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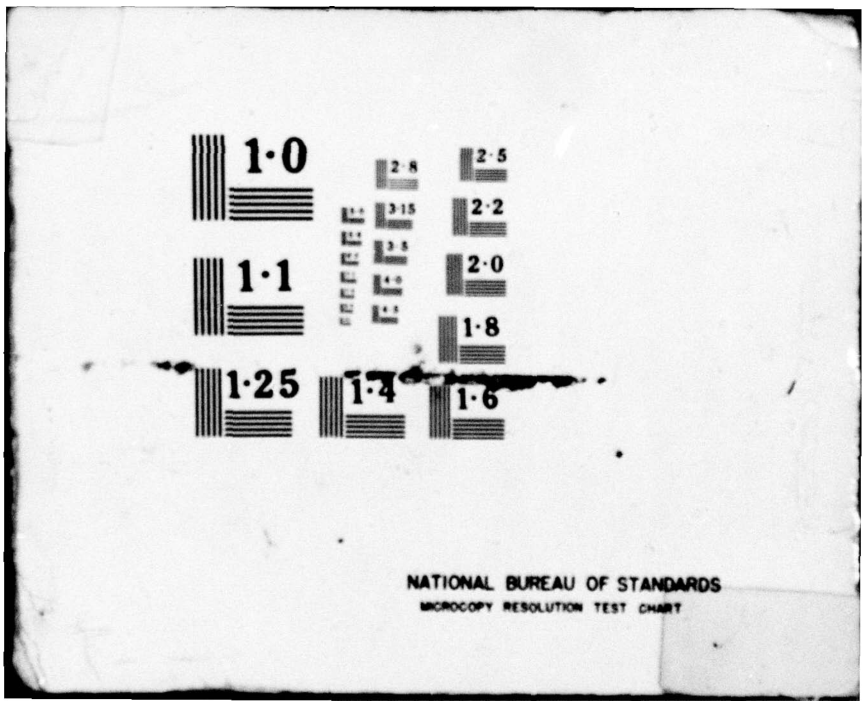
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Floodplain tree species: a bibliographic literature search with abstracts

C. Ritchie Bell
Jane Morley

SEPTEMBER 1979

U.S. ARMY CORPS OF ENGINEERS
ENGINEER TOPOGRAPHIC LABORATORIES
FORT BELVOIR, VIRGINIA 22060

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A thorough review of the scientific and technical literature for the period 1950 through the present was conducted of the soil-water relationships of 25 "bottomland" or flood plain tree species commonly found in eastern North America. The 25 tree species, and a compiled list of 110 keywords associated with the flood plain environment of these species, guided the search of 6 computerized bibliographical data bases, 9 abstract and index listings, and 67 serial publications.

A brief abstract of the 281 references found applicable to the subject topic is cont.

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provided, as are the citations for 67 references of a more general nature. A matrix was generated which consists of the 25 tree species, and 13 soil and water parameters, i.e. soil texture, soil moisture, soil chemistry, water table, soil type, flooding and plant physiology, plant age, flooding frequency and season, duration of inundation, flooding depth, water oxygen, seed germination, and general flooding. The number of the literature citation was entered in the matrix to expedite the use of this literature review for a specific species-factor interaction.

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SECTION I

INTRODUCTION

PREFACE

This report was prepared by Dr. C. Ritchie Bell (Botanist) and Jane Morley (Bibliographer), North Carolina Botanical Garden, University of North Carolina, Chapel Hill, North Carolina. The report was reviewed by Melvin B. Satterwhite of the U. S. Army Topographic Laboratory, Fort Belvoir, Virginia.

The literature search and review was conducted under contract #DAAK70-79-M-2525 for the U. S. Army Topographic Laboratory, Fort Belvoir, Virginia.

Introduction

By virtue of their topographic position, flood plains have a potential to support a relatively varied woody flora dominated by those tree species that are adapted to specific flood plain selective pressures. In the portion of the United States east of the 100th meridian there are some two dozen "indicator" tree species commonly associated with flood plains. Most of these species have extensive, and essentially overlapping, geographic ranges and they may often grow sympatrically in appropriate bottomland habitats throughout much of the eastern United States. For these tree species, flood plain selective pressures, such as leaching, siltation, low soil oxygen, and actual inundation for varying periods, are superimposed in the more general patterns of natural selection that result from the considerable latitudinal, altitudinal, seasonal, soil and other local environmental variations across the wide geographic range of each species. Despite the almost limitless potential for intraspecific variation that might occur under such contrasting selective forces, flood plains tend to maintain a relatively characteristic dominant flora of critical ecological, cultural and fiscal importance to the communities, states and regions located within a given watershed. It is therefore not surprising to find a relatively broad array of scientific and other literature dealing with the varied aspects of flood plains.

The objectives of this project were thus: 1) to conduct a thorough review of the literature pertaining specifically to the effects of flooding on the plant-soil-water relationships of these characteristic "bottomland" tree species commonly found east of the 100°W longitude in North America; 2) to evaluate cirtically each reference; and 3) to prepare a current bibliography and cross-listed reference matrix which will help investigators identify those soil and water conditions, or other environmental factors, that affect the distribution of "bottomland" tree species.

The bibliographical literature search "The Effects of Flooding on the Plant-Soil-Water Relationships of Bottomland Tree Species East of the 100°W Longitudinal Meridian" was initiated to provide a body of available literature regarding the "indicator" value, or characteristics, of certain plant species under particular soil and water conditions. The search was designed to provide access to information useful to: 1) environmental specialists and engineers working in flood plain or bottomland areas who are concerned with the interrelationships of trees, water and soils; 2) water resource agencies preparing impact statements; 3) field researchers investigating any aspect of soil-water relations concerning the dominant woody species of areas subject to intermittent inundation; and 4) foresters and timber management personnel concerned with optimum yield of timber and wood products from flood plain areas. A valuable by-product of the search is an indication of the geographical regions and topical areas lacking the relevant data needed for realistic biological or cultural planning involving flood plain areas.

Methodology

The search was conducted in the following phases:

Phase 1 — A list of the 25 most appropriate bottomland or flood plain tree species was compiled with nomenclature following the current "Synonymized Checklist of the Vascular Flora of North America" (Kartesz and Kartesz, in preparation at the University of North Carolina at Chapel Hill). This list enabled the search to maintain a consistency in regard to the scientific names. Many articles, however, listed the species by common name only and presented a problem in the maintenance of taxonomic consistency (see Table 1). In addition to the species list, a list of 110 keywords associated with flood plain environments was also compiled (see Table 2) to guide the search. With these lists as guides, computerized bibliographical data base searches were conducted through the Reference Department of D. H. Hill Library, North Carolina State University Library, Raleigh; the Math-Physics Library at the University of North Carolina at Chapel Hill; and the Southern Water Resources Institute in Raleigh. The following bibliographic files were used: (see Table 3)

a. AGRICOLA

b. BIOSIS PREVIEWS

c. CAB ABSTRACTS

d. GEOREF

e. NTIS

f. WRA

The retrievals conducted using the data files did not yield as complete a list of available literature as expected: for example, CAB ABSTRACTS yielded 58 citations, only 20 of which were relevant. Another minor problem encountered with the searches was the retrieval of many irrelevant foreign references covering only European and Asian research studies. This was especially true with CAB ABSTRACTS, which is prepared in England and indexes sources which are not ordinarily picked up by U. S. bibliographical services; almost half of the 58 references from this data base were foreign. It is important to note that the search term "flood" could be entered in a truncated form: "flood?". This form retrieved all references which contained the word or word root "flood" anywhere in the citation, abstract or subject fields of the reference. For further results of the computerized searches, see Table 3.

Concurrently with the computer searches, a manual search was begun. A few significant articles on the subject by Broadfoot, Hook and Hosner (see references #64, 126x, 135x); the two excellent summary volumes by Miller (see reference #190); and especially the six volumes by Teskey and Hinckley (see references #249-254) were used to begin a "snowball" type literature search. This type of search examines the references cited in the latest or most comprehensive articles and then in turn examines the references cited in those articles. The available abstracting and indexing publication (see Table 4) dating back to 1950 were also thoroughly searched manually to obtain more relevant citations which were then examined and evaluated. Forestry Abstracts and Selected Water Resource Abstracts, for example, employ controlled vocabularies of terms and phrases such as "floodplains" or "flooding, effects of," whereas Biological Abstracts and Science Citation Index use a "Permuterm" indexing method. This copyrighted method essentially "truncates" terms and compiles lists of titles with the word or word root somewhere in the title. Although this indexing method is very thorough, it seems to yield much more irrelevant information as it is not as specific as a controlled vocabulary.

After reviewing these indexes, an exhaustive manual search of individual serial titles was conducted to cover any material overlooked by the indexes (see Table 5). These serial titles included all journals, scientific and technical reports, unpublished manuscripts such as dissertations, and government publications possibly related to the subject including silvicultural, botanical, biological, agricultural, ecological and geological publications.

Phase II — Abstracts of all pertinent literature references were compiled. The citations were arranged alphabetically and numbered consecutively. To aid in the differentiation of articles dealing primarily with experimental work (or non-site-specific data extrapolations) the letter "x" was placed after the abstract or citation number.

Phase III — The Development of the Data Matrix. In order to provide ready access to those references concerned with specific flood plain tree species or flood plain soil or water characteristics, a 325 category data matrix was constructed (see Table 6, Section II) in which the 25 plant species, arranged alphabetically (by scientific name), comprise the vertical axis, and a series of 13 pertinent soil and flooding conditions comprise the horizontal axis. Such an information grid also provides, as mentioned previously, an interesting comparison of the amount of relatively current research being done on specific flood plain trees and soils and their various interactions. For example, it should be noted that one search topic, "water temperature," produced only a single reference, and this was not concerned specifically with the tree species of particular interest. Accordingly, the column was not included in the final data matrix but, because of general interest and relevance to the assigned topic, the reference and abstract are included in the literature citations.

Two very important, but very general information categories, relating to flood plain species are "tolerance" and "succession." Both categories are so broad that they do not fit appropriately into the relatively specialized blocks in the data matrix. For this reason any reference in either Section III (Literature Citations and Abstracts) or Section IV (General Bibliography) that relates to flood plain species tolerance or to flood plain succession is listed by reference number under the appropriate heading of Table 7 in Section II (Data Summaries) even though the reference may also be listed, if appropriate, in a specific block of the data matrix.

All pertinent references concerned with field studies associated with a particular state are summarized, by state, in Figure 1 by means of individual reference numbers being given, as appropriate, in each state. Numbers including the aforementioned "x" are not included on the map, as the scientific value of the work was assumed to be independent of the geographic locality in which the work was done.

The present report contains the following elements:

1. A listing of the bottomland tree species and keywords used in formulating the search strategy. (Section I, Tables 1 and 2, pp. x and xi.)
2. A listing of the computerized bibliographical data bases and manual abstracting and indexing publications (including background information such as type of journals indexed, inclusive dates and subject coverage) used in conducting the literature search. (Section I, Tables 3 and 4, pp. xiii and xvi.)
3. An alphabetical listing of all serial publications reviewed including volume numbers and dates that were covered. (Section I, Table 5, p. xviii.)
4. A compendium of all bibliographical citations and corresponding abstracts, arranged alphabetically by author and numbered consecutively. (Section III.)
5. A two-dimensional matrix correlating tree-indicator species and flood-factor relationships with numbered

entries corresponding to the citation from which the relationship was established. (Section II, Table 6, p. xxii.)

6. A map with numbered entries indicating the geographical location referred to in each citation. (Section II, Figure 1, p. xxiv: References by State.)
7. A table listing references concerning the topics "Flooding Tolerance" and "Flooding and Succession" including citations from Section III and the General Bibliography. (Section II, Table 7, p. xxv.)
8. A General Bibliography of citations of related references on flood plain tree species. (Section IV, pp. 281-286.)

TABLE 1

BOTTOMLAND TREE SPECIES

Acer negundo	Box elder
Acer rubrum	Red maple
Acer saccharinum	Silver maple
Betula nigra	River birch
Carpinus caroliniana	Ironwood
Carya aquatica	Water hickory
Celtis laevigata	Sugarberry
Celtis occidentalis	Hackberry
Fraxinus pennsylvanica	Green ash
Liquidambar styraciflua	Sweetgum
Liriodendron tulipifera	Yellow poplar
Magnolia tripetala	Umbrella magnolia
Nyssa aquatica	Water tupelo
Nyssa sylvatica var. biflora	Black gum
Pinus taeda	Loblolly pine
Planera aquatica	Water elm
Platanus occidentalis	Sycamore
Populus deltoides	Cottonwood
Quercus falcata var. pagodaefolia	Cherrybark oak
Quercus palustris	Pin oak
Quercus phellos	Willow oak
Quercus shumardii	Shumard oak
Salix nigra	Black willow
Taxodium distichum	Baldcypress

TABLE 2
KEY WORD LISTING

Aeration
Aerobic
Alluvial
Anaerobic
Banks
Biological communities
Bog
Bottomland
Central U.S.
Climate/vegetation relationships
Coniferous trees
Deciduous trees
Depth
Distribution patterns
Drainage
Duration
Ecology
Ecoregions
Edaphic factors
Environmental factors
Excess water
Flood
Flood control
Flood damage
Flood frequency
Flood stages
Flooding
Floodplain
Floods
Forest management
Forests
Forestry
Geology
Germination
Gradients
Groundwater
Habitats
Hardwoods
Impoundment
Indicators
Intolerant
Inundation
Lakes
Life history
Lowlands
Marsh
Microenvironments
Micronutrients
Mineral indicators
Moisture tension
Moisture regines
Mortality
Much soils
Northeastern U.S.
Nutrients
Osmotic potential
Oxidize
pH
Phenology
Physiology
Physiography
Plant
Plant age
Plant communities
Plant distribution
Plant ecology
Plant growth
Plant morphology
Plant nutrition
Plant populations
Plant-soil-water relations
Regeneration
Resistance
Riparian
Root systems
Roots
Saturation
Seeds
Site index
Soaking
Soil aeration
Soil aggregation
Soil moisture
Soil salinity
Soil structure
Soil temperature
Soil texture
Soil water
Soils
Southeastern U.S.
Streamside
Submergence
Subsoil
Succession
Survival
Swamps
Tolerance
Tree-water requirements

TABLE 2 (Cont'd)

Trees	Water oxygen
Uptake	Water quality
Vegetation	Water relations
Water capacity	Water table
Water level fluctuations	Waterlogged
Water nutrients	Wetlands

TABLE 3

COMPUTERIZED FILES USED

References Retrieved	References Used	File
47	1	AGRICOLA — Produced by the National Agricultural Library and accessed through DIALOG (Lockheed). This data base covers the field of agriculture in the broadest sense and specific areas of botany and forestry are included. More than 6,000 serials, pamphlets, government documents, research reports, USDA publications and conference proceedings titles are reviewed for indexing annually. The file size is currently over 1,000,000 citations and increases by 10,000 new records monthly. AGRICOLA is retrospective to 1970.
63	32	BIOSIS PREVIEWS — Produced by the BioSciences Information Service and accessed through DIALOG. This file contains citations from both Biological Abstracts and Bioresearch Index, the major publications of the Service. All of the life sciences are covered and the material scanned for this file includes periodical literature, monographs, book reviews, textbooks, technical reports, theses, symposia, institutional and governmental reports, and conference proceedings. The file size is now over 1,300,000 items and is updated monthly by approximately 20,000 records. Over 8,000 titles are reviewed yearly and the file is retrospective to 1972.
58	20	CAB ABSTRACTS — Produced by the Commonwealth Agricultural Bureau and accessed through DIALOG.

References Retrieved	References Used	File
		This file is made up of agricultural information and contains all of the records of the 22 abstracting journals published by CAB including Forestry Abstracts and Soils & Fertilizers. Over 8,500 serial titles in 37 languages are scanned, as well as books, technical reports, conference proceedings, annual reports and other communications. The file size is over 600,000 citations and is increased monthly by 10,000 records; it is retrospective to 1973.
9	0	GEOREF — Produced by the American Geological Institute and accessed through ORBIT (Systems Development Corp.). It is made up of citations taken from the Bibliography and Index of Geology (1967-1978) and was greatly enlarged in 1978 to include other index publications dating to 1961. The subject areas include economic geology, areal geology and hydrology and items are selected from geo-science journals, books, dissertations, conference proceedings and papers and technical reports totalling over 3,000 individual titles. The file size is over 300,000 citations and increases by 5,000 monthly.
107	10	NTIS — Produced by the Dept. of Commerce for DIALOG. The data base consists of government-sponsored research, development and engineering reports plus analyses, journal articles and translations prepared by over 300 federal agencies, their contractors or grantees. NTIS includes both "hard" and "soft" sciences including agriculture, environmental pollution and

References Retrieved	References Used	File
		regional development. It corresponds to Weekly Government Abstracts and the semi-monthly Government Reports Announcements. The file contains over 580,000 citations, is updated biweekly by 2,500 references, and is retrospective to 1964.
85	10	WRA — Produced by the Water Resources Scientific Information Center, Dept. of the Interior, and corresponds to the semi-monthly publication Selected Water Resources Abstracts. The file is updated monthly, contains approximately 135,500 records and is retrospective to 1968.

TABLE 4

ABSTRACTS AND INDEXES SEARCHED

1. Bibliography and Index of Geology. (Geological Society of America in cooperation with the American Geological Institute). Vols. 33-42, 1969-1979.
   This bibliography includes major and minor geological literature pertaining to North America in the form of books, monographs, journal articles and technical reports.

2. Biological Abstracts. (BioSciences Information Service). Vols. 38-67, 1950-1979.
   This publication abstracts 8,000 individual serial titles, books, reports and other literature under 85 broad life sciences categories. It indexes by subjects-in-context based on titles, as well as by author's name and taxonomic codes.

3. Bioresearch Index. (BioSciences Information Service). 1967-1979.
   Supplements Biological Abstracts by indexing life sciences research and includes theses, symposia and meetings, along with other research communications. There are author and subject-in-context based on title indexes.

4. Forestry Abstracts. (Commonwealth Forestry Bureau in cooperation with the Commonwealth Agricultural Bureau). Vols. 12-40, 1950-1979.
   Covers all aspects of forestry and is international in scope. Books, serial publication pamphlets, reports, conference proceedings and government reports are indexed and abstracted. Forestry Abstracts makes use of a controlled-vocabulary subject index.

5. Index to U.S. Government Periodicals. (U.S. Superintendent of Documents). 1970-1979.
   This monthly publication indexes all government periodicals using a controlled-vocabulary subject index. It covers periodicals produced by the various departments and agencies of the government such as the Forest Service's Tree Planters' Notes.

6. Science Citation Index. (Institute for Scientific Information). 1961-1979.
   A comprehensive computer-produced index that

provides access to over 2,500 individual journals, reports, proceedings and patents, SCI access related references by listing both cited and citing (source) authors and references. It utilizes a permuted subject index by titles, author index, and citation index.

7. Selected Water Resources Abstracts. (Water Resources Scientific Information Center). Vols. 1-12. 1968-1979.

   Covers primarily serial publications, books, technical reports and conference proceedings on such topics as water cycles, plant-soil-water relations, plant physiology and other hydrological topics. Subject index using a controlled-vocabulary and author index provide access to the abstracts.

8. Soils & Fertilizers. (Commonwealth Forestry Bureau in cooperation with the Commonwealth Agricultural Bureau). Vols. 13-40, 1950-1979.

   This CAB publication covers soil science and agricultural publications.

9. U.S. Superintendent of Documents Monthly Catalog. 1965-1979.

   The Catalog indexes all government agency publications and issued documents. It provides access to material produced by the Dept. of Agriculture, the Forest Service and other related groups.

