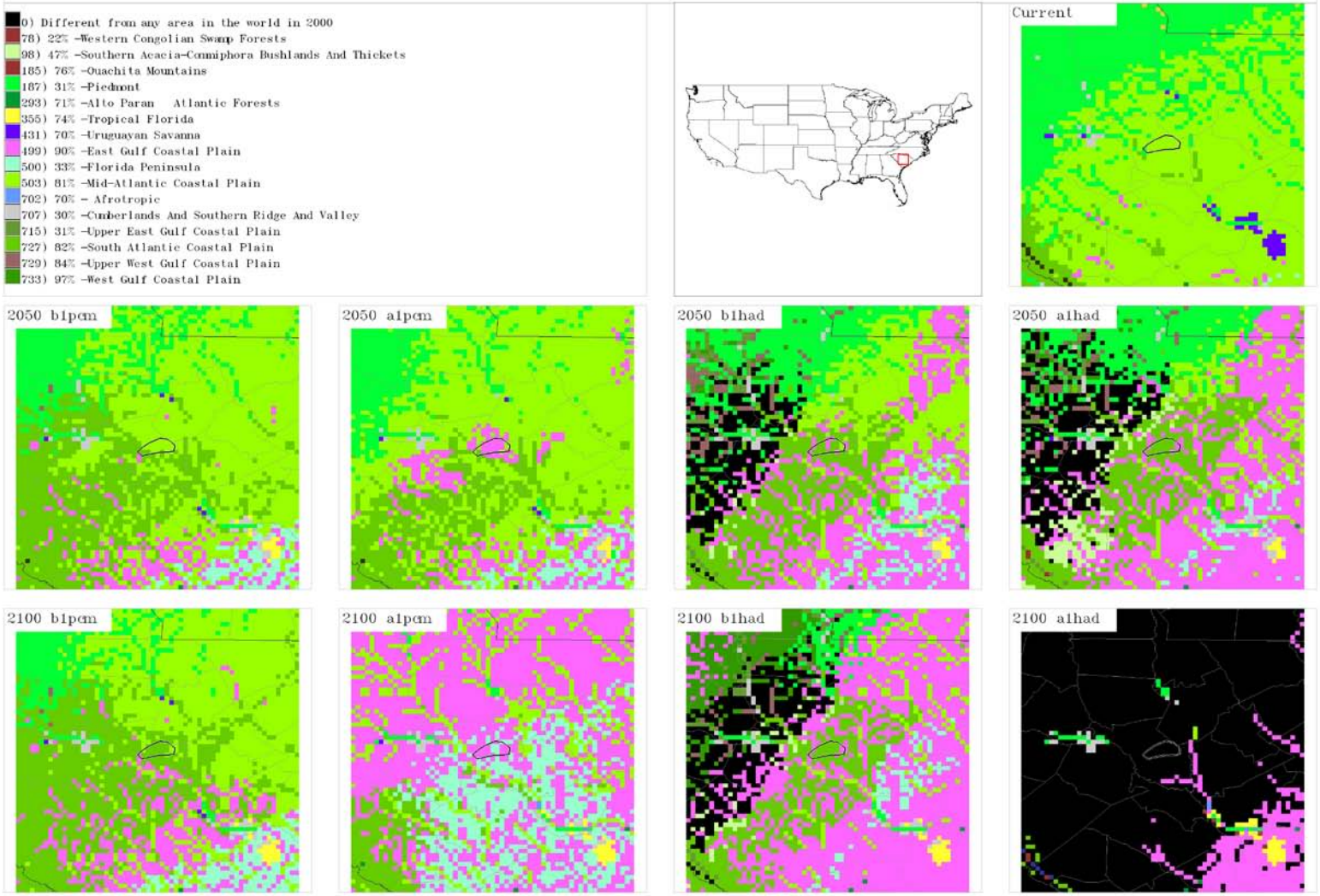


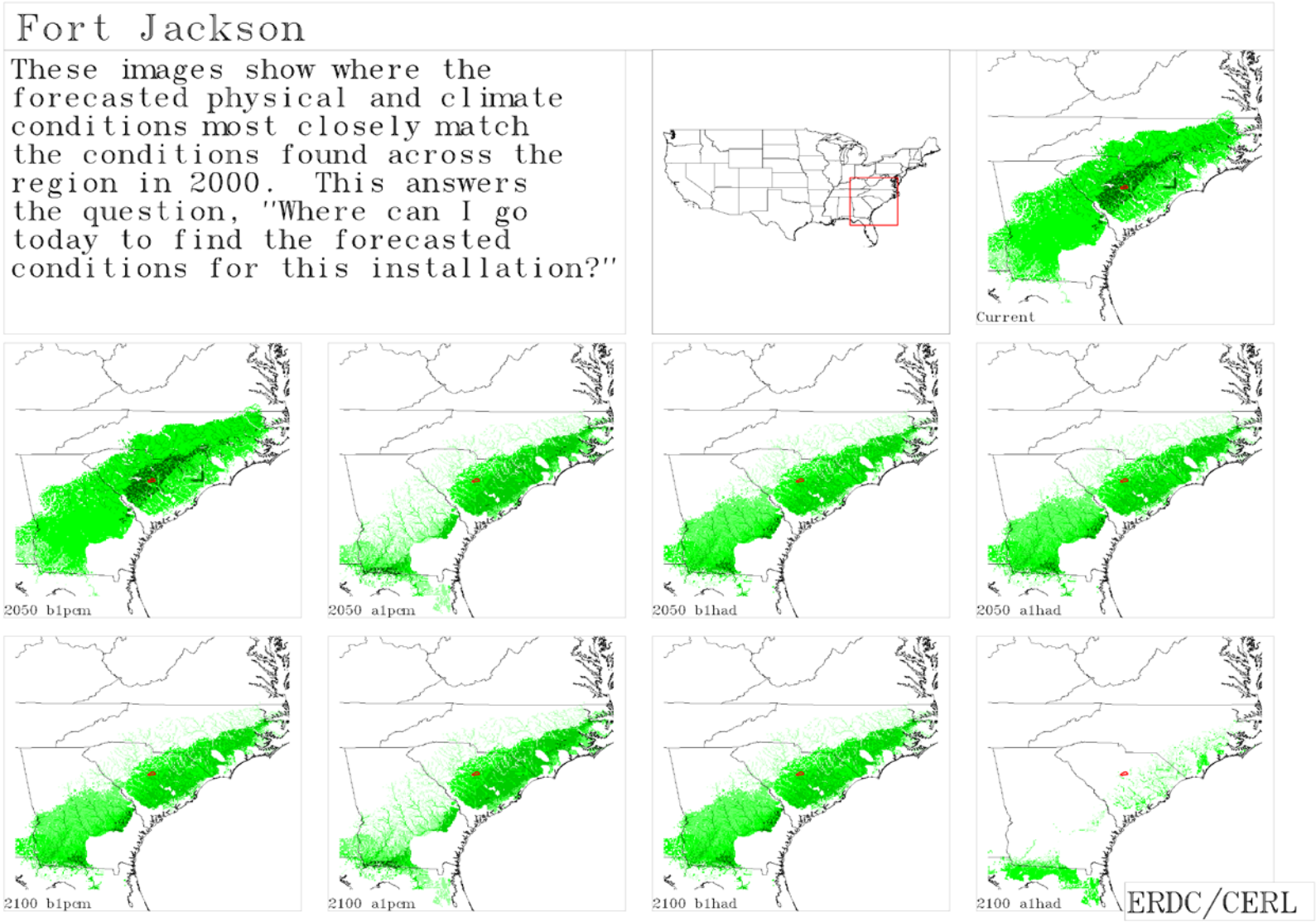

## Fort Jackson

# Fort Jackson



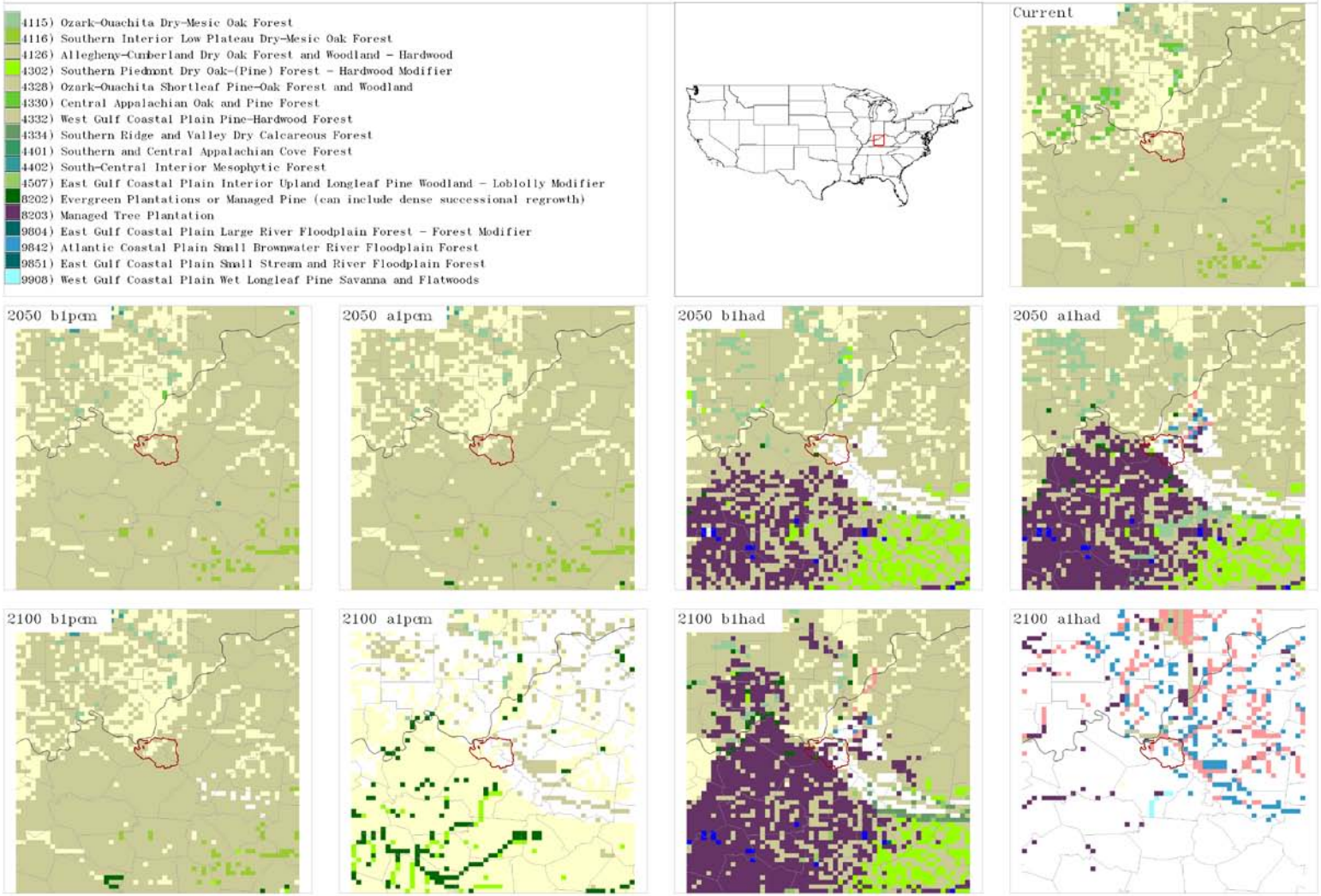
# Fort Jackson



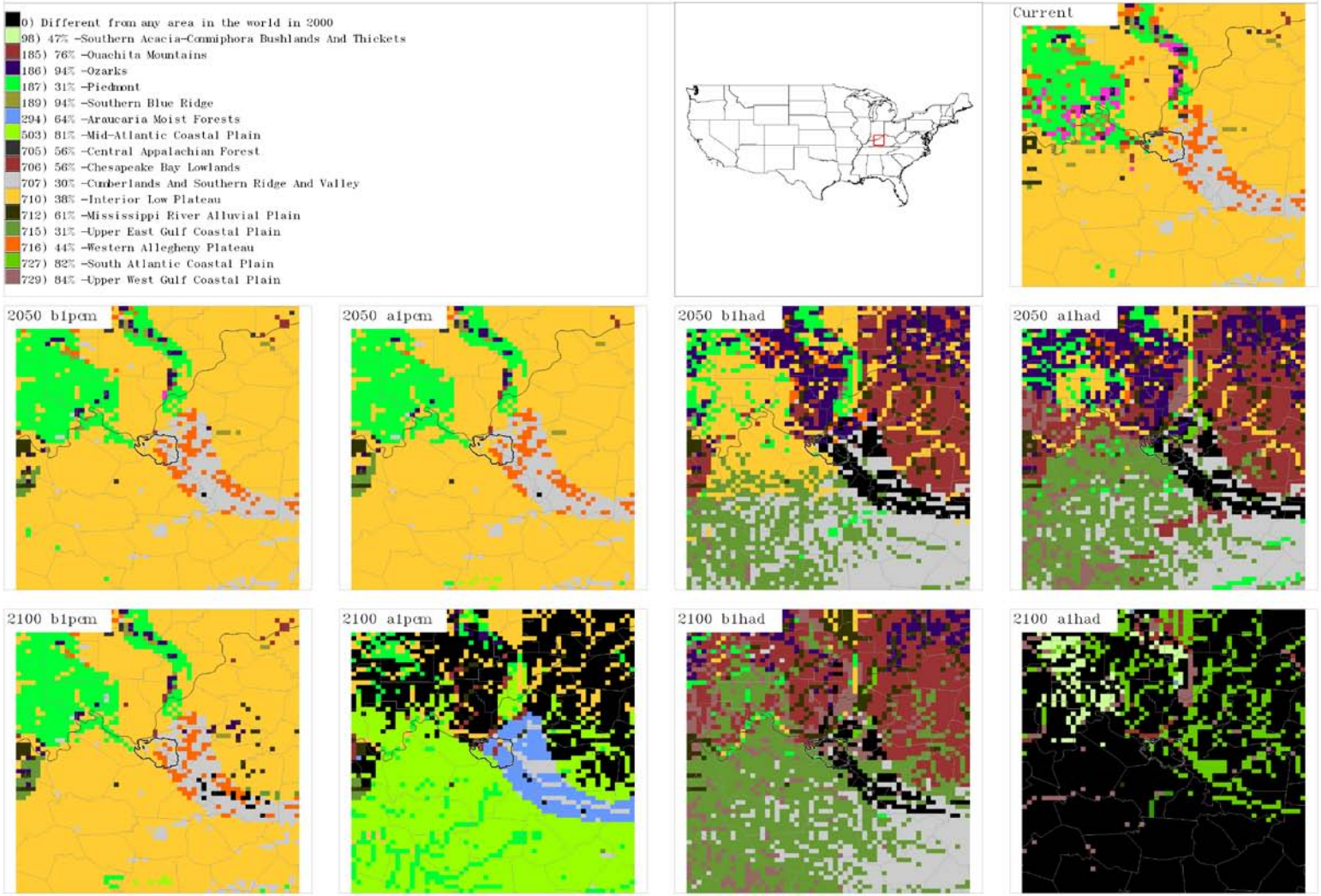

Fort Jackson
These images show where the forecasted physical and climate conditions most closely match the conditions found across the region in 2000. This answers the question, "Where can I go today to find the forecasted conditions for this installation?"
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had
ERDC/CERL

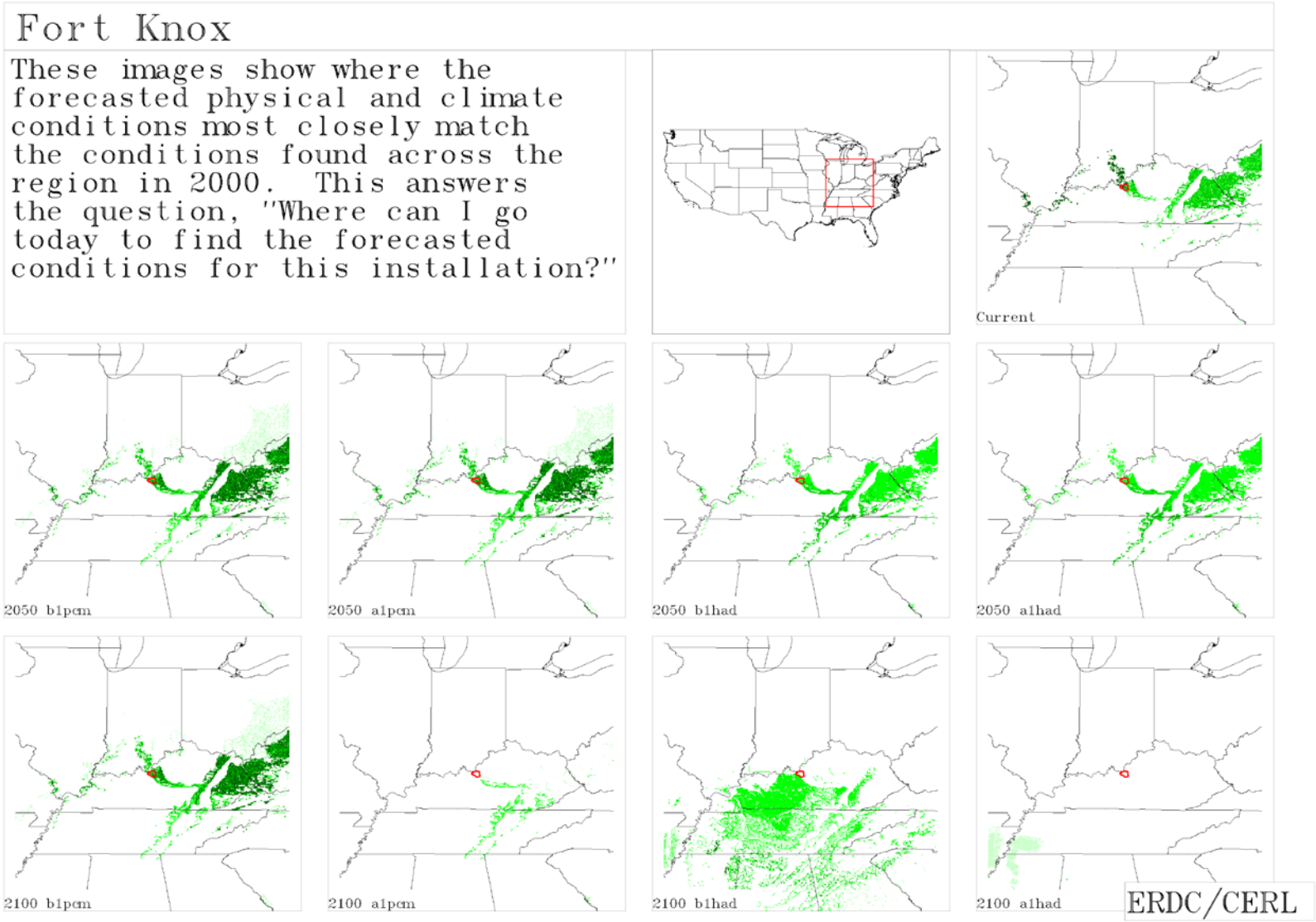
**Fort Knox**

# Fort Knox

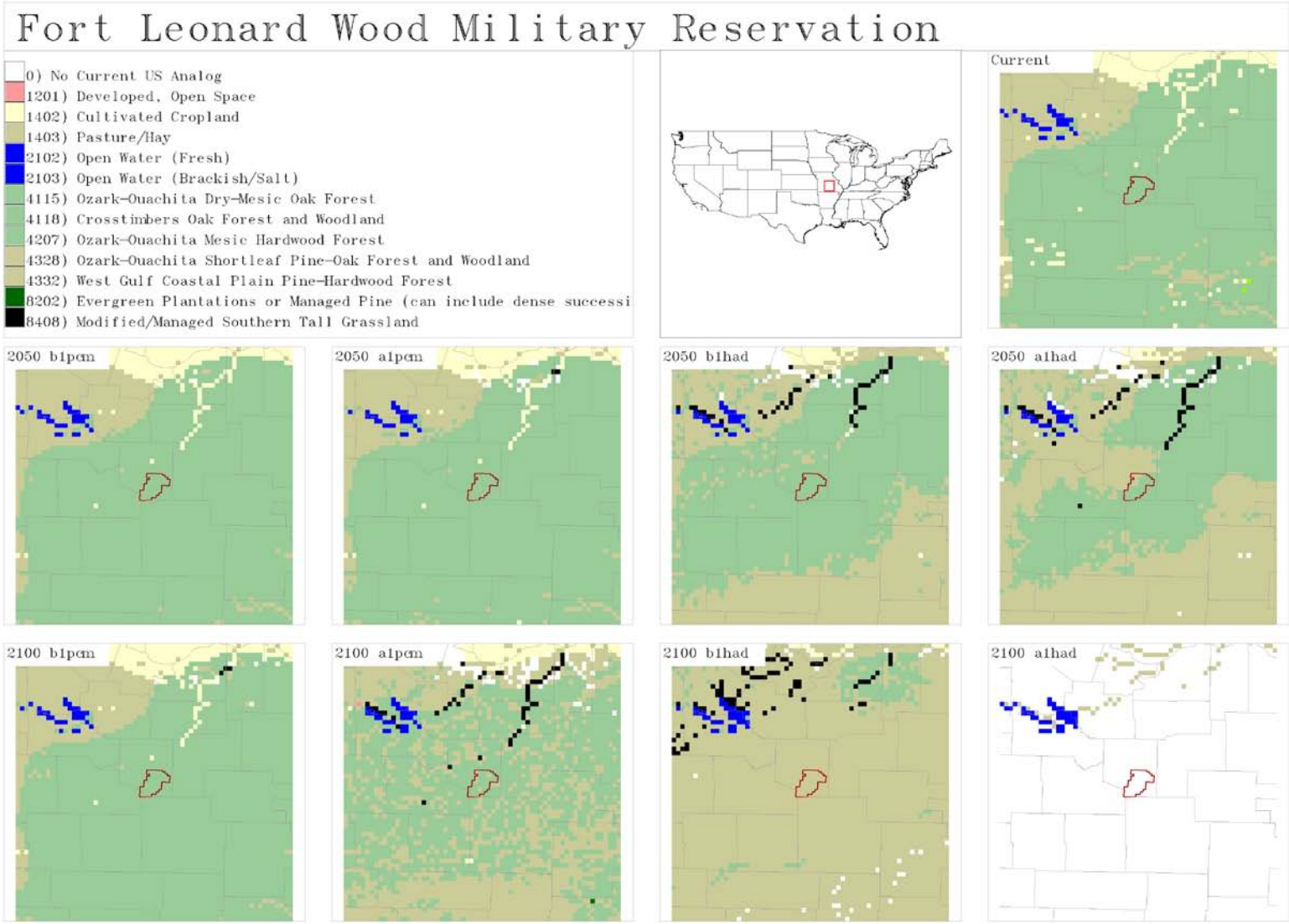

4115) Ozark-Ouachita Dry-Mesic Oak Forest
4116) Southern Interior Low Plateau Dry-Mesic Oak Forest
4126) Allegheny-Cumberland Dry Oak Forest and Woodland - Hardwood
4302) Southern Piedmont Dry Oak-(Pine) Forest - Hardwood Modifier
4328) Ozark-Ouachita Shortleaf Pine-Oak Forest and Woodland
4330) Central Appalachian Oak and Pine Forest
4332) West Gulf Coastal Plain Pine-Hardwood Forest
4334) Southern Ridge and Valley Dry Calcareous Forest
4401) Southern and Central Appalachian Cove Forest
4402) South-Central Interior Mesophytic Forest
4507) East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland - Loblolly Modifier
8202) Evergreen Plantations or Managed Pine (can include dense successional regrowth)
8203) Managed Tree Plantation
9804) East Gulf Coastal Plain Large River Floodplain Forest - Forest Modifier
9842) Atlantic Coastal Plain Small Brownwater River Floodplain Forest
9851) East Gulf Coastal Plain Small Stream and River Floodplain Forest
9908) West Gulf Coastal Plain Wet Longleaf Pine Savanna and Flatwoods
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