TABLE 5

SERIAL PUBLICATIONS SEARCHED

1. Ambio, Vols. 1-8, 1972-1979
2. American Journal of Botany, Vols. 37-67, 1950-1979 (Am. Jour. of Bot.)
3. American Midland Naturalist, Vols. 43-101, 1950-1979 (Am. Mid. Nat.)
4. American Naturalist, Vols. 84-113, 1950-1979 (Am. Nat.)
5. Annals of Botany, New Series, Vols. 14-43, 1950-1979 (Ann. of Bot.)
6. Botanical Gazette, Vols. 112-139, 1950-1979 (Bot. Gaz.)
7. Botanical Review, Vols. 16-45, 1950-1979 (Bot. Rev.)
8. Canadian Journal of Botany, Vols. 28-57, 1950-1979 (Can. Jour. of Bot.)
9. Canadian Journal of Forest Research, Vols. 1-9, 1971-1979 (Can. Jour. of For. Res.)
10. Castanea, Vols. 15-42, 1950-1979
11. Central Hardwood Forest Conference, Proceedings, 1st, 1976
12. Central States Forest Tree Improvement Conference, Proceedings, 1st - 10th, 1959-1976
13. Communications in Soil Science and Plant Analysis, Vols. 1-10, 1969-1979 (Comm. Soil Sci. and Plant An.)
14. Earth Science Reviews, Vols. 1-13, 1966-1978 (Earth Sci. Rev.)
15. Ecology, Vols. 31-59, 1950-1979
16. Ecological Monographs, Vols. 20-49, 1950-1979 (Ecol. Monogr.)
17. Environment, Vols. 1-20, 1959-1979

18. Environmental and Experimental Botany, Vols. 16-17, 1976-1977
(Environ. and Exp. Bot.)

19. Environmental Geology Notes, Nos. 16-72, 1967-1974
(Environ. Geo. Notes)

20. Environmental Management, Vols. 1-3, 1976-1978
(Environ. Mgmt.)

21. Flora of Texas, Vols. 9-37, 1950-1978

22. Florida University State Museum Bulletin, Vols. 4-15, 1950-1971
(Bull. Fla. State Mus.)

23. Forest Science, Vols. 1-25, 1950-1979
(For. Sci.)

24. Forestry, Vols. 23-53, 1949-1979

25. Forestry Chronicle, Vols. 26-55, 1950-1979
(For. Chron.)

26. Geological Journal, Vols. 1-18, 1961-1978

27. Geology, Vols. 1-6, 1973-1978

28. Hortscience, Vols. 1-14, 1966-1979

29. Illinois State Academy of Science, Transactions, Vols. 43-85, 1950-1979
(Trans. Ill. State Acad. Sci.)

30. Indiana Academy of Science, Proceedings, Vols. 60-88, 1950-1978
(Proc. Ind. Acad. Sci.)

31. Journal of Applied Ecology, Vols. 1-14, 1964-1978
(Jour. of Appl. Ecol.)

32. Journal of Ecology, Vols. 38-66, 1950-1978
(Jour. of Ecol.)

33. Journal of the Elisha Mitchell Scientific Society, Vols. 66-92, 1950-1976
(Jour. of Elisha Mitchell Sci. Soc.)

34. Journal of Experimental Botany, Vols. 1-29, 1950-1978
(Jour. of Exp. Bot.)

35. Journal of Forestry, Vols. 48-77, 1950-1979
(Jour. of For.)

36. National (later International) Shade Tree Conference,

Proceedings, 26th - 49th, 1950-1973

37. North American Forest Soils Conference, 1st - 3rd, 1958-1968

38. Northeastern Forest Tree Improvement, Proceedings, 3rd - 23rd, 1953-1976

39. Oecologia, Vols. 1-36, 1967-1978

40. Ohio Journal of Science, Vols. 50-78, 1950-1978
(Ohio Jour. of Sci.)

41. Physiologia Plantarum, Vols. 3-43, 1950-1978

42. Plant Disease Reporter, Vols. 34-62, 1950-1978
(Plant Dis. Rep.)

43. Plant and Soil, Vols. 2-48, 1950-1978

44. Plant Physiology, Vols. 25-63, 1950-1979

45. Soil Biology and Biochemistry, Vols. 1-10, 1968-1978
(Soil Biol. and Biochem.)

46. Soil Science, Vols. 71-127, 1950-1979

47. Soil Science Society of America, Proceedings, Vols. 15-42, 1950-1978
(Proc. Soil Sci. Soc. Am.)

48. Texas Journal of Science, Vols. 2-30, 1950-1978
(Tex. Jour. of Sci.)

49. Torrey Botanical Club, Bulletin, Vols. 77-105, 1950-1978
(Bull. Torrey Bot. Club)

50. U.S. Department of Agriculture Handbook, 1949, Trees

51. USDA Forest Service, Tree Planters' Notes, Vols. 2-29, 1951-1973

52. USFS Central States Experiment Station. Research Papers Nos. 1-12, 1963-1965
(USFS Res. Paper CS-)

53. USFS North Central Forest Experiment Station. Research Notes, Nos. 1-238, 1966-1978
(USFS Res. Note NC-)

54. USFS North Central Forest Experiment Station. Research Papers, Nos. 1-167, 1966-1979
(USFS Res. Paper NC-)

55. USFS Northeastern Forest Experiment Station. Research Notes, Nos. 1-270, 1950-1978
(USFS Res. Note NE-)

56. USFS Northeastern Forest Experiment Station. Research Papers, Nos. 1-431, 1963-1979
(USFS Res. Paper NE-)

57. USFS Southeastern Forest Experiment Station. General Technical Reports, Nos. 1-7, 1972-1974
(USFS Gen. Tech. Rep. SE-)

58. USFS Southeastern Forest Experiment Station. Research Notes, Nos. 1-270, 1952-1978
(USFS Res. Note SE-)

59. USFS Southeastern Forest Experiment Station. Research Papers, Nos. 1-198, 1963-1979
(USFS Res. Paper SE-)

60. USFS Southeastern Forest Experiment Station. Station Papers, Nos. 1-156, 1948-1962

61. USFS Southern Forest Experiment Station. General Technical Reports, Nos. 1-16, 1973-1977
(USFS Gen. Tech. Rep. SO-)

62. USFS Southern Forest Experiment Station. Occasional Papers, Nos. 112-194, 1948-1962
(USFS Occ. Paper SO-)

63. USFS Southern Forest Experiment Station. Research Notes, Nos. 1-244, 1963-1979
(USFS Res. Note SO-)

64. USFS Southern Forest Experiment Station. Research Papers, Nos. 1-151, 1963-1979
(USFS Res. Paper SO-)

65. Water, Air and Soil Pollution, Vols. 1-8, 1971-1978
(Water, Air and Soil Pol.)

66. Water Resources Bulletin, Vols. 1-14, 1964-1978
(Water Res. Bull.)

67. Water Resources Research, Vols. 1-14, 1965-1978
(Water Res. Res.)

TABLE 6

TREE INDICATOR SPECIES-FLOOD FACTOR MATRIX

1-24 Tree Species	Soil Characteristics A Texture	B Moisture	C Chemistry	D Water Table	E Type	F Flooding and Physiology	Flooding Impact G Plant Age	H Frequency of Season	I Duration	J Depth	K Water O_2	L Seed Germination	M General Flooding
1 Acer negundo	30,150	30,83 139e,260e	30,205	30		140e,249 250,251 252,253 254		64,94,150 241,275	137e,140e 175e,275	64,175e 241,249 250,251 252,253 254		175e,198	25
2 Acer rubrum	30,232	7,30,139e 164,180e 260e	30,196 210e	30		72e,80 140e,201e 209e,210e 244e,249 250,251 252,253 254		232	132e,137e 140e,180e 232	232,249 250,251 252,253 254		132e,179e 180e,181e	79,271
3 Acer saccharinum	30,172 232	30,83 139e	30,31e 163	30	172	201e,230e 243e,249 250,251 252,253 254		20,23,64 94,148 140,172 232,241	132e,134e 137e,138e 175e,232	64,134e 175e,232 241,249 250,251 252,253 254		132e,175e 198	134e,138e
4 Betula nigra	30	30,180e 260e	30,104 217	30,276		249,250 251,252 253,254		40,64 241,275	180e,275	64,241 249,250 251,252 253,254		179e,180e 181e	
5 Carpinus caroliniana	30	30	30,205	30		249,250 251,252 253,254				249,250 251,252 253,254			
6 Carya aquatica	30	30	30,217	30		249,250 251,252 253,254		64		64,249 250,251 252,253 254			
7 Celtis laevigata	30	30,139e 220	30,220	30,60	220	140e,249 250,251 252,253 254			140e	249,250 251,252 253,254			255
8 Celtis occidentalis	30	30,139e 220	30,220	30	220	140e,249 250,251 252,253 254		17,30,140 149	115,135e 137e,140e	249,250 251,252 253,254		76,198	25
9 Fraxinus pennsylvanica	1,14e,30 232	1,14e,30 59,87e 139e,142e 220,242 257	1,14e,30 59,142e 205,220	30,170 242	13,220	140e,200e 249,250 251,252 253,254		23,24,140 149,232 242	115,134e 135e,137e 140e,175e 232	58,134e 175e,206 232,242 249,250 251,252 253,254	14e,58 139	129,175e	129,134e 255,209
10 Liquidambar styraciflua	14e,30 49e,92e 232,267e	14e,30 32e,34e 39e,56 59,62 106,111e 139e,161 212,213 219e,242 265,267e	14e,30,60 49e,59 111e,161 196,205 219e	30,60 170,242	13,30e 57,117 212,213	140e,230e 249,250 251,252 253,254		17,40,232 242,265	32e,115 132e,134e 135e,137e 140e,139 232,265	58,99e 134e,232 247,249 250,251 252,253 254	14e,58 139,265	33e,63e 92e,99e 129,132e 265,267e	129,134e 155,184 222,255 271
11 Liriodendron tulipifera	30,119	30,106 151,153e 164,219e 265	30,31e 100e,217 219e	30,60	117,265	167e,201e 229e,230e 244e,249 250,251 252,253 254		245e,265	150,177 245e,265	245e,249 250,251 252,253 254	139,265	76,77,129 265	129,176 235,245e
12 Magnolia tripetala	30	30	30	30		249,250 251,252 253,254				249,250 251,252 253,254			

13 Nyssa aquatica	10,30	9a,30,87a 88a,89a 114a,121 139a,142a 161,242 265	30,31a 88a,89a 142a,161	30,120 161,242	13,114a	89a,140a 249,250 251,252 253,254		10,64 124a,125a 158,262 265	10,140a 265	10,64,85 158,206 242,249 250,251 252,253 254	88a,139 265	10,124a 125a,129 265	8a,9a,10 79,85 124a,125a 129
14 Nyssa sylvatica	10,30	9a,30,106 114a,121 156,161	18a,30 156,161 196	30,88	114a	157,249 250,251 252,253 254		10,17,156	10	10,249 250,251 252,253 254	157	10,86,122a 126a	9a,10,126a 271
15 Pinus taeda	119,267a	98,145a 151,153a 166,214 258,267a 264a	217,264a	71,258	30	75a,167a 174,201a 204a,209a 249,250 251,252 253,254		64	70a,186a 272a,273	64,249 250,251 252,253 254		145a,186a 263a,267a 270, 272a	109a,222
16 Planera aquatica					30	249,250 251,252 253,254				249,250 251,252 253,254			
17 Platanus occidentalis	14a	14a,32a 36a,38a 87a,139a 142a,180a 242,260a	14a,31a 142a,277 278a	60	13,30 38a 242	140a,249 250,251 252,253 254		23,64,149 241,262 275	32a,115 132a,135a 137a,140a 180a,275	64,241 242,249 250,251 252,253 254	14a,129	65a,129 132a,180a 181a,198	129,184 277
18 Populus deltoides	14a,150 266	14a,35a 52a,63a 83,96a 139a,260a 265,266	14a,28a 29a,31a 36a,151 217,266	60,61 266	13,28a 30,36a 50,51 52a,57 226	160a,238a 278a,249 250,251 252,253 254	266	23,48,94 149,150 241,265	137a,140a 159,175a 187a,265	170,175a 241,249 250,251 252,253 254	14a,265	175a,187a 265	25,169 184,223 276
19 Quercus falcata	14a,232	14a,59 139a,257 265	14a,59 217	60	30,57 117	37a,171a 249,250 251,252 253,254		46,64 232,265	78a,135a 137a,138a 232,265	46,64 78a,232 249,250 251,252 253,254	14a,265	14a,78a 138a,171a 265	42,184
20 Quercus palustris		87a,139a 142a,257 260a,265	142a,163 217		30	37a,140a 249,250 251,252 253,254		191,292 265	135a,137a 140a,265 280	249,250 251,252 253,254 280	265	265	
21 Quercus phellos	14a	14a,59 139a,242 265	14a,59 205	242	15,30 57	171a,249 250,251 252,253 254		17,46 242,265	265	46,242 249,250 251,252 253,254	14a,265	171a,265	
22 Quercus shumardii	232	139a			30	249,250 251,252 253,254		232	137a,232	232,249 250,251 252,253 254			
23 Salix nigra	120,172 189,203	16,257 260a,265	217	120	4,16 30,172	140a,208a 246a,249 250,251 252,253 254		172,241 265,275	137a,140a 265,275	170,241 249,250 251,252 253,254	265	265	203
24 Taxodium distichum	172	242,260a	194a,196 205	120,170 262	30,172 195	73a,194a 204a,249 250,251 252,253 254		10,64 172,262	10,84 175a,262	64,93 175a,262 249,250 251,252 253,254 262	73a,194a	93,175a	8a,79 169,203 223,255
25 Other species	1,105 107,150 172,232	1,6,11a 22,30a,56 59,88a 89a,98 107,116 139a,141 164,165 193,202a 219a,220 242,257 260a	1,6,26a 59,88a 89a,131a 205,211a 219a,225 228,236a	60,120 170,242	30,38a 57,87 110,123 172,225	12a,133a 140a,154a 166a,171a 185,201a 204a,208a 230a,246a 249,250 251,252 253,254 256		17,20,21 23,27,39 43,46,64 66,100 148,150 172,197 199,225a 232,238a 261,262 275	3,21,84 110,132a 134a,137a 140a,143 175a,182 186a,232 275,280	21,45,46 50,64 110,134a 175a,206 232,237 241,242 249,250 251,252 253,256 280	50,80a 89a,131a 239a	64a,65a 91a,132a 171a,175a 179a,181a 186a,225a	2,25,53 54,102a 130a,133 134a,166a 182,200 235,268

SECTION II

DATA SUMMARIES FIGURE 1

REFERENCES BY STATE

Alabama:
60, 106, 235, 266

Arkansas:
17, 45, 143

Connecticut:
6

Delaware:
213

Florida:
108, 194x, 195, 196, 247, 262

Georgia:
10, 43, 100, 101, 176, 233

Illinois:
20, 21, 22, 23, 24, 77, 83, 103, 104, 136, 138x, 141, 148, 149, 193, 198, 231, 232, 257, 280

Indiana:
77, 80, 172, 234

Kansas:
25

Kentucky:
112, 277, 278x

Louisiana:
40, 45, 79, 93, 152, 203, 255

Maryland:
213, 240x, 241

Michigan:
67, 237

Mississippi:
13, 15, 16, 46, 45, 50, 51, 53, 54, 56, 58, 61, 92x, 94, 155, 169, 224, 271, 272x, 273

Missouri:
66, 163, 191, 192, 198

Nebraska:
223

New Hampshire:
39, 97x, 182

New Jersey:
68, 212, 213, 275

New York:
200

North Carolina:
4, 7, 97x, 98, 119, 164, 214, 222, 258, 276

North Dakota:
69, 150, 269

Ohio:
105

Oklahoma:
1, 115, 228

South Carolina:
85, 86, 116, 156, 157, 160, 161, 162, 239x

South Dakota:
147, 274

Tennessee:
117, 242, 262

Texas:
113, 188, 197

Virginia:
84, 107, 205, 214, 251, 261

Wisconsin:
268

Ontario:
27

Quebec:
170

TABLE 7

SPECIFIC FLOOD TOLERANCE AND SUCCESSION REFERENCES

Flood Tolerance

Abstract or Citation #	General Bibliography #
3, 8x, 9x, 10, 13, 16, 17, 20, 21, 23, 27, 43, 46, 58, 64, 66, 70x, 73x, 78x, 80, 81x, 82x, 84, 85, 86, 88x, 97x, 103, 110, 112, 115, 120, 121, 126x, 127x, 128x, 129, 132x, 134x, 135x, 137x, 139x, 140x, 142x, 144x, 145x, 149, 151, 152, 156, 157, 158, 159, 161, 162, 172, 175x, 176, 177, 180x, 182, 185x, 186x, 187x, 199, 204x, 208x, 217, 232, 241, 242, 246x, 249, 250, 251, 252, 253, 254, 260x, 263x, 264x, 265, 272x, 280	21, 58

Flooding and Succession

Abstract or Citation #	General Bibliography #
4, 7, 14x, 24, 25, 65x, 68, 69, 83, 93, 94, 95, 97x, 102x, 108, 113, 120, 133, 136, 141, 143, 147, 150, 170, 172, 180x, 181x, 183, 203, 205, 207, 223, 237, 240x, 241, 248, 265, 274, 275	6, 17, 34, 37, 41, 43, 46, 51, 54, 58, 59, 60, 61, 63

SECTION III

LITERATURE CITATIONS AND ABSTRACTS

1

Abdul-Wahab, A.S.

1970

Vegetation in relation to some edaphic factors in Olivers Wildlife Preserve Floodplain Forest, Oklahoma

Iraq Nat. Hist. Mus. Publ. 27:19-28

Two plots of 1 acre each were studied. Edaphic factors studied and analyzed were pH, organic C, total N, total P, base exchange capacity, exchangeable ly, soil compaction, and soil texture at the 0 to 6 and 18 to 24 levels. On the basis of frequency, density, basal area, and importance percentage the type community in the south plot was *Quercus macrocarpa*, and the dominant tree in the north plot was *Fraxinus pennsylvanica*. The pH was generally above 8.0 at 0 to 6 and 18 to 24 inch levels in both plots. There was no correlation between the type of vegetation and the soil analyzed. The best correlation was between waterlogging and vegetation type.

Ahlgren, C.E.

1952

Some effects of flooding on forest trees in northern Minnesota

Ph.D. thesis, School of For., Univ. of Minnesota

No abstract available.

Ahlgren, C.E.; Hansen, H.L.

1957

Some effects of temporary flooding on coniferous trees

Jour. of For. 55:647-650

Weather conditions of the fall and winter of 1949 resulted in flood conditions during the spring of 1950 adjacent to lakes and streams and on many lowlands in northern Minnesota. Flood prevailed for as long as four months in some areas. The subsidence of the water made possible observations on trees flooded for periods varying from a few days up to most of the growing season.

At the Basswood Lake area, proximity to the Quetico-Superior Wilderness Research Center made possible more intensive study of the affected trees. Special attention was directed to the effect of flooding on growth rate of terminals, on the ability of the foliage to endure and recover from submergence, and on tree mortality for white pine, red pine, jack pine, white spruce, black spruce, and balsam fir. The observations were continued through 1951, the year following flooding. Data on mortality and general observations in other flood areas were completed in 1952. The data collected have been summarized by species, size-class, and length of the submergence period.

Allen, P.H.

1962

Black willow dominates baldcypress-tupelo swamp eight years after clearcutting

SEFES, Res. Note 177. 2 pp.

On a deep dark-brown muck soil in North Carolina, in an area logged by high-lead in autumn or winter, Salix nigra formed the dominant canopy, and though Tupelo (Nyssa sylvatica and N. aquatica) coppiced vigorously from high on the stumps over the whole area, its reproduction and that of Taxodium distichum was patchy and insufficient.

5x

Allison, L.E.; Bernstein, L.; Bower, C.A.; et al.

1954

Diagnosis and improvement of saline and alkali soils

USDA Agricultural Handbook 60:109-110

No abstract available.

Anderson, P.H.; Lefor, M.W.; Kennard, W.C.

1978

Transition zones of forested inland wetlands in northeastern Connecticut

Conn. Univ., Storrs. Inst. of Water Resources, Ofc. of Water Rsch and Techn., Wash., D.C. (Report No. 29). 107 pp.

Inland wetlands are valuable natural resources intimately associated with the hydrologic cycle. This study was designed to (1) investigate vegetation distribution and selected physical and chemical properties of wetland and bordering upland soils and the interface between the two, and (2) provide the ground truth necessary for the identification and delineation of deciduous wetland forests using false-color infrared (FCIR) imagery. All study sites were within the 45-sq. mile town of Mansfield in northeastern Connecticut. In order to describe the distribution of plant societies among the various zones (wetland, transition, upland), a statistical index of abundance was developed. Discriminant analysis applied to the abundance data showed which plant species best separate wetlands from uplands and which are representative of natural plant associations. Of the criteria studied, vegetation distribution, soil water content and relief are the most useful for delineating deciduous wetland forests. These results are valuable for identifying and delineating inland wetlands using remote sensing imagery.

Andrews, L.S.

1978

Forest encroachment of a marsh in the Great Dismal Swamp, North Carolina

Paper presented at the fifty-sixth annual meeting of the Virginia Academy of Science, May 9-12, 1978, Blacksburg

A portion of the Great Dismal Swamp, in North Carolina, was examined for vegetation change occurring over the past fifty years. This change was marked by the encroachment of trees species, primarily Acer rubrum, into a once open marsh environment. Analysis methods included aerial photographic interpretation, and examination of increment borings from trees in the area. Interpretation of historical aerial photographs has indicated that invading tree species have claimed 93% of the marsh area since 1937. Examination of increment borings has revealed that the major extent of this invasion has occurred within the past thirty years. The recent change in vegetation type appears to have been associated with the reconstruction of old drainage canals in the 1940's.

8x

Applequist, M.B.

1959

Longevity of submerged tupelogum and baldcypress

LSU Forestry Note 27. 2 pp.

The results obtained in this study suggest that seed of both baldcypress and water tupelo will tolerate limited submergence of a few months under field conditions. Baldcypress seeds apparently lost viability within about one year, whereas water tupelo seeds will retain viability 14 months but not as long as 21 months.

Applequist, M.B.

1959

Soil site studies of southern hardwoods

LSU, Proc. 8th Ann. For. Symp.:49-63

Much remains to be learned about the growth relations of swamp blackgum and tupelogum. The available evidence, however, indicates that physical soil characteristics which increase the amount of available soil moisture during the growing season also increase height growth. Perhaps of critical importance is the time and duration of floods that occur during the growing season. These and other factors that affect the amount and availability of soil moisture are worthy of more research. The somewhat common belief that swamp species "tolerate" flooding but actually make their best growth under well-drained conditions deserves critical analysis. Several lines of evidence from this study, as well as other work currently being done on other wet-site species, point up the importance of ample soil moisture during the growing season for maximum growth. It is suggested that the hydrophytic swamp blackgum and tupelogum may not only tolerate but may literally thrive under flooded or near-flooded conditions.

Applequist, M.B.

1959

A study of soil and site factors affecting the growth and development of swamp blackgum and tupelogum stands in southeastern Georgia

D.F. thesis, School of Forestry, Duke Univ.

Results obtained in this study warrant the following conclusions:

Tupelogum stands in southeastern Georgia have an average site index of 75 feet, while swamp black gum sites stands average 65 feet. Differences in site index among the major swamp black gum sites are not large, swamps being the highest, ponds intermediate, and runs the lowest.

Flooded tupelogum seedlings grow taller and produce more dry-weight tissue than similar seedlings of swamp blackgum.

Intermittent flooding of the surface soil during the growing season markedly increases diameter growth of young tupelogum as compared to unflooded conditions. The growth and development of swamp blackgum, tupelogum, and baldcypress—the three common hydrophytic trees of southern swamps—are determined very largely by water. This water may be excessive or deficient; both conditions are critically important depending on time, place, and quantity. A rather considerable amount of evidence suggests that these unusual species not only can tolerate flooding; they may literally thrive on it. Intermittent flooding during the growing season, just short of continuous surface flooding, may actually provide near-optimum soil moisture conditions for height and diameter growth.

Armstrong, W.