# Fort Knox

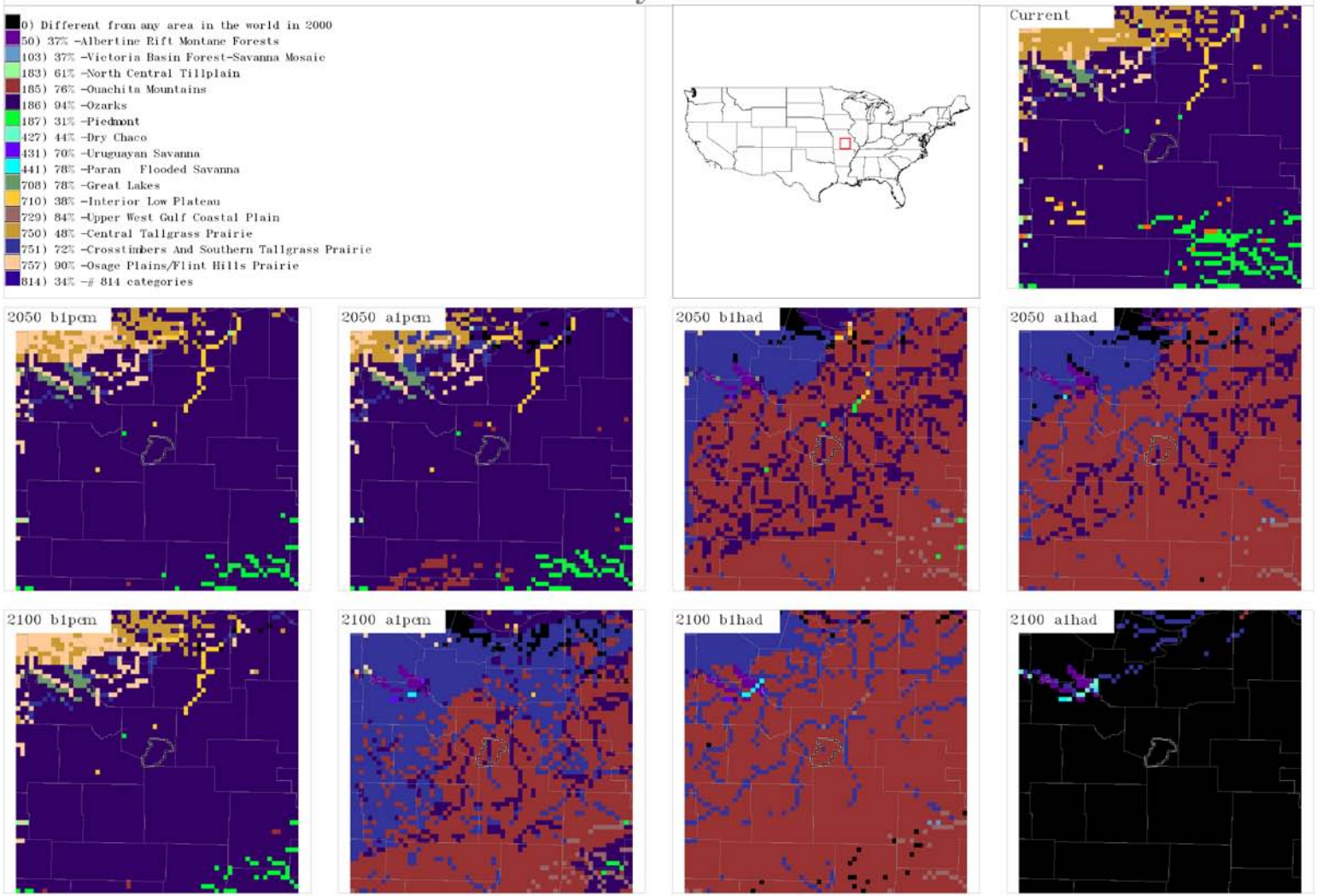

0) Different from any area in the world in 2000
98) 47% -Southern Acacia-Commiphora Bushlands And Thickets
185) 76% -Ouachita Mountains
186) 94% -Ozarks
187) 31% -Piedmont
189) 94% -Southern Blue Ridge
294) 64% -Araucaria Moist Forests
503) 81% -Mid-Atlantic Coastal Plain
705) 56% -Central Appalachian Forest
706) 56% -Chesapeake Bay Lowlands
707) 30% -Cumberlands And Southern Ridge And Valley
710) 38% -Interior Low Plateau
712) 61% -Mississippi River Alluvial Plain
715) 31% -Upper East Gulf Coastal Plain
716) 44% -Western Allegheny Plateau
727) 82% -South Atlantic Coastal Plain
729) 84% -Upper West Gulf Coastal Plain
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

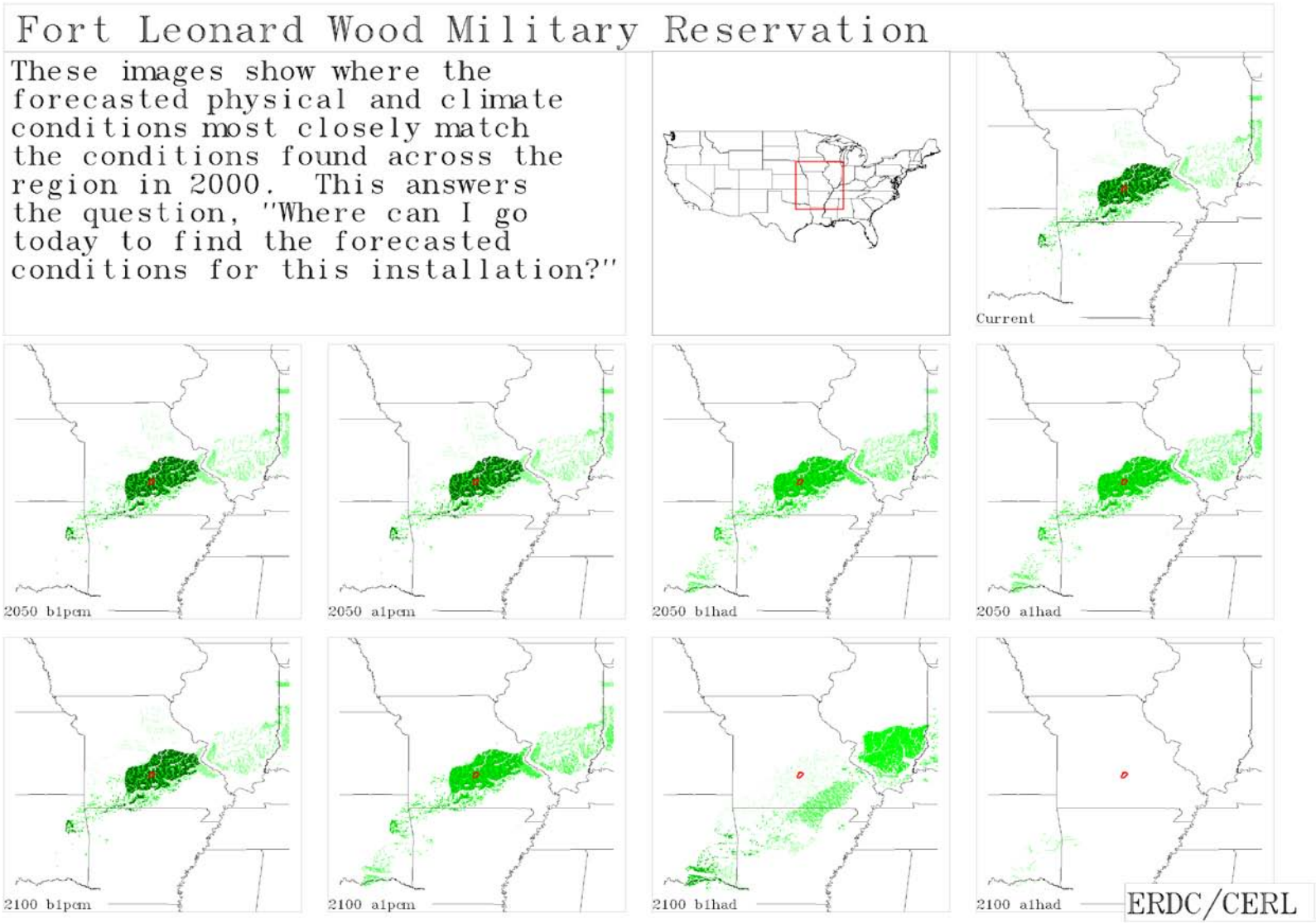



**Fort Leonard Wood Military Reservation**


Fort Leonard Wood Military Reservation
0) No Current US Analog
1201) Developed, Open Space
1402) Cultivated Cropland
1403) Pasture/Hay
2102) Open Water (Fresh)
2103) Open Water (Brackish/Salt)
4115) Ozark-Ouachita Dry-Mesic Oak Forest
4118) Crosstimbers Oak Forest and Woodland
4207) Ozark-Ouachita Mesic Hardwood Forest
4328) Ozark-Ouachita Shortleaf Pine-Oak Forest and Woodland
4332) West Gulf Coastal Plain Pine-Hardwood Forest
8202) Evergreen Plantations or Managed Pine (can include dense successi
8408) Modified/Managed Southern Tall Grassland
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

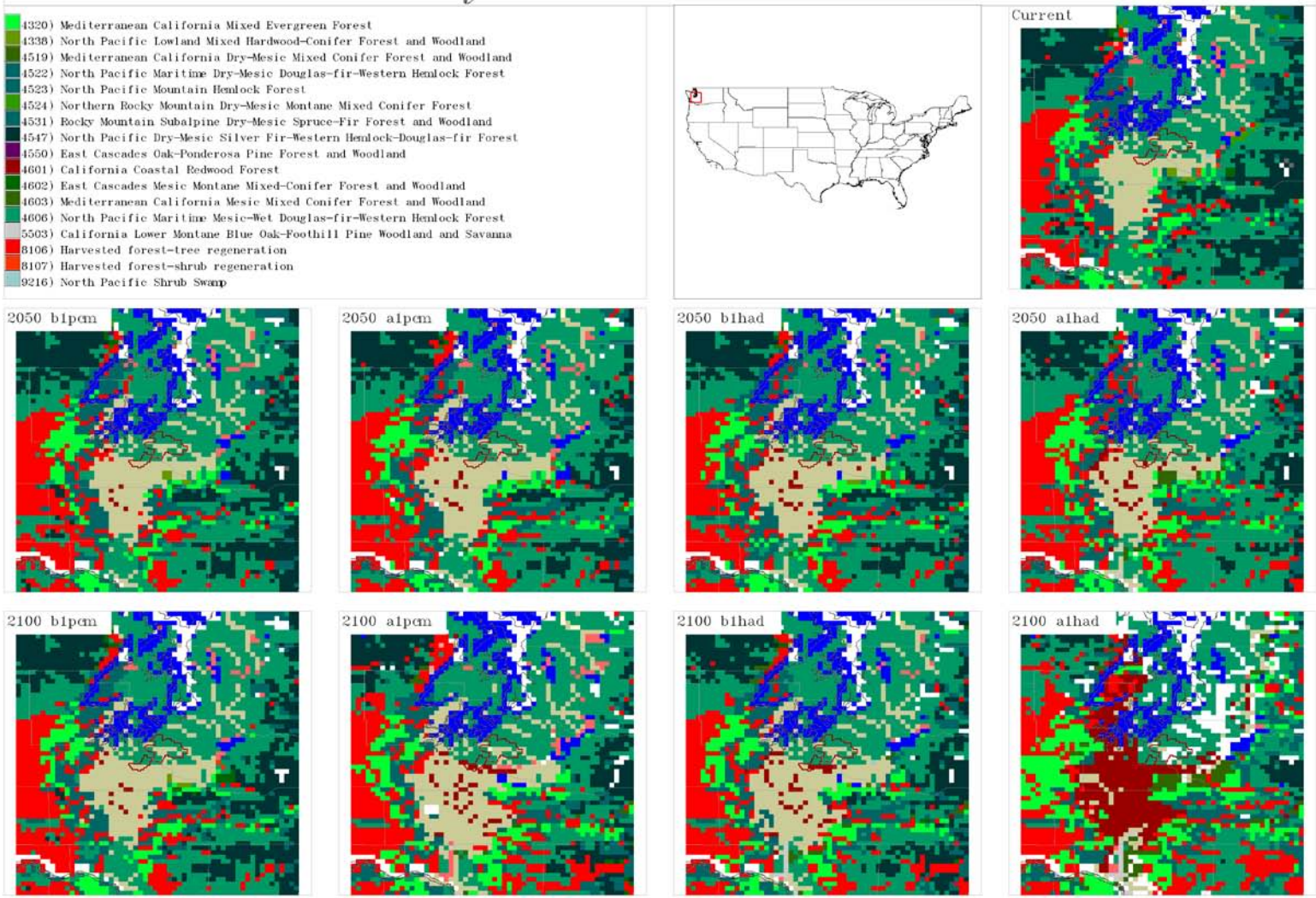
# Fort Leonard Wood Military Reservation



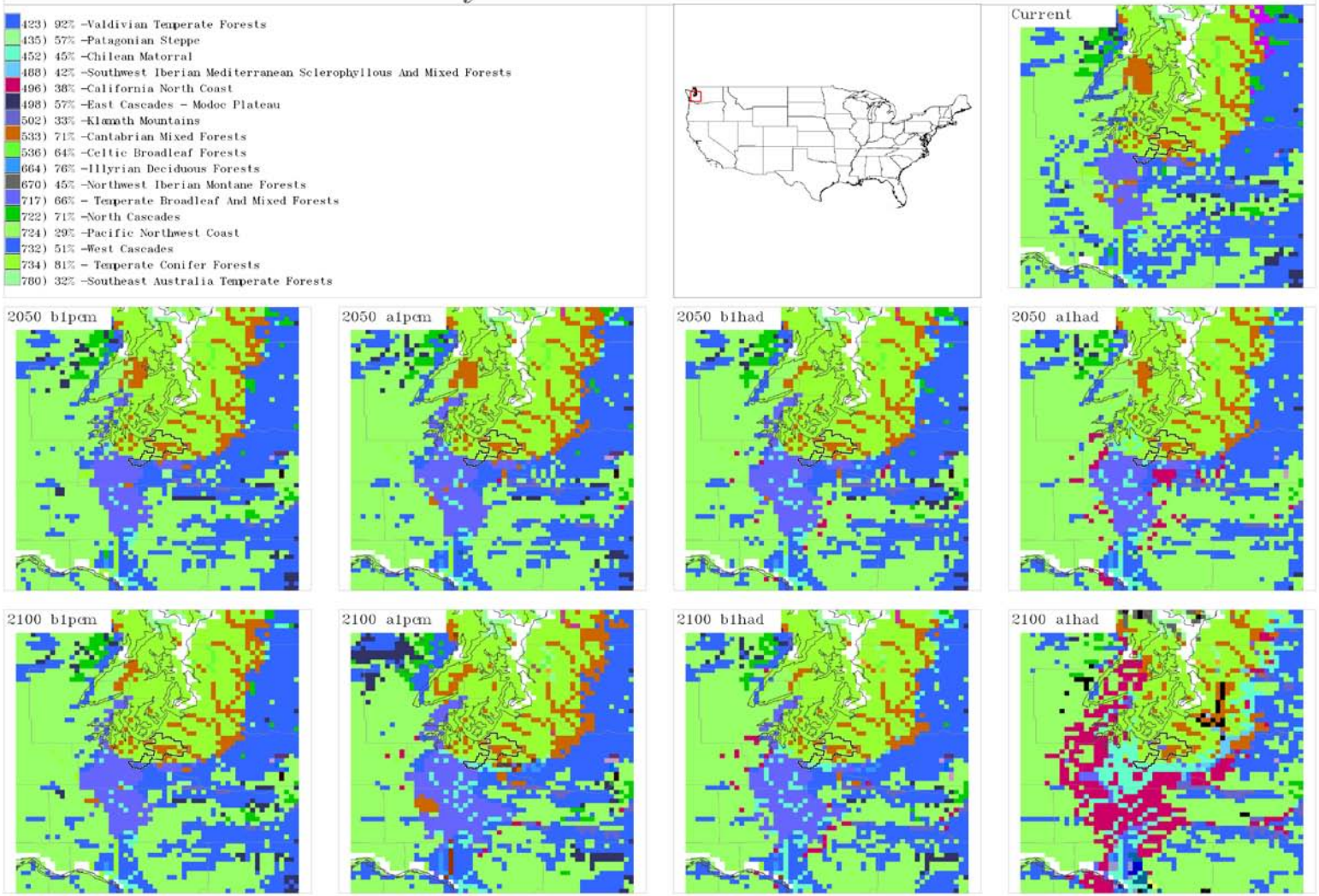


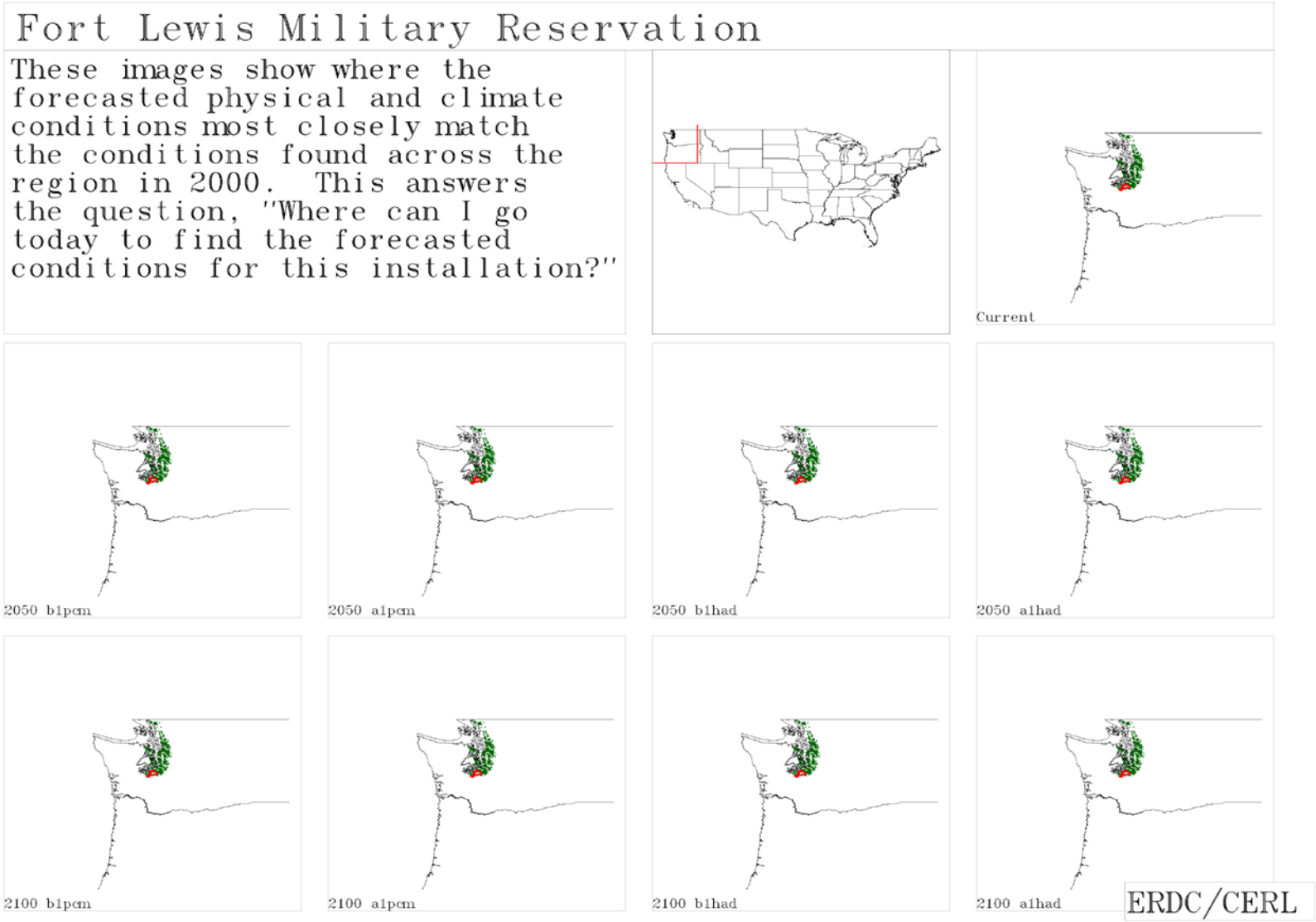

**Fort Lewis Wood Military Reservation**

# Fort Lewis Military Reservation

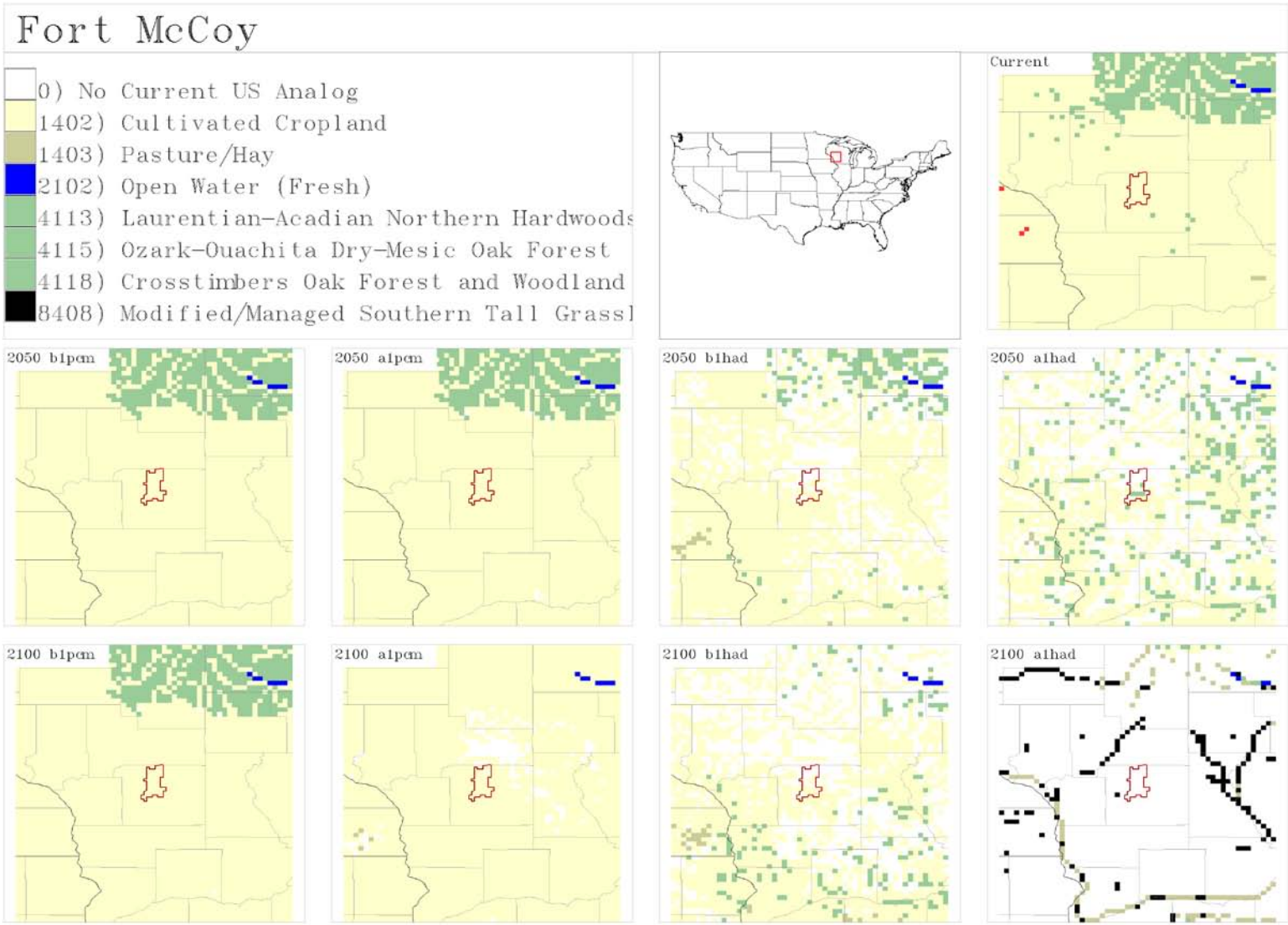


# Fort Lewis Military Reservation

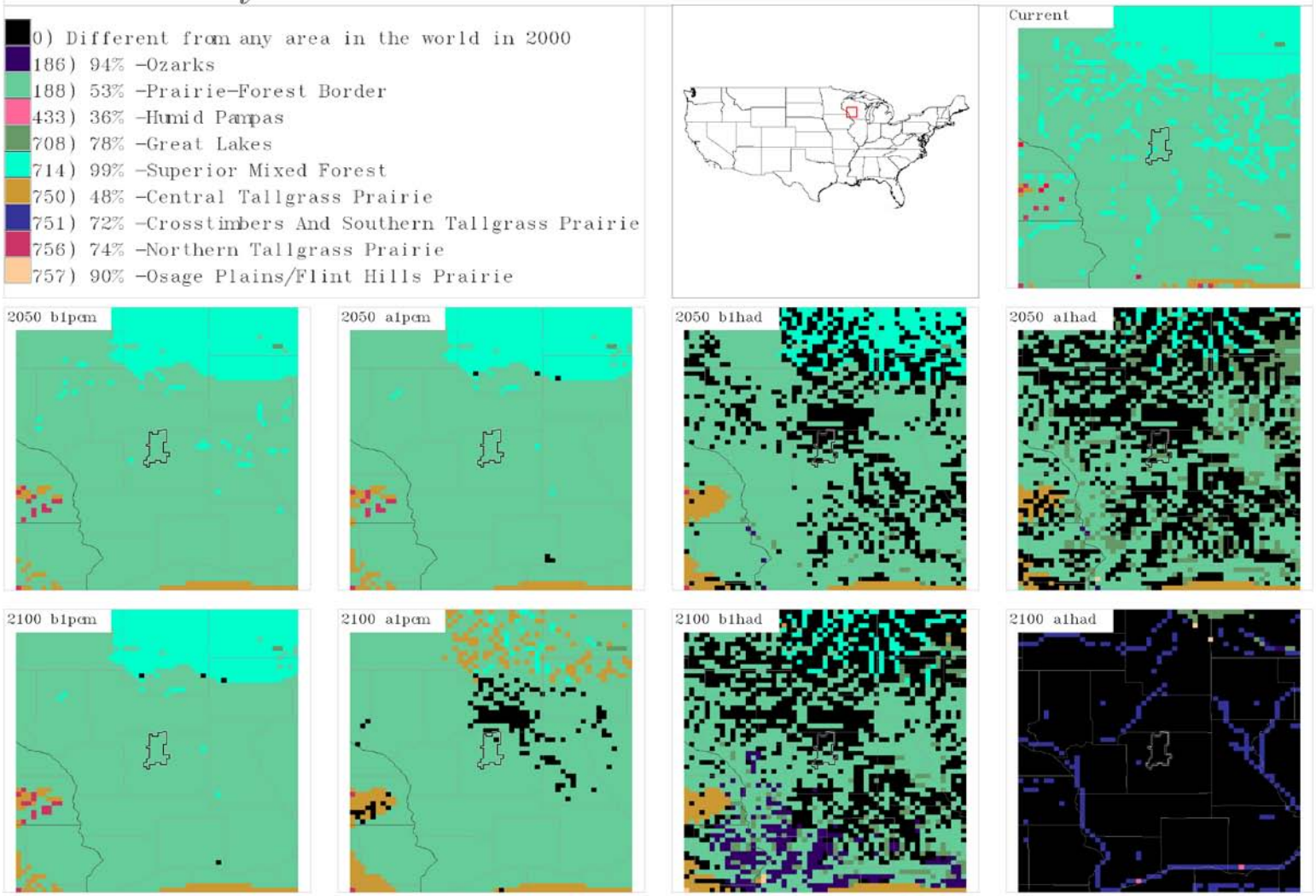


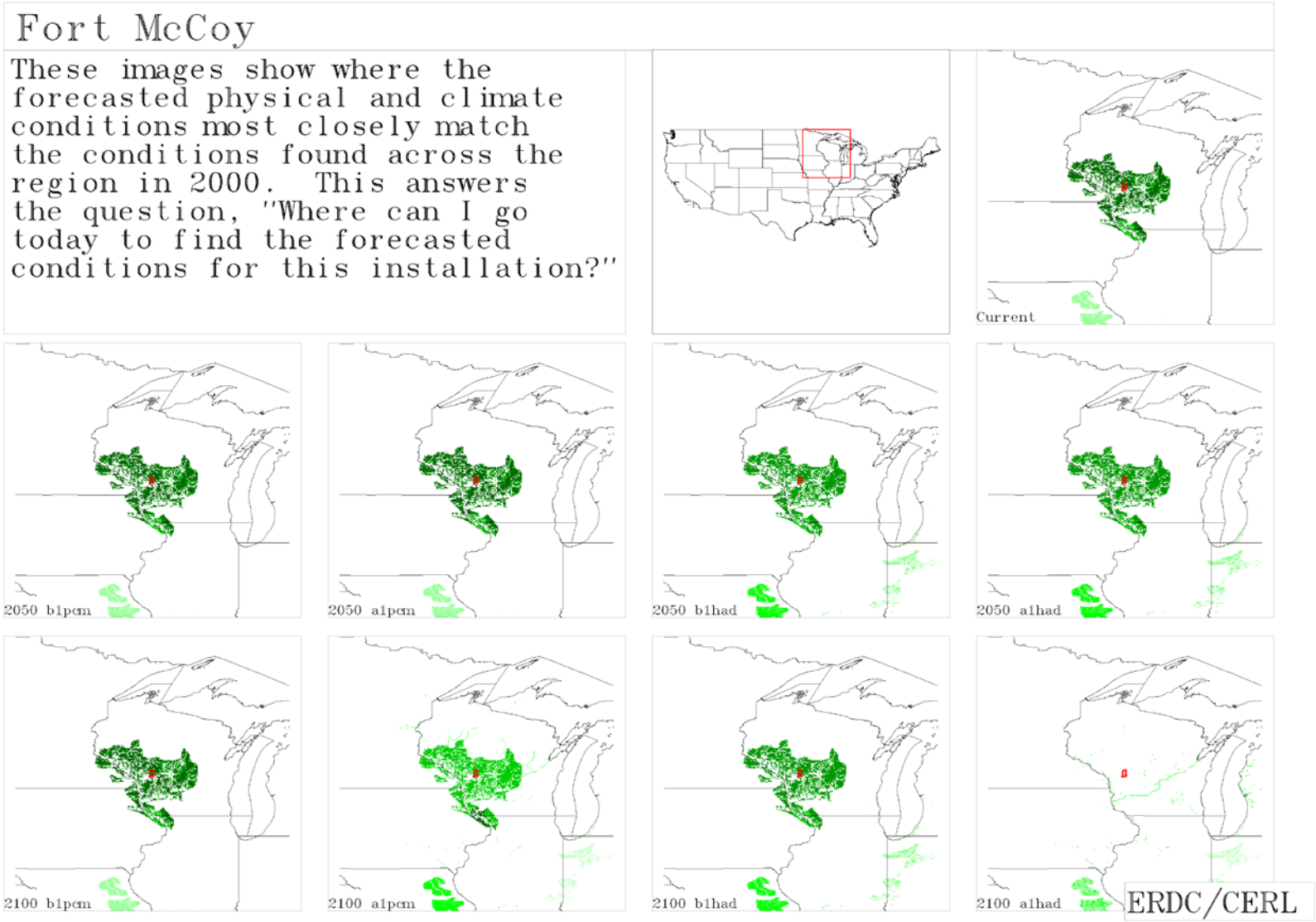

Fort Lewis Military Reservation
These images show where the forecasted physical and climate conditions most closely match the conditions found across the region in 2000. This answers the question, "Where can I go today to find the forecasted conditions for this installation?"
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had
ERDC/CERL

## Fort McCoy


Fort McCoy
0) No Current US Analog
1402) Cultivated Cropland
1403) Pasture/Hay
2102) Open Water (Fresh)
4113) Laurentian-Acadian Northern Hardwoods
4115) Ozark-Ouachita Dry-Mesic Oak Forest
4118) Crosstimbers Oak Forest and Woodland
8408) Modified/Managed Southern Tall Grassl
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

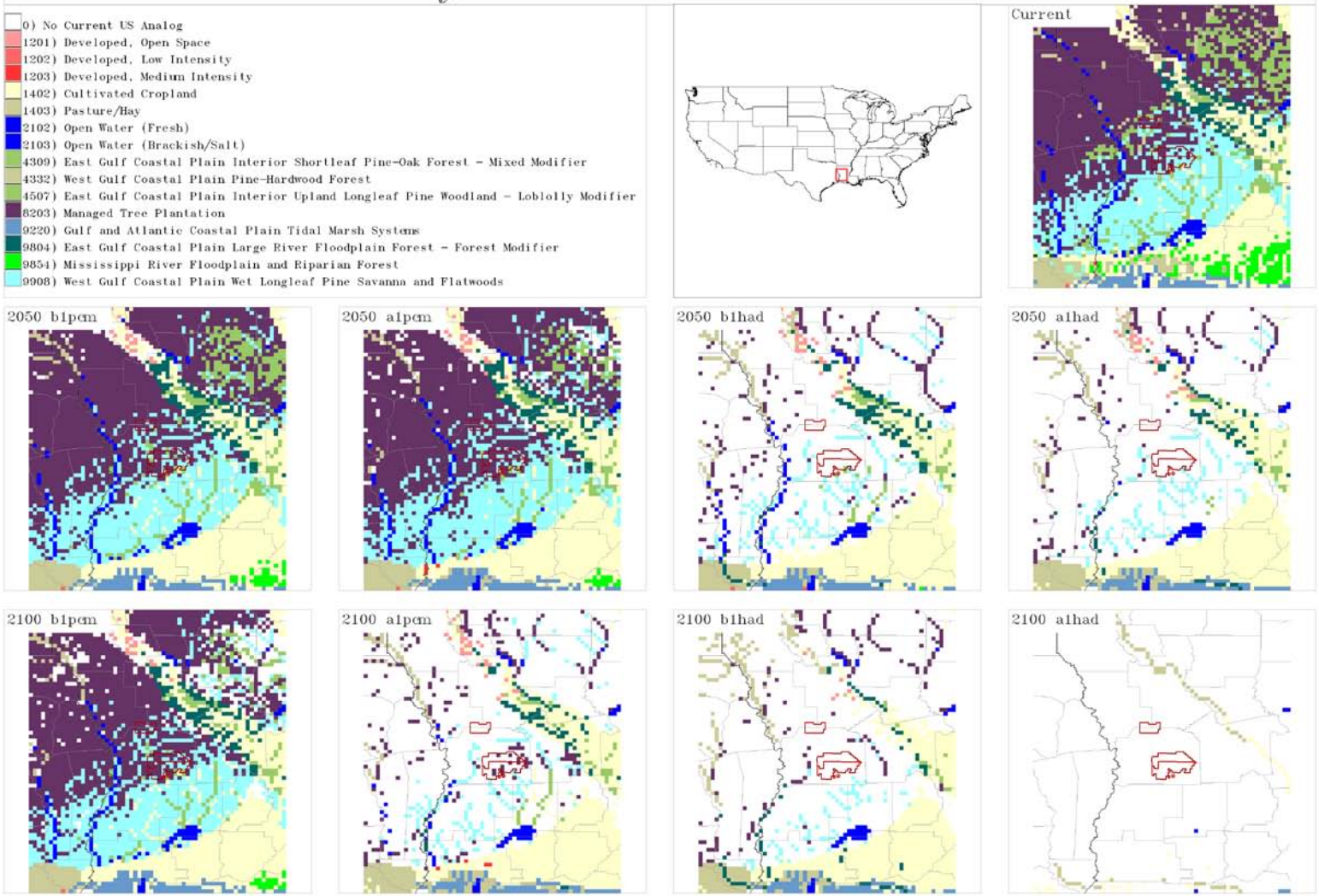
# Fort McCoy


0) Different from any area in the world in 2000
186) 94% -Ozarks
188) 53% -Prairie-Forest Border
433) 36% -Humid Pampas
708) 78% -Great Lakes
714) 99% -Superior Mixed Forest
750) 48% -Central Tallgrass Prairie
751) 72% -Crosstimbers And Southern Tallgrass Prairie
756) 74% -Northern Tallgrass Prairie
757) 90% -Osage Plains/Flint Hills Prairie
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