1967

The oxidizing activity of roots in waterlogged soils

Physiologia Plantarum 20:920-926

The ability of a number of plants to grow under conditions of experimental flooding has been examined. There was an increase in ethanol production under anaerobic conditions in those species whose growth was reduced by flooding. The period of flooding induced a marked increase in alcohol dehydrogenase activity of the roots of these plants. Plants not adversely affected by flooding showed no increase in ethanol production and no induction of alcohol dehydrogenase activity. It is suggested that species in which such activation occurs are excluded from wet areas because of the accumulation of toxic quantities of ethanol.

Armstrong, W.

1968

Oxygen diffusion from the roots of woody species

Physiologia Plantarum 21:539-543

Application of the 'polarographic' technique for studying oxygen diffusion from roots has provided preliminary results which establish that oxygen passes through the woody species *Salix atrocincrea*, *Salix fragilis*, *Salix repens*, and *Myrica gale* in the gaseous phase as it does in other wetland species. Entry into the shoots occurs through the bark directly above the water table and in the willow cuttings the effective length of shoot for gas intake was the basal three centimetres above the water table. The length of shoot involved was longer in *Myrica gale* and the roots were of the normal (un-nodulated) type.

A fortunate response in willow is the rapid and prolific development of adventitious roots immediately below flooded levels.

Baker, J.B.

1977

Tolerance of planted hardwoods to spring flooding

Sou. Jour. of Applied For. 1:23-25

Cuttings of eastern cottonwood (Populus deltoides) and seedlings of sweetgum (Liquidambar styraciflua), water tupelo (Nyssa aquatica), American sycamore (Platanus occidentalis), and green ash (Fraxinus pennsylvanica) were planted on a slackwater clay (Vertic Haplaquept) in western Mississippi in two consecutive years and inundated soon after foliation. During each of the two years, survival following flooding was consistently high for water tupelo, green ash, and sycamore, low for cottonwood, and intermediate for sweetgum. With the exception of green ash, however, all species lost their leaves and died back to the root collar during flooding. Thus trees, other than ash, that were living at the end of the growing season had originated from root collar sprouts.

Baker, J.B.; Broadfoot, W.M.

1977

A practical field method for site evaluation for eight important southern hardwoods

USFS Gen. Tech. Rep. SO-14. 31 pp.

This paper presents a new method of site evaluation for cottonwood, sweetgum, sycamore, green ash, and Nuttall, water, willow, and cherrybark oaks. The method incorporates an evaluation of the physical, moisture, nutrient, and aeration properties of a soil into a site quality rating. Field tests have demonstrated the accuracy of the technique. The site evaluation technique also provides a basis for possible soil improvement treatments for the eight hardwood species and estimates of potential productivity for cottonwood plantations.

Beaufait, W.R.

1956

Influence of soil and topography on willow oak sites

SFES, Occ. Paper 148. 12 pp.

In the Mississippi Delta, growth of willow oak can be predicted from the topographic position of the stand and the percent of clay in the soil. In non-Delta river bottoms of the South the topographic position and amount of potassium can be used as indices.

Beaufait, W.R.

1955

Soil profile observations relating to drought damage in black willow stands

Jour. of For. 53:517

During drought, black willow is quite sensitive to subsoil differences. In 1954, a 16-acre area of a willow stand along the Mississippi river was a complete loss. Soil pits revealed that a deposit of 32 inches of heavy clay overlaid deep fine sand. Tree roots extended only about three inches into the normally saturated, but at the time, desiccated sand. Pits in an adjacent healthy stand revealed a much deeper layer of heavy clay, with tree roots penetrating it to six feet.

Bedinger, M.S.

1971

Forest species as indicators of flooding in the lower White River Valley, Arkansas

Geol. Sur. Prof. Paper 750-C, pp. 248-253

The dominant environmental factor of forest habitats within the lower valley of the White River, Arkansas, is flooding. The flood plain consists of a series of terraces. Distribution of forest species on the terrace levels is related to flooding. The relationship is sufficiently distinct to permit determination of flood characteristics at a given site by evaluation of forest-species composition. The vegetation of the lower White River valley can be divided into four groups. Each group occurs on sites having distinctly different flooding characteristics. On sites flooded 29-40 percent of the time, the dominant species are water hickory and overcup oak. On sites flooded 10-21 percent of the time, a more varied flora exists—including nuttall oak, willow oak, sweetgum, southern hackberry, and American elm. The third group of sites is subject to flooding at intervals of from 2 to 8 years. This group is marked by presence of southern red oak, shagbark oak, and black gum. The presence of blackjack oak marks the fourth group (not flooded in historic times).

Beeson, K.C.; Lazar, V.A.; Boyce, S.G.

1955

Some plant accumulators of the micronutrient elements

Ecology 36:155-156

Swamp blackgum, sweet bay, gallberry, pepper bush, and broomsedge were sampled at three periods in each of two years. Swamp blackgum was found to have extremely high concentrations of cobalt, while gallberry accumulated large quantities of zinc. The widespread occurrence of both swamp blackgum and gallberry on uncultivated soils should contribute to their value as indicators of the cobalt and zinc status, respectively, of Coastal Plain soils.

Bell, D.T.

1972

How a dam may affect the environment

Ill. Res. 14(3):10-11

No abstract available.

Bell, D.T.

1974

Tree stratum composition and distribution in the streamside forest

Am. Mid. Nat. 92:35-56

The woody vegetation of the streamside forest in Robert Allerton Park, Piatt Co., Illinois, is described in relation to the distribution of river level frequencies of the Sangamon River. The habitats most frequently flooded are dominated by Acer saccharinum. With decreasing flooding frequency, dominance is transferred to Celtis occidentalis and Quercus imbricaria. The areas experiencing no flooding are dominated by Q. alba. Changes in the vegetational structure of elevational increments of .304 m (1 ft.) are discussed. The principle that communities change gradually along environmental gradients is illustrated in a vertical elevation of less than 4 m.

Bell, D.T.; Johnson, F.L.

1974

Flood-caused tree mortality around Illinois reservoirs

Trans., Ill. State Acad. Sci. 67:28-37

The effects of high reservoir levels in Rend Lake and Lake Shelbyville, both located in southern Illinois, on species of the streamside forest are described. Tolerances to growing season inundation for 24 tree species were determined from data on tree elevation and duration of flooding. A limit of 30 days of flooding during spring and summer months is suggested to insure survival of tree vegetation around reservoir margins.

Bell, D.T.; Johnson, F.L.

1974

Ground-water level in the flood plain and adjacent uplands of the Sangamon River

Trans., Ill. State Acad. Sci. 67:376-383

The influence of river level, precipitation, and evapo-transpiration on the water table fluctuations of the stream-side forest ecosystem was determined from observation well data at four locations in the upper Sangamon River bottoms and adjacent uplands. Water levels in the soil profile of the flood-plain areas of the streamside forest were strongly controlled by the level of the water in the stream channel. Changes in the upland water table, however, were not closely correlated to river level changes. Precipitation was the environmental variable most strongly influencing changes in the upland ground-water system. Evapo-transpiration losses in mid-transect areas may exceed infiltration of ground water from the river and drainage from higher levels during certain summer periods. An hypothesis concerning the possible changes which may occur upon construction of the William L. Springer Project is discussed. The study is a contribution of the Springer-Sangamon Environmental Research Program.

Bell, D.T.; Johnson, F.L.

1975

Phenological patterns in the trees of the streamside forest

Bull. Torrey Bot. Club 102:187-193

Phenological spectra of the principal tree species of the streamside forest ecosystem suggest that severe late spring freezes and the first fall frost can markedly affect the progression of phenological events. Fourteen tree species of the streamside forest were observed at weekly intervals in four sites of the Sangamon River valley in east-central Illinois. Phenophase development was compared to photoperiod, an index of heat sum, and accumulated solar energy during the 1973 and 1974 growing seasons. Phenological progression was found to correlate to both progression of heat sum and daylength; however, the occurrence of freezing temperatures strongly affected the regular rate of phenophase development. Variations on phenophase development rate between species and between portions of the flood-induced eocnocline are discussed.

Bell, D.T.; del Moral, R.

1977

Vegetation gradients in the streamside forest of Hickory Creek, Will County, Illinois

Bull. Torrey Bot. Club 104:127-135

Vegetation of the proposed Hickory Creek Dry Reservoir of Will County, Illinois, is described by an indirect gradient of time and a direct gradient of flooding frequency. Mature uplands are dominated by *Acer saccharum* with *Tilia americana* the most common associate. Mature flood-plain regions harbor a *Fraxinus pennsylvanica*-*Tilia americana* dominated complex. The first forest stage in the successful sequence of both regions is dominated by *Crataegus mollis*. Successional development was determined from inter-stand relationships. Stand structure was also influenced by the response of species to an elevational gradient associated with flood frequency. Species richness and species diversity tended to increase with increasing maturity and decreasing flood stress. Mature, unflooded uplands supported the greatest number of species and the greatest species diversity.

Bellah, G.R.; Hulbert, L.C.

1974

Forest succession on the Republican River floodplain in Clay County, Kansas

Southwestern Nat. 19:155-166

On the Republican River floodplain in Clay County, Kansas, 39 forest stands were plot sampled in 1968. Salix interior (sandbar willow), S. amygdaloides (almondleaf willow), and Populus deltoides (cottonwood) appeared the first or second year after alluvium was exposed above water level. Salix interior rarely persisted more than 10 years, S. amygdaloides not more than 30 years, and P. deltoides about a century. Young of these species did not survive in established stands.

After about 100 years dominant trees included Ulmus americana (American elm), Celtis occidentalis (common hackberry), Fraxinus pennsylvanica (green ash), Morus rubra (red mulberry), and Acer negundo (boxelder). No stand had attained climax, but Celtis occidentalis and Ulmus americana would likely have been dominants. Celtis may be the sole dominant in the future now that Dutch elm disease has entered the area.

For young (0-10) and old (>60 years stands), mean tree density was 24,000/ha (9,710/acre) and 5,000/ha (2,020/acre), mean basal area was 20 m^2/ha (87 ft^2/acre) and 39 m^2/ha (170 ft^2/acre) and mean basal area per tree > 6 cm diameter was 58 and 638 cm^2, respectively. The amount of light that penetrated the forest capony ranged from 18% in young to 2% in old stands. Competition, especially effects of shading, is thought to be more important than changes in soil in eliminating pioneer woody species.

Bennett, F.A.

1961

Silvical characteristics of Southern magnolia

SEFES, Sta. Pap. 139. 9 pp.

The "silvical characteristics" bulletins cover the following topics: Extent and climate of botanical range, edaphic and physiographic site conditions, reproduction and growth habits, ecology, plant and animal pests, and response to management.

Beschel, R.E.; Webber, P.J.

1962

Gradient analysis in swamp forests

Nature 194:207-209

During 1960 and 1961 a study was made of periodically flooded land dominated by Larix laricina, Thuja occidentalis, and Ulmus americana along transects from lake margins to the upland in the Rideau Lakes region of Ontario. This vegetation shows distinct belts of the dominants from the air, which have often been described as stages in a hydrosere. No sufficiently sharp break was found along transects to warrant a separation into different communities.

Blackmon, B.G.; Broadfoot, W.M.

1969

Lime, fertilizer cottonwood tests

Miss. Farm Res. 32(7):6,8

The Southern Hardwoods Laboratory at Stoneville tested four common bottomland soils in which cottonwood grows: Sharkey clay, Commerce loam, Adler silt loam, and Bibb sandy loam. The last-named soil is poorly aerated, strongly acid, and deficient in nutrients.

The soils were placed in 3-gallon glazed crocks. Seeds from a single cottonwood tree were planted, and seedlings were thinned to one per pot. After three months, the seedlings were measured for height, dried, and weighed.

The first three soils were fertilized with various combinations of nitrogen, phosphorus, and potassium. Seedlings in Sharkey and Adler soils showed no response to fertilizer. Those in Commerce soil, which is relatively low in nitrogen and organic matter, showed a definite response to the addition of nitrogen.

The acid Bibb soil received applications of complete fertilizer, lime, and combinations of the two. Although the seedlings grew considerably less than those in the other soils, they responded markedly to all fertilizer treatments, with the combination treatment yielding the greatest benefits.

Drainage, and the resulting aeration, would probably increase the productivity of the Bibb soil. Fertilization probably will not increase the yields of the Sharkey and Adler soils on uncleared land; however, heavily cropped old fields may require fertilizer.

29x

Blackmon, B.G.; White, E.H.

1972

Nitrogen fertilization increases cottonwood growth on old-field soil

USDA Forest Service Res. Note SO-143. 5 pp.

Eastern cottonwood is known to grow rapidly when planted on fertile alluvial soils of the Mississippi River floodplain. With increased flood control, however, exhaustive agriculture has reduced the fertility of many sites to the point where fertilization, particularly with nitrogen, is necessary for the production of agricultural crops. This paper reports first-year results of nitrogen and phosphorus fertilization of a 6-year-old cottonwood plantation on a site that had been cropped for many years.

Blackmon, B.G.

1979

Site-species relationships for southern hardwoods

North America's Forests: Gateway to Opportunity (Proc. of the 1978 Joint Convention of the Soc. of Am. Foresters and the Can. Inst. of For.), pp. 354-359

The subjective-objective approach of Baker and Broadfoot (1977) provides reliable estimates of productivity based on soil-site properties which are reasonably easy to identify in the field. Knowledge of soil series descriptions is not necessary. A few hours of instruction from a soil scientist should enable a land manager to apply the technique. The method can be applied over a range of geographic provinces and soil-site conditions. The approach may also provide general indication of factors limiting tree growth.

For the reasons mentioned earlier in this paper, the purely objective approach of Broadfoot (1969) does a relatively poor job of providing reliable site indices.

The subjective techniques (Broadfoot 1964b and 1976) are reliable but are limited to certain soil series, and ability to identify soils by series name is required, a major disadvantage overcome in the more recent technique of Baker and Broadfoot (1977).

31x

Bonner, F.T.; Broadfoot, W.M.

1964

Soil nutrients and pH in southern hardwood nurseries

Region 8 Forest Nurserymen's Conf. Proc. 1964:125-127
USFS, Southern Region

The pH must be 7.0 or less for southern oaks, tupelos, and yellow-poplar. Cottonwood, sycamore, pecan, and silver maple can be grown on alkaline soils.

Bonner, F.T.

1965

Some influences of soil moisture upon the survival and growth of planted hardwood seedlings in the Mississippi River valley

Ph.D. thesis, Duke Univ.

This study involves three important species—sycamore, sweetgum, and Nuttall oak—and two common soils of the Mississippi delta region. The soils, Sharkey clay and Commerce silt loam, are representative soils of the slackwater clay and batture areas, respectively. These areas probably will be extensively planted in the near future. The author sought to determine the effects of excessive soil moisture in the late winter and early spring, and deficient moisture later in the season, on the survival and first-year growth of planted hardwood seedlings.

Bonner, F.T.; Farmer, R.E., Jr.

1966

Germination of sweetgum in response to temperature, moisture stress, and length of stratification

For. Sci. 12:40-43

Seed from a single sweetgum tree near Stoneville, Mississippi, was collected and randomly assigned to five stratification periods: 0, 2, 4, 6, and 8 weeks. Further division was made between six moisture stress treatments (0, 1.0, 2.5, 5.0, 10.0, or 15.0 atmospheres) and four temperature regimes (60-75°, 70-85°, 75-90°, and 85-100° F.). The seeds were germinated in covered petri dishes.

Both total germination and rate of germination increased as temperatures were raised. Increases in osmotic stress lessened total germination and rate of germination, and 15 atmospheres of stress completely inhibited germination. Raising the temperatures decreased the influence of osmotic stress. Lengthening the stratification time diminished both temperature and osmotic effects.

Bonner, F.T.

1966

Survival and first-year growth of hardwoods planted in saturated soils

USFS, Res. Note SO-32. 4 pp.

Up to 16 weeks of soil saturation from the time of planting did not significantly affect survival, date of bud-break, or initiation of height growth of sycamore, sweetgum, and Nuttall oak seedlings. But when soil temperatures were rapidly increasing in mid-April, saturation for more than 10 to 12 weeks did severely reduce height, root, and stem-diameter growth. Saturation was more detrimental in Commerce silt loam than in Sharkey clay.

Bonner, F.T.

1967

Responses of 1-year-old cottonwood to increasing soil moisture tension

USFS, Res. Note SO-56. 3 pp.

One hundred cottonwood cuttings from the same clone were planted in clay pots, half of them filled with clay and half with sandy loam. Each pot was enclosed in a polyethylene bag tied to prevent any moisture loss except by transpiration. After four weeks in a controlled environment chamber with daily watering, the watering was stopped, and five randomly selected plants from each soil were measured after 1, 2, 3, and 7 days without watering for (1) transpiration, (2) terminal growth, (3) leaf water deficit, (4) leaf area, (5) shoot dry weight, (6) root dry weight, and (7) soil moisture content.

Transpiration rates began decreasing at leaf water deficits of 2.5% in sandy loam and 4.5% in clay. The larger plants in the clay transpired at almost double the rate of the plants in the sandy loam; but when transpiration was expressed on a leaf area or shoot weight basis, the rates did not differ significantly by soil type.

Terminal growth stopped abruptly when leaf water deficits reached about 5% in clay and 4% in sandy loam. This indicates a sensitive control of water loss in cottonwood in response to moisture stress. In comparison, values obtained in another study were 6.9% for sycamore, 6.4% for sweetgum, and 8.9% for Nuttall oak in clay, and slightly less in silt loam. Put in more general terms cottonwood uses large amounts of soil moisture, but apparently reduces its needs at relatively low levels of moisture tension.

Bonner, F.T.; Broadfoot, W.M.

1967

Growth response of eastern cottonwood to nutrients in sand culture

USFS Res. Note SO-65. 4 pp.

Seedlings of eastern cottonwood were grown in 63 5-gallon glazed stone crocks of sized quartz sand at the Southern Hardwoods Laboratory. Nutrient solution levels tested were:

N - 0, 10, 25, 50, 100, 200, and 300 p.p.m.
P - 0, 5, 10, 25, 50, 75, and 100 p.p.m.
K - 0, 25, 50, 100, 200, 300, and 400 p.p.m.

Automatic irrigations with the nutrient solutions were delivered at 15-minute intervals from reservoir crocks.

The seedlings were grown from May to late July, after which time measurements were made of (a) seedling height; (b) foliage, stem, and root fresh weight; (c) foliage, stem, and root dry weight. Foliage samples were stored for later analyses of N, P, and K.

Seedlings grown with 0 p.p.m. of individual nutrients showed the deficiency symptoms commonly seen in agricultural crops. N-deficiency was characterized by chlorosis; P-deficient shoots were small with a red pigmentation; K-deficiency caused burning of leaf margins.

Based on total seedling dry weight, the best growth occurred at nutrient solution levels of 100 p.p.m. N, 75 p.p.m. P, and 100 p.p.m. K. There was significant stunting of growth with the highest levels—300 p.p.m.—of N.

The data indicates that under these study conditions, best growth was obtained when foliage concentration of nitrogen was about 4%, when phosphorus concentration was about 0.6%, and when potassium concentration was about 3.5%.

Bonner, F.T.

1968

Water uptake and germination of red oak acorns

Bot. Gaz. 129:83-85

Stratified acorns of Nuttall oak, pin oak, cherrybark oak, and northern red oak were subjected to the following treatments: sealing of cup scars with wax, splitting of pericarps, removal of pericarps, killing the embryo by autoclaving but leaving pericarp intact, and control. The acorns were weighed, immersed in distilled water, and reweighed after 10, 24, 48, 72, 96, 144, 192, and 240 hours at 19°C. After 240 hours, dry weights were obtained, and water contents after the various periods of immersion were then calculated as percentages of acorn dry weight.

In all cases, the acorns with pericarp removed absorbed the most water. In most cases, the remaining treatments ranked as follows: split pericarp, second; dead seed, third; untreated seed, fourth; cup scar sealed, fifth. This indicates that a great deal of moisture is normally absorbed through the vascular openings of the cup scar.

Water uptake appeared to be divided into two phases: rapid uptake, caused mainly by imbibition, and slower but steady uptake related to metabolic activity in germination.

Nuttall oak and pin oak acorns absorbed much less water than did those of northern red oak and cherrybark oak. This is attributed to the thick coating of wax on acorns of Nuttall and pin oaks, which may also explain their high tolerance to submergence reported by other investigators.

Bonner, F.T.

1968

Response to soil moisture deficiency of seedlings of three hardwood species

USFS Res. Note SO-70. 3 pp.

This study deals with seedlings of sweetgum, sycamore, and Nuttall oak. Seventy 1-year-old seedlings of each species were taken from the nursery in February. Half were planted in 1-gallon cans containing Sharkey clay, the other half in cans containing Commerce silt loam. In May, when shoots were growing rapidly, the cans were carefully sealed to prevent all water loss except by transpiration. Soil moisture tension was maintained at 1/3 atmosphere for a week, after which watering was discontinued.

On the following morning, five seedlings of each species in each soil were measured for transpiration, terminal growth, leaf water deficit, total leaf area, shoot fresh weight, shoot dry weight, and soil moisture tension. Six other groups were similarly analyzed as soil moisture was depleted by transpiration--the last group when the leaves had wilted and the plants appeared to be nearly dead.

In general, seedlings that grew fastest transpired most, and transpiration rates decreased as soil moisture was depleted. Terminal growth slowed when leaf water deficits reached 6% to 9%. This point was reached after five to seven days without water in Sharkey clay and after three to five days in Commerce silt loam. Terminal growth stopped completely after 13 to 15 days without water in clay, and after about 11 days in loam. Average leaf water deficits at these times varied widely among species, but in both soils, they were highest in sycamore and lowest in sweetgum leaves.

Seedlings in Sharkey clay were still transpiring slowly at moisture tensions somewhat higher than the 15 atmospheres commonly considered to represent the wilting point.

Bormann, F.H.; Siccama, T.G.; Likens, G.E.; Whittaker, R.H.

1970

The Hubbard Brook ecosystem study; composition and dynamics of the tree stratum

Ecol. Monogr. 40:373-388

The synecology of tree species was studied in a mature second-growth forest in the Hubbard Brook ecosystem. The forest, on a 13-ha undisturbed watershed ecosystem covering a 245-m range of elevation, has a basal area of about 23 $m^2 ha^{-1}$. Dominance is shared by *Acer saccharum*, *Fagus grandifolia*, and *Betula alleghaniensis*. Direct gradient analysis and regression analysis indicated a strong response in both stand and species characteristics to an elevational complex gradient. Basal area per hectare, basal area per tree, deciduousness, and canopy height decreased with increasing elevation, whereas density, evergreenness, and species diversity increased. A lower rate of net primary productivity is correlated with higher elevations. Gradient analyses indicated that no two tree species have identical patterns of importance values over the elevational complex gradient. Sugar maple shows a decreasing trend; balsam fir, paper birch, and mountain ash show increasing trends. Beech, red spruce, mountain maple, and striped maple show intermediate patterns. Seedlings and saplings respond to the elevational gradient as do larger trees; however, the behavior of trees, seedlings, and saplings of the same species is clearly different. The Hubbard Brook ecosystem is located in relation to the vegetational zonation systems of earlier authors. The only generally agreed upon vegetational boundary, ca. 760 m (2,500 ft.), is accounted for by a steepened rate of environmental change in the vicinity of that elevation. Various lines of evidence indicate that the present second-growth forest at Hubbard Brook approximates old-age mature northern hardwood forest. Therefore, the biogeochemical productivity, and ecological data obtained from this study are representative of a mature ecosystem in dynamic balance with regional and local controlling factors, i.e., climate, geology, and topography.

Bourgeois, G.W.

1964

Variation of ash content in sweetgum on different soil types

Thesis, Louisiana State Univ.

In this study, based on wood and soil samples from seven different localities in Louisiana, the author found positive correlations between available calcium, phosphorus, potassium, magnesium, and sodium contents in the soil, and calcium content in the ash, and between available magnesium, phosphorus, and potassium contents in the soil and magnesium content in the ash.

Braun, E. Lucy

1950

Deciduous forests of Eastern North America

The Blakiston Company. 596 pp.

This book is based on some 25 years of field study throughout the deciduous forest, 65,000 miles of travel, on many years of familiarity with the deciduous forest as a whole, and on intimate association with and study of parts of this forest. It attempts, first, to portray what is (or was) present in any geographic area and to reconstruct the pattern of original forest insofar as the fragments remaining permit; second, to give data on composition and aspect of forest communities in all parts of the deciduous forest; and third, to trace through geologic time the development of the present pattern of forest distribution.

Briscoe, C.B.

1955

Diameter growth of selected bottomland hardwoods as affected by species and site

La. Agr. Exp. Sta., LSU For. Notes 5. 2 pp.

Study of the last ten years' radial growth of 160 trees of seven bottomland species indicated that:

(1) Growth on flats and ridges was essentially equal.

(2) Growth in sloughs was slower than on flats or ridges.

(3) Growth varies between species, but species were not affected to the same degree by change in site; therefore, no species was the fastest growing on all sites, nor was any species the slowest growing on all sites. Any statement as to relative growth rates between species must be qualified as to site.

The most rapid ten-year growth recorded was for cherrybark oak on a flat (4.3 inches).

Briscoe, C.B.

1957

Diameter growth and effects of flooding on certain bottom-land forest trees

Ph.D. diss., Duke Univ. Sch. of For., 103 pp.

Ten-year diameter growth of dominant and codominant trees of 17 bottomland species growing on seven physiographic sites in southeastern Georgia was studied. Formulas are given for calculation of the 10-year diameter growth of each species. The apparent degree of tolerance of flooding and submersion was strongly correlated with the frequency of flooding of the typical natural site of the species.

Briscoe, C.B.

1961

Germination of cherrybark and Nuttall oak acorns following flooding

Ecology 42:430-431

Acorns of cherrybark and Nuttall oaks were enclosed in open-mesh bags and submerged in swamp water and in tap water for periods up to 34 days; cherrybark acorns were also submerged in sealed bottles of tap water. Type of water or container did not affect germination of either species. Cherrybark oak typically grows on sites seldom or never flooded; germination percent of its acorns was significantly lowered by prolonged submersion. Nuttall oak is common on sites flooded annually; submersion for periods up to 34 days did not reduce germination percentage of its acorns. There was some indication that resistance to flooding effects was associated with size of acorn.

Broadfoot, W.M.

1958

Effects of impounded water on trees

Miss. Farm Res. 21(6):1-2

In fall and early winter, many landowners build temporary lakes in hardwood forests, usually to attract migrating waterfowl. Study of 16 such shallow impoundments in Arkansas and Mississippi showed that they increase the amount of water going into soil storage, and thus may benefit trees during a dry summer. The water must be released each spring, before tree growth begins. Continuous impoundment kills some species in one or two years, and all trees in four years.

Broadfoot, W.M.

1958

Reaction of hardwood timber to shallow-water impoundment

Miss. State Univ. Agri. Exp. Sta. Inf. Sheet 595

A study was made in a stand that had been flooded for four consecutive years. All species had made a surprising spurt in diameter growth during the first year of flooding. From there on until the trees died, the reaction was quite variable between species, and occasionally within species. Cherrybark oak was the only important commercial species in which occasional trees died at the end of the first year of flooding. In the second year, all cherrybark oaks slowed down in growth and many died. All elm, sugarberry, honey-locust, and persimmon trees died sometime during the second season of continuous flooding. Willow oak and water oak lasted a little longer. Some trees began to decline in growth during the second year, but few died until the third and sometimes the fourth year. Some willow oak and water oak even spurted in growth for three consecutive years before decreasing and dying.

Overcup oak, green ash, sweetgum, and Nuttall oak made up the most water-tolerant group. Some trees in these species increased in diameter growth all 4 years of flooding, while others declined during the third year, and died in the fourth year.

Difference in reaction within species was probably due to vigor differences and possibly to differences in depth of impounded water. Acorn production stopped after one year of continuous flooding, even though the trees sometimes continued to grow in diameter.

In short, the study showed that with careless or bad handling of water impoundments, all of the trees will ultimately be killed and forest benefits such as increased tree growth and better mast production (usually the reasons for the impoundment) will not be achieved. But about 6 to 12 inches of water impounded in September or October and drained in April will increase the amount of moisture stored in the soil for use by the trees during dry summers. The impounded water will not damage the trees if it is drained off promptly each spring.

Broadfoot, W.M.; Burke, H.D.

1958

Soil-moisture constants and their variation

SFES, Occas. Paper 166. 27 pp.

Values for the most commonly used constants, under specific soil and cover conditions.

Broadfoot, W.M.

1959

Soil-water shortages and a means of alleviating resulting influences on Southern hardwoods

LSU, Proc. Ann. For. Symp. 8:115-119

Hardwoods throughout the South have suffered dieback and mortality during recent years. In general, losses have been most severe in cottonwood, sweetgum, and black willow. Drought is now understood to be the basic cause. It is recommended that water from winter rains be impounded. Investigations show that about 6 to 12 inches of water impounded in September or October and drained in April, if not already used by the timber, will increase the amount of moisture stored in the soil and therefore benefit hardwood growth, especially during dry summers. The impounded water will not damage the trees if it is drained off promptly each spring.

49x

Broadfoot, W.M.; Krinard, R.M.

1959

Guide for evaluating sweetgum sites

SFES, Occas. Paper 176. 8 pp.

Three methods of estimating sweetgum sites in the Midsouth: from amounts of clay and exchangeable potassium in the 36- to 48-inch soil layer; from texture and drainage characteristics of the soil; and from tabulated averages for standard soil series and phases.

Broadfoot, W.M.

1960

Cottonwood growth varies with type of soil

Miss. Farm. Res. 23(10):7

Trees on Robinsonville silt-loam were 43 feet tall after five years in the field.

Broadfoot, W.M.

1960

Early growth of planted cottonwood on Delta soils

Miss. Farm. Res. 23(10):7

Growth of cottonwood trees varies considerably between soil types. Data are given for Sharkey clay, Alligator clay, Forestdale silty clay loam, and Robinsonville silt loam.

Broadfoot, W.M.

1960

Field guide for evaluating cottonwood sites

SFES, Occas. Paper 178. 6 pp.

Two methods applicable to the Midsouth. The first provides a fast field classification of sites from determinations of soil texture, internal drainage, and inherent moisture conditions. The second requires the soil to be identified by standard series and phase.

Broadfoot, W.M.; McKnight, J.S.

1961

Soil suitability for hardwoods in the Mississippi Delta

Miss. St. Univ. Agr. Exp. Sta. Information Sheet 716

Tabular summary.

Broadfoot, W.M.; McKnight, J.S.

1962

Suitability of soils for hardwoods in coastal plain areas

Miss. St. Univ. Agr. Exp. Sta. Information Sheet 745

Tabular summary of suitability of soils in this land resource area for growing about 30 commercial hardwood species.

Broadfoot, W.M.

1963

Guide for evaluating water oak sites

USFS, Res. Paper SO-1. 8 pp.

Site index can be gaged by three methods: (1) estimated from amount of sodium in the soil, depth of topsoil, and presence or absence of a hardpan; (2) determined in the field from soil texture, depth to mottling, presence of a pan, depth of topsoil, and inherent moisture conditions; (3) read from a table of averages after soil series and phase have been identified. The first method was found most accurate.

Broadfoot, W.M.

1964

Hardwoods respond to irrigation

Jour. of For. 62:579

Dikes were built around two quarter-acre plots of 40-year-old hardwoods on Sharkey clay. During six consecutive summers, well water was applied directly on the ground surface of the diked areas whenever soil moisture fell below 50 percent of available water capacity. All species (sweetgum, Nuttall oak, green ash, hackberry, persimmon, and overcup oak) showed substantial gains in diameter growth under irrigation.

Broadfoot, W.M.

1964

Soil suitability for hardwoods in the Midsouth

USFS, Res. Note SO-10. 10 pp.

A study of the growth of willow oak, cottonwood, cherrybark oak, water oak, sweetgum and other species in the Delta, Loess, Coastal plain, Red, and Blackland soil areas. The species are classified according to their frequency of occurrence and their desirability for management in a given soil area.

Broadfoot, W.M.

1967

Shallow-water impoundment increases soil moisture and growth of hardwoods

Soil Sci. Soc. Amer. Proc. 31:562-564

Forest owners in the Mississippi delta have questioned the effects of shallow-water impoundment on tree growth in the green-timber reservoirs built by hunting clubs to attract water fowl. The present study was designed to answer this question and also to determine the effect of water impoundment early in the growing season on soil moisture supply.

The average increase in radial growth due to flooding, for all species combined, was about 52%. There were striking differences in the response of species. Oaks had the best growth of all species without impounded water, but ranked at or near last in growth increase after water impoundment. Cottonwood with no extra water ranked seventh, but impounded water boosted it to top ranking. Green ash trees, which ranked ninth without treatment, rose to second or third place with extra moisture.

Oxygen in the impounded water was found to be depleted rapidly in periods of no rainfall, but was quickly replenished, even by small showers. If no rain occurred in an impoundment for an extended period, the oxygen supply might become critical. This may be why timber varies greatly in its ability to withstand extended flooding.

Broadfoot, W.M.

1969

Problems in relating soil to site index for southern hardwoods

For. Sci. 15:354-364

Various soil-site characters were correlated with height growth of _Liquidambar styraciflua_, _Quercus falcata_ var. _pagodaefolia_, _Q. nigra_, _Q. phellos_, _Q. nuttallii_, _Fraxinus pennsylvanica_, and _Populus deltoides_ in the Midsouth. Equations developed by multiple regression, however, do not predict site index of new populations with sufficient precision over a large area. Incomplete sampling of the conditions under which southern hardwoods grow may have contributed, but the failure resulted mainly from the inability to measure the true causes of productivity—soil moisture and nutrient availability during the growing season, soil aeration, and physical condition including root growing space.

Broadfoot, W.M.

1973

Raised water tables affect southern hardwood growth

USFS, Res. Note SO-168. 4 pp.

In natural stands near Demopolis Lock and Dam Reservoir in Alabama, the average growth in tree radius increased about 50% in the five years after the water table was raised from an indefinite depth to within reach of the tree roots. In natural stands near the Jim Woodruff Reservoir in Florida, radial growth of trees also increased markedly after the water table was raised, but only when no sediment was deposited around the trees.

Broadfoot, W.M.

1973

Water table depth and growth of young cottonwood

USFS, Res. Note SO-167. 4 pp.

Planted cottonwood grew best when the water table was about 2 feet deep, whether the tree was planted on soil with a high water table or the water table was raised 1 year after planting. Growth over a 1-foot-deep water table was about the same as over no water table, but a surface water table restricted growth of cuttings planted in the water, and killed trees planted the year before.

Broadfoot, W.M.; Toole, E.R.

1956

Soil factors may cause gum blight

SFES, Sou. For. Notes 106

Soil moisture stress may be the main cause of sweetgum blight.

63x

Broadfoot, W.M.; Farmer, R.E., Jr.

1969

Genotype and moisture supply influence nutrient content of eastern cottonwood foiliage

For. Sci. 15:46-48

Foliar contents of nutrients are being used as indicators of nutrient requirements of tree species. Several reviews note that, although foliar analysis is potentially valuable, numerous environmental, physiological, and procedural variables must be formally considered to insure useful results. In this study, the effects of clone and soil moisture stress were investigated.

The effects of clone were significant for all three elements. Soil moisture effects were significant only for nitrogen and phosphorus.

The authors conclude that clone and environmental conditions during growth must be considered in nutritional studies of juvenile cottonwood, and that in many cases total quantities per plant, per leaf, or per unit area should be determined as well as concentrations by weight.

Broadfoot, W.M.; Williston, H.L.

1973

Flooding effects on southern forests

Jour. of For. 71:584-587

Spring floods in the lower Mississippi Valley can improve growth of dominant, vigorous hardwoods, primarily by supplying additional water later in the growing season. Flood-resistant hardwoods are damaged where silt and sand are deposited to depths of three or more inches, where soil conditions are adverse, and in depressions where water does not leave promptly. In these areas, mortality may occur over the next four years. Young seedlings of resistant species die back if inundated after they leaf out, but many will sprout from surviving rootstocks. The pines and many hardwoods in uplands behind flood control dams are not tolerant of flooding. There, high water for just a few weeks during the growing season may cause severe mortality.

Brunk, E.L.; Hansbrough, T.

1960

Effect of temperature and light intensity on the germination of sycamore, sweetgum and American elm seed

LSU For. Notes 39. 2 pp.

In an effort to explain the fact that pure sycamore stands are frequently succeeded by American elm, an experiment was made with three temperature ranges and two light intensities, using sycamore, sweetgum, and American elm seed. Elm exceeded sycamore in germination in five out of six treatment combinations. It was concluded that American elm succession may be due to the fact that temperature and light conditions are more favorable for the germination of elm than they are for sycamore.

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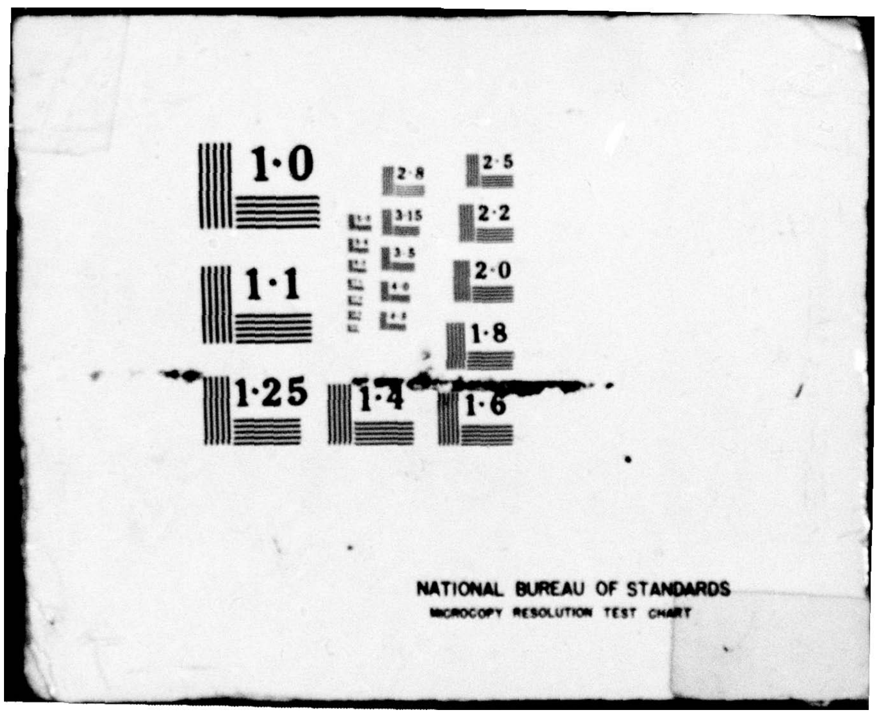
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NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

Brunk, E.L.; Allmon, A.R.; Dellinger, G.P.

1975

Mortality of trees caused by flooding during the growing season at two midwest reservoirs

Missouri Dept. Cons., Jefferson City, Mo.

No abstract available.

Bryant, R.L.

1963

The lowland hardwood forests of Ingham County, Michigan: their structure and ecology

Ph.D. thesis, Mich. State Univ.

A considerable acreage occupied by lowland-hardwood forests in southern Michigan is considered to have a storage and stabilizing influence on groundwater supplies. Since little is known about the composition, groundwater hydrology, successional relationships, and general ecology of these forests the present study is an attempt to provide preliminary information on these subjects.

Measurement of the number, size, and distribution of tree species in the lowland-hardwood stands was accomplished using four sampling methods. A plot method was used as a standard for the study against which data were compared from the other methods. Non-areal methods included random pairs, the point-centered quarter, and the variable plot-radius methods.

The effects of five and pathogenic influences, windthrow and rooting systems on community structure of lowland-hardwood stands were discussed. Windthrow and rooting habits of certain lowland tree species served to influence the eventual stand-age-structure of lacustrine forests.

An examination of the soil profiles showed that the majority of soil types were alpha-gleys which were poorly drained.

Buell, M.F.; Wistendahl, W.A.

1955

Floodplain forests of the Raritan River

Bull. Torrey Bot. Club 82:463-472

1. Evidence from the one example studied indicates that the low terraces that lie just above the flood level of the Raritan River can support a forest dominated by sugar maple, beech, and basswood. Their two principal but minor associates will be red oak and bitternut hickory.

2. The flood plains will support forests that are much more varied in composition.

3. The part of the flood plain farthest from the river, the inner flood plain, is less well drained than the part adjacent to the river. The inner flood plain forest which was investigated in this study occupies a site where surface erosion at flood times scours the ground resulting in an uneven surface. Sugar maple, red maple, ash and beech as a group are becoming dominant in place of the earlier established elm, box-elder, red oak, basswood, pinoak, river birch and tulip tree. This succession cannot be presumed for the inner flood plain of the river as a whole because more often deposition rather than surface erosion occurs during flooding and the conditions then are exceedingly different. No extensive relatively undisturbed stands occur on the latter type of site.

4. The outer flood plain sites or broad more or less level areas of deposition next to the river have a deep, well-drained soil and support a deciduous forest of mixed composition in which no convincing trend toward the dominance of a few species is evident.

Burgess, R.L.; Carter, W.C.; Keammerer, W.R.

1973

Vegetation of the Missouri River Floodplain in North Dakota

N. Dak. Water Resources Res. Inst. Res. Proj. Techn. Completion Rpt. 162 pp.; 170 refs.

An 80-mile-long study area, bordered by Garrison Dam and Oahe Reservoir, includes the only extensive, remaining floodplain forest vegetation in the Missouri Valley in the Dakotas. Data were collected to assess the water relations and nutrient status of each stand, to determine the abundance of plant species, and to examine species' behavior along environmental gradients. Attainment of the study objectives filled a gap in the knowledge of the forest vegetation of North Dakota. We now know, in detail, what plant species comprise the forests of the Missouri Valley, how they are arranged into plant communities, the environmental conditions found within each community, and how the meandering nature of the river influences community dynamics and development.

Second, this work has provided information regarding the forest habitat used by agricultural Indian tribes less than a century ago. Many of the remaining forests are currently being cleared, selectively cut, and grazed, and it was necessary to collect data from these forests before they, too, disappeared.

Finally, the construction of dams has eliminated periodic flooding throughout the study area. Data collected during the course of this study indicate that flood protection has led to decreased tree growth and may also be responsible for an observed decline in tree reproduction.

Burton, J.D.

1971

Prolonged flooding inhibits growth of loblolly pine
seedlings

USFS, Res. Note SO-124. 4 pp.

Subsequent growth of potted 2-year-old Pinus taeda seedlings was retarded by flooding to the soil surface for 14 or 21 weeks beginning January 3. After flooding, normal drainage was restored until November 17, when plants were harvested. Flooding for 14 and 21 weeks affected stem height, dry weight of roots and new stem, average needle length, and number of growth flushes. Dry matter in foliage decreased with increasing flooding duration; mineral concentrations did not.

Campbell, R.G.

1976

Drainage of lower coastal plain soils

Proceedings, 6th Sou. For. Soils Workshop, Charleston, S.C., Oct. 1976, pp. 17-27

Drainage differentials can create ranges of site index (25) from 37 to 65 feet for loblolly pine within a plantation. Ditch spacings prescribed by soil type can control water table depth and alleviate these growth differences. Drainage systems and water table management over the rotation are two approaches to maximum growth potential.

Carpenter, J.R.; Mitchell, C.A.

1977

Root respiration characteristics of flood tolerant red maple (*Acer rubrum*) and flood intolerant sugar maple (*Acer saccharum*) trees

Hortscience 12:422

Differences in respiratory metabolism of roots may contribute to the relative flood tolerance of trees. Roots of red and sugar maple have an alternate (CN-insensitive) electron transport pathway of respiration as well as the classical cytochrome (CN-sensitive) pathway. Although less efficient in energy transduction, alternate electron flow may be induced by CN or various stress treatments. Characterization of various parameters of respiration (RQ, response to different O_2 tensions, sensitivity to inhibitors, etc.) has been determined for both species as a function of variable moisture regimes.