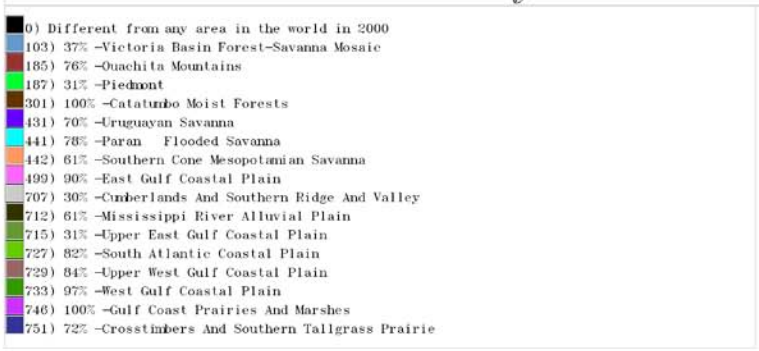


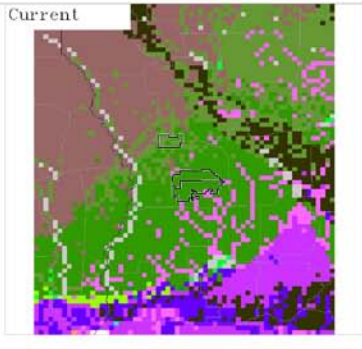

**Fort Polk Military Reservation**

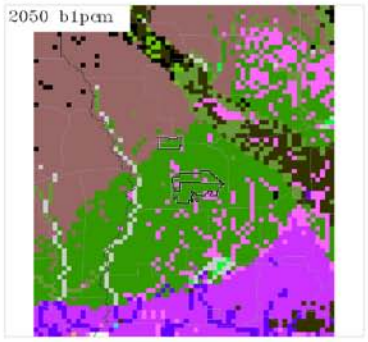
# Fort Polk Military Reservation

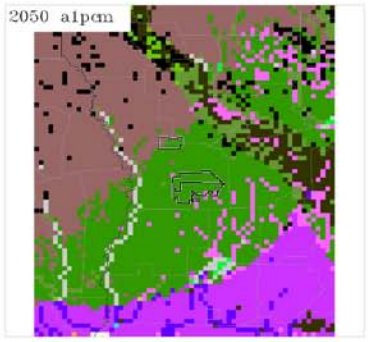


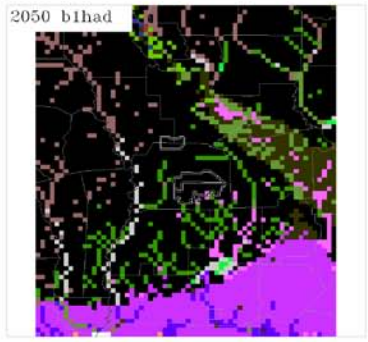
# Fort Polk Military Reservation

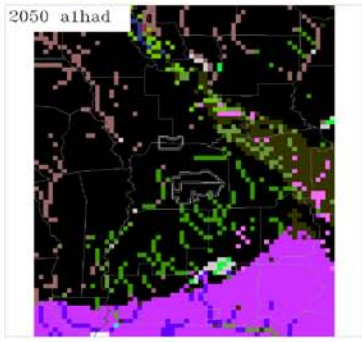


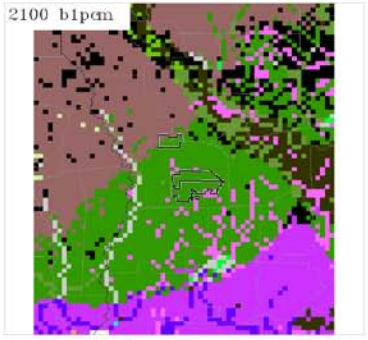



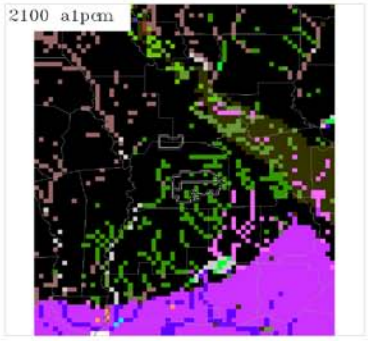



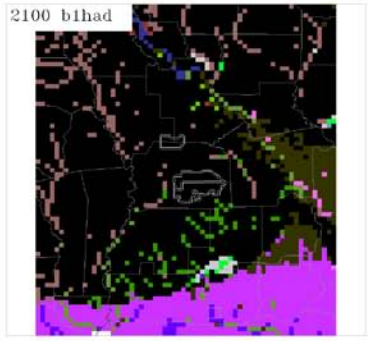



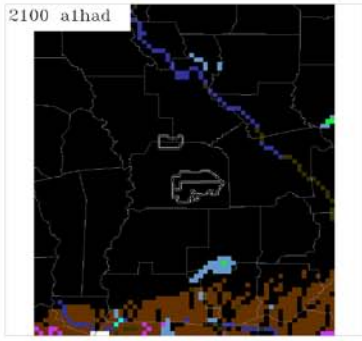



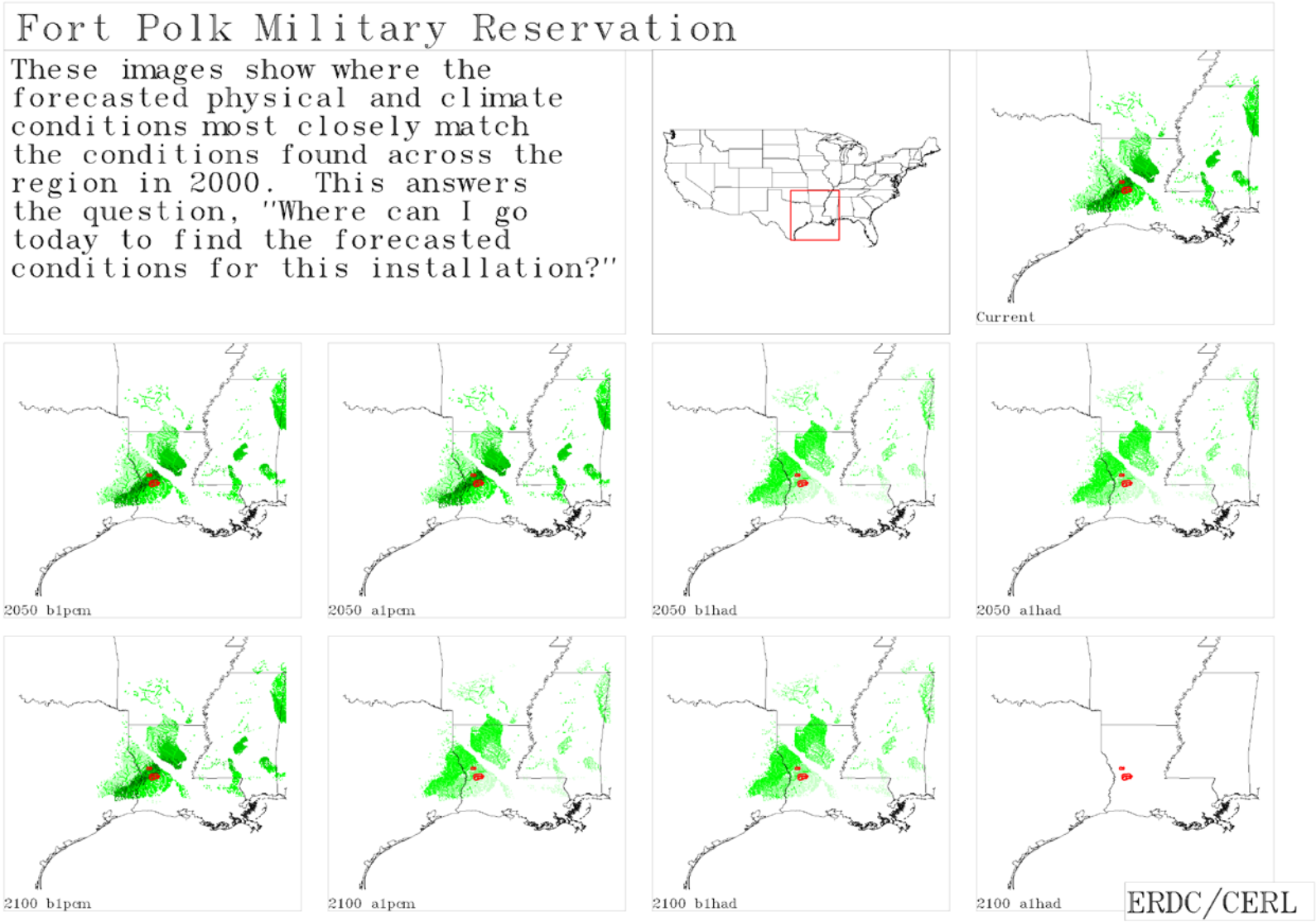



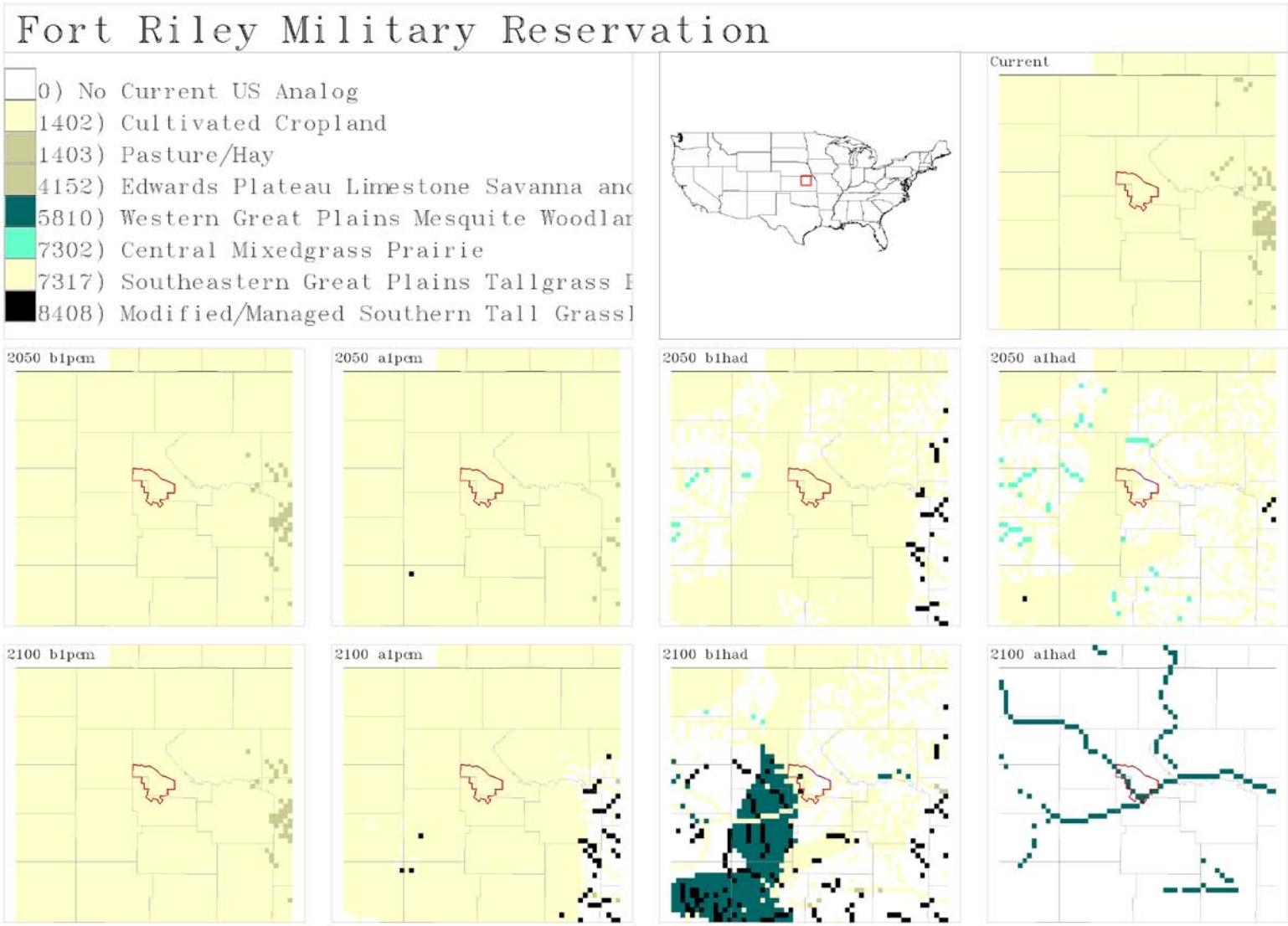



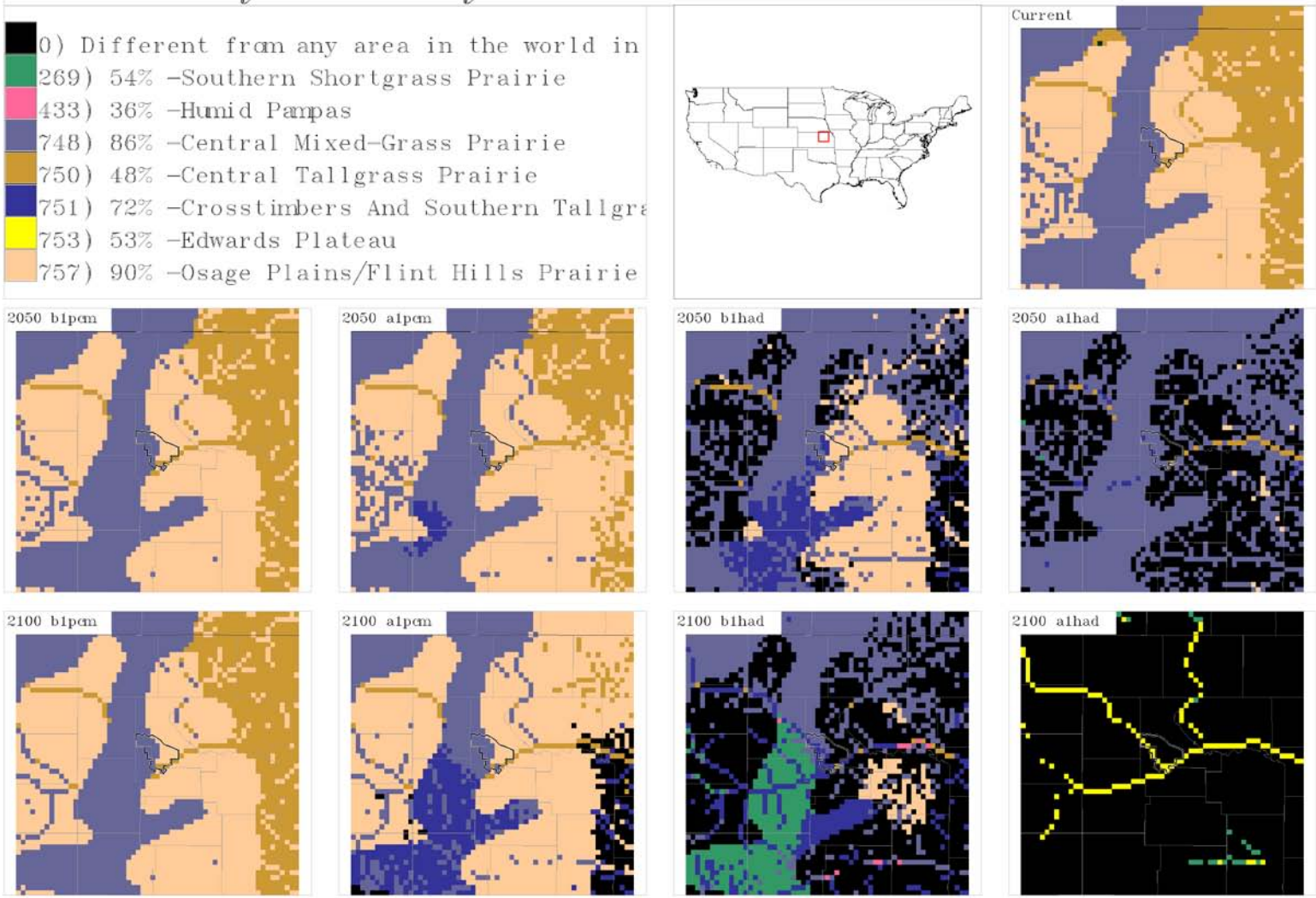



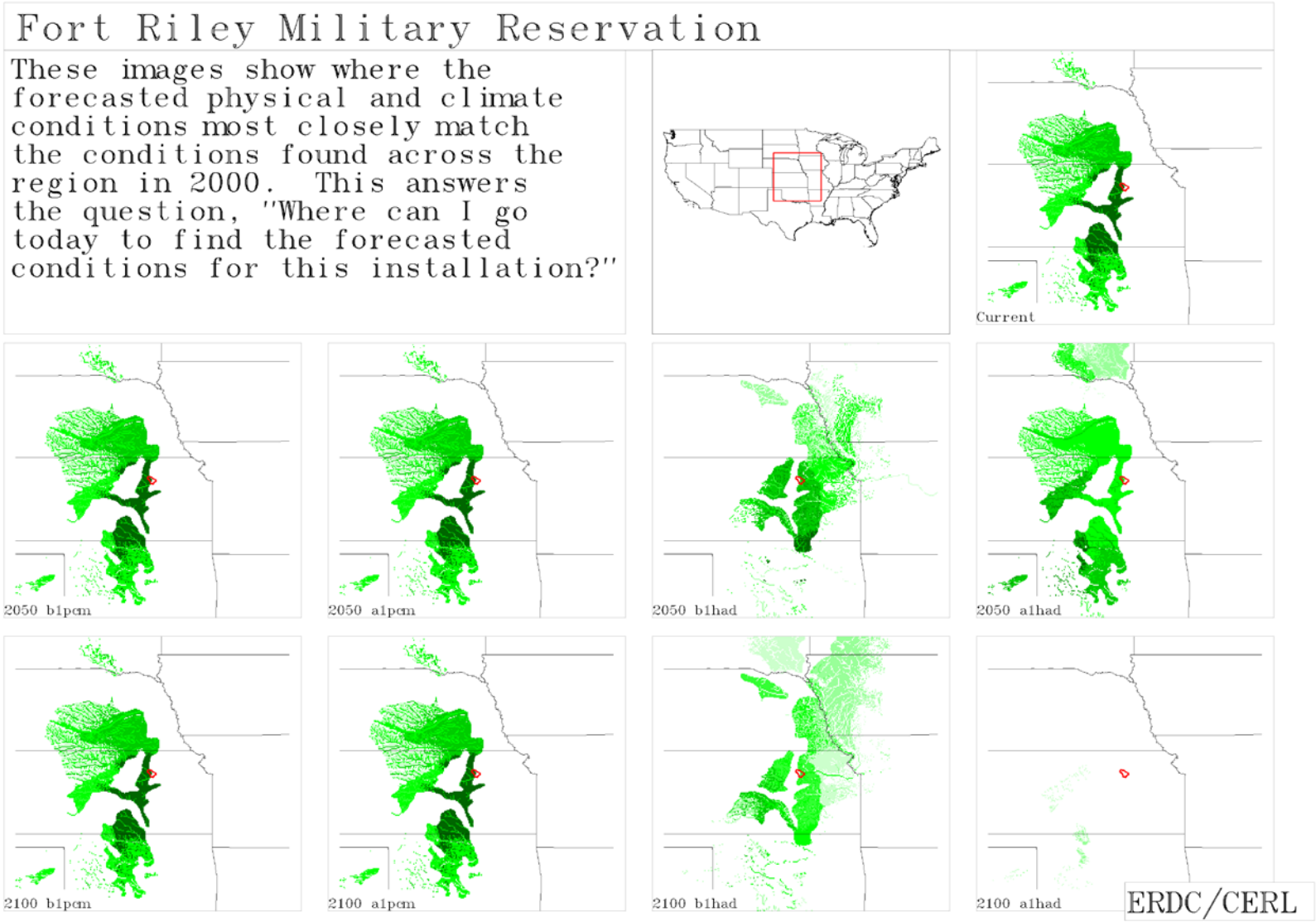



**Fort Riley Military Reservation**


Fort Riley Military Reservation
0) No Current US Analog
1402) Cultivated Cropland
1403) Pasture/Hay
4152) Edwards Plateau Limestone Savanna and
5810) Western Great Plains Mesquite Woodlar
7302) Central Mixedgrass Prairie
7317) Southeastern Great Plains Tallgrass P
8408) Modified/Managed Southern Tall Grassl
Current
2050 b1pcm
2050 a1pcm
2050 b1had
2050 a1had
2100 b1pcm
2100 a1pcm
2100 b1had
2100 a1had

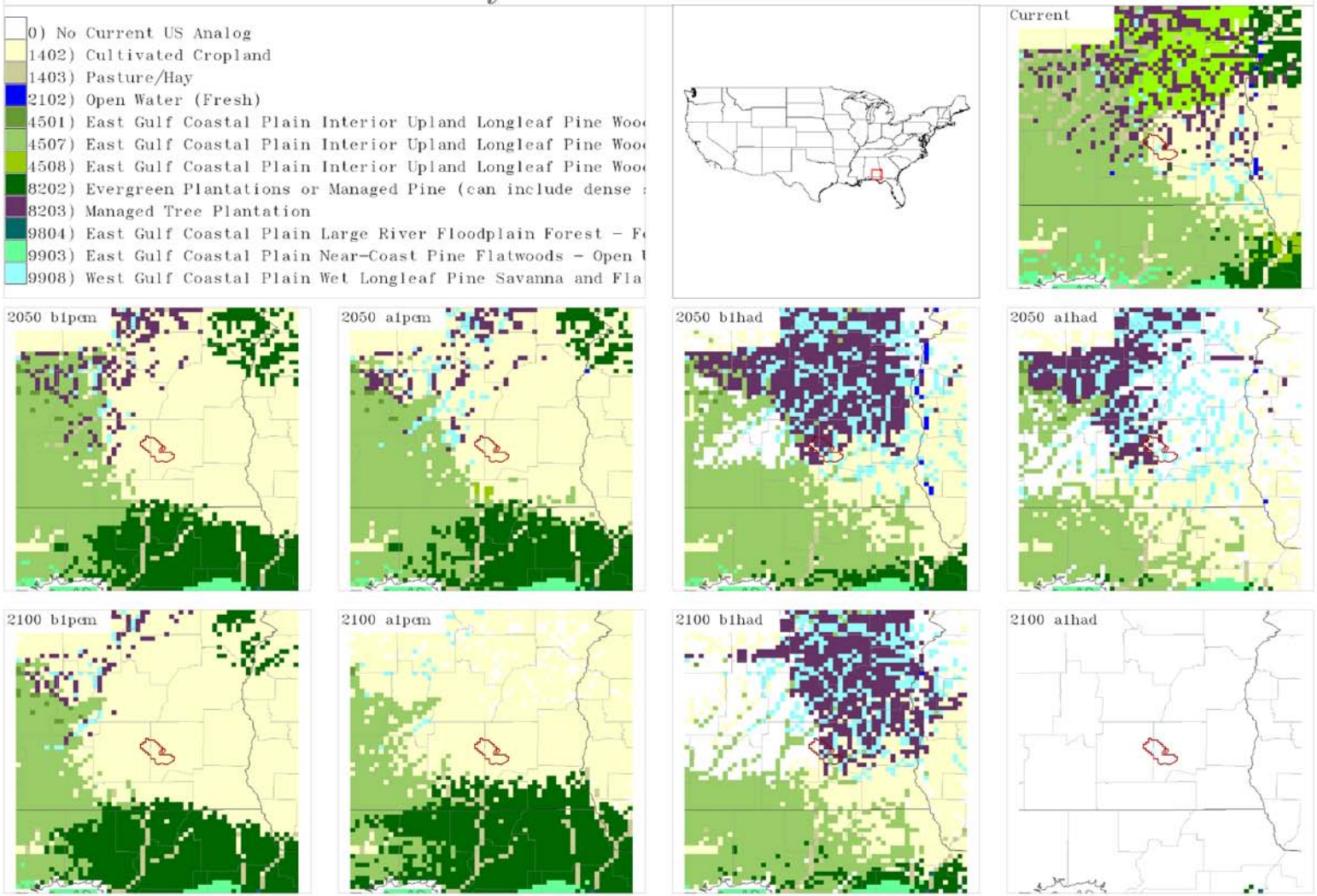
# Fort Riley Military Reservation



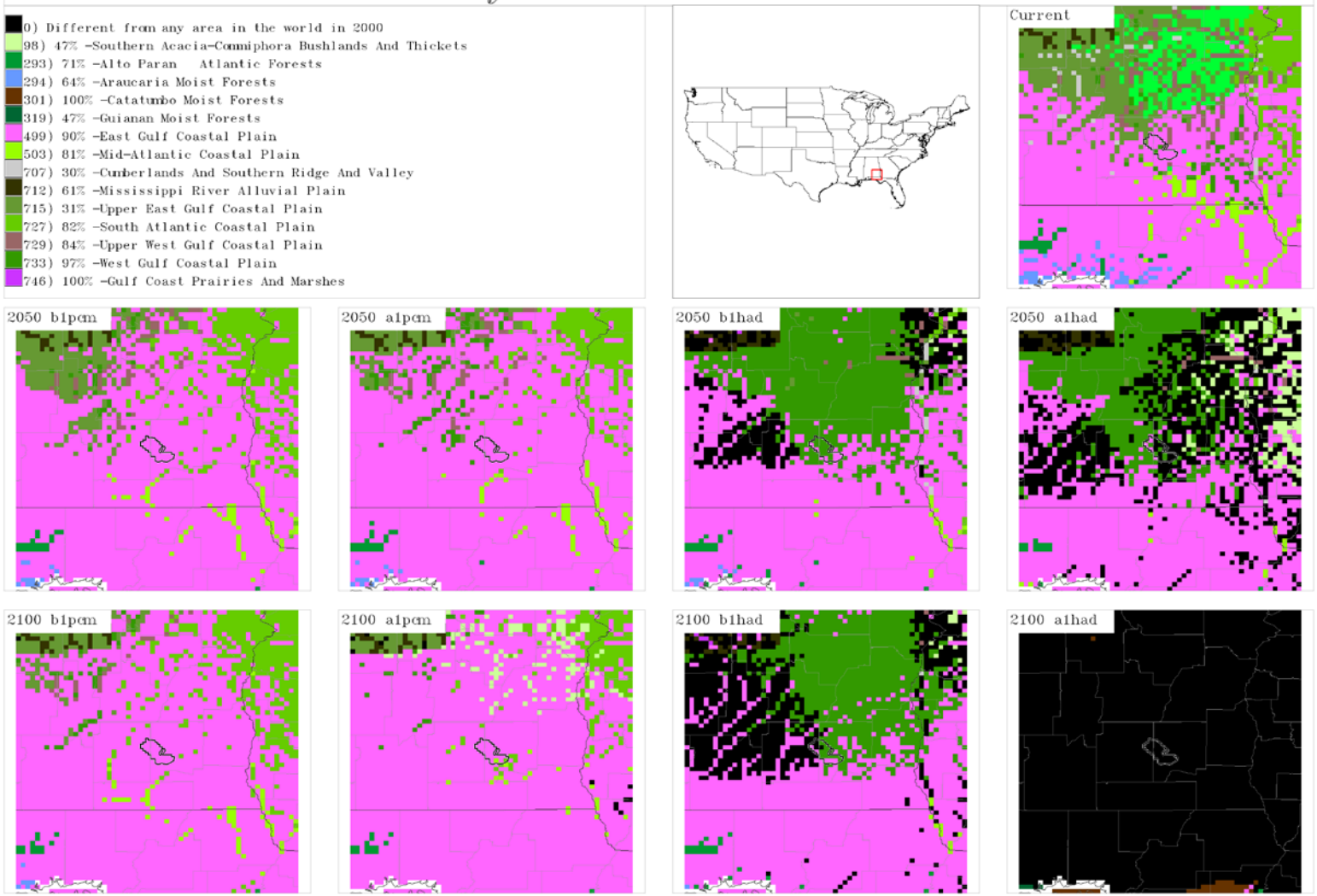


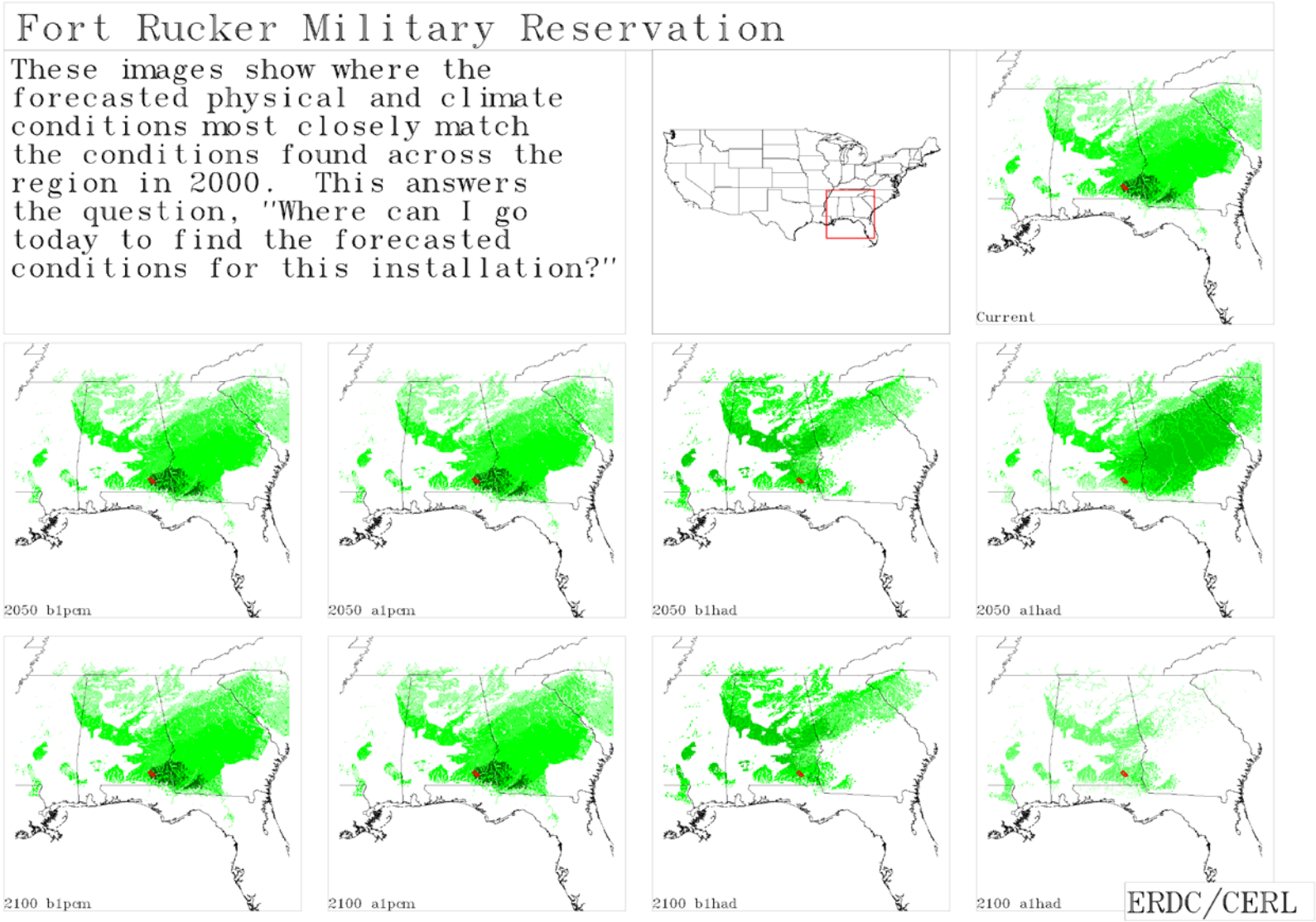

**Fort Rucker Military Reservation**

# Fort Rucker Military Reservation



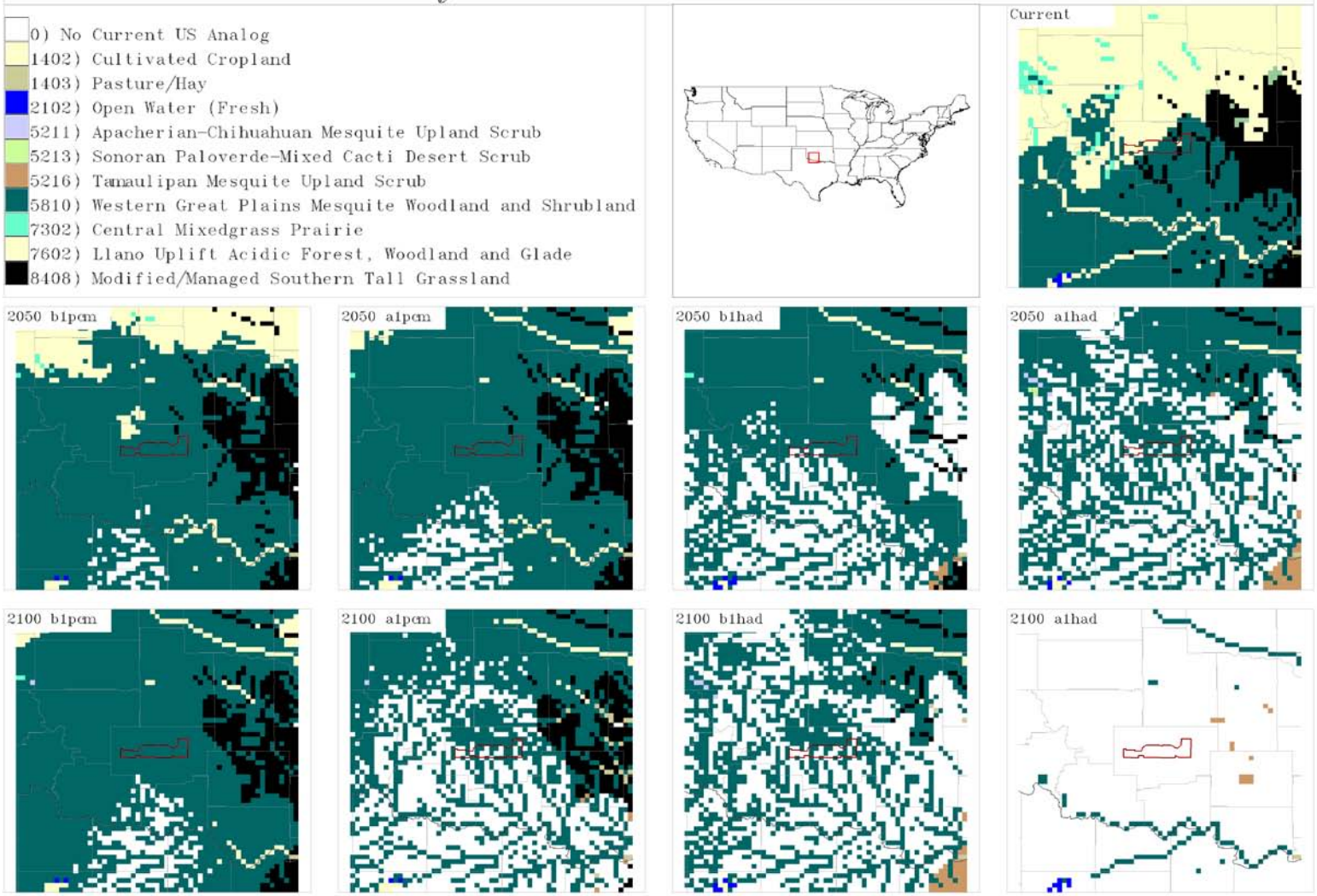
# Fort Rucker Military Reservation



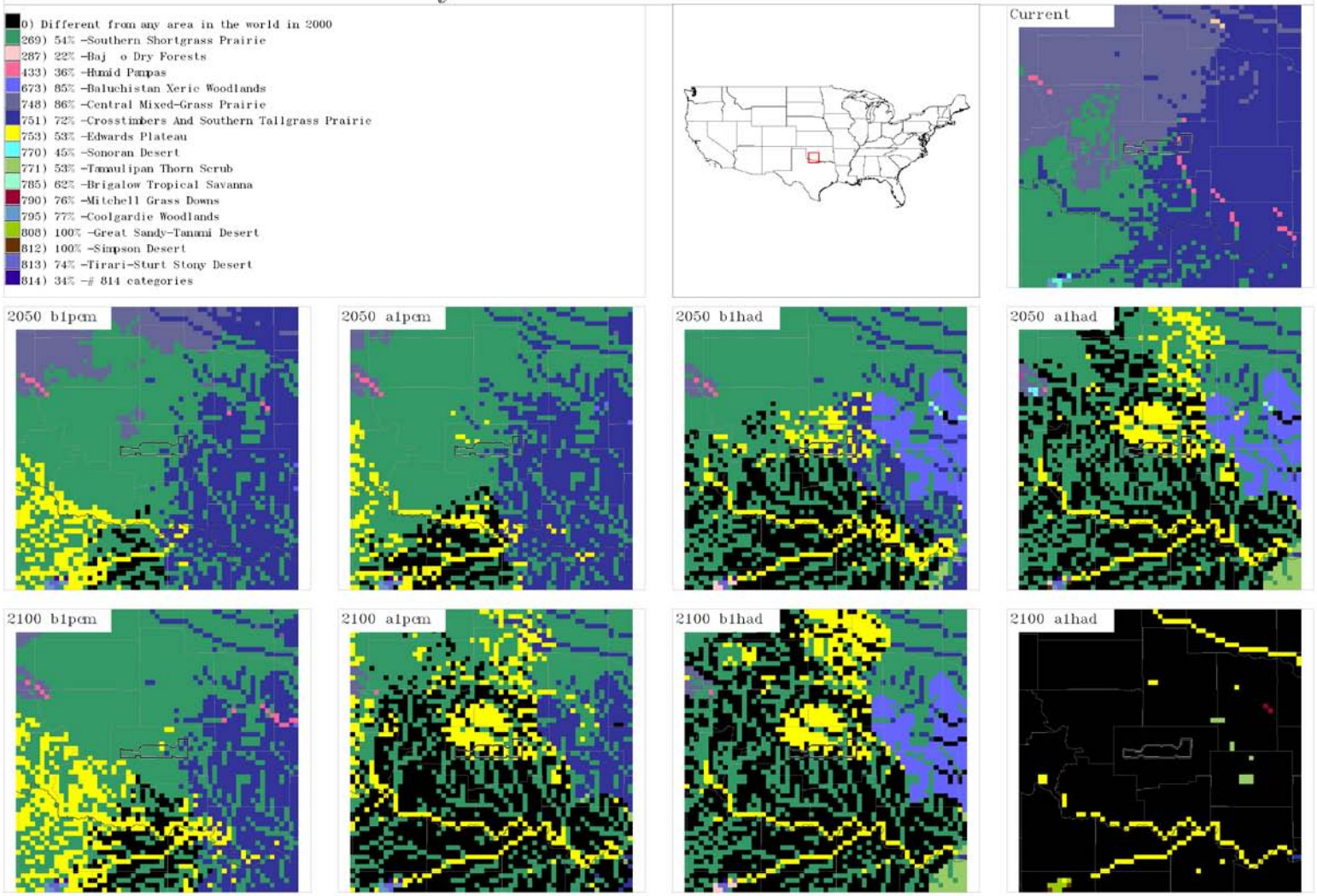


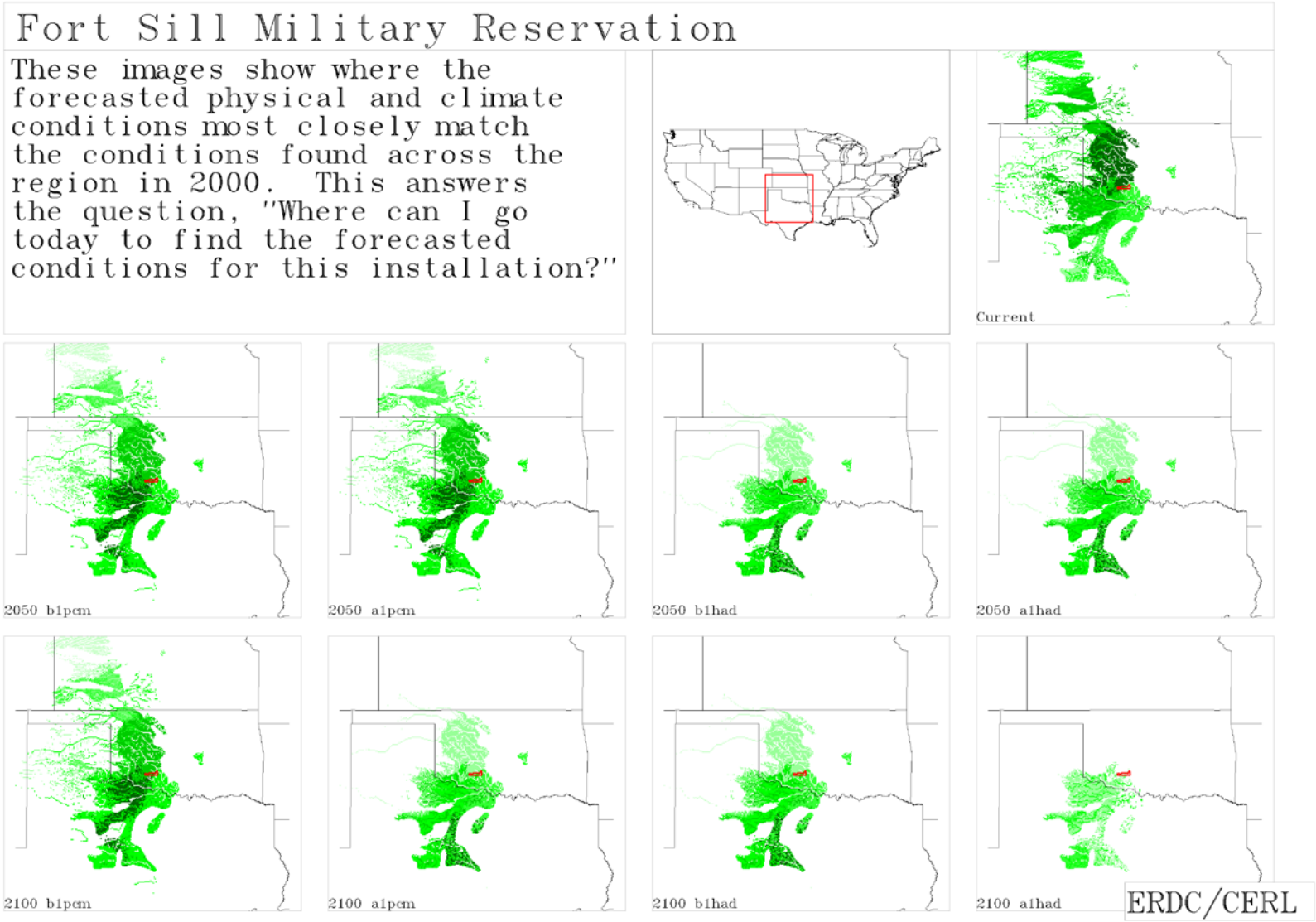

**Fort Sill Military Reservation**

# Fort Sill Military Reservation



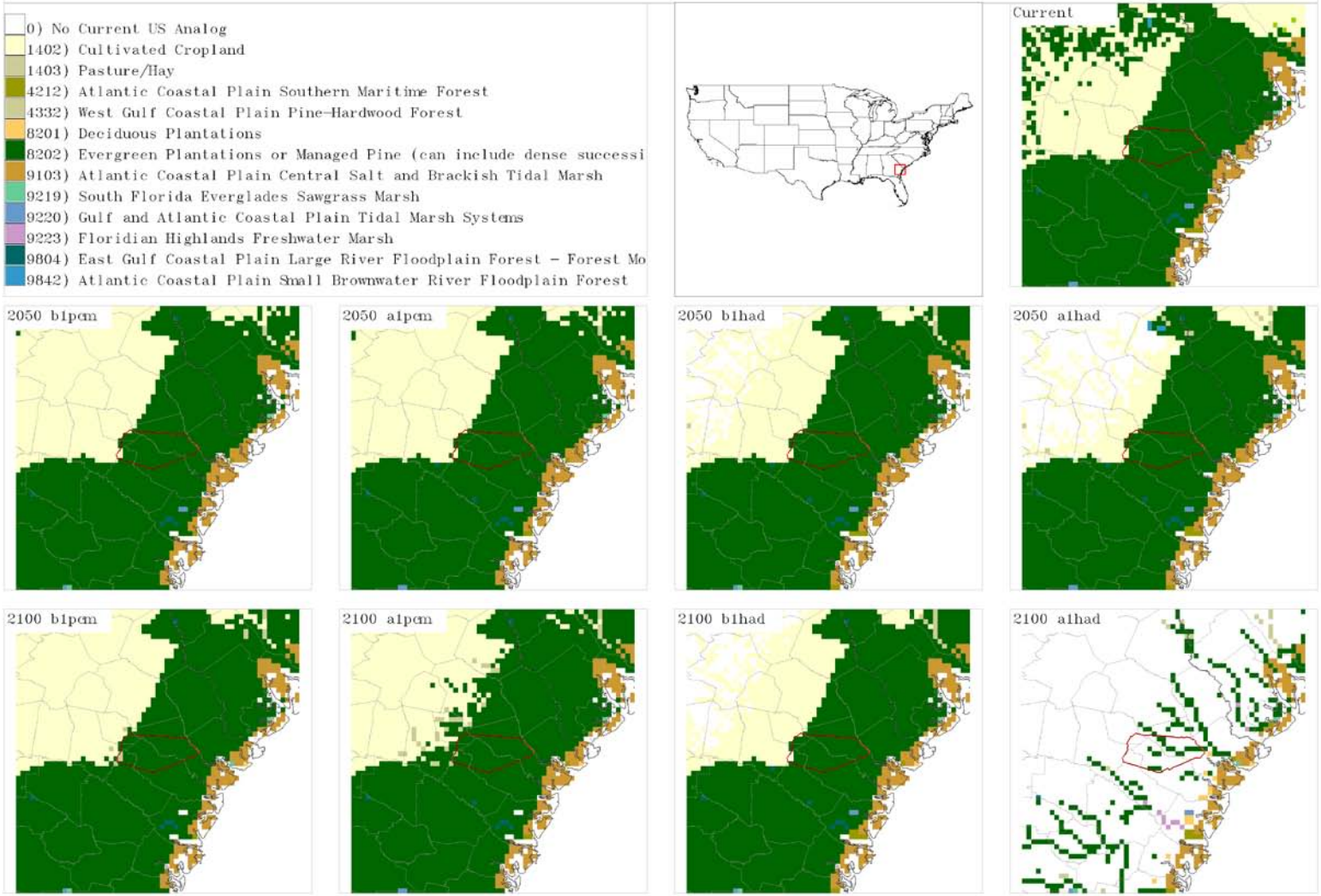
# Fort Sill Military Reservation



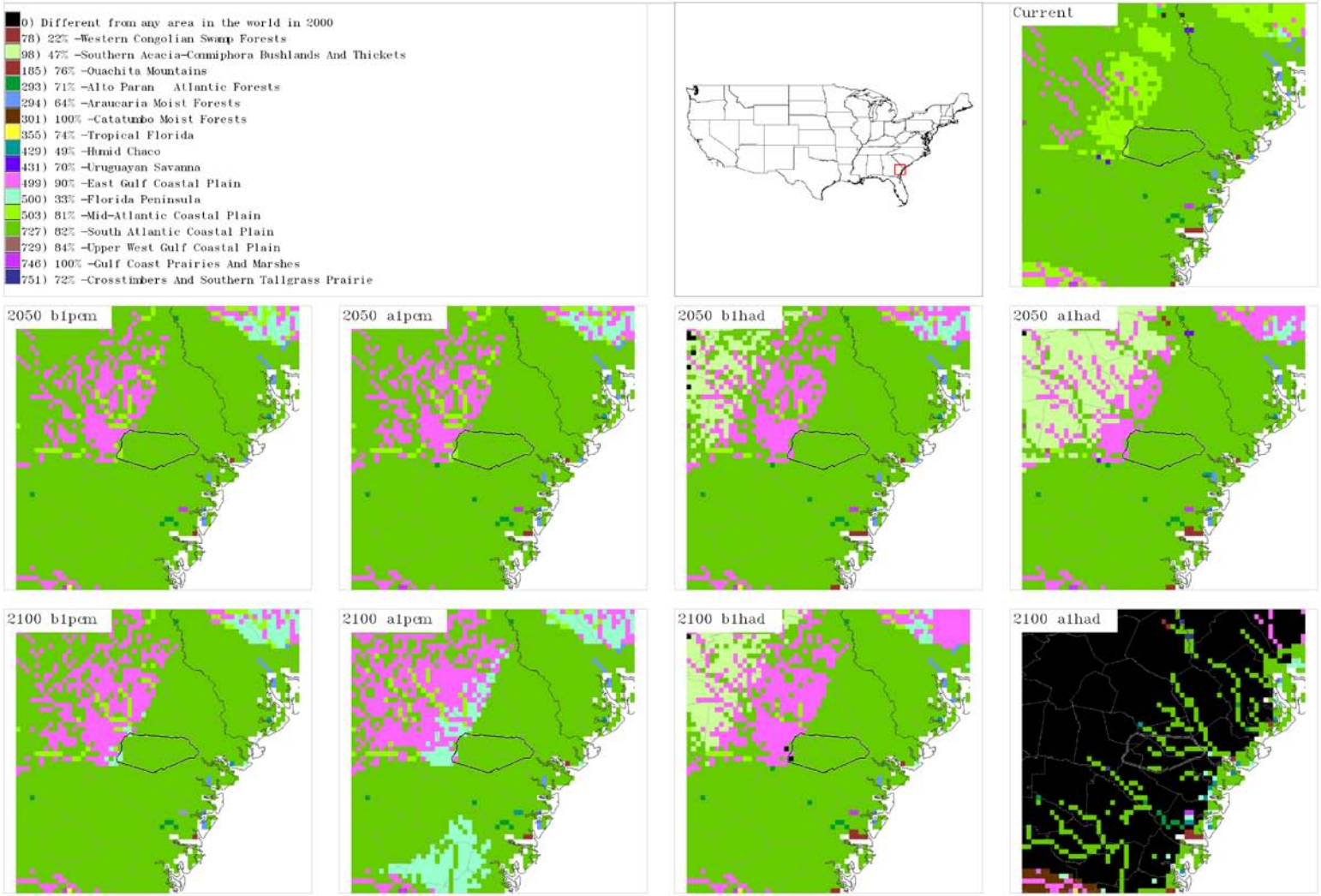


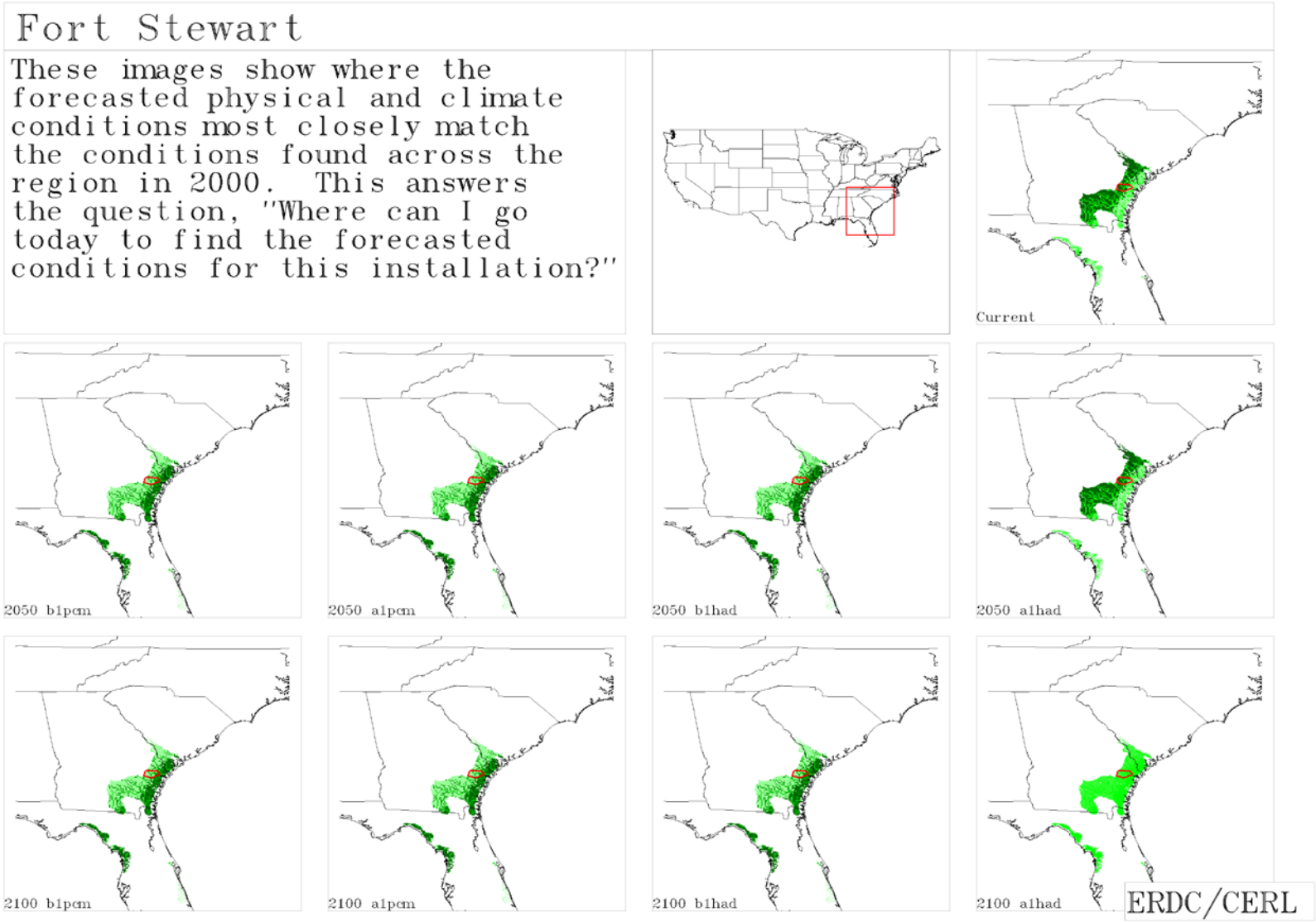

## Fort Stewart

# Fort Stewart



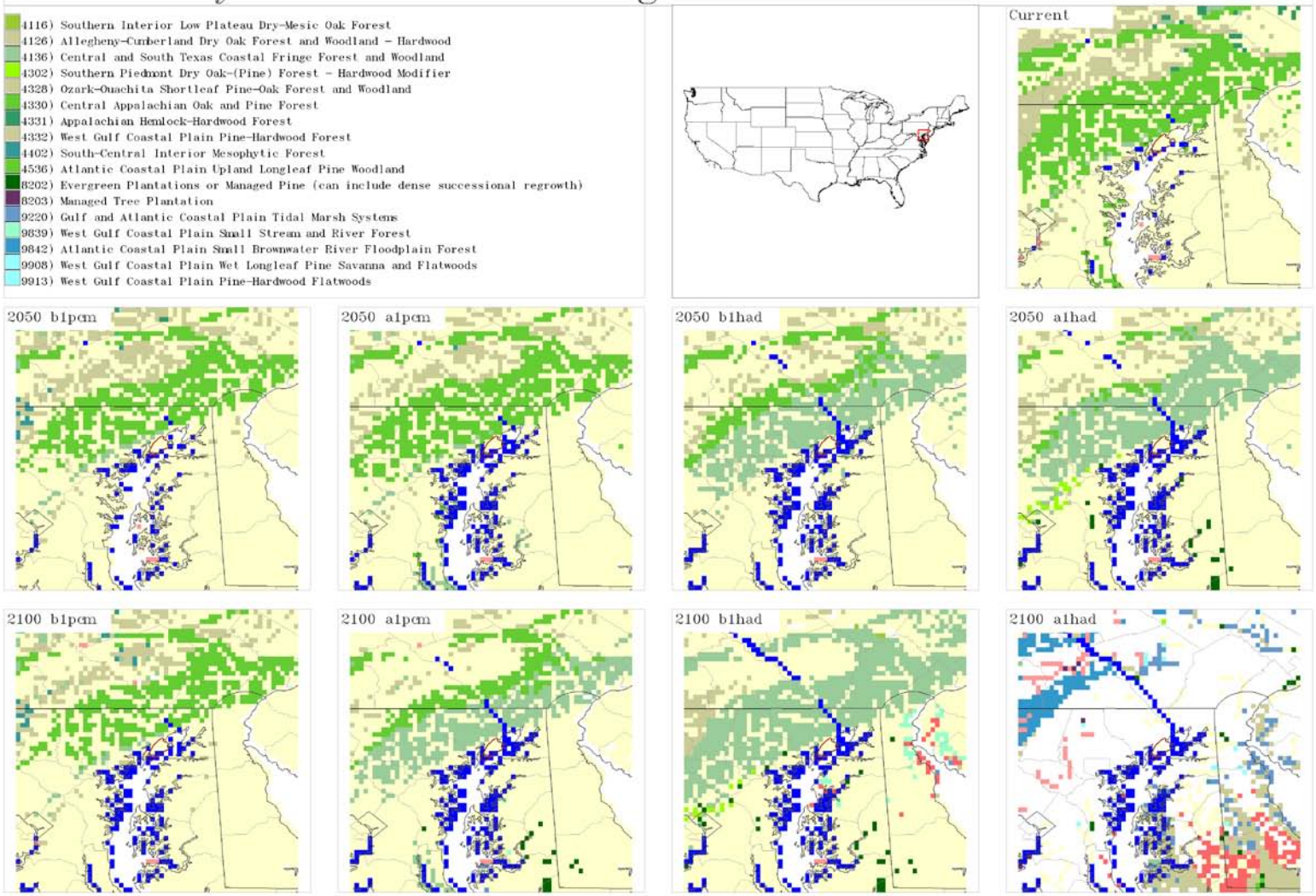
# Fort Stewart



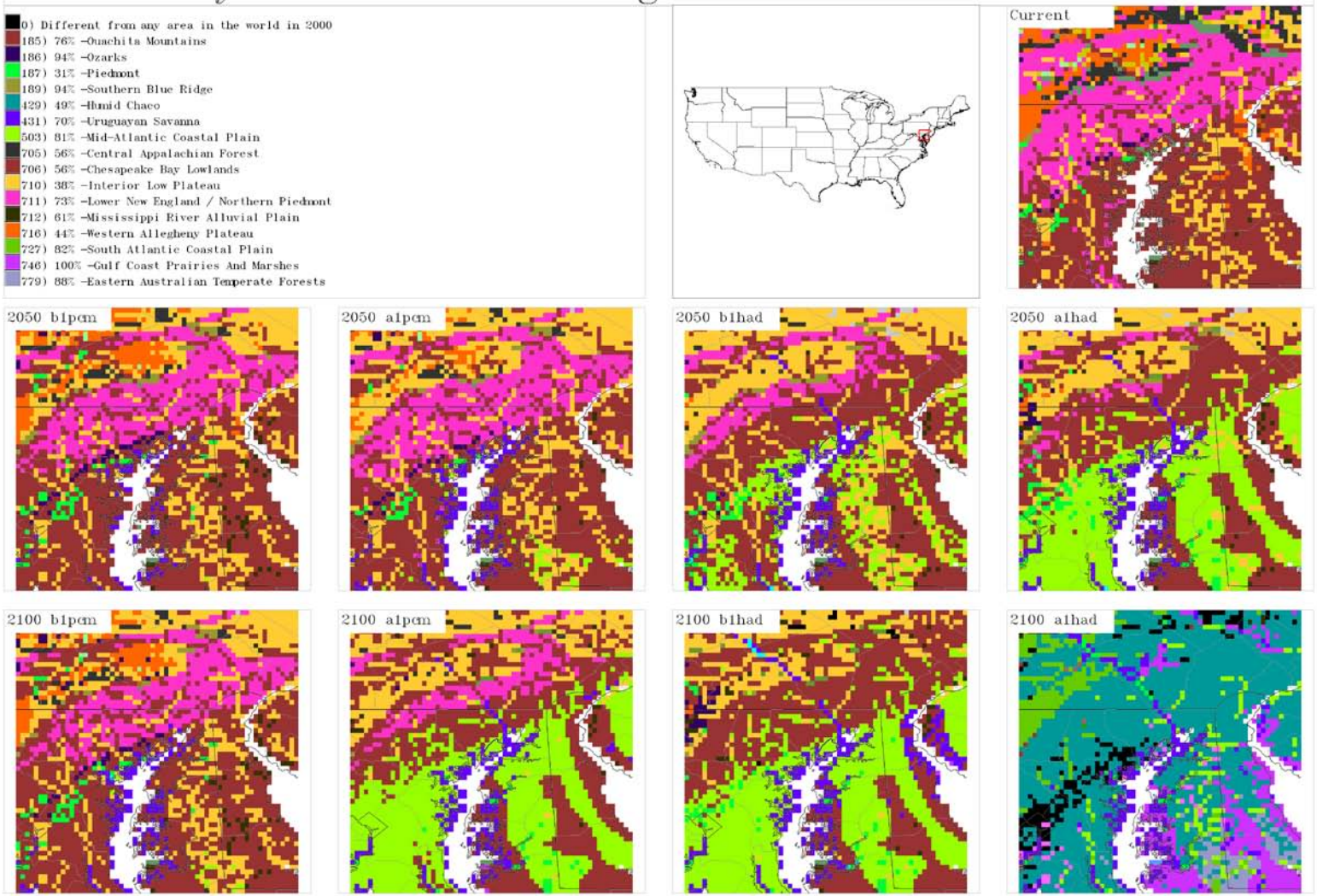


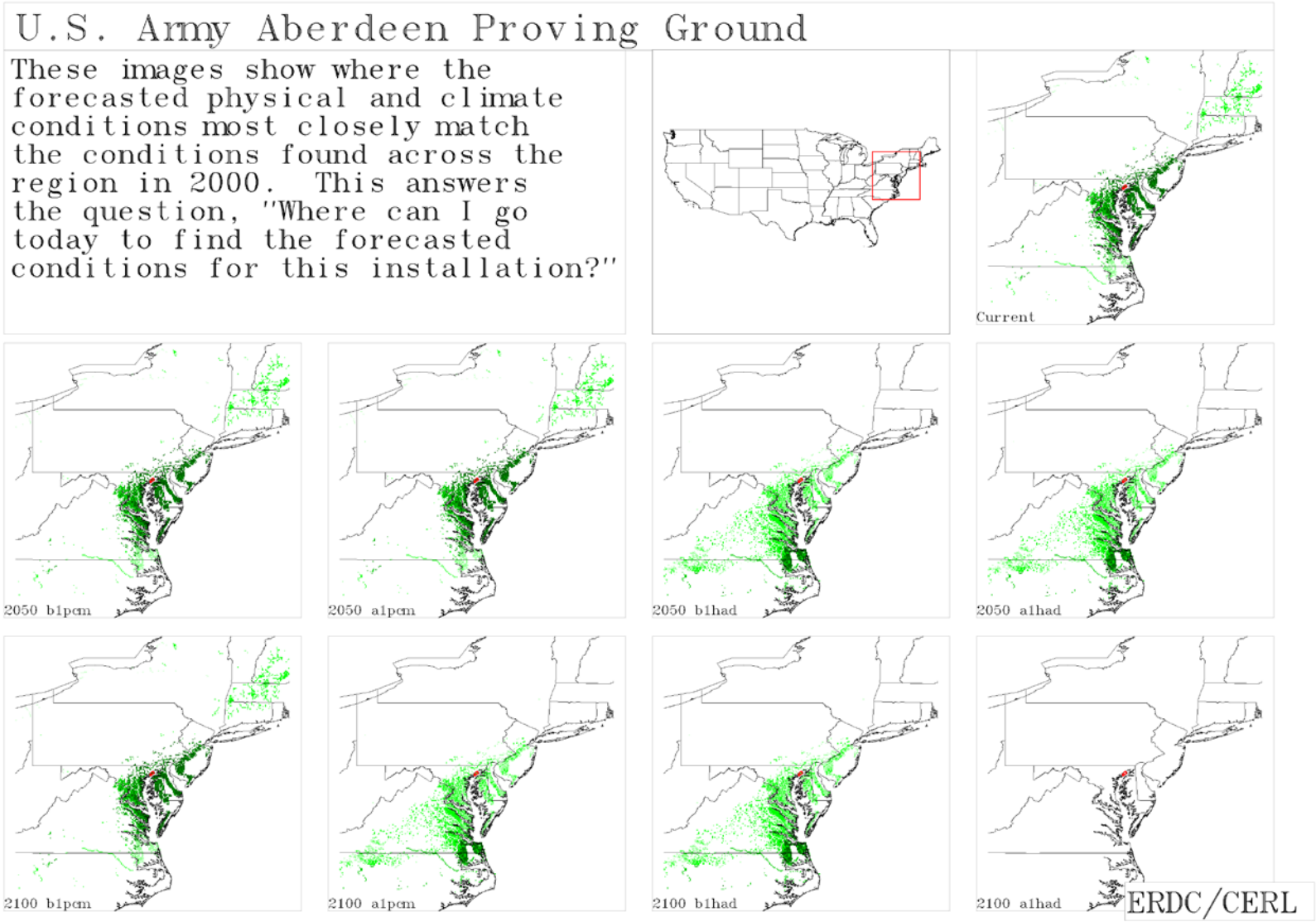

**U.S. Army Aberdeen Proving Ground**

# U.S. Army Aberdeen Proving Ground



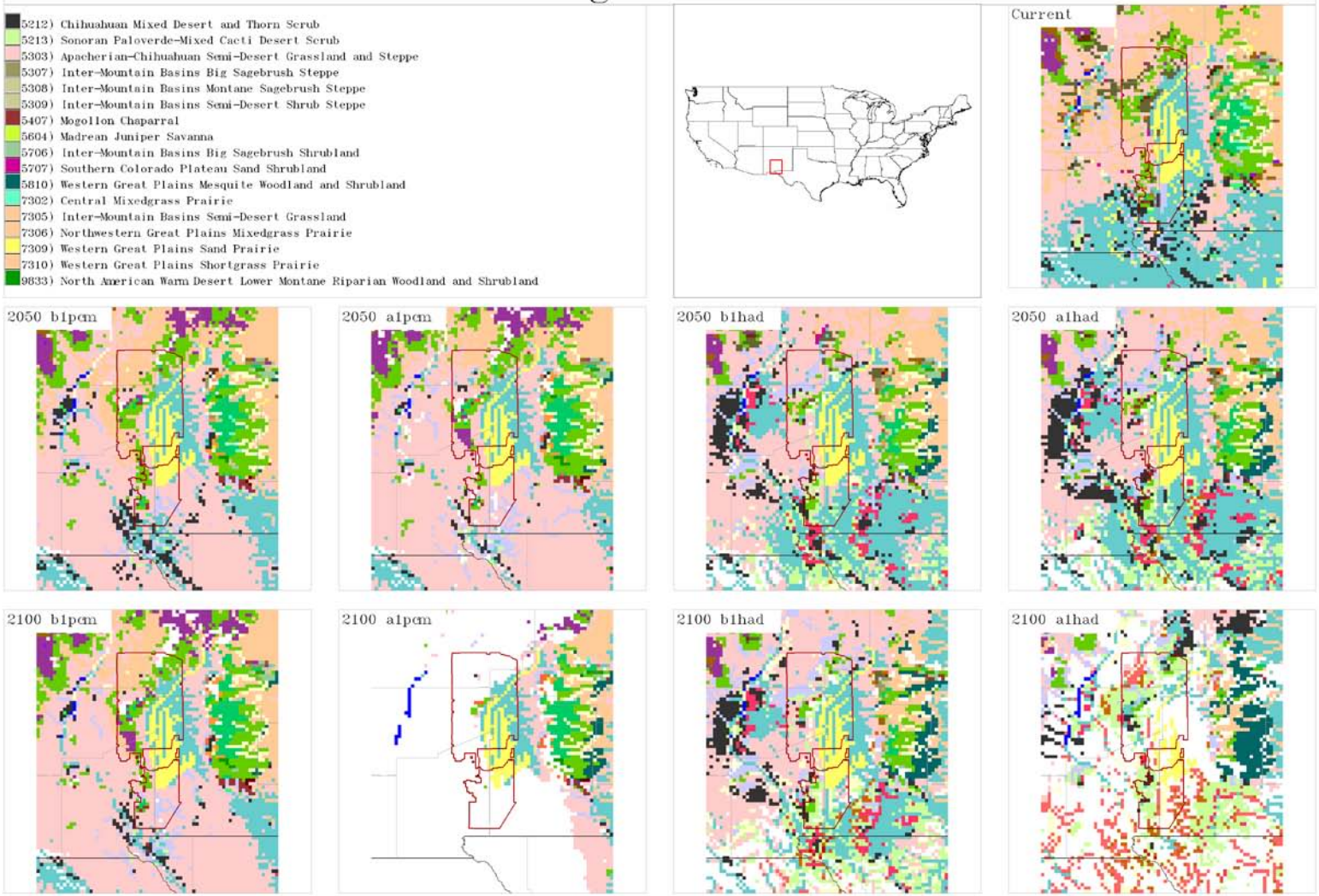
# U.S. Army Aberdeen Proving Ground



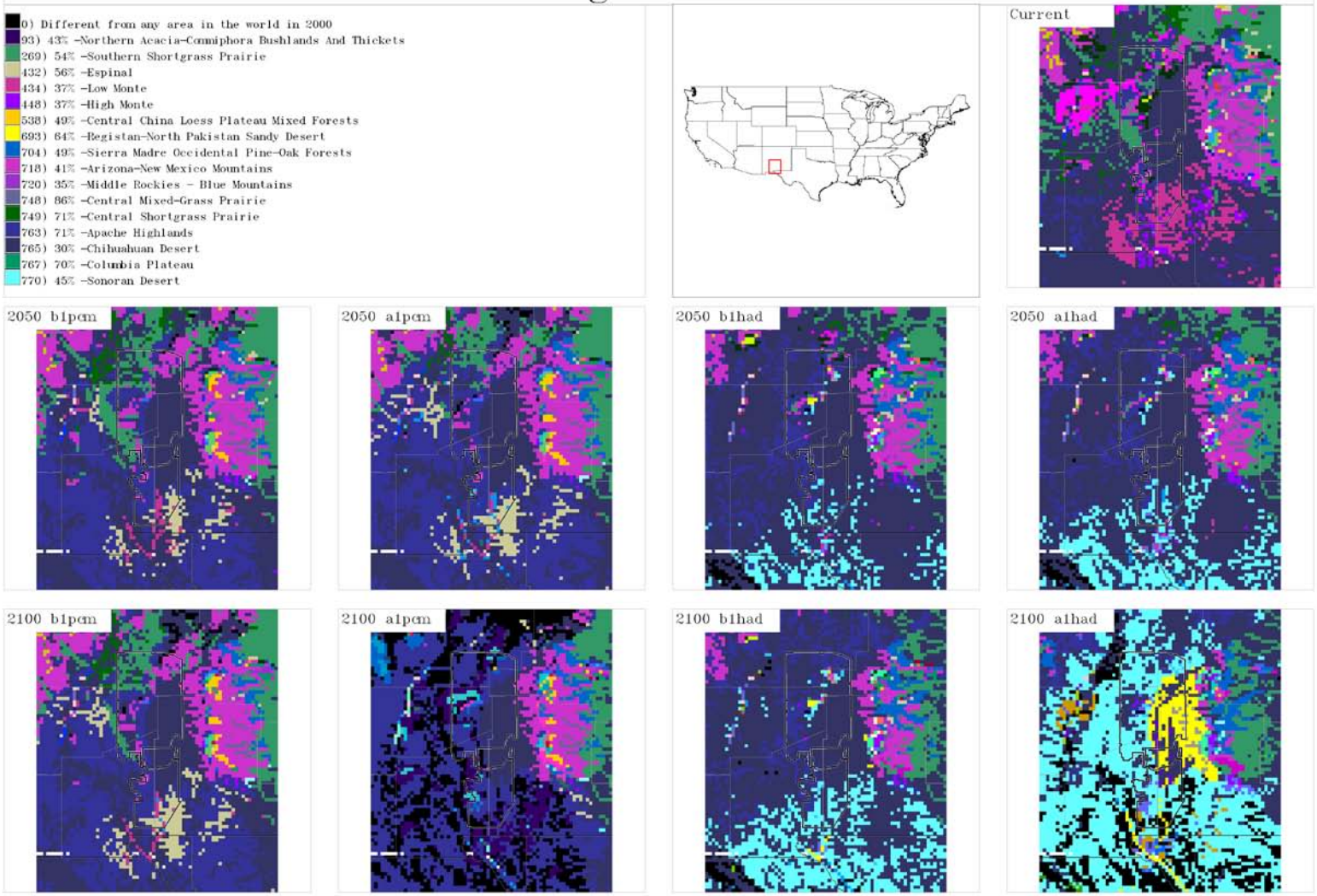