Carpenter, J.R.; Mitchell, C.A.

1978

Comparative root respiration characteristics of flood tolerant Baldcypress vs. flood intolerant Japanese yew

Hortscience 13:369

Continuous flood stress prevented root growth in *Taxus*, but permitted adventitious root formation in *Taxodium*. Capability of roots excised from flooded plants to respire in an atmosphere containing 21% O_2 declined with increasing time of stress in both species, but recovered in *Taxodium* after 10 days of treatment. On the other hand, roots of *Taxus* flooded for 10 days were unable to sustain O_2 uptake from an atmosphere containing $\leq$ 1% O_2, while *Taxodium* roots regenerated during submersion respired effectively at 0.1% O_2. Flood stress progressively enhanced the sensitivity of root respiration in both species to CN, an inhibitor of cytochrome oxidase. Flooding also increased the sensitivity of *Taxus* roots to SHAM, an inhibitor of alternate oxidase, whereas SHAM sensitivity of *Taxodium* remained constant with increasing duration of stress.

Chaney, W.R.; Kozlowski, T.T.

1977

Patterns of water movement in intact and excised stems of *Fraxinus americana* and *Acer saccharum* seedlings

Ann. Bot. 41:1093-1100

Patterns of water movement in intact and excised stems of *Fraxinus americana* and *Acer saccharum* seedlings were delineated with periodic acid-reduced basic fuchsin staining technique and microscopy. In intact *Fraxinus* stems water movement occurred primarily in the large early-wood vessels of the current xylem increment except in the current shoot where the ring porous character was not developed and water movement occurred in large vessels scattered throughout the xylem. In intact *Acer* stems water movement occurred in large vessels in the current annual ring and in the outer two-thirds of the prior-year annual ring. The pattern of water movement in excised stems under suction was similar to the pattern in stems of intact transpiring *Fraxinus* plants, whereas in *Acer* a larger portion of the cross-sectional area of stems was used when suction was applied to excised stems. Relative conductivity was similar for the two species as a result of conduction in *Fraxinus* in a small number of large-diameter vessels and in *Acer* in a large number of small-diameter vessels.

Chung, H.H.; Kramer, P.J.

1975

Absorption of water and ^{32}P through suberized and unsuberized roots of loblolly pine

Can. Jour. of Res. 5:229-235

Measurements were made of the rate of intake of water and ^{32}P through suberized and unsuberized roots and root segments from seedlings of Pinus taeda under a pressure gradient of 31 cm Hg (41 KPa), produced by use of a vacuum pump. Water and ^{32}P intake through suberized root segments from seedlings in storage was only 11% of the intake through unsuberized segments from roots grown in nutrient solution. Water intake through entirely suberized root systems grown in nutrient solution was about 71% and ^{32}P uptake about 58% of those through root systems grown in nutrient solution but with 40-50% of their surface unsuberized. Uptake of water and ^{32}P through root segments and root systems grown in vermiculite was intermediate between that for seedlings grown in nutrient solution and that for dormant root systems. Removal of all unsuberized root surface reduced the total root surface by 42%, water uptake by 54%, and ^{32}P uptake by 70% per seedling. These results indicate that absorption of water and mineral nutrients through suberized roots may play an important role in the water economy and mineral nutrition of woody plants.

Clark, F.B.

1963

White ash, hackberry, and yellow-poplar seed remain viable when stored in the forest litter

Proc. Ind. Acad. Sci. 72:112-114

Knowing that the seed of some species will remain viable for several years, the forester or forest manager should be able to improve composition in the new stand. For yellow-poplar, white ash, and hackberry, the current seed crop does not necessarily dictate the time of cutting. The forest manager has at his disposal a reservoir of seed stored in the forest floor rather than just a fresh layer of seed on top of the litter. There appears to be no good reason to perpetuate the classical seed-tree method of harvest cutting yellow-poplar.

Clark, F.B.; Boyce, S.G.

1964

Yellow-poplar seed remains in the forest litter

Jour. of For. 62:564-567

Yellow-poplar seed remained viable for four winters in forest litter in experimental areas in Illinois and Indiana. Under natural conditions viable seed accumulates for several years and germinates when seedbed conditions are suitable. With proper cutting and a favorable seedbed there is little need to reserve seed trees on areas cut to reproduce yellow-poplar. The study provides some basic information about the germination of yellow-poplar seed. Some seeds germinate in the forest litter without a mineral seedbed, but such seedlings rarely live more than one growing season. Sandflat tests showed that stratification for one winter does not break dormancy in all seeds, but after stratification for two winters most of the seed will germinate if conditions are favorable.

Clark, R.H.

1958

Direct seeding of cherrybark oak

LSU, Proc. 7th Ann. For. Symp., pp. 5-9

Acorns of Quercus pagodaefolia were seeded under stands of low-quality gum and oak in November 1951 and November 1953. The overwood was killed by girdling or poisoning. The removal of the dense canopy created a succulent growth of grasses, which was ideal for the illegal open range policy of Arkansas. This heavy concentration of grazing, plus the severe drought which prevailed after each seeding, were the main contributing factors in the heavy loss of seedlings. Only 2% of the acorns sown resulted in established seedlings.

Germination of the acorns was surprisingly high. It was evident that the highest overall percent of germination occurred on the areas where large openings were made in the overstory prior to seeding. The fact that germination occurred over a period of three months during the growing period indicated that cherrybark acorns may remain dormant and still have the ability to germinate.

It appeared that the second seeding, which was at an average depth of one inch, gave a greater and quicker germination than those seeded at an average depth of two inches.

The ability of young plants to withstand complete submergence from one to four days was somewhat of a surprise.

Conner, W.H.; Day, J.W.

1976

Productivity and composition of a baldcypress-water tupelo site and bottomland hardwood site in a Louisiana swamp

Am. Jour. of Bot. 63:1354-1364

The productivity and composition of two study sites in a southern Louisiana freshwater swamp were studied from October 1973 to November 1974. Net productivity was determined from measurements of litter-fall, stem growth of woody species, and harvest samples of annual herbaceous understory. Tree composition was determined by the point-centered quarter method. Relative frequency, relative density, absolute density, relative dominance, and importance value (IV) were calculated for the tree species along each transect. In the bottomland hardwood area many woody species exist with Acer rubrum var. drummondii (IV = 23.9) and Nyssa aquatica (IV = 18.4) the most dominant. In the baldcypress-water tupelo area, fewer woody species exist and Taxodium distichum (IV - 39.2) and N. aquatica (IV = 37.6) dominated. Comprison of productivity data from several southeastern swamps indicate that flowing water regimes tend to result in the highest swamp forest productivity.

Craske, A.G.

1968

Ecological site preference and taxonomic differences within 2 *Acer saccharum-Acer nigrum* complexes found in Parke County, Indiana

Proc. Ind. Acad. Sci. 78:201-209

A study was conducted on the ecological site preferences and taxonomic differences within two *Acer saccharum-Acer nigrum* complexes found in Parke County, Indiana. A suitable means of identification was determined for the two species based on leaf characteristics. A significant difference was found between flood plain and slope and flood plain and upland populations based on leaf morphology. The flood plain was found to have significantly higher pH and phosphorus values and significantly less canopy cover than those values for slope or upland. No significant differences were found between slope and upland for the ecological parameters. Sugar maple, black maple and the intermediates were found to represent three populations. The intermediate population represented the central portion of a continuum of leaf characters running from black maple to sugar maple. *Acer nigrum* showed a definite site preference for the flood plain. *Acer saccharum* showed a definite site preference for the slope and upland. It would thus appear that the character of site preference would be valuable for identification and should be incorporated into descriptions of the two species.

Crawford, R.M.M.

1967

Alcohol dehydrogenase activity in relation to flooding tolerance in roots

Jour. of Exp. Bot. 18:458-464

Root oxidising activity has been studied quantitatively in two species: Menyanthes trifoliata and Molinia coervlea, using a non-specific dye technique, and an oxygen-specific "polarographic" technique in conjunction with artificial roots constructed from silicone rubber tubing.

Oxidising activity in these two species has been found to be up to nine times greater than can be accounted for by oxygen diffusing from the roots. Enzymatic oxidation is thought to be the cause of such high oxidising activity.

The characteristic patterns of iron oxidation found on and around roots are discussed, and oxidation of iron at the rhizophere "boundary" is illustrated.

Earlier work on root oxidising activity is briefly reviewed.

Crawford, R.M.M.; McManmon, M.

1968

Inductive responses of alcohol and malic dehydrogenases in relation to flooding tolerance in roots

Jour. of Exp. Bot. 19:435-441

The levels of alcohol dehydrogenase and malic dehydrogenase activity were investigated in the roots of various species grown for several days, in aerated and non-aerated culture solutions. The activity of these enzymes in non-aerated cultures increased but only in those species previously found to be intolerant of experimental flooding. The induction of alcohol dehydrogenase was reversible. Physiological concentrations of acetaldehyde induced alcohol dehydrogenase activity, this induction being greatest in the species intolerant of flooding. It is suggested that the ineffectiveness of the inductive stimulus in the plants tolerant of flooding contributes to their homeostatic survival properties under high water-table conditions.

Crites, R.W.; Ebinger, J.E.

1969

Vegetation survey of floodplain forests in east-central Illinois

Trans. Ill. State Acad. Sci. 62:316-330

Woody and herbaceous vegetation surveys were made of six areas (13.75 acres) located in the Embarrass River Floodplain in east-central Illinois. A total of twelve species were found with Acer saccharinum, Populus deltoides, Acer negundo, and Salix nigra being the most important. Reproduction in the areas indicate that Acer negundo and Acer saccharinum will continue to be of major importance. However, there was very little Populus deltoides reproduction and Salix nigra was only able to reproduce in wet areas near the river's edge. Observations indicate that these floodplain forests are becoming drier since Celtis occidentalis, Ulmus rubra, Ulmus americana, and Fraxinus americana are beginning to invade these areas.

Day, F.P.

1978

Tree diameter growth in four plant communities in the Great Dismal Swamp

Paper presented at the 56th annual meeting of the Virginia Acad. of Sci., May 9-12, 1978, Blacksburg

The radial growth of prominent tree species was measured by aluminum vernier tree bands in four plant communities in the Dismal Swamp (mixed hardwood, red maple-gum, baldcypress, and Atlantic white cedar). Growth rates were variable but peaks occurred in May, June, and July of 1977. The mean annual growth rate for all trees measured in each community was greatest in the most extensively flooded community (cypress) and least in the most infrequently flooded community (mixed hardwood). Radial growth was apparently greatest on the wettest sites, at least for those species normally associated with swamps. Two oak species exhibited slower growth rates than oaks located in a Southern Appalachian mesic forest. The summer of 1977 was extremely dry so measurements during additional growing seasons are required to fully evaluate tree growth in the Dismal Swamp.

DeBell, D.S.; Auld, I. Dennis

1971

Establishment of swamp tupelo seedlings after regeneration cuts

USDA For. Service Res. Note SE-164. 7 pp.

Reproduction was studied on plots seven chains square in a stand of even-aged, 90-year-old swamp tupelo in Bluebird swamp in South Carolina. Plots were cut completely clear, to 15 trees per acre, to 30 trees, to 90 trees, and to 250 trees (control). Mist-blowing, injector treatment, and stump spraying were used to control undesirable vegetation. These treatments were applied to different blocks in 1967 and 1968.

The following conclusions were drawn:

Seedling establishment is related to seed production, but swamp tupelo is a prolific seeder and seed production is not ordinarily a limiting factor.

Germination and early growth are extremely dependent on water levels, as determined from results of different years. Swamp tupelo will not germinate when the water table is at or above the soil surface. After seedlings are established, however, water levels slightly above the surface but below the seedlings' leaves are beneficial to growth. Prolonged complete submergence of actively growing seedlings is likely to kill them.

Because of competition from other vegetation, the success or failure of regeneration established in the various cutting treatments cannot be fully determined for some time. In the interim, the authors recommend the use of other methods—advanced reproduction, stump sprouting, and planting nursery grown seedlings—where early establishment is not so dependent upon favorable water level.

DeBell, D.S.; Naylor, A.W.

1972

Some factors affecting germination of swamp tupelo seeds

Ecology 53:504-506

While swamp tupelo (Nyssa sylvatica var. biflora) is a major species in hardwood swamps of the southeastern United States, methods of regenerating the species have not been developed because of lack of information concerning the effects of environmental factors on germination of seeds. This study was designed to determine the effects of temperature, water level, and aeration on germination of swamp tupelo seeds.

An experiment in which seeds were submerged in unaerated water without soil resulted in 40% germination. When aeration was introduced, or seed coats were partly removed, the germination ranged from 50% to 80%.

Under forest conditions, swamp tupelo seeds apparently will not germinate while submerged in flooded soil. This delay in germination is advantageous to the seed's survival. In some years, water remains above the soil surface in swamps for several months during the growing season. If germination occurs under water, the seedlings will probably be killed, and the entire seed crop could be lost. Seedlings can be submerged for long periods during the dormant season without suffering damage, but when in the cotyledon stage, a few days of submergence is likely to kill them.

The fact that germination did not occur in soil-water regimes in which the water level was at or above the soil surface, but did occur under water in the absence of soil, may be accounted for by decreased oxygen supply and microbial complications.

87x

Dickson, R.E.; Hosner, J.F.; Hosley, N.W.

1965

The effects of four water regimes upon the growth of four bottomland tree species

For. Sci. 11:299-305

Seedlings of four wet-site species--tupelogum (Nyssa aquatica), pin oak (Quercus palustris), green ash (Fraxinus pennsylvanica), and sycamore (Platanus occidentalis) were grown under four moisture regimes: (1) continuously water-saturated soil, (2) soil watered to moisture equivalent daily, (3) soil watered to moisture equivalent when 50% or more of the available water was removed and (4) soil watered to the moisture equivalent when the wilting point was reached. On the basis of height growth and total dry weight, tupelo and green ash seedlings grew best under the continuously saturated conditions. Sycamore and pin oak grew best under the moisture equivalent regime. With few exceptions, seedlings of all species grown under the wilting point regime were the smallest. The significance of the results to the segregation of species along soil moisture gradients in bottomland areas is discussed.

Dickson, R.E.

1968

Effects of aeration, water supply, and mineral nutrition on growth and development of tupelo gum (Nyssa aquatica) and baldcypress (Taxodium distichum)

Ph.D. thesis, Univ. of California

Seedlings of tupelo gum and baldcypress were grown in saturated-aerated, saturated-nonaerated, and unsaturated soil, fertilized with two forms of nitrogen, nitrate and urea. On the basis of height and dry weight, both species grew best in water-saturated soil plus aeration. Growth was better in saturated-nonaerated soil than in unsaturated soil only if water in the unsaturated soil decreased substantially below field capacity before rewatering.

Internal moisture stress or water potential of the seedlings was determined with a pressure bomb technique. When available water was allowed to decrease from field capacity to the wilting point, the daily maximum moisture tension increased from 7.0 to 12.8 and from 8.5 to 18.6 atmospheres in tupelo and cypress seedlings, respectively.

In cypress, grown in saturated-aerated, saturated-nonaerated, and unsaturated soil at field capacity, average tensions were 10.0, 10.9, and 8.5 atmospheres, respectively. With tupelo there were no significant differences in tension among these water treatments.

Differences in nutrient uptake and distribution within the seedlings among the water treatments were considered to be the result of growth differences produced by the water treatments. Total uptake and often the concentrations of P, K, Ca, and Mg were highest in both species when grown on saturated-aerated soils and lowest when grown on unsaturated soils.

Total uptake and concentration of N were highest in seedlings from unsaturated soil. The low levels of nitrogen in seedlings grown on saturated soils were probably the result of denitrification in saturated soils, and could not be attributed to the effect of these treatments on nitrogen absorption by the seedlings.

Dickson, R.E.; Broyer, T.C.

1972

Effects of aeration, water supply and nitrogen source on growth and development of tupelo gum and baldcypress

Ecology 53:626-634

Seedlings of tupelo gum (Nyssa aquatica) and baldcypress (Taxodium distichum) were cultured in saturated-aerated, saturated, and unsaturated soil. Experiments were designed to (1) measure and evaluate the relative reaction of tupelo and cypress to various soil-moisture conditions; (2) determine the effects of aeration and water availability on plant moisture stress and growth; and (3) compare effects of two forms of nitrogen fertilizer (urea and nitrate) on growth. On the basis of height and dry weight, both tupelo and cypress grew best in saturated-aerated soil. Growth was better in saturated soil than in unsaturated soil, but only when water in the unsaturated soil decreased substantially below field capacity before rewatering. Plant moisture stress was determined by a pressure-bomb technique. For tupelo, average daily maximum tensions were 7.2 and 7.0 atm (atm = 1.013 bar) with saturated and unsaturated soil, respectively; for cypress, comparative tensions were 10.9 and 8.5 atm. When soil moisture decreased from field capacity to the wilting point, the daily maximum tension in plants increased from 7.0 to 12.8 and from 8.5 to 17.6 atm in tupelo and cypress, respectively. Growth of plants was related to the cumulative effect of their internal moisture stress. When tupelo plants were subjected to 595 atm-days (daily maximum tension × number of days with that tension), height growth was 37% and dry weight 40% less than plants subjected to 490 atm-days. Fertilization with urea produced more growth than fertilization with nitrate.

Downs, R.J.; Borthwick, H.A.

1956

Effects of photoperiod on growth of trees

Bot. Gaz. 117:310-326

The effects of photoperiod on the growth of elm (*Ulmus americana*), dogwood (*Cornus florida*), horsechestnut (*Aesculus hippocastanum*), red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipfera*), paulownia (*Paulownia tomentosa*), birch (*Betula mandschurica*), two spp. of catalpa (*Catalpa bignonioides* and *C. speciosa*) and three spp. of pine (*Pinus taeda*, *P. virginiana* and *P. sylvestris*) were investigated. In general, short days induced dormancy, and long days prolonged growth. The various spp. differed in their response to short days (eight-hour), ranging from tulip poplar, which stopped further growth after about ten eight-hour days, to elm, which required 20 weeks of eight-hour days before the plants stopped elongating new structures. However, most of the spp. tested seemd to require about four weeks of eight-hour days before they stopped growing.

DuBarry, A.P., Jr.

1963

Germination of bottomland tree seed while immersed in water

Jour. of For. 61:225-226

Observations suggest that, even if bottomland tree seed were to germinate while immersed in water in actual field conditions, eventual establishment of the seedling would be most unlikely unless the immersing waters receded before the seedling perished from other causes.

Eggler, W.A.

1953

Description of a bottomland hardwood forest in Sharkey County, Mississippi, with a possible explanation of why red gum fails to reproduce

Abst. in Bull. Ecol. Soc. Amer. 34:70-71

Tests on germination of seeds of Liquidambar styraciflua in six different materials from the forest floor, suggest an explanation of why the species fails to regenerate under a closed canopy. The percentage of healthy plants obtained was as follows: Sharkey clay, 37-69%; partially decomposed fermentation layer, 22-78%; humus, 16-59%; leaves, 0-41%.

Eggler, W.A.; Moore, W.G.

1961

The vegetation of Lake Chicot, Louisiana, after eighteen years' impoundment

Southwestern Nat. 6:175-183

The vegetation of the basin of Lake Chicot, originally cypress tupelo gum swamp bordered by upland hardwood forest, was studied by Penfound following impoundment. This paper gives results of a re-examination of the same area. After eighteen years of flooding, cypress has decreased in density in the channel but has increased in the shallow peripheral zone. Radial growth of cypress trees has not decreased, even in the deepest water. Upland forest trees have all died; a few bottomland hardwoods survive in shallow water. The lake is presently dominated by submerged weedy aquatics, especially cabomba and clodea. Winter draw-down of the lake level has not solved the aquatic weed problem.

Evans, D.K.

1974

The flora and vegetation of a Mississippi River unprotected floodplain

ASB Bull. 21(2):54

The flora and vegetation of the unprotected Mississippi River floodplain between St. Louis, Missouri, and Cairo, Illinois, was studied as a part of an environmental impact statement for the U.S. Army Corps of Engineers. Six vegetation types were identified and mapped and the species of vascular plants were documented in the 48,000 acre, 170 mile long area. Of the 320 species of vascular plants, 80% are native and 13% are rare or uncommon elements in the Illinois and Missouri flora. Plant community development proceeds from an annual grass-forb type of high diversity on sand and mud flats to forested stands of lower diversity which occur on infrequently flooded sites. Salix interior, an important species in young stands, and Populus deltoides along with Salix nigra, which are important elements in both young and old stands, are not reproducing. More shade tolerant Acer saccharinum and Acer negundo are succeeding in young stands and become more important as stand age increases. Factors influencing plant community development include fortuitous seeding following floods, frequency and duration of floods, and time.

Evans, D.K.

1975

Characteristics of flora and succession in the middle Mississippi River Floodplain

W. Vir. Acad. Sci. 47:7-13

No abstract available.

Farmer, R.E., Jr.

1970

Variation and inheritance of eastern cottonwood growth and wood properties under two soil moisture regimes

Silvae Genetica 19:5-8

This paper describes a pot study of genetic variation among 30 cottonwood clones growing under both favorable and stressful moisture regimes. The objectives were to determine how moisture stress may alter variation patterns and to provide information on variation in relationships between leaf, stem, and root growth.

The study involved 300 potted cottonwood cuttings, divided into five replications. In each replication, 30 pots ("Favorable" moisture regime) were watered only after incipient wilting was observed; at this time they were watered to saturation. The test ran from May 23 to September 9 in 1966. The stressed plants were watered an average of four times during the test.

Plants under the favorable moisture regime made about twice the height and diameter growth of stressed plants, and their average dry weight was seven times greater.

Specific gravity and fiber length proved to be greater under the favorable moisture regime, as expected. Leaf, stem, and root weights all increased under favorable moisture conditions, and the three weights had comparable broad-sense heritabilities.

Federer, C.A.; Lash, D.

1978

BROOK: a hydrologic simulation model for eastern forests

New Hampshire Univ., Durham. Water Resources Rsch. Center. Northeastern For. Experiment Sta., Durham, N.H. Ofc. of Water Rsch. and Techn., Wash., D.C. (Report No. RR-19) 92 pp.

A hydrologic model called BROOK simulates water budgets for forest land in the eastern United States. BROOK is a water-yield model for small areas: it was not designed to simulate flood peaks or watersheds with multiple aspects. It operates with a daily time interval, and requires daily precipitation and daily mean temperature as input variables. BROOK can simulate hardwood, conifer, mixed, cleared, and regrowing vegetation types, but these types must be uniform over the watershed. Partial cuts cannot be simulated. Evapotranspiration is divided into five components and streamflow into three components. The model was calibrated and verified using experimental watersheds at the Hubbard Brook Experimental Forest in New Hampshire and the Coweeta Hydrologic Laboratory in North Carolina. BROOK was designed to study the response of streamflow on different slopes and aspects to cover changes caused by harvesting and regrowth or by conversion from hardwoods to conifers.

Ferrell, W.K.

1953

Effect of environmental conditions on survival and growth of forest tree seedlings under field conditions in the Piedmont region of North Carolina

Ecology 34:667-688

In this study of reproduction of loblolly pine, shortleaf pine, white oak, southern red oak, sweetgum, and dogwood, it was concluded that improving the soil moisture conditions in the forest is the most important initial step in securing satisfactory reproduction of all species.

Filer, T.H., Jr.; Broadfoot, W.M.

1968

Sweetgum mycorrhizae and soil microflora survive in shallow-water impoundment

Phytopathology 58:1050

By means of impounding dikes, 15-30 cm. of winter and spring precipitation were retained on a hardwood forest until July of each of the three years tested. Impoundment did not eliminate endotropic mycorrhizal fungi of sweetgum and increased timber growth by 50%.

Microtome sections of roots collected before and after flooding show mycorrhizal fungi present in the roots. Isolation from mycorrhizal roots showed that 26% had viable fungi after six months of impoundment, as compared with 31% from trees not flooded.

Results from soil dilution plates indicate that population of soil microflora is reduced by 25% in impounded areas. Oxygen content in the water was depleted in about 15 days, but was quickly replenished by rain.

Mycorrhizal fungi such as *Boletus fraternus* and *Inocybe rimosa* produced sporophores in the impoundment area within two weeks after water was drained; none were produced in the dry area.

Finn, R.F.

1966

Mineral nutrition of yellow-poplar

Diss. Abst. 27(9):2998-9B

A sand culture technique was used to determine the relationships between solution nutrient concentrations, foliar nutrient concentrations, and the growth of yellow-poplar seedlings. Nitrogen, phosphorus, potassium, and calcium solution nutrient concentrations were varied; all other nutrients were maintained at a fixed concentration.

The main findings of the study are that a solution nutrient concentration, and consequently a foliar nutrient concentration, can be identified for maximum growth. However, maximum growth values determined separately in the N, P, K, and Ca series differ by as much as 70%. This appears to be caused by the strong ion antagonism between N, P, K, and Ca. This antagonism is reflected in different foliar concentrations for elements which have the same solution concentration in two or more of the series.

It is, therefore, doubtful that foliar nutrient concentration derived from single element studies will be very useful as a standard for estimating the adequacy of soil nutrients. Apparently, there is a range of foliar percentage combinations of elements that are correlated with essentially the same amount of growth.

Fralish, J.S.; Weaver, G.T.; Schlesinger, R.C.

1976

Central Hardwood Forest Conf. Proceedings 1st, October 17-19, 1976, Carbondale, Ill. 484 pp.

Franz, E.H.

1971

A probabilistic model of a floodplain forest: prediction of changes due to variable backwater conditions during reservoir operation

Diss. Abst. 32:5741B; Ph.D. thesis, Univ. of Ill., 148 pp.

Prediction of ecosystem changes resulting from environmental modification provides a growing class of ecological problems. This study was initiated to investigate an approach to the solution of one such problem: prediction of the relative impacts of alternative reservoir designs on vegetation in the backwater zone. Heuristically it was determined that if the relationships between species population distributions and the historical patterns of flooding could be defined and it was assumed that the relationships reflected causation to some degree, then changes in species distributions could be predicted from changes in the flooding regime.

The approach was to develop a probabilistic model of the relationship between vegetation pattern, as exhibited in the distributions of individual species populations, and the flooding regime. Existing methodologies provided estimates of the flooding regime modifications produced by variable backwater conditions for two levels of reservoir operation. The model was exercised, with each modification as input, to simulate predicted shifts in species distribution.

The model is applicable to other problems of the same class. Only modification of the imput parameters is necessary provided the data conform to the submodels proposed. It can also be used to simulate the effect of reduced flooding downstream from a reservoir and has potential utility as a systems design tool. Given a probability distribution for flooding in a bottomland area, the model can be used to generate a species pattern which is compatible with the flooding regime. Planting of tree species and management of the area can then proceed on a more rational basis.

Franz, E.H.; Bazzaz, F.A.

1977

Simulation of vegetation response to modified hydrologic regimines: a probabilistic model based on niche differentiation in a floodplain forest

Ecology 58:176-183

This study was initiated to develop a model for predicting the relative impacts of alternative reservoir designs on vegetation in the backwater zone.

The result is a probabilistic model based on niche differentiation in the floodplain forest. Existing methodologies provided estimates of the flooding regime modifications produced by variable backwater conditions during reservoir operation. The model is exercised, with hydrologic modifications as input, to simulate shifts in species distribution.

The model has been applied to evaluate the impact of a proposed reservoir on the vegetation of Robert Allerton Park, a 607 km^2 natural area in east-central Illinois. Comparison of simulations for three alternative plans for the reservoir provides a basis for distinguishing among them, and suggests that the impact of one would be substantially less than the other two.

Fritts, H.C.; Kirkland, B.J.

1960

The distribution of River birch (Betula nigra) in Cumberland County, Illinois

Trans. Ill. State Acad. Sci. 53:68-70

The species, common beside streams on acid alluvia, was generally absent where these were alkaline, a fact in accordance with its general distribution in the Midwest. Regeneration was found on two sites only, and it is thought that recent farming practice (high rates of lime and fertilizers) may have raised the pH of the alluvia to prohibitive levels.

Gaiser, R.N.

1952

Root channels and roots in (hardwood) forest soils

Proc. Soil Sci. Soc. Amer. 16:62-65

The vertical channels formed in the soil through the decay of the roots of hardwood trees were studied on a site in southeastern Ohio. Data were obtained by exposing the soil profile through trenching, and by probing with a flexible wand to find regions of low resistance. The number of vertical channels found exceeded 4,000 per acre, but this estimate is probably low, because not all channels could be discovered by the methods used. The channels are probably interconnected by lateral ones. Because the channels contain material relatively more permeable to water than the surrounding soil horizons, they probably serve as pathways for the rapid movement of a large part of the free water in the soil profile. It is probable, therefore, that estimates of the physical and hydrological characteristics of forest soils will be seriously in error, unless some allowance is made for the discontinuities in the soil profile resulting from the decay of taproots and their laterals.

Gemborys, S.R.; Hodgkins, E.J.

1971

Forests of small stream bottoms in the coastal plain of southwestern Alabama

Ecology 52:70-83

Overstory and understory data were collected from 49 forest stands in 27 small stream bottoms in the Gulf Coastal Plain region of southwestern Alabama. The stands were arranged in a single-dimensioned ordination on the basis of the importance values of the persistent species in the overstories. Leading dominant species, from the "dry" end to the "wet" end of the ordination gradient were *Cornus florida*, *Pinus palustris*, *Quercus nigra*, *Liquidambar styraciflua*, *Nyssa sylvatica* v. *sylvatica*, *Magnolia virginiana*, and *N. sylvatica* v. *biflora*. Two important seral species, most prominent at the middle of the ordination gradient and of relatively little importance at either end, were *Pinus elliottii* and *Liriodendron tulipifera*. The stand position on the ordination gradient, referred to as the moisture-regime index, was significantly related to water-table depth, soil-surface gradient, and soil pH at 63.5 cm. Failure to obtain significant relationship with other soil variables was attributed to the high frequency of fresh soil deposition in the small stream bottoms. As a check on the ordination analysis, species-presence data were used to construct a species-correlation diagram. When species moisture-regime numbers from the ordination analysis were inserted in this diagram, good agreement was revealed in the results of the two independent analyses.

Gembroys, S.R.

1974

The structure of hardwood forest ecosystems of Prince Edward County, Virginia

Ecology 55:614-621

Describes the results of a plant-sociological study of 32 stands representing oak/hickory habitats ranging from wet floodplain to dry upland sites within the Piedmont region. The pattern of stand composition was correlated with the distribution of various characteristics of the vegetation and soil, viz. stand density, b.a., depth of litter, percentage of organic matter, pH, soluble salts, Ca, Ms and depth of the A horizon.

Goodrick, R.L.; Milleson, J.F.

1974

Studies of floodplain vegetation and water level fluctuation in the Kissimmee River Valley

Central and Southern Florida Flood Control District, West Palm Beach, Resources Planning Dept., Techn. Publ. 74-2, Mar. 1974, 60 pp.

The Central and Southern Florida Flood Control Project in the Kissimmee River Basin consisted of enlarging existing canals connecting the upper chain of lakes, installing water control structures in several of these canals, and channelizing and providing control structures in the river proper (which extends from Lake Kissimmee to Lake Okeechobee). One major canal, designated C-38, was constructed within the Kissimmee River floodplain. Six regulatory structures were situated along the canal to control the drop in elevation. Stabilization of the water level in the impoundment area behind the regulatory structures since January 1969 has had a pronounced impact on the vegetational composition of the marshes. The lack of seasonal fluctuation has resulted in the dominance of terrestrial plants in the north end of the impoundment, the dominance of aquatic plants in the south end of the impoundment, and the inhibition of growth for most aquatic annuals. When competition was eliminated or reduced substantially and the underlying subsirate was exposed during a drawdown, many additional species of both annual and perennial plants germinated and flourished.

Grano, C.X.

1961

Germination of stratified latex-coated loblolly pine seed after submergence

Jour. of For. 59:452

In a recent study, submergence for 14 days had no deleterious effect on the germination of stratified, latex-coated loblolly pine seed. This finding has practical significance in direct seeding, where stratified and repellent-coated seeds often lie submerged for many days following heavy rains.

Seed was stratified in wet sand for 30 days at 37°F. and then coated with Dow Latex. Samples were placed in stainless steel screen containers and submerged in water 4 inches deep. The bath was fully exposed to sunlight in a greenhouse; air temperatures ranged between 57° and 93°F. Submergence was for 0, 1, 2, 4, 6, 8, 10, 12, and 14 days.

The tabulation below shows the percentage of full seed that germinated after 28 days in a sand flat, following submergence. Results were also evaluated by Czabator's Germination Value (GV)[1], which varies directly with speed or totality of germination, or both. Higher GV ratings indicate more vigorous germination.

Days submerged	Full seeds germinating	Czabator's germination value (GV)
	Percent	
0	51	8.02
1	44	5.63
2	38	4.61
4	41	5.43
6	47	7.04
8	48	7.31
10	46	6.59
12	52	8.22
14	49	7.74

Statistical analysis showed no significant difference among treatments, either in total germination or GV ratings.

Green, W.E.

1947

Effect of water impoundment on tree mortality and growth

Jour. of For. 45:118-120

Where the root crown was not permanently covered with impounded water, bottomland trees survived remarkably well. Mortality as an immediate effect of flooding was generally restricted to those trees, regardless of species, which were located where the water levels remained over the root crown. Further, so long as the root crown is covered permanently, the actual depth of water over it appears to be of little consequence. Trees standing in four feet of water survived as well as those where the root crown was covered only a few inches. Thus, the major factor in tolerance to flooding appears to be the relationship of the root crown to normal water levels.

Some trees above the two-foot contour have shown continued decrease in growth following the stimulation of first impoundment and may eventually die. More study will be given this matter to determine how long trees in this situation will survive.

Hacskaylo, J.

1961

Deficiency symptoms in forest trees

Trans. 7th Int. Congr. Soil Sci., Madison, 1960. Vol 3: 393-405

Scots pine, white pine, and sweetgum seedlings were grown from seed under greenhouse conditions. Black locust was started from root cuttings of a given tree.

The plants were subjected to the following inorganic culture solutions: Exchange water (XX-H_2O) complete, -N, -P, -K, -Ca, -Mg, -S, -Fe, -Cu, -Zn, -B.

Visual deficiency symptoms are described of the leaves, stem, and root. Growth is expressed as the total amount of wet and dry weight produced, and the total height and diameter of each series of plants.

Water requirement appears to be higher in some of the deficiency series of white pine and sweetgum. In the case of black locust there is no significant difference in the water requirement of the plant when subjected to the various treatments.

Hall, T.F.; Smith, G.E.

1955

Effects of flooding on woody plants, West Sandy dewatering project, Kentucky reservoir

Jour. of For. 53:281-285

The West Sandy dewatering project has operated more or less as an uncleared or partially cleared flood control reservoir with fixed maximum discharge. Flooding has had an adverse effect on bottomland forests, and much of the timber in the storage basin has been killed. The tolerance of 39 woody species to periodic flooding was determined. All woody species were killed where the root crowns were periodically flooded more than 54 percent of the time during all the growing seasons the project had been in operation. However, those species subjected to less flooding at higher elevations showed varying degrees of tolerance with survival contours stratified over some 12 feet vertically.

Harcombe, P.A.; Marks, P.L.

1978

Tree diameter distributions and replacement processes in southeast Texas forests

For. Sci. 24:153-166

Stand tables were determined for 15 stands on dry upland, mesic slope and wet floodplain sites in order to assess the future replacement of canopy dominants. Sample units were nested circular plots in which species and d.b.h. were determined for trees, saplings and shrubs; seedling numbers were counted. Stand age was estimated from increment cores. Results are tabulated for principal tree species by 4-cm diameter classes (seedlings separately), with some graphic data for understory trees and shrubs. Saplings of overstory species were underrepresented in the 4-11 cm d.b.h. classes, particularly in wet and mesic stands, although seedlings and saplings in the 0-3 cm class were frequently numerous; saplings of understory species (Ilex opaca and Carpinus caroliniana on mesic and wet sites respectively) were well-represented over the complete size range. Age (studied in 90 trees in one mesic stand) showed a multiple correlation with d.b.h., indicating that the gaps in diameter class represented gaps in age structure. Possible causes of underrepresentation are discussed and it is concluded that sapling mortality is primarily due to competition from both overstory and understory species. It is suggested that replacement of canopy trees in southeast Texas stands probably occurs after disturbances of moderate intensity creating multiple-tree gaps of 0.05-0.3 ha. The causes of such disturbances are unknown.

Harms, W.R.

1973

Some effects of soil type and water regime on growth of tupelo seedlings

Ecology 54:188-193

Nyssa sylvatica var. biflora and N. aquatica seedlings were grown in large tanks in a silty clay-loam soil from a river swamp or in a sandy loam soil from a non-alluvial headwater swamp, and in their second year were continuously flooded to depths of 20 cm above the soil surface with moving water, 20 cm above the soil surface with stagnant water, or at the soil surface with moving water. Height growth of N. aquatica was on average 1.8 times as great, and dry weight 2 to 3 times as great, in the more fertile soil from the river swamp as in soil from the headwater swamp. Soil type had no effect on the growth of N. sylvatica var. biflora. Growth and dry weight of both species were poorest in the regime with stagnant water, which also had the highest CO_2 and lowest O_2 content. At the end of the growing season, N. sylvatica var. biflora grew 50 cm more in height in the surface-flooded regime than in either deep-flooded regime; N. aquatica trees in both regimes with moving water grew 37 cm taller than those in the stagnant regime.

Harris, M.D.

1975

Effects of flooding on forest vegetation at two Oklahoma lakes

Jour. of Soil Water Cons. 30:294-295

Post-flood surveys were made of hardwood trees in flood pools of Keystone and Oologah Impoundments, Oklahoma. Inundation lasted 7-100 days, with the first 10 feet lasting 67-73 days. Flood damage was most severe in the first 10 feet above normal pool level. Above this, mortality of smaller trees and shrubs was greatest though most larger trees survived. Most completely submerged trees were killed. Trees with some crown above water or which were only submerged for a few days showed stress in July--small, malformed, yellowing leaves on main branches only. Increment borings revealed discolored cambium layers and sour smells. About 80% of the trees that showed stress and were less than 10 inches in diameter at breast height and 25 feet tall died. Larger, taller trees showed no visible stress except for reduced later summer growth rates. Mortality was highest among oak-hickory types and increased as size decreased. Mortality was less with hackberry, pecan, elm, green ash, sycamore, cottonwood, and willows. When properly planted and maintained, green ash, sycamore, cottonwood (cottonless), buttonbush, willow, mulberry (fruitless), silver maple, baldcypress, and river birch grow rapidly and are soon tall and large enough in diameter to withstand flooding.

Hatchell, G.E.; Henderson, J.E.

1976

Moisture characteristics of some Coastal Plain soils on the Francis Marion National Forest

USFS Res. Paper SE-150. 44 pp.

Twenty-one soil pits representing 10 soil series were established on the Francis Marion National Forest in Berkeley and Charleston Counties, South Carolina. Pits were primarily on very poorly drained and poorly drained soils, but somewhat poorly drained, moderately well-drained, and well-drained soils were each represented by a single soil pit. Soil physical properties that affect the storage and availability of water were evaluated, and data on saturated porosity, moisture at various tensions, available moisture by horizons, and bulk density are presented.

A summary and discussion of soil properties are provided for foresters and other resource managers, and detailed information is given for hydrologists and soil scientists working with forest soils of the Lower Coastal Plain of South Carolina. General soil moisture characteristics are presented. Where precise estimates of the available moisture storage capacity and other soil properties are needed for a particular site or location, soil samples should be collected and analyzed at a laboratory.

Hebb, E.A.

1961

The relation of soil and other site factors to forest composition and productivity in west Tennessee

Diss. Abstr. 22(1):10-1

Growth of Quercus falcata, Q. alba, Q. falcata var. pagodaefolia, Liriodendron tulipifera and Liquidambar styraciflua was studied in relation to soil and to stand measurements and species composition. Increment cores taken at intervals up the stem were used to produce a height-growth curve from which a height-over-age value could be read for each tree. Results were inconclusive for Q. falcata and Q. alba, but satisfactory for all the other species.

Multiple regression showed poor association of nine variables of soil and environment with height growth for Q. falcata and Q. alba; the coefficient of determination (R^2) was larger with L. tulipifera (0.676), L. styraciflua (0.608) and Q. falcata var. pagodaefolia. In all five, the variables found most significantly related to growth were topographic position and apparent surface drainage. In multiple regressions, some variables significant in simple regressions failed to contribute a significant amount. Important factors for the different species were: L. tulipifera—soil depth to mottling in combination with topographic position and direction of exposure; Q. falcata var. pagodaefolia—basal area and apparent surface drainage; Q. falcata and L. styraciflua—topographic position and apparent surface drainage; and Q. alba—only topographic position. With L. styraciflua, productivity appeared to be related to species composition, higher indices being associated with greater frequency of Betula nigra and Q. falcata var. pagodaefolia and lower ones with Q. marilandica, Q. velutina and Q. stellata. Soil series was only the roughest indicator, soils of upland sites having low, and those of lowland sites high, growth rates, but with considerable overlapping of range. Correlation between tree grade and site was almost nil.

Hinckley, T.M.; Lassoie, P.P.; Running, S.W.

1977

Temporal and spatial variations in water status of forest trees

For. Sci. 24(3):1-72

This review focuses on the development of naturally occurring spatial and temporal variations in tree water relations and illustrates how the various components of a tree's hydraulic system interrelate. In developing this review, emphasis is given to mature forest-grown trees. Specifically, three points are developed: (1) the spatial variation of total water potential within a tree, (2) the state of the soil-plant-atmosphere continuum which causes these potentials, and (3) the tree properties which lead to the internal adjustment of total water potential. While examining tree water status as it is related to the soil-plant-atmosphere continuum, several deficiencies in current knowledge are revealed. For example, tissue capacitance has generally been ignored in describing waterflow even though it is known that internally stored water can supply as much as 15% of the total amount of water transpired during the summer. Over a 3-month, summer period a mature conifer may transpire 4,000 liters of water. Furthermore, there are various unanswered questions concerning physiological activities at the root-soil and leaf-air interfaces. This review also provides an appreciation of the similarities and differences in internal waterflow, water deficit formation, and stomatal activity between seedlings, saplings, and large trees and between deciduous and coniferous species. This review consolidates and synthesizes information valuable to those researchers currently involved in developing directions and methodologies for new physiological studies of tree water relations and should be useful to those presently evaluating experimental results as well as those interested in model simulations.

Hocker, H.W., Jr.

1953

Relative growth and development of loblolly pine (Pinus taeda) and yellow-poplar (Liriodendron tulipifera) on a series of soil sites in the lower Piedmont of North Carolina

MF thesis, School of For., N.C. State College

Loblolly pine attains somewhat greater size and better development on shallow and medium soils than does yellow-poplar. On deep soils both species exhibited their best growth and development, and on these sites yellow-poplar showed an increase in its relative size and here equalled loblolly pine, except in merchantable heights.

Although loblolly pine had a greater merchantable height on the deep soils, the two species had almost equal clear lengths, diameter growth, and form class, indicating that there was little difference in quality growth on these sites.

Hodges, J.D.; Switzer, G.L.

1979

Some aspects of the ecology of southern bottomland hardwoods

Miss. Agri. and For. Exp. Sta. Jour. Paper No. 4087

This brief review emphasizes that the bottomland hardwood resource of the southeast is an expression of a complex set of topographic circumstances and species interactions which, relative to other forest formations and types, are difficult to understand and direct. This complexity and the relative economic value of the resource and the sites it occupies both for forestry and agriculture has greatly contributed to the inadequate state of our present knowledge. However, the potential of the resource continues to attract the interest of research scientists and tests the skill of practitioners.