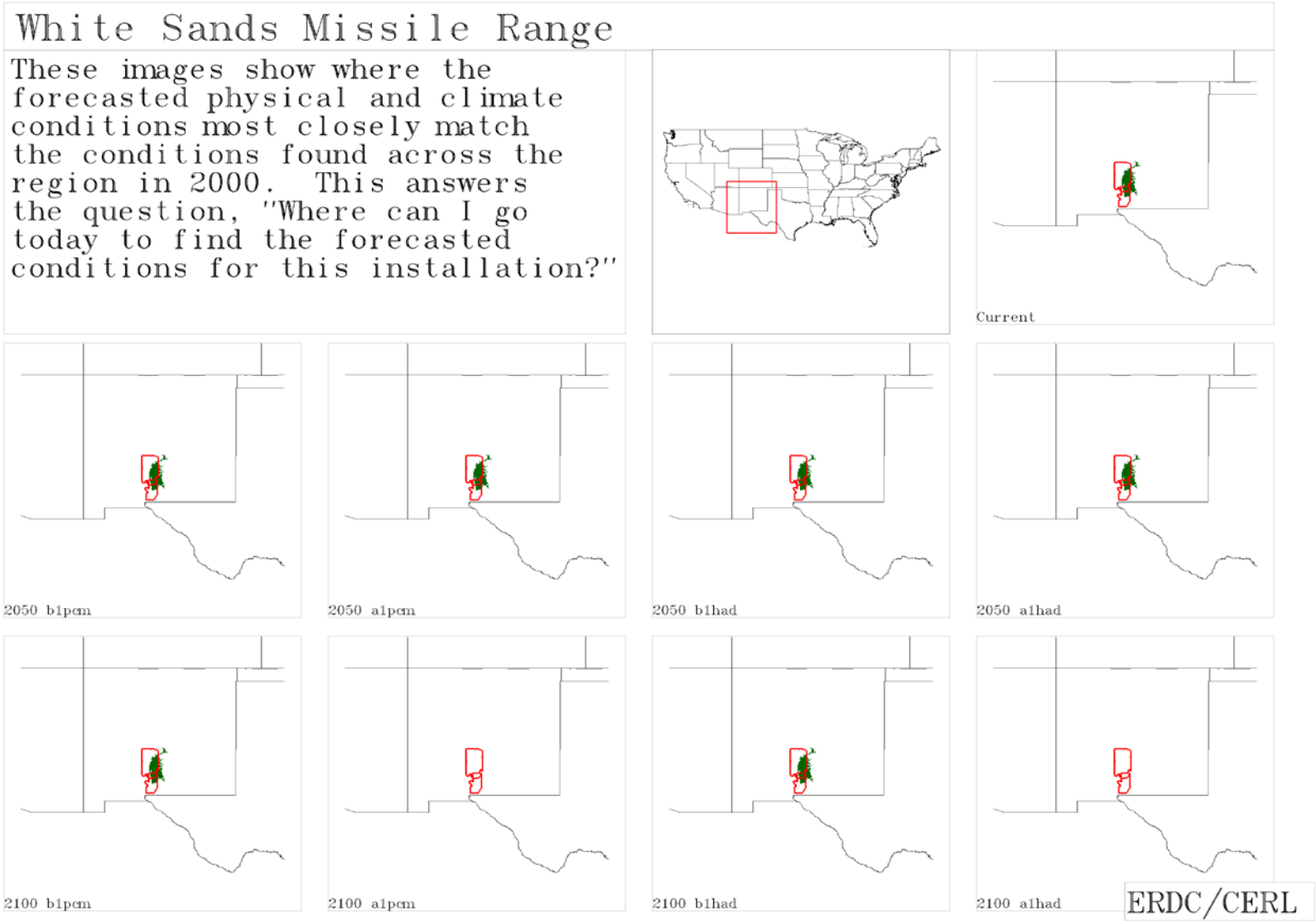

**White Sands Missile Range**

# White Sands Missile Range



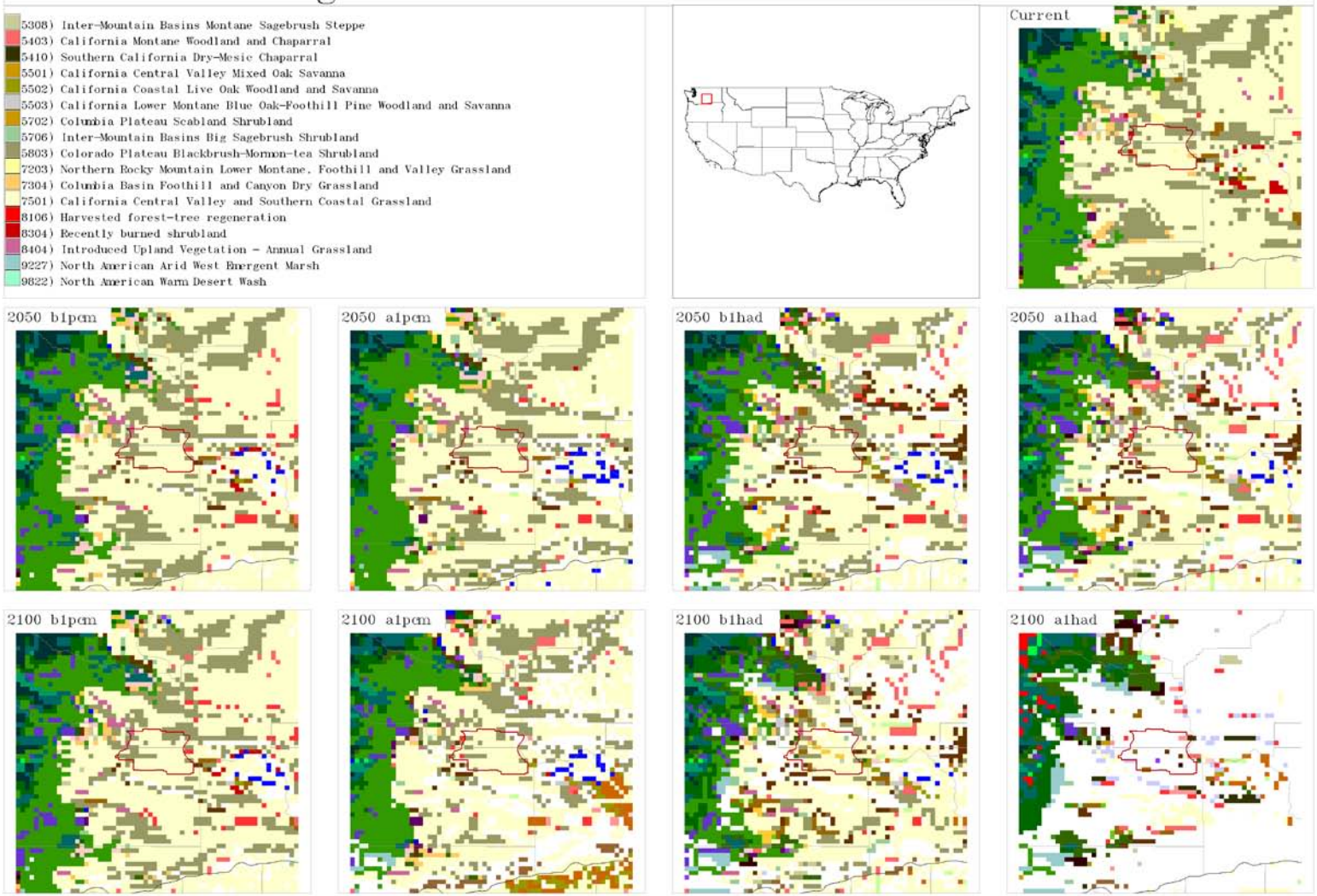
# White Sands Missile Range



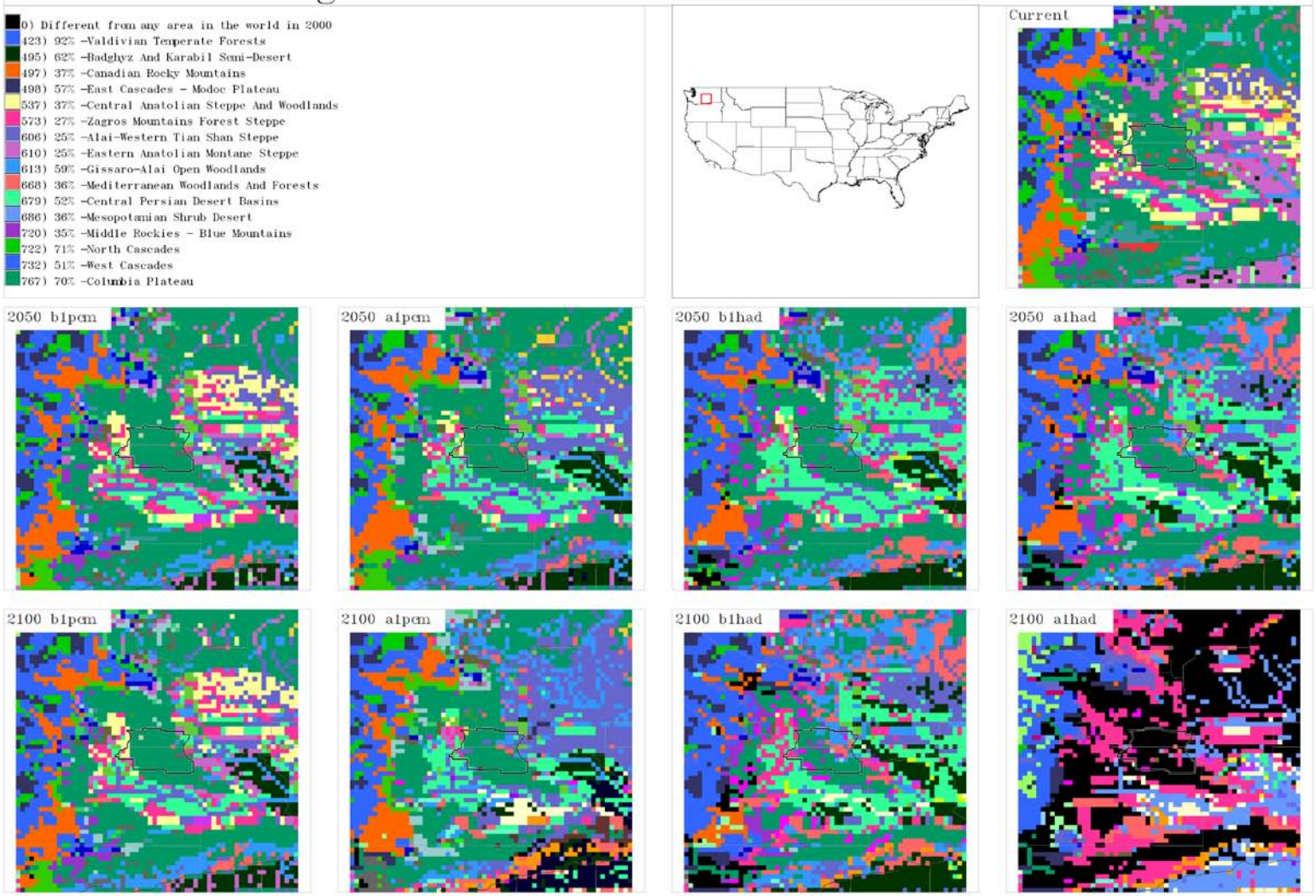


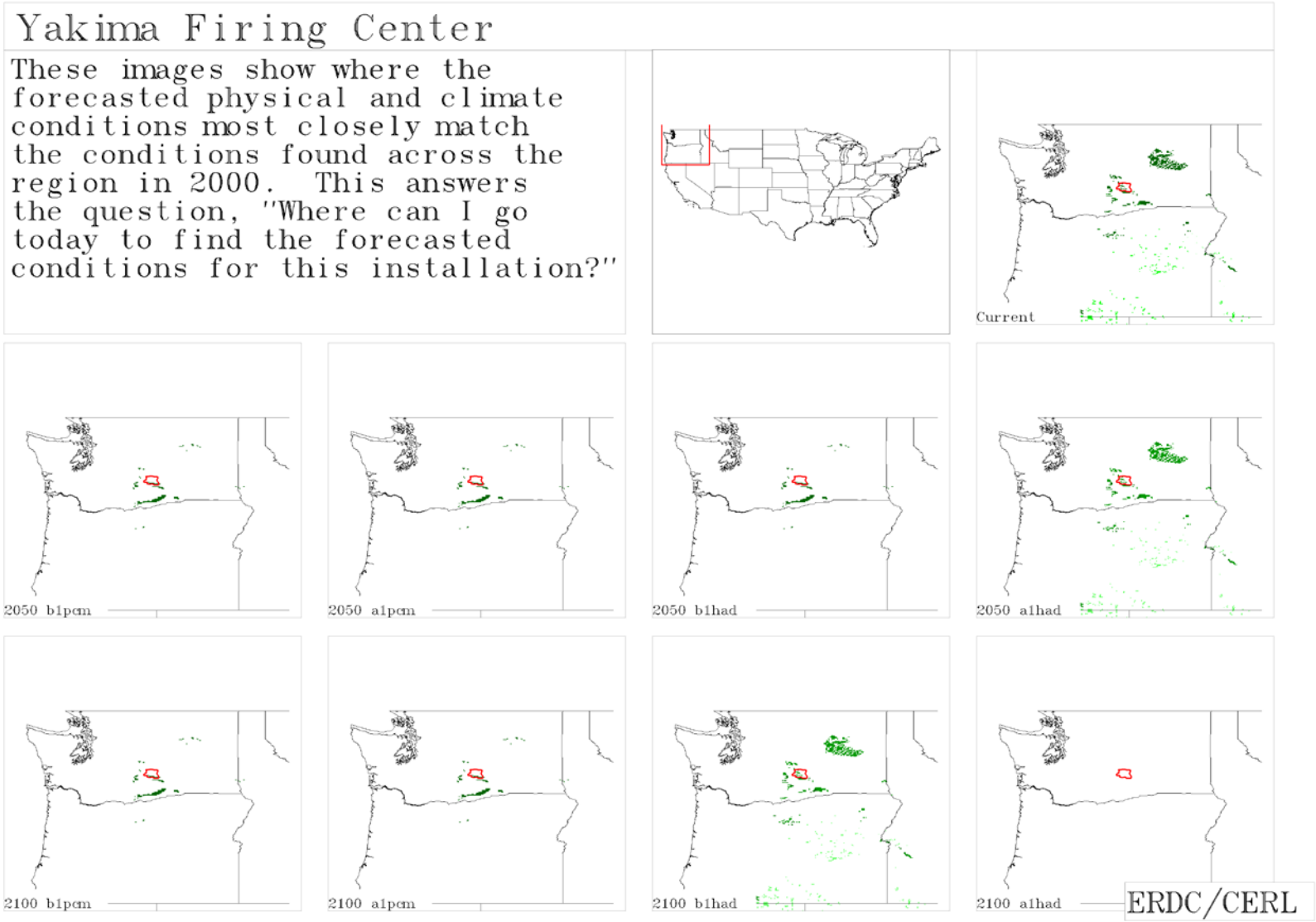

## Yakima Firing Center

# Yakima Firing Center



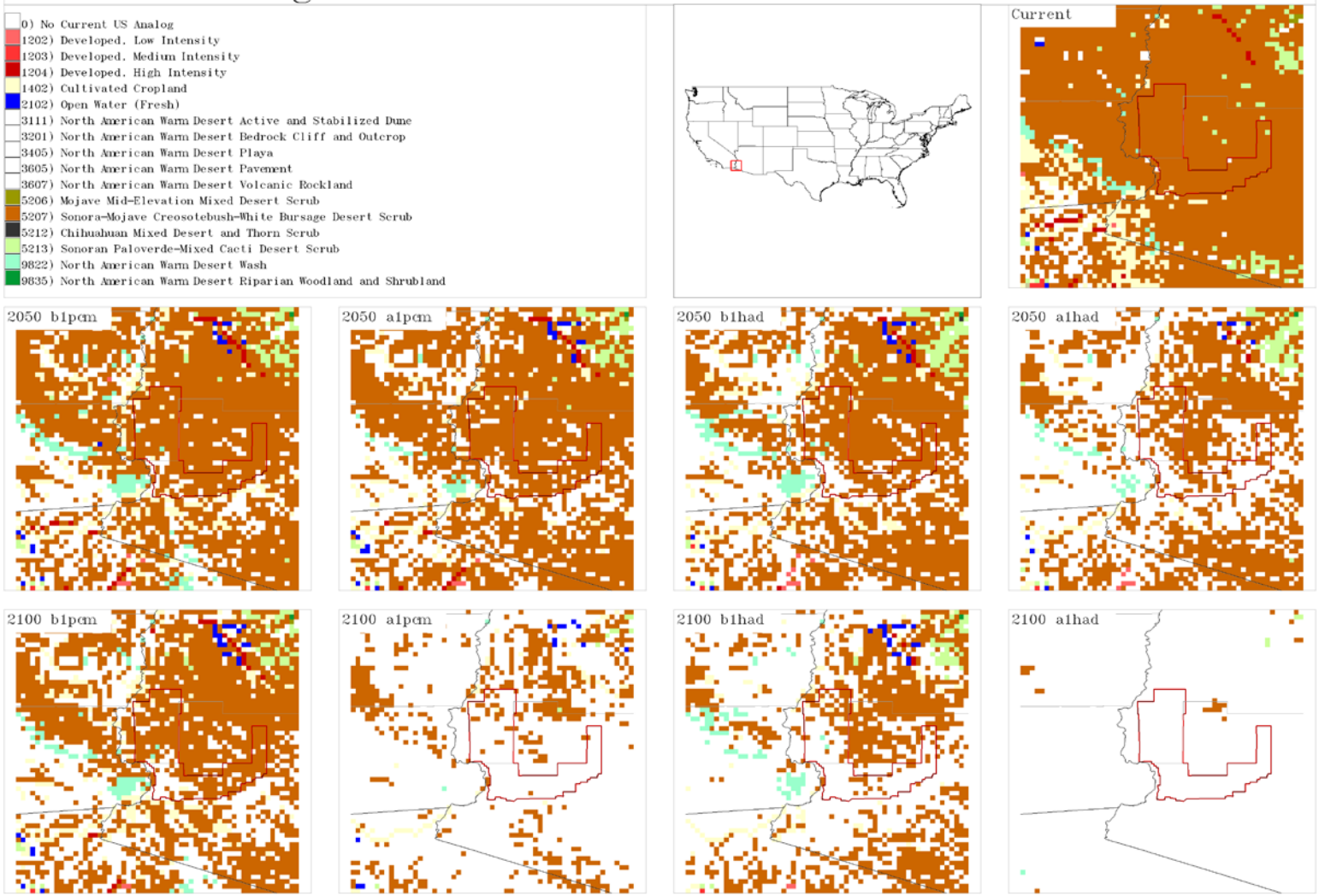
# Yakima Firing Center



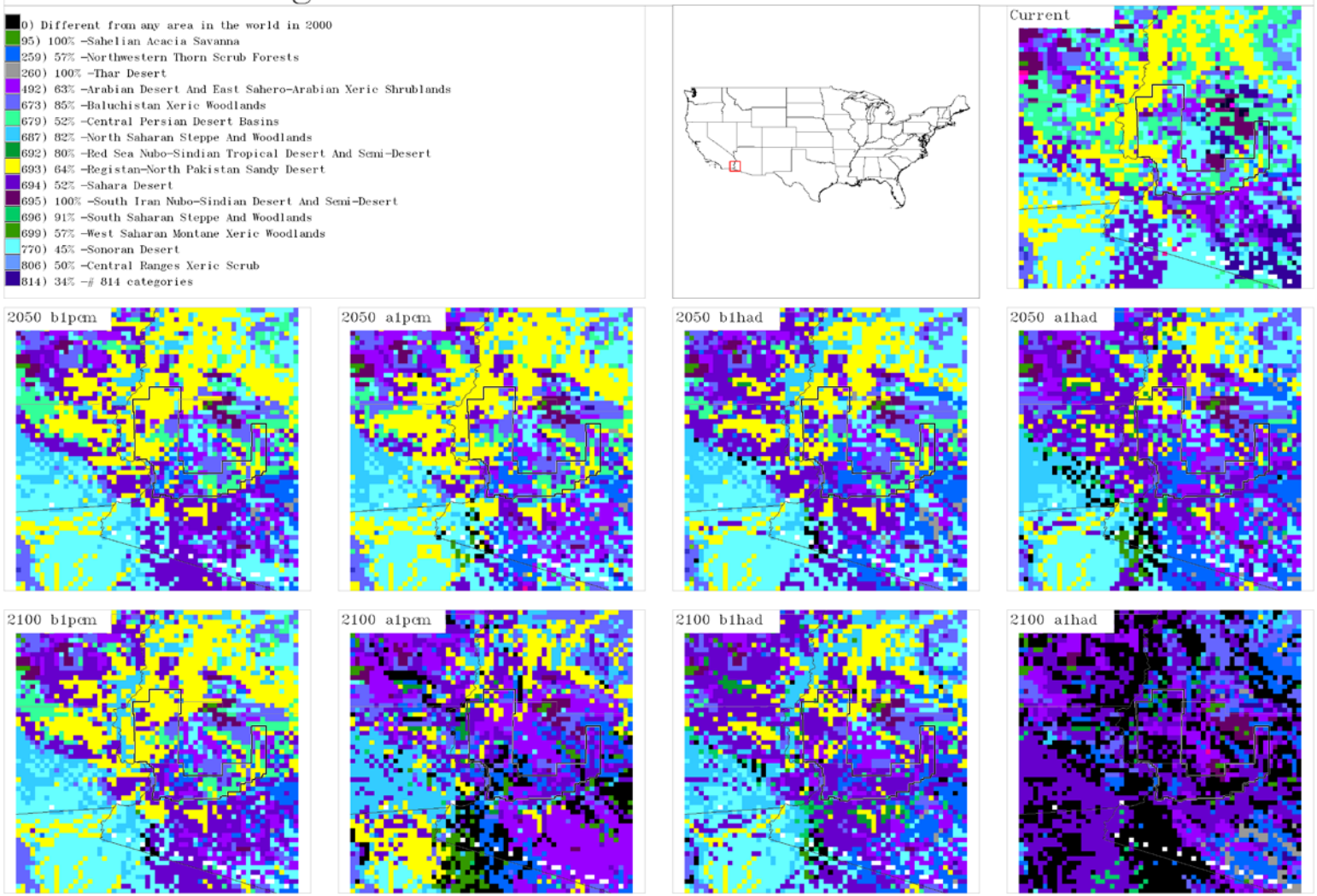



## Yuma Proving Ground

# Yuma Proving Ground

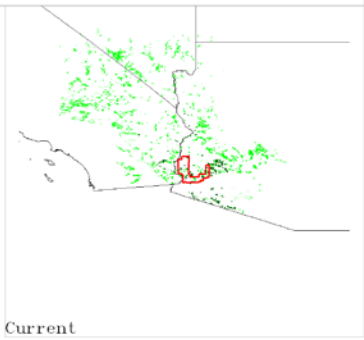


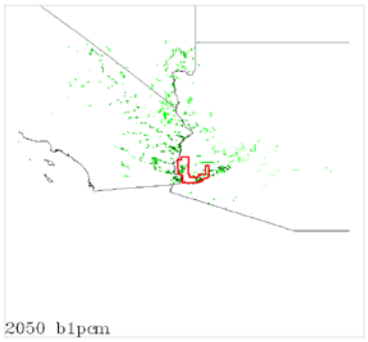
# Yuma Proving Ground

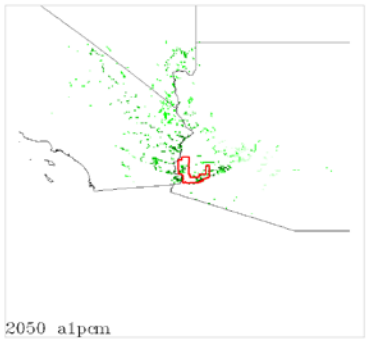


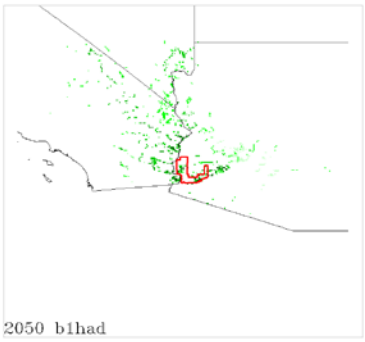
# Yuma Proving Ground

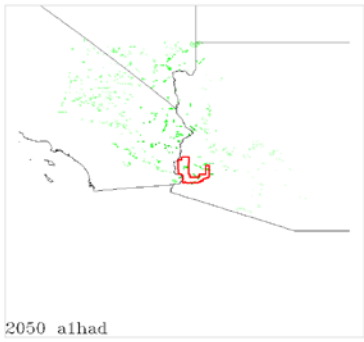
These images show where the forecasted physical and climate conditions most closely match the conditions found across the region in 2000. This answers the question, "Where can I go today to find the forecasted conditions for this installation?"