Hook, D.D.; Stubbs, J.

1967

Physiographic seed source variation in tupelo gums grown in various water regimes

Ninth South Conf. Forest Tree Impr. Proc. 1967:61-64

No abstract available.

Hook, D.D.

1968

Growth and development of swamp tupelo (*Nyssa sylvatica* var. *biflora* (Walt.) Sarg.) under different root environments

Ph.D. thesis, Univ. of Georgia

Swamp tupelo seedlings were grown under different root environments to determine how this species is able to live and thrive in a poorly aerated root environment.

Under controlled flooded conditions, growth in stagnant water was about one-half that in moving water. Development of lenticels and water roots under certain flooded conditions suggested that these structures might function in gas exchange between atmosphere and roots.

Swamp tupelo appears to have a dual metabolic system in its roots. Both aerobic and anaerobic respiration are active in the presence of oxygen, and in the absence of oxygen lactic acid fermentation appears to function as an energy source. Tolerance to high carbon dioxide concentrations apparently enables tupelo to withstand conditions in submerged soils that are toxic to sweetgum.

Limited gas exchange may occur through lenticels, but contiguous intercellular space from lenticel surface to cortex and phloem is present only under continuous flooding. Gas exchange under these conditions is limited by the diffusion rate through water.

Hook, D.

1969

Influence of soil type and drainage on growth of swamp chestnut oak (Quercus michauxii) seedlings

USFS Res. Note SF-106. 3 pp.

Swamp chestnut oak has a wide range in the Coastal Plain and Mississippi delta, but is irregular in occurrence within the range. Broadfoot lists two of nine soils on which this species should be favored in management, whereas sweetgum is recommended for eight of the same soil types.

Swamp chestnut oak seedlings were grown for two years in five soil types in drained and undrained pots. The soils used were Lakeland loamy fine sand, Wagram loamy coarse sand (formerly called Fort Meade loamy coarse sand), Dunbar sandy loam (formerly called Coxville loam), Meggett silt loam (formerly called Chastain silt loam), and Meggett clay loam (formerly called Bayboro clay loam).

First-year height growth appeared to be affected by pot drainage and soil type, although differences were small. Second-year and total height growth were significantly affected by soil type, but not by drainage. Meggett silt loam had consistently better growth than the other soil types.

The author's tentative conclusions are as follows:

The significant response of height growth to drainage and soil type the first year, and only to soil type the second year, suggests that drainage may be more important to establishment than to subsequent growth.

Of the five soils tested, only Meggett silt loam appears to afford the proper composite of edaphic factors (structure, texture, nutrients and other physical and chemical properties) necessary for best growth of swamp chestnut oak. This suggests the species is site-sensitive.

The best height growth in any treatment was 2 inches the first year and 4 inches the second—poor by any standard. Until more is learned about the growth of this oak, planting the species should be only a last resort in regeneration.

These findings suggest that, under the natural selective regime of excessive soil moisture, species have responded differently in time. Some have lost or have never acquired any root adaptations necessary for survival in flooded soils. Others have maintained or acquired a series of root adaptations, the number and degree of development of which, convey varying degrees of flood tolerance.

124x

Hook, D.D.; Brown, C.L.; Kormanik, P.P.

1970

Lenticel and water root development of swamp tupelo under various flooding conditions

Bot. Gaz. 131(3):217-224

Lenticels are believed to function in gas exchange because of the continuity of intercellular spaces in the lenticel tissues with those in the interior of the phloem. In order to describe the anatomy of stem lenticels and the development of new roots (termed "water roots") on swamp tupelo seedlings, the authors conducted this experiment at the hydro-edaphytron located on the Santee Experimental Forest, Berkeley County, South Carolina.

One-year-old seedlings of swamp tupelo (Nyssa sylvatica var. biflora) were planted in April 1964 and March 1965 under the following conditions:

1. Continuous surface saturation of the soil with stagnant water.

2. Continuous surface saturation with moving water.

3. Intermittent flooding with stagnant water; one week of flooding and two weeks of surface saturation.

4. Intermittent flooding with moving water.

5. Continuous flooding with stagnant water.

6. Continuous flooding with moving water.

7. Seedlings from the same seed source were grown nearby in a moist but well-drained nursery bed as a control.

Development of water roots was restricted almost exclusively to the treatment of continuous flooding with moving water although a few water roots were found under flooding with stagnant water. Physiological studies indicate that stem lenticels are functional in aerating the newly formed roots. Water roots were adventitious in origin because their vascular connections terminated within the outer annual ring. Most water roots had lenticel remnants around their bases and probably originated within lenticel tissue.

The formation of water roots appears to be beneficial because they occur in the upper flood water where the oxygen is higher and toxic compounds such as CO_2 are lower than in the soil. Water roots also increase the absorption area for water and nutrients.

Hook, D.D.; Langdon, O. Gordon; Stubbs, J.; Brown, C.L.

1970

Effect of water regimes on the survival, growth, and morphology of tupelo seedlings

For. Sci. 16:304-311

A study of the development of tupelo seedlings under different degrees of flooding, in both moving and stagnant water, was made in the hydroedaphytron on the Santee Experimental Forest, South Carolina. This equipment consists of six growing compartments, each a 1.83-meter cube. Each compartment has individual controls for regulating water flow and internal soil drainage. Depth, rate, and time of flooding can be regulated, as can vertical and horizontal movement of water across and within the soil. Tops of seedlings are exposed to natural environment.

One-year-old seedlings of swamp tupelo and water tupelo were planted in each compartment. They were subjected to continuous flooding, intermittent flooding, or continuous surface saturation, and to moving or stagnant water in each degree of flooding, thus providing six different water treatments.

Oxygen was found to be more abundant in moving water, and carbon dioxide in stagnant water. Growth in height and weight of both species were correlated positively with O_2 and negatively with CO_2 concentration.

These results explain the frequently observed fact that tupelo trees of sawlog size are usually found growing in the deeper portions of the swamps where the water is moving and has an adequate supply of oxygen.

Hook, D.D.; Brown, C.L.; Kormanik, P.P.

1971

Inductive flood tolerance in swamp tupelo (Nyssa sylvatica var. biflora)

Jour. of Exp. Bot. 22(70):78-89

Swamp tupelo is seldom found on sites that are not inundated most of the growing season, and experimental evidence shows that it grows as well in flooded as in well-drained moist soils. Flood tolerance in higher plants is generally attributed to one of two adaptive mechanisms: (a) diffusion of oxygen from the atmosphere to the roots via the stem, or (b) anaerobic respiration in the roots. It has been assumed that either of the above mechanisms is sufficient to account for flood tolerance. The authors believe that this assumption is inadequate for the following reasons:

First, oxygen is transported through the stem to the roots of buckwheat, cabbage, corn, and other species, yet none of these species are tolerant to flooding. Second, the energy yield per glucose molecule from anaerobic respiration is about one-tenth that from aerobic respiration, yet many flood-tolerant species make the best growth with their roots and lower stem flooded, e.g., rice and swamp and water tupelo.

Results of the study indicate that flood tolerance in swamp tupelo seedlings is due to three factors: anaerobic respiration, oxygen transport, and tolerance to CO_2.

Under flooding, swamp tupelo seedlings develop new roots that accelerate anaerobic respiration rate in the absence of oxygen, oxidize their rhizosphere, and tolerate high concentrations of CO_2.

The combination of these adaptations of the new roots appears to be sufficient to account for flood tolerance in swamp tupelo. The absence of any one of these root adaptations would appear to reduce the flood tolerance of a species.

Hook, D.D.; Brown, C.L.

1972

Permeability of the cambium to air in trees adapted to wet habitats

Bot. Gaz. 133:304-310

The permeability of the cambium to gas exchange varies significantly among tree species. The amount of tension required to pull air across the cambium of water tupelo and green ash is sufficiently low to permit free gas exchange with the atmosphere, whereas air movement is restricted across the cambia of sweetgum, yellow poplar, and sycamore. Water tupelo and green ash stems possess prominent intercellular spaces among the cambial ray initials forming an open interconnecting aeration system between the xylem and phloem rays on either side. Similar openings in the cambium are absent or less than 1μ in size in the other species examined. In mesophytic trees the transpiration stream undoubtedly plays a vital role in supplying oxygen to, and removing carbon dioxide from, the actively dividing and differentiating cells on the xylem side of the relatively impervious cambium. Conversely, in hydrophytes where air is often limiting to the roots and water is plentiful the cambium is increasingly more permeable to air.

128x

Hook, D.D.; Wetmore, R.H.

1972

Aeration in trees

Bot. Gaz. 133:443-454

The purpose of this review is to discuss some of the problems associated with aeration of massive tissues and organs of arborescent plants, with emphasis on those adaptive mechanisms which enable certain species to grow and flourish on frequently flooded and poorly aerated sites, in stagnant ponds, or in brackish coastal waters where less tolerant species could not long survive.

Hook, D.D.; Brown, C.L.

1973

Root adaptations and relative flood tolerance of five hardwood species

For. Sci. 19:225-229

Previous studies of bottomland hardwood species suggest that flood tolerance is largely dependent upon a combination of root adaptations. To test this hypothesis, seedlings of five hardwood species were grown in flooded and unflooded pots in a growth chamber and greenhouse, measured for growth, and tested for specific root adaptations.

Three morphological root adaptations were observed: (1) ability of secondary roots to survive prolonged flooding; (2) ability of seedlings to regenerate new secondary roots from the primary root, and (3) ability of seedlings to develop adventitious water roots on the submerged stem. Three physiological root adaptations tested were the ability of flood tolerant roots (1) to accelerate anaerobic respiration rate in the absence of oxygen, (2) to oxidize their rhizospheres, and (3) to tolerate high concentrations of CO_2.

Of the five species tested, water tupelo is known to be very tolerant to flooding, and yellow-poplar is known to be very intolerant. Sycamore, green ash, and sweetgum were chosen because they appeared to fall between water tupelo and yellow-poplar in flood tolerance.

Hook, D.D.; Crawford, R.M.M.

1977

Plant Life and Anaerobic Environments

Ann Arbor: Ann Arbor Science Publ.

This book is designed to provide the reader with an understanding of th influence of hypoxia and anoxia on the physiology and adaptations of higher plants and the chemical and microbiological factor which affect plant growth in wetland soils.

The first part of the book has authoritative chapters on the influence of hypoxia and anoxia on the ultrastructure of plant organelles, energetics, metabolism, gaseous diffusion and gas exchange, growth and development of higher plants. It also contains chapters on the chemical and microbiological properties of short- and long-term flooded soils.

The second part of the book contains recent contributions on cytoenzymology, nitrate metabolism, alcohol and lactate dehydrogenase identification and lipid production of higher plants under hypoxia.

Chapter 10: Adaptation and Flood Tolerance of Tree Species
by D.D. Hook and J.R. Scholtens

Hopkins, H.T.; Specht, A.W.; Hendricks, S.B.

1950

Growth and nutrient accumulation as controlled by oxygen supply to plant roots

Plant Physiology 25:193-209

Growth response, nutrient accumulation, and nutrient transport were measured for tomato, soybean, and tobacco in their dependence on oxygen supply in the root zones.

Root growth of all plants was stopped at an oxygen content of 0.5% in the gas around the roots. Top growth and ion accumulation continued at this level.

In tomato, response was proportional to log pO_2 from 0.5% to 21% oxygen for growth and ion accumulation. The log (transport rate) was a function of time independent of oxygen supply to the roots. This indicates that rate of transfer from the root to the shoot is independent of aerobic mechanisms in the roots.

Accumulation of major nutrient elements with the exception of Mg for tomato parallels top growth in dependence upon oxygen supply to roots. Minor nutrient elements with the exception of Mn and Fe for tomato remain constant or increase with lowered oxygen levels. The increase of sodium is most striking.

Hosner, J.F.

1957

Effects of water upon the seed germination of bottomland trees

For. Sci. 3:67-70

Seeds of six species of bottomland hardwood trees were soaked in tapwater for four to 32 days. Red maple, silver maple, sycamore, and elm seeds failed to germinate while soaking in water, but immediately upon removal germination was rapid and consistently high for all periods of soaking. Cottonwood and willow completed their germination in the water in four days of soaking.

Hosner, J.

1957

A study of the factors associated with regeneration and succession of bottomland hardwood tree species in southern Illinois

Ph.D. diss., State Univ. Col. of For. at Syracuse

No abstract available.

Hosner, J.F.

1958

The effects of complete inundation upon seedlings of six bottomland tree species

Ecology 39:371-373

This study suggests that floods in bottomland hardwood areas during the growing season exercise a selective effect upon the species of tree seedlings surviving. Only willow seedlings can survive 32 or more days of complete inundation. Where complete submergence occurs for half that period, many green ash, some redgum, and possibly a few boxelder can survive. Cottonwood and silver maple seedlings survive only with less than 16 days' inundation. The rate of recovery of the surviving trees also varies. In general, the willow and ash recovered more quickly than the others.

Hosner, J.F.

1959

Survival, root and shoot growth of six bottomland tree species following flooding

Jour. of For. 57:927-928

Current year seedlings of six species were flooded for 38 days and transferred to well-drained soil for 60 days. The species were ranked as follows in ability to withstand and recover from flooding: Cottonwood, green ash, sycamore, pin oak, cherrybark oak, hackberry. Survival and growth of cottonwood and sycamore is directly related to the formation of adventitious roots; whereas ash, in addition to the formation of adventitious roots, is also able to produce new roots in poorly aerated media. The latter result suggests that ash may have the ability to translocate oxygen or oxidized substrate to the roots via the shoot.

Hosner, J.F.; Minckler, L.S.

1960

Hardwood reproduction in the river bottoms of southern Illinois

For. Sci. 6:67-77

Study of 62 sample stands indicated that an adequate number of seedlings of desirable species occurs initially on all sites studied. Undesirable species are more numerous, but will not necessarily predominate in the final stand.

Hosner, J.F.

1960

Relative tolerance to complete inundation of fourteen bottomland tree species

For. Sci. 6:246-251

Current year seedlings in pots were subjected to flooding for periods of 5, 10, 20, and 30 days. The species were ranked as follows, from most to least tolerant of flooding: Silver maple, buttonbush, boxelder, black willow, cottonwood, green ash, American elm, pin oak, sycamore, red maple, Shumard oak, sweetgum, hackberry, and cherrybark oak. Several factors are suggested as contributing to tolerance to flooding. Water apparently is most likely to become the limiting factor only on sites that are consistently flooded for fairly long periods of time during the growing season.

Hosner, J.F.

1961

Flooding affects regeneration of bottomland hardwood forests in southern Illinois

Abstr. in Bull. Ecol. Soc. Amer. 43:96-97

Short periods of flooding do not reduce germination of most species, but where flooding extends into the growing season for 30-60 days, the seeds of bottomland red oaks are almost completely killed. Greenhouse tests of complete inundation of potted seedlings during the growing season show that *Acer saccharinum* seedlings, the most tolerant tested, can withstand 30 or more days complete inundation, three-six times as long as *Quercus falcata* var. *pagodaefolia*, the least tolerant of the species tested.

Hosner, J.F.; Boyce, S.G.

1962

Tolerance to water saturated soil of various bottomland hardwoods

For. Sci. 8:180-186

Current year seedlings in pots were kept in completely saturated soil for periods of 15, 30, and 60 days. Species were classified as follows according to tolerance to saturated soil conditions: Tolerant—green ash, pumpkin ash, water tupelo, and willow; intermediate—eastern cottonwood, boxelder, red maple, silver maple, pin oak, and sycamore; intolerant—Shumard oak, cherrybark oak, American elm, willow oak, sweetgum, hackberry, and sugarberry.

The mechanism of tolerance to saturated soil conditions is attributed to one or more of the following seedling characteristics:

(a) the ability of established roots to continue to grow and function under poorly aerated soil conditions.

(b) the formation of adventitious roots at and above the root collar and,

(c) the drought resistant characteristics of the stems and leaves of different species.

Hosner, J.F.; Leaf, A.L.

1962

The effect of soil saturation upon the dry weight, ash content, and nutrient absorption of various bottomland tree seedlings

Proc. Soil Sci. Soc. Amer. 26:401-404

Current-year seedlings of 14 bottomland tree species surviving 60 days of completely water-saturated soil conditions were compared with control seedlings grown in well-watered but non-saturated soil. Comparisons were made of: dry weight per seedling top, and contents of ash, N, P, K, Ca and Mg. Based on root and shoot growth and nutrient absorption, the species are grouped according to their relative tolerances to water-saturated soil as follows: Tolerant—*Nyssa aquatica*, *Fraxinus profunda*, *Salix nigra*, *F. pennsylvanica*; intermediate—*Quercus palustris*, *Populus deltoides*, *Platanus occidentalis*, *Acer negundo*, *A. rubrum*, *A. saccharinum*; intolerant—*Ulmus americana*, *Celtis occidentalis*, *Liquidambar styraciflua*, and *C. laevigata*.

Hosner, J.F.; Minckler, L.S.

1963

Bottomland hardwood forests of southern Illinois--regeneration and succession

Ecology 44:29-41

Sixty-two areas of bottomland timber were sampled in a systematic manner to determine the frequency of regeneration of different species. Two separate tests were made to determine the relationship of dominant and codominant trees of different species to the moisture-holding capacities of associated soils. The first consisted of tests of homogeneity of variance of the soil moisture constants associated with trees of each species that reached at least a codominant crown position. The second consisted of a test for significance among the means of soil moisture constants associated with trees of each species. Tree succession on better drained areas starts with pioneer cottonwood-willow and progresses to mixed soft-hardwoods in the next generation.

Hosner, J.F.; Leaf, A.L.; Dickson, R.; Hart, J.B., Jr.

1965

Effects of varying soil moisture upon the nutrient uptake of four bottomland tree species

Proc. Soil Sci. Soc. Amer. 29:313-316

Tupelo gum, pin oak, green ash, and sycamore seedlings were subjected to four soil moisture regimes for 84 days in greenhouse soil cultures. The moisture regimes included (1) saturated soil; (2) moisture equivalent: return to moisture equivalent daily; (3) 50% available water: return to moisture equivalent when 50% of the available water had been removed; and (4) wilting point: return to moisture equivalent when the wilting point had been reached. Comparisons among species and treatments were made on dry weight per seedling top, and contents per seedling top and foliar concentrations of ash, N, P, K, Ca, and Mg.

All species showed a consistent decrease in seedling top dry weight and nutrient uptake from soil moisture equivalent to 50% available water to wilting point. Distinct species differences in reaction to moisture levels occurred between the moisture equivalent and the saturated soil treatments. The pin oak and sycamore seedlings showed a large reduction in dry weight between the moisture equivalent and the saturated regimes, whereas green ash exhibited a small increase and tupelo gum a very large increase. Roots of pin oak and sycamore seedlings died under flooded conditions, whereas green ash and tupelo seedlings maintained actively growing root systems under these conditions.

Pin oak and sycamore seedlings contained over 50% of their dry weight in foliage, while green ash contained 40-45% and tupelo gum 30-40%. Generally, tissue nutrient concentrations tended to be low for seedlings subjected to saturated soils and high for those subjected to wilting point regime. Under the higher soil moisture stresses, apparently, the effect of water upon the seedling metabolic processes became limiting well before the absorption of nutrients did; in other words, moisture treatment affected growth more than did nutrient absorption.

Huffman, R.T.

1979

The relation of flood duration pattern to the community diversity of Coastal Plain forest within the Ouachita River basin of southern Arkansas

Ecology (In press)

Huikari, O.

1960

On the effect of anaerobic media upon the roots of birch, pine, and spruce seedlings

Commun. Inst. Forestalis Fenniae 50(9):1-16

Seedlings of pine, spruce, and birch were grown in flasks under sterile and non-sterile conditions, and anaerobic conditions were created by covering the substrate with paraffin oil. Anaerobic conditions did not retard the growth of birch roots while the growth of pine and spruce roots was heavily suppressed in anaerobic substrates.

Hunt, F.M.

1951

Effects of flooded soil on growth of pine seedlings

Plant Physiology 26:363-368

An experiment was conducted to determine the effects of various degrees and methods of flooding on seedlings of shortleaf pine, loblolly pine, and pond pine growing in soil. One group of trees was flooded continuously with standing water, another group with flowing water. A third group was alternately flooded for two weeks and kept at field capacity.

The experiment was started in February, and after 12 weeks the only effect was slightly reduced growth of the seedlings continuously flooded with stagnant water. After 12 weeks, the soil in half of the containers from each treatment was allowed to dry down to permanent wilting, then re-watered to field capacity. This cycle was repeated for seven months with little effect except that those seedlings flooded with running water during the first 12 weeks made less growth than the other groups. The plants continuously flooded with standing water had a lower dry weight than those receiving other treatments. No significant difference in mortality occurred.

In general these pine seedlings proved unusually resistant to injury by flooding.

Jarvis, P.G.; Jarvis, M.S.

1963

The water relations of tree seedlings. I. Growth and water use in relation to soil water potential

Physiologia Plantarum 16:215-235

Pine, spruce, birch and aspen seedlings were grown in soil, under controlled water regimes, in a growth room. Mean daily transpiration was measured by pot weighing. Continuous records of transpiration after the beginning of the light period were obtained using a corona hygrometer.

The continuous records show that the maximum rate of transpiration was usually achieved in the first few hours after illumination began, followed by a fall to a rate which was usually maintained more or less constant. For all species, the maximum transpiration, and the mean rate for the day, were less in soil of low water potential. Pine was most sensitive in response to decreasing soil water potential, spruce least and birch and aspen intermediate.

Plants which had previously been subjected to low soil water potential transpired less in soils of high water potential than plants which had grown continuously in soil of high soil water potentials.

Possible reasons for differences between species in transpiration response to soil water potential are discussed.

Johnson, D.F.

1950

Plant succession on the Missouri River floodplain

MS thesis, Univ. of South Dakota, Vermillion, 44 pp.

No abstract available.

Johnson, F.L.; Bell, D.T.

1976a

Tree growth and mortality in the streamside forest

Castanea 41:34-41

Growth and mortality rates were determined for *Acer saccharinum*, *Fraxinus pennsylvanica*, *Celtis occidentalis*, *Ulmus americana*, *U. rubra*, and *Quercus alba* over a three-year period in an east-central Illinois streamside forest. Tree size and the distance to the nearest larger tree accounted for significant portions of the variance in growth rates. Flood frequency apparently has no significant effect on growth rates. Mortality rates were much higher in the suppressed crown class than in larger trees.

Johnson, F.L; Bell, D.T.

1976b

Plant biomass and net primary production along a flood-frequency gradient in the streamside forest

Castanea 41:156-165

Biomass and net annual primary production were calculated for three flood-frequency zones in the streamside forest coenocline. Aboveground biomass estimates were 290.0 t/ha in the lower flood plain, 142.1 t/ha in the occasionally flooded transition zone, and 234.2 t/ha in the upland. Aboveground net primary production estimates were 12.5 t/ha/yr in the flood plain, 8.0 t/ha/yr in the transition zone, and 10.8 t/ha/yr in the upland. Data on the species distribution of biomass are presented. Biomass and primary production differences along the coenocline are considered to be the result of individual species responses to flooding, available water, disease, and timber cutting.

Johnson, W.C.; Burgess, R.L.; Keammerer, W.R.

1976

Forest overstory vegetation and environment on the Missouri River floodplain in North Dakota

Ecol. Monogr. 46:59-84

The study area, bounded north and south by two large reservoirs, includes the most extensive remnant of floodplain forest in the Dakotas. Structure and composition of the forest overstory are strongly related to stand age and horizontal and vertical position on the floodplain. Populus deltoides and Salix amygdaloides predominate in young stands which generally occur on low terraces near the center of the floodplain. Fraxinus pennsylvanica, Acer negundo, Ulmus americana, and Quercus macrocarpa, which replace Populus and Salix through time, predominate in old stands on high terraces near the edge of the floodplain. Stands intermediate in composition are uncommon because of the discontinuous meandering pattern of the river across its floodplain.

Surface soil environment and species diversity change markedly during the course of succession. The soils of young stands are generally sandy and low in organic matter. Soil nutrient content and available water capacity are generally higher in older stands because of higher organic matter content and repeated inputs of nutrient-rich silt from past floods. Tree species diversity initially increases as stands age, reaches a maximum in stands with mixtures of both pioneer and terminal species, and declines slightly in the oldest stands. Both variety and evenness follow a similar pattern.

Analyses of population structure indicate a recent decline in the establishment of small stems of Acer and Ulmus. Tree core analyses show a similar decline in diameter growth rate for Acer, Ulmus, and Fraxinus. Available data suggest that these changes can be attributed to the removal of periodic spring flooding caused by the presence and operation of the reservoirs. It is also hypothesized that the lack of seedling-sapling stands of Populus in the region is the result of a presumed reduction in the meandering rate of the river following reservoir construction and poor seedbed conditions in the absence of flooding.

Jones, E.P.

1959

Wet site survival and growth

SEFES Res. Note 130. 2 pp.

Survival and growth of planted yellow-poplar, eastern cottonwood, slash pine, and loblolly pine.

Kaskurewicz, A.; Burns, P.Y.

1960

Growth of planted hardwoods on a bottomland terrace site in southern Louisiana

LSU For. Notes 37. 2 pp.

History of a 30-year-old plantation of Nuttall oak, water oak, live oak, cow oak and yellow-poplar on the LSU campus. It was tentatively concluded that the best species for planting were yellow-poplar, water oak, cow oak, and sweetgum.

Kaufman, M.R.

1968

Evaluation of the pressure chamber technique for estimating plant water potential of forest tree species

For. Sci. 14:369-374

The pressure chamber method for rapid field or laboratory estimation of plant water stress was evaluated, using the thermocouple psychrometer technique. The psychrometer is believed to provide the most accurate measurements of leaf water potential available when certain precautions are taken. The pressure chamber method estimates xylem pressure potential. Comparisons were made by bringing seedlings or large branches into the laboratory and making measurements on leaf samples in the psychrometer and on single leaves or stem tips in the pressure chamber. Most comparisons on _Pinus taeda_, _P. strobus_, _Picea engelmannii_, and _Liriodendron tulipifera_ agreed within 5 bars. With _Quercus rubra_ and _Q. alba_, however, the observed pressure potentials were as much as 16 bars lower than leaf water potential. These discrepancies prevent using the values obtained by the pressure chamber technique as direct estimates of leaf water potential for the species studied. The most appropriate way to use the pressure chamber method in evaluating plant water stress is to first determine calibration curves for each species relating the estimate of xylem pressure potential to known leaf water potential.

Kawase, M.

1973

Rooting and ethylene metabolism in cuttings

Res. Summary, Ohio Agricultural Res. and Develop. Center, 1973, No. 71, pp. 5-8. Another version appears in Combined Proceedings, Int. Plant Propagators' Soc. 22 (1972):413-430.

Ethephon (which releases ethylene in plant tissues) stimulated root formation in cuttings of Salix fragilis. Submerging the cuttings in water, or centrifuging them with water, increased the natural concentration of ethylene, and also led to better root formation. Excess ethylene gas causes symptoms resembling those produced in plants by flooding (wilting, chlorosis, adventitious roots, etc.), and the accumulation of excessive ethylene in flooded plants may be responsible for these reactions.

Kearney, N.S., Jr.; Bonner, F.T.

1968

Sweetgum seed production on soils in central Mississippi

USFS Res. Note SO-75. 2 pp.

This study was conducted in the area between 32°30' and 33°30' north latitude in the state of Mississippi. Twenty dominant and codominant seed-bearing sweetgum trees between 12 and 24 inches dbh were selected on each of the three sites, Delta, deep loess, and Coastal Plain alluvium, during June, 1965. Seeds were collected from these trees in the summer and fall of 1965 and 1966.

The number of fruits and the number of seeds per fruit were counted and germinative capacity and germinative energy were determined in the laboratory. Regressions were computed to determine influence of the following 10 variables on productivity and quality: diameter at breast height, 5-year radial growth, tree age, current year's twig growth, previous year's twig growth, site index (by method of Broadfoot and Krinard), crown surface area, fruit diameter, fruit weight, and number of epicormic branches.

Fruit production was significantly greater on trees on the Delta site than on the other two sites, and fruits from Delta trees contained more than twice as many full seeds as fruits from trees on other areas. Germinative capacity and energy were approximately equal on the three sites.

Fruit diameter and weight were found to be positively correlated with seed production and quality. The rest of the 10 variables studied showed only a very weak correlation with seed production and quality.

It is concluded that, for reasons not evident, the Delta is the best site in central Mississippi for sweetgum seed production.

Keeley, J.E.

1977

The role of environmental heterogeneity in population differentiation along a flood frequency gradient

Ph.D. thesis, Univ. of Georgia, Athens

The hardwood Nyssa sylvatica (sensu lato) is distributed along a soil moisture gradient from upland sites, which are never flooded, to floodplains, which are periodically flooded and drained, to permanently flooded swamps. Seedlings, grown from seed collected along this gradient, responded to one year of experimental flooding as follows: In terms of survival, there was a distinct dichotomy between the upland plants, with over 75% mortality, vs. the floodplain and swamp plants, with less than 5% mortality. In total biomass the floodplain population was intermediate; there was a highly significant reduction in biomass for the upland population, but no significant effect on the swamp population. Patterns of biomass allocation indicated that the floodplain plants were plastic in response, dependent upon conditions; for drained controls the root/shoot ratio was significantly greater than 1.0 for upland and floodplain plants (but not for the swamp plants), and for the one-year experimental flooding treatment, the root/shoot ratio was significantly less than 1.0 for the floodplain and swamp plants (but not for the drained plants).

Comparing nutrient concentrations in the roots of drained plants with flooded ones showed the floodplain population intermediate in two ways. Under flooding, the upland population had significant increases in many nutrients, the floodplain plants fewer and swamp plants least. With respect to Fe and Mn, two of the more important redox systems in flooded soils, the upland plants under flooding accumulated very high concentrations of both of these potentially toxic elements, the floodplain plants had an order of magnitude less Fe, and half as much Mn as the upland plants, and the swamp plants had an order of magnitude less Fe, and half as much Mn, as the floodplain population.

Evidence is presented indicating that the changes in alcohol fermentation can be accounted for by changes in internal oxygen transport. Rates of internal oxygen diffusion, from the stem to the roots, increased from drained conditions to short-term flooding, to long-term flooding for both the floodplain and swamp plants. Swamp plants grown under drained conditions had significantly greater rates than floodplain plants. It is concluded that the strategy for surviving permanent flooding is qualitatively different from the strategy evolved for surviving periodic flooding. Environmental heterogeneity in a floodplain has selected for genotypes capable of greater phenotypic plasticity.

Keeley, J.E.

1979

Population differentiation along a flood frequency gradient: physiological adaptations to flooding in *Nyssa sylvatica*

Ecol. Monogr. 49:89-108

Throughout the southeastern United States the hardwood *Nyssa sylvatica* is distributed along a soil moisture gradient from upland sites, which are never flooded, to floodplains, which are periodically flooded and drained, to permanently flooded swamps. Population differentiation with respect to flood tolerance and related physiological attributes was investigated using 1-year-old seedlings grown in a greenhouse from seed collected along this gradient.

Upland plants were very intolerant of flooded soils. Their root systems deteriorated, root respiration rates dropped and, after a year under such conditions, survival was poor and those that did remain were greatly stunted and had accumulated large concentrations of many nutrient elements.

In contrast swamp plants were quite tolerant of flooded soils. Upon flooding, parts of the original root system were lost but new roots were initiated which had an increased capacity for alcoholic fermentation. Many of these new roots were more succulent, larger in diameter, and less branched than drained roots. Such succulent roots, however, were only a temporary response to short-term flooding; plants flooded for a year did not have such roots, rather the root system superficially resembled drained roots. Concomitant with this return to drained-like roots was an increase in internal oxygen transport to the roots and a drop in alcoholic fermentation.

Floodplain plants under drained conditions allocated less biomass to roots than to shoots and had high respiration rates, traits similar to upland plants. Under flooded conditions, they initiated new roots with medium respiration rates, allocated less biomass to roots than to shoots, significantly increased oxygen transport to roots and had high survival, traits similar to swamp plants. Thus, the floodplain population produced a distinctly flood-tolerant phenotype; but not nearly as tolerant of flooded conditions as the swamp phenotype. Floodplain plants differed from swamp plants in transporting less oxygen to the roots under drained conditions, initiating fewer succulent-type roots and not accelerating alcoholic fermentation upon flooding and after a year under flooded conditions having less total biomass, less oxygen transport to the roots and a greater accumulation of Fe and Mn in the roots.

Kennedy, H.E., Jr.

1970

Growth of newly planted water tupelo seedlings after flooding and siltation

For. Sci. 16:250-256

Water tupelo is a valuable timber species growing in swamps which are usually flooded from January or February until late May or early June. In wet years the water may not leave until midsummer. The wet conditions have discouraged attempts at reforestation after logging. The present study was executed to secure information on the effects of flooding and siltation on newly planted seedlings.

Flooding was shallow (0-8 cm. above groundline), moderate (15 to 20 cm. above groundline), or deep (10 to 15 cm. above the tallest seedlings).

All treatments were replicated three times.

Survival was high under all types of flooding except deep flooding continued from February to August 1. Dieback resulted frequently after deep flooding and after reflooding, but the seedlings sprouted readily just below the lowest dead stem tissue.

Height growth in plots with shallow flooding until June 1 was approximately the same as that on nonflooded control plots. When this depth of water was retained to July or August, height growth was significantly reduced. Moderate flooding, deep flooding, reflooding, and shallow and deep siltation also reduced height growth.

These results indicate that water tupelo seedlings have a remarkable ability to resist flooding for extended periods, and that they make good growth under shallow flooding until June 1.

Kennedy, H.E.; Krinard, R.M.

1974

1973 Mississippi River flood's impact on natural hardwood forests and plantations

USFS Res. Note SO-177. 6 pp.

Through October, the 1973 Mississippi River flood had not caused extensive damage to natural hardwood forests or plantations that were 1 year or older and had been flooded only during the first 2 months of the growing season. New plantings of cottonwood were virtually destroyed, however, and 1-year-old sweetgum, flooded about 3 months, was killed. All yellow-poplar observed was killed. Siltation up to 5 feet deep has not caused appreciable damage, but trapped water has caused some mortality.

Kitchens, W.M.; Dean, J.M.; Stevenson, L.H.; Cooper, J.H.

1974

The Santee Swamp as a nutrient "sink"

In Proc. of the Savannah River Ecology Lab. Symp. on Mineral Cycling in the Southeastern Ecosystem, May 1-3, 1974

A water-quality survey was conducted in the Upper Santee Swamp in South Carolina during the winter and early spring of 1973. Among the parameters measured were (1) dissolved oxygen, (2) temperature, (3) pH, (4) turbidity, (5) reactive phosphate, (6) total phosphate, (7) nitrite, (8) nitrate, (9) ammonia, (10) heterotrophic bacteria, (11) total coliforms, and (12) fecal coliforms. The Wateree and Congaree Rivers, whose dissected confluent floodplains make up the Santee Swamp, transported very heavy nutrient loads in the various forms of nitrogen and phosphorus and had high turbidity and oxygen levels. The primary source of flowing waters in the swamp during this period was overflow of the Wateree River. There was a significant reduction in nutrient concentrations (particularly phosphorus) and in bacterial counts (including fecal coliforms) with little or no oxygen depletion as the waters coursed through the swamp.

Klawitter, R.A.

1963

Sweetgum, swamp tupelo, and water tupelo sites in a South Carolina bottomland forest

Diss. Abstr. 24(1):12

The results of the study showed that sweetgum sites were better drained, higher in soil pH and lower in loss on ignition values than those of the tupelos; water tupelo soils were high in clay content and flooded deeply; and swamp tupelo soils averaged lowest in pH, and silt plus clay. Furthermore, site factors that indicated or were conducive to abundant soil moisture and long hydro-periods were directly related to the total height of water tupelo, while annual radial growth responded favorably to warm, moist springs and flooding throughout the year.

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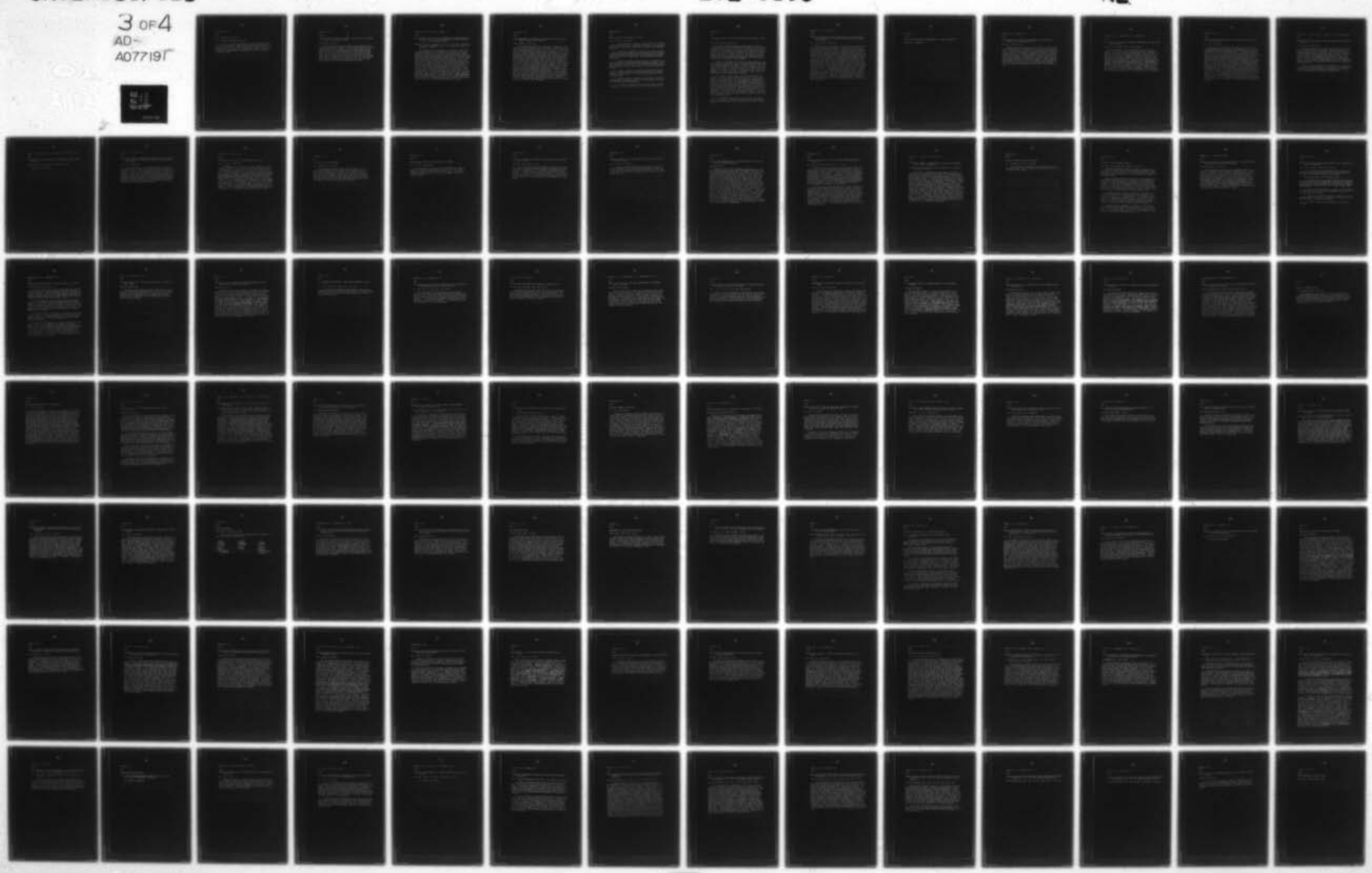

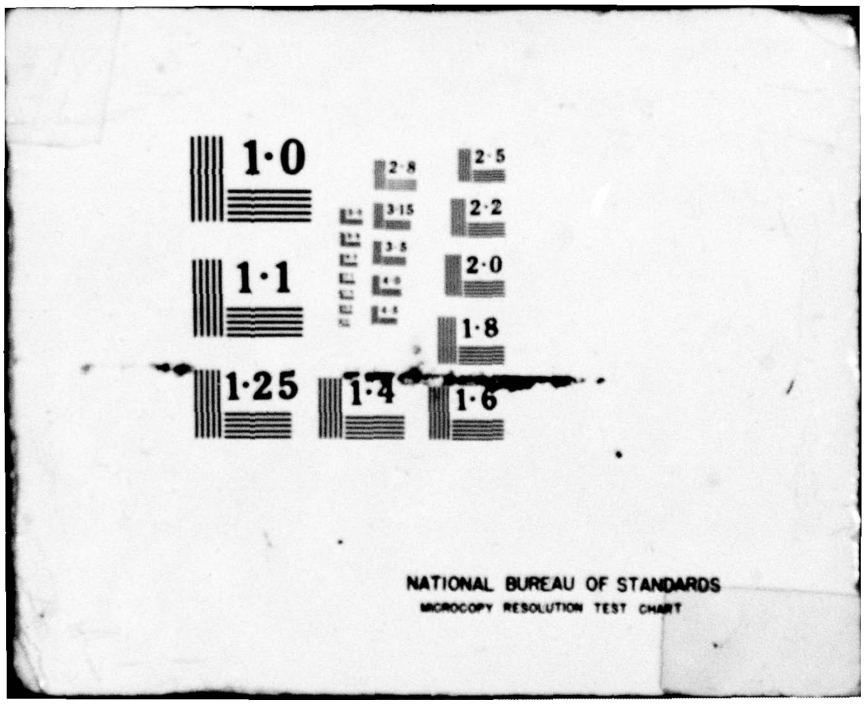
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NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

Klawitter, R.A.

1964

Water tupelos like it wet

Sou. Lumberman 209(2609):108-109

Along the lower Santee River in South Carolina, taller water tupelos occurred where soil and other site conditions were characteristic of poor drainage and long periods of wetness. Water levels play an important role in the growth, development, and probably, distribution of water tupelo in bottomland swamps.

Klawitter, R.A.

1963

Sweetgum, swamp tupelo, and water tupelo sites in a South Carolina bottomland forest

Diss. Abstr. 24(1):12

The results of the study showed that sweetgum sites were better drained, higher in soil pH and lower in loss on ignition values than those of the tupelos; water tupelo soils were high in clay content and flooded deeply; and swamp tupelo soils averaged lowest in pH, and silt plus clay. Furthermore, site factors that indicated or were conducive to abundant soil moisture and long hydro-periods were directly related to the total height of water tupelo, while annual radial growth responded favorably to warm, moist springs and flooding throughout the year.

Klein, W.M.; Daley, R.H.; Wedum, J.

1975

Environmental inventory and assessment of Navigation Pools 24, 25, and 26, Upper Mississippi and Lower Illinois Rivers: a vegetational study

Missouri Botanical Garden, St. Louis. Army Engr. Waterways Exp. Sta., Vicksburg, Miss. (Contract No. DACW39-74-C-0088). 151 pp.

The purpose of the study was to provide a vegetation map and descriptions of vegetational types and their successional patterns to be used in an environmental impact analysis of the effects of maintenance and operation of the nine-foot navigation channel in Pools 24, 25, and 26 on the Upper Mississippi and Lower Illinois Rivers. Seven vegetation types were described after field examination of 116 stands: Two nonforest types, old fields and wetlands, and five forest types — willow, silver maple-cottonwood, silver maple-cottonwood-pin oak, pin oak, and oak-hickory. All of these types were mapped with the exception of old fields, which were omitted because they are often subject to cultivation after a short period of abandonment. The silver maple-cottonwood community was found to be the most extensive type. Analysis of successional trends