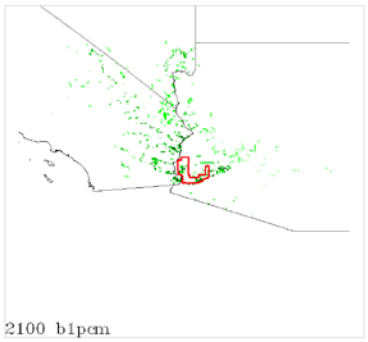


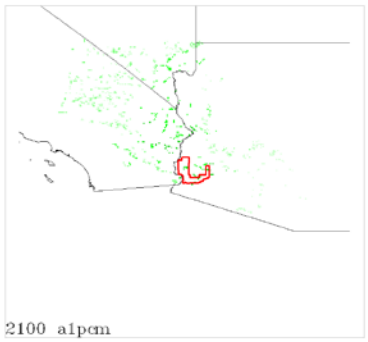



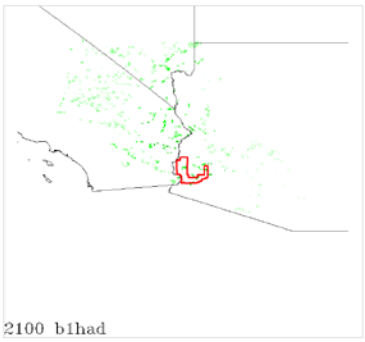



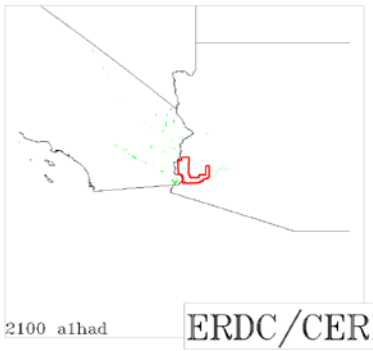




ERDC/CERL

# Appendix C: Ranking Army Installations

Which installations are most at-risk for change due to the consequences of potential ecosystem shift? To rank-order installations, the boundary of each installation was used to "cookie-cutter" into the current and future maps over the eight future GAP-based maps to tabulate the ecosystem type and amount of each type. For each future map, the percent of the installation that still held the current ecosystem types was calculated. The percentage across all eight future maps was then averaged and used to rank-order the installations. The following table lists all of the Army installations ranked by their "risk for change," beginning with the least changeable and ending with the installations likely to be most dramatically affected.

The change counts for each of the model/scenario/time combination are listed in the columns with the average of these (not listed) used to sort the table. The color-breaks are arbitrarily set at 80 and 50 percent.

| Legend: |
|---|
| Percent Habit Unchanged By Climate Change |
| 80-100% unchanged |
| 50-80% unchanged |
| 0-50% unchanged |

| | | PCM Model | | | | | Hadley Model | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Low Emissions | | High Emissions | | | Low Emissions | | High Emissions | |
| **Installation** | **Size (0.02 x 0.02) degree cells** | **PCM B1 2050** | **PCM B1 2080** | **PCM A1 2050** | **PCM A1 2080** | | **HAD B1 2050** | **HAD B1 2080** | **HAD A1 2050** | **HAD A1 2080** |
| Camp Adair Military Reservation | 2 | 100 | 100 | 100 | 100 | | 100 | 100 | 100 | 100 |
| Hunter Army Airfield | 77 | 100 | 100 | 100 | 100 | | 100 | 100 | 100 | 21 |
| **Fort Stewart** | 2294 | 100 | 97 | 100 | 95 | | 100 | 99 | 100 | 14 |
| Arlington National Cemetery | 4 | 100 | 100 | 100 | 100 | | 100 | 100 | 100 | 0 |
| Army Reserve Outdoor Training Area | 4 | 100 | 100 | 100 | 100 | | 100 | 100 | 100 | 0 |
| Army Training Area | 20 | 100 | 100 | 100 | 100 | | 100 | 100 | 100 | 0 |
| Globecom Radio Receiving Station | 15 | 100 | 100 | 100 | 100 | | 100 | 100 | 100 | 0 |
| Kearney Rifle Range | 8 | 100 | 100 | 100 | 100 | | 100 | 100 | 100 | 0 |
| LaPorte Outdoor Training Facility | 6 | 100 | 100 | 100 | 100 | | 100 | 100 | 100 | 0 |
| Malabar Transmitter Annex | 4 | 100 | 100 | 100 | 100 | | 100 | 100 | 100 | 0 |
| US Army Reserve Center | 4 | 100 | 100 | 100 | 100 | | 100 | 100 | 100 | 0 |
| Florence Military Reservation | 56 | 100 | 100 | 89 | 79 | | 89 | 89 | 89 | 63 |
| Camp Grayling Military Reservation | 2451 | 97 | 97 | 97 | 97 | | 97 | 94 | 97 | 13 |
| Savanna Army Depot (Scheduled to close) | 228 | 100 | 100 | 100 | 95 | | 97 | 95 | 95 | 0 |
| **Fort Irwin** | 5112 | 91 | 91 | 95 | 88 | | 90 | 86 | 92 | 46 |
| Fort Belvoir Military Reservation | 110 | 100 | 100 | 97 | 90 | | 90 | 69 | 90 | 29 |
| Camp Roberts Military Reservation | 425 | 95 | 91 | 100 | 97 | | 91 | 84 | 89 | 10 |

| Legend: |
|---|
| Percent Habit Unchanged By Climate Change |
| 80-100% unchanged |
| 50-80% unchanged |
| 0-50% unchanged |

| | | PCM Model | | | | | Hadley Model | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Low Emissions | | High Emissions | | | Low Emissions | | High Emissions | |
| **Installation** | **Size (0.02 x 0.02) degree cells** | **PCM B1 2050** | **PCM B1 2080** | **PCM A1 2050** | **PCM A1 2080** | | **HAD B1 2050** | **HAD B1 2080** | **HAD A1 2050** | **HAD A1 2080** |
| Fort Detrick | 8 | 100 | 100 | 100 | 100 | | 100 | 50 | 100 | 0 |
| Badger Army Ammunition Plant | 35 | 100 | 100 | 100 | 100 | | 83 | 83 | 83 | 0 |
| Fort William H. Harrison Military Reservation | 30 | 100 | 100 | 100 | 100 | | 100 | 70 | 70 | 0 |
| Fort George G. Meade | 56 | 100 | 100 | 100 | 79 | | 100 | 79 | 79 | 0 |
| Cornhusker Army Ammunition Plant | 8 | 100 | 100 | 100 | 100 | | 100 | 100 | 25 | 0 |
| Bearmouth National Guard Training Area | 15 | 100 | 100 | 100 | 73 | | 100 | 67 | 67 | 13 |
| Joliet Army Ammunition Plant | 182 | 100 | 100 | 100 | 52 | | 100 | 77 | 88 | 0 |
| Custer Reserve Forces Training Area | 96 | 100 | 100 | 100 | 51 | | 100 | 78 | 78 | 0 |
| **Fort Riley Military Reservation** | 1280 | 98 | 98 | 98 | 98 | | 95 | 54 | 60 | 0 |
| Buckeye National Guard Target Range | 10 | 100 | 100 | 100 | 0 | | 100 | 100 | 100 | 0 |
| Fitzsimons Army Medical Center (Closed) | 4 | 100 | 50 | 50 | 50 | | 100 | 100 | 100 | 50 |
| Natick Laboratories Military Reservation | 36 | 100 | 100 | 100 | 0 | | 100 | 100 | 100 | 0 |
| Louisiana Ordnance Plant | 95 | 92 | 92 | 92 | 75 | | 75 | 62 | 75 | 0 |
| Nap of the Earth Army Helicopter Training Are | 5338 | 75 | 73 | 73 | 71 | | 72 | 71 | 70 | 50 |
| Camp Dodge Military Reservation | 25 | 100 | 100 | 100 | 32 | | 24 | 92 | 92 | 0 |
| Fort Pickett Military Reservation (Closed) | 352 | 97 | 97 | 88 | 91 | | 91 | 18 | 53 | 0 |
| Sharpe General Depot (Field Annex) | 3 | 100 | 100 | 100 | 100 | | 67 | 67 | 0 | 0 |

| Legend: |
|---|
| Percent Habit Unchanged By Climate Change |
| 80-100% unchanged |
| 50-80% unchanged |
| 0-50% unchanged |

| | | PCM Model | | | | | Hadley Model | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Low Emissions | | High Emissions | | | Low Emissions | | High Emissions | |
| **Installation** | **Size (0.02 x 0.02) degree cells** | **PCM B1 2050** | **PCM B1 2080** | **PCM A1 2050** | **PCM A1 2080** | | **HAD B1 2050** | **HAD B1 2080** | **HAD A1 2050** | **HAD A1 2080** |
| **Fort McCoy** | 713 | 100 | 100 | 100 | 98 | | 50 | 47 | 34 | 0 |
| Newport Army Ammunition Plant | 24 | 100 | 100 | 100 | 100 | | 75 | 25 | 25 | 0 |
| **Dugway Proving Grounds** | 3640 | 86 | 78 | 77 | 63 | | 71 | 67 | 69 | 8 |
| **US Army Aberdeen Proving Ground** | 205 | 82 | 77 | 73 | 67 | | 62 | 67 | 62 | 27 |
| Aberdeen Proving Ground Military Reservation | 445 | 89 | 78 | 69 | 66 | | 57 | 66 | 64 | 22 |
| Camp Bullis | 234 | 100 | 100 | 100 | 48 | | 60 | 55 | 48 | 0 |
| Edgewood Arsenal | 40 | 70 | 70 | 70 | 70 | | 70 | 70 | 70 | 20 |
| New Cumberland General Depot (US Military R | 130 | 88 | 88 | 78 | 54 | | 66 | 54 | 66 | 8 |
| Milan Arsenal And Wildlife Management Area | 234 | 97 | 84 | 84 | 91 | | 74 | 12 | 59 | 0 |
| Fort Wolters | 25 | 100 | 100 | 100 | 36 | | 52 | 52 | 52 | 0 |
| **Fort Lewis Military Reservation** | 3089 | 61 | 61 | 64 | 54 | | 60 | 56 | 60 | 40 |
| Charles Melvin Price Support Center | 8 | 100 | 100 | 100 | 100 | | 25 | 0 | 25 | 0 |
| Fort Devens (Closed) | 140 | 66 | 66 | 66 | 50 | | 66 | 66 | 66 | 0 |
| Radford Army Ammunition Plant | 240 | 90 | 87 | 97 | 70 | | 27 | 27 | 27 | 19 |
| Camp Swift N. G. Facility | 650 | 100 | 100 | 100 | 37 | | 31 | 24 | 29 | 8 |
| **Yuma Proving Ground** | 6052 | 84 | 74 | 81 | 15 | | 73 | 42 | 52 | 1 |
| **Fort Rucker Military Reservation** | 702 | 74 | 74 | 74 | 74 | | 48 | 43 | 28 | 0 |

| Legend: |
|---|
| Percent Habit Unchanged By Climate Change |
| 80-100% unchanged |
| 50-80% unchanged |
| 0-50% unchanged |

| | | PCM Model | | | | | Hadley Model | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Low Emissions | | High Emissions | | | Low Emissions | | High Emissions | |
| **Installation** | **Size (0.02 x 0.02) degree cells** | **PCM B1 2050** | **PCM B1 2080** | **PCM A1 2050** | **PCM A1 2080** | | **HAD B1 2050** | **HAD B1 2080** | **HAD A1 2050** | **HAD A1 2080** |
| Fort Benjamin Harrison (Closed) | 35 | 100 | 100 | 100 | 100 | | 0 | 0 | 0 | 0 |
| Los Alamitos Armed Forces Reserve Center | 8 | 100 | 100 | 100 | 100 | | 0 | 0 | 0 | 0 |
| Sacramento Army Depot (Closed) | 4 | 50 | 50 | 100 | 50 | | 50 | 50 | 50 | 0 |
| **Fort Carson Military Reservation** | 30777 | 62 | 57 | 57 | 26 | | 57 | 55 | 71 | 11 |
| Rock Island Arsenal | 5 | 100 | 40 | 40 | 0 | | 0 | 100 | 100 | 0 |
| Kansas Army Ammunition Plant | 44 | 100 | 100 | 100 | 73 | | 0 | 0 | 0 | 0 |
| Fort McClellan Military Reservation (Closed) | 242 | 93 | 85 | 93 | 37 | | 30 | 7 | 21 | 0 |
| Fort A. P. Hill Military Reservation | 728 | 65 | 48 | 89 | 72 | | 33 | 23 | 33 | 0 |
| Navajo Army Depot (Closed) | 221 | 69 | 64 | 67 | 20 | | 44 | 34 | 43 | 16 |
| Camp Atterbury Military Reservation | 198 | 58 | 58 | 60 | 57 | | 57 | 34 | 32 | 0 |
| Redstone Arsenal | 273 | 96 | 44 | 100 | 38 | | 27 | 23 | 23 | 0 |
| **Fort Leonard Wood Military Reservation** | 756 | 100 | 100 | 100 | 12 | | 15 | 0 | 7 | 0 |
| **White Sands Missile Range** | 13522 | 52 | 51 | 45 | 29 | | 46 | 47 | 40 | 24 |
| Camp Joseph T. Robinson | 288 | 82 | 74 | 72 | 24 | | 24 | 24 | 24 | 6 |
| Red River Army Depot | 242 | 59 | 51 | 51 | 51 | | 54 | 23 | 31 | 0 |
| **Fort Polk Military Reservation** | 3450 | 94 | 93 | 90 | 18 | | 10 | 4 | 7 | 0 |
| Fort Wingate Depot Activity (Closed) | 144 | 83 | 77 | 77 | 0 | | 49 | 15 | 14 | 0 |

| Legend: |
|---|
| Percent Habit Unchanged By Climate Change |
| 80-100% unchanged |
| 50-80% unchanged |
| 0-50% unchanged |

| | | PCM Model | | | | Hadley Model | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Low Emissions | | High Emissions | | Low Emissions | | High Emissions | |
| **Installation** | **Size (0.02 x 0.02) degree cells** | **PCM B1 2050** | **PCM B1 2080** | **PCM A1 2050** | **PCM A1 2080** | **HAD B1 2050** | **HAD B1 2080** | **HAD A1 2050** | **HAD A1 2080** |
| **Fort Bragg Military Reservation** | 1392 | 75 | 52 | 32 | 45 | 31 | 50 | 30 | 1 |
| Lake City Army Ammunition Plant | 18 | 100 | 100 | 100 | 6 | 6 | 0 | 0 | 0 |
| Camp Johnson | 9 | 44 | 44 | 44 | 44 | 44 | 22 | 44 | 22 |
| Fort Leavenworth Military Reservation | 63 | 87 | 100 | 100 | 0 | 16 | 0 | 0 | 0 |
| **Fort Hood** | 4321 | 72 | 72 | 73 | 22 | 22 | 21 | 21 | 0 |
| Fort Gillem Heliport | 15 | 100 | 100 | 100 | 0 | 0 | 0 | 0 | 0 |
| Fort McPherson | 4 | 100 | 100 | 100 | 0 | 0 | 0 | 0 | 0 |
| Fort Monmouth Military Reservation | 8 | 100 | 100 | 100 | 0 | 0 | 0 | 0 | 0 |
| Longhorn Ordnance Army Ammo Plant | 42 | 100 | 100 | 100 | 0 | 0 | 0 | 0 | 0 |
| **Fort Benning Military Reservation** | 1599 | 78 | 48 | 81 | 38 | 30 | 11 | 14 | 0 |
| Mount Baker Helicopter Training Area | 8017 | 42 | 42 | 39 | 34 | 40 | 36 | 36 | 25 |
| Buckley Air National Guard AF Base | 30 | 30 | 30 | 30 | 0 | 100 | 50 | 50 | 0 |
| US Army Ammunition Depot | 169 | 98 | 89 | 100 | 2 | 0 | 0 | 0 | 0 |
| Military Ocean Terminal Sunny Point | 150 | 100 | 100 | 80 | 0 | 0 | 0 | 0 | 0 |
| West Point US Military Academy | 121 | 61 | 56 | 68 | 23 | 50 | 10 | 10 | 0 |
| **Fort Gordon** | 792 | 78 | 64 | 80 | 12 | 19 | 13 | 13 | 0 |
| **Fort Campbell** | 925 | 96 | 74 | 82 | 4 | 19 | 0 | 1 | 0 |

| Legend: |
|---|
| Percent Habit Unchanged By Climate Change |
| 80-100% unchanged |
| 50-80% unchanged |
| 0-50% unchanged |

| | | PCM Model | | | | Hadley Model | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Low Emissions | | High Emissions | | Low Emissions | | High Emissions | |
| **Installation** | **Size (0.02 x 0.02) degree cells** | **PCM B1 2050** | **PCM B1 2080** | **PCM A1 2050** | **PCM A1 2080** | **HAD B1 2050** | **HAD B1 2080** | **HAD A1 2050** | **HAD A1 2080** |
| **Fort Sill Military Reservation** | 900 | 42 | 38 | 38 | 38 | 38 | 38 | 38 | 0 |
| Pine Bluff Arsenal | 288 | 89 | 83 | 87 | 3 | 0 | 0 | 0 | 0 |
| **Fort Bliss McGregor Range** | 11190 | 35 | 31 | 29 | 35 | 43 | 44 | 23 | 12 |
| Sunflower Army Ammunition Plant | 35 | 83 | 83 | 83 | 0 | 0 | 0 | 0 | 0 |
| Anniston Army Depot | 90 | 70 | 53 | 70 | 20 | 11 | 11 | 11 | 0 |
| Umatilla Chemical Depot (Closed) | 88 | 59 | 55 | 27 | 23 | 24 | 20 | 24 | 0 |
| Warrenton Training Center Military Reservatio | 130 | 47 | 25 | 64 | 18 | 31 | 18 | 22 | 0 |
| Fort Lee Military Reservation | 66 | 36 | 50 | 50 | 27 | 50 | 0 | 0 | 0 |
| Belle Mead General Depot | 8 | 50 | 50 | 50 | 50 | 0 | 0 | 0 | 0 |
| **Fort Knox** | 2311 | 39 | 39 | 40 | 22 | 25 | 12 | 16 | 0 |
| Iowa Army Ammunition Plant | 170 | 72 | 55 | 36 | 7 | 7 | 7 | 7 | 0 |
| **Fort Jackson** | 527 | 64 | 13 | 13 | 54 | 13 | 13 | 13 | 0 |
| Fort Ritchie Military Reservation (Closed) | 2011 | 27 | 25 | 27 | 19 | 19 | 23 | 22 | 8 |
| **Hunter-Liggett Military Reservation** | 11581 | 23 | 22 | 23 | 22 | 21 | 19 | 21 | 11 |
| Lexington-Blue Grass Army Depot (Closed) | 1915 | 37 | 36 | 37 | 4 | 4 | 7 | 5 | 0 |
| Fort Dix Military Reservation | 1529 | 20 | 20 | 20 | 14 | 19 | 14 | 13 | 1 |
| **Fort Drum** | 3877 | 24 | 21 | 24 | 7 | 17 | 10 | 11 | 3 |

| Legend: |
|---|
| Percent Habit Unchanged By Climate Change |
| 80-100% unchanged |
| 50-80% unchanged |
| 0-50% unchanged |

| | | PCM Model | | | | Hadley Model | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Low Emissions | | High Emissions | | Low Emissions | | High Emissions | |
| **Installation** | **Size (0.02 x 0.02) degree cells** | **PCM B1 2050** | **PCM B1 2080** | **PCM A1 2050** | **PCM A1 2080** | **HAD B1 2050** | **HAD B1 2080** | **HAD A1 2050** | **HAD A1 2080** |
| **Fort Huachuca** | 6280 | 14 | 15 | 18 | 10 | 17 | 13 | 10 | 4 |
| Army Chemical Center | 4 | 0 | 0 | 100 | 0 | 0 | 0 | 0 | 0 |
| Blossom Point Field Test Facility | 15 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Greencastle Military Reservation | 9 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 |
| Indiana Arsenal Army Ammuniton Plant (Closed) | 1439 | 15 | 15 | 15 | 10 | 10 | 9 | 11 | 0 |
| **Yakima Firing Center** | 12237 | 11 | 11 | 11 | 10 | 10 | 8 | 10 | 0 |
| Ravenna Arsenal | 1381 | 13 | 13 | 13 | 12 | 6 | 2 | 6 | 6 |
| Tooele Army Depot | 4069 | 9 | 9 | 7 | 6 | 6 | 4 | 4 | 3 |
| Fort Bliss | 8206 | 7 | 5 | 3 | 5 | 9 | 7 | 5 | 5 |
| Seneca Army Depot (Scheduled to close) | 1281 | 6 | 6 | 6 | 4 | 6 | 4 | 4 | 3 |
| Fort Ord Military Reservation (Closed) | 5071 | 6 | 5 | 5 | 6 | 6 | 5 | 7 | 1 |
| Fort Eustis Military Reservation | 1268 | 5 | 5 | 5 | 5 | 6 | 4 | 7 | 3 |
| Fort Ethan Allen Military Reservation | 1273 | 6 | 6 | 6 | 5 | 6 | 6 | 4 | 0 |
| Fort Chaffee (Closed) | 8316 | 7 | 7 | 7 | 4 | 5 | 1 | 3 | 0 |
| Camp MacKall Military Reservation | 66 | 12 | 9 | 0 | 0 | 0 | 12 | 0 | 0 |
| Picatinny Arsenal | 1305 | 6 | 5 | 6 | 3 | 5 | 0 | 0 | 0 |
| Fort Indiantown Gap Military Reservation (Clo | 1513 | 8 | 5 | 5 | 1 | 1 | 1 | 2 | 1 |

| Legend: |
|---|
| Percent Habit Unchanged By Climate Change |
| 80-100% unchanged |
| 50-80% unchanged |
| 0-50% unchanged |

| | | PCM Model | | | | | Hadley Model | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Low Emissions | | | High Emissions | | Low Emissions | | | High Emissions | |
| Installation | Size (0.02 x 0.02) degree cells | PCM B1 2050 | PCM B1 2080 | | PCM A1 2050 | PCM A1 2080 | HAD B1 2050 | HAD B1 2080 | | HAD A1 2050 | HAD A1 2080 |
| Letterkenny Army Depot | 1321 | 5 | 4 | | 5 | 2 | 2 | 3 | | 2 | 0 |
| Pueblo Chemical Depot (Closed) | 5344 | 2 | 2 | | 2 | 2 | 2 | 2 | | 3 | 0 |
| Sierra Army Depot | 7107 | 3 | 2 | | 3 | 2 | 3 | 2 | | 2 | 0 |
| Camp Bonneville Military Reservation (Closed) | 1226 | 2 | 2 | | 2 | 2 | 2 | 2 | | 3 | 0 |
| Craney Island Disposal Area | 1222 | 2 | 2 | | 2 | 2 | 2 | 2 | | 2 | 0 |
| Fort Story Military Reservation | 1220 | 1 | 1 | | 1 | 1 | 1 | 1 | | 1 | 0 |
| Utah Launch Complex White Sands Missle | 5301 | 2 | 1 | | 3 | 1 | 1 | 1 | | 1 | 0 |
| Camp Parks Military Reservation | 1221 | 2 | 0 | | 0 | 0 | 0 | 0 | | 0 | 0 |
| Defense Depot Ogden (Closed) | 1208 | 0 | 0 | | 0 | 0 | 0 | 0 | | 0 | 0 |
| Fort Sheridan (Closed) | 1202 | 0 | 0 | | 0 | 1 | 0 | 0 | | 0 | 0 |
| Oakland Army Base (Closed) | 3606 | 0 | 0 | | 0 | 0 | 0 | 0 | | 0 | 0 |
| Presidio of Monterey | 3609 | 0 | 0 | | 0 | 0 | 0 | 0 | | 0 | 0 |
| Camden Test Annex | 3 | 0 | 0 | | 0 | 0 | 0 | 0 | | 0 | 0 |
| Fort Ritchie Raven Rock Site | 9 | 0 | 0 | | 0 | 0 | 0 | 0 | | 0 | 0 |
| Vint Hill Farms Station Military Reservation | 4 | 0 | 0 | | 0 | 0 | 0 | 0 | | 0 | 0 |

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Military installation training lands must be managed to support species at risk as well as to be effective training environments for soldiers. Forecasts from various global climate change models suggest that the habitats associated with some military training installations will face pressures that induce biome-shifts, invasive species, loss of habitat, and changes in training opportunities. This study combined worldwide habitat forecast data with a current habitat map to identify major installations that appear to be most and least at-risk for habitat change.

**15. SUBJECT TERMS**
ecosystem management, climate change, habitat, military training, modeling

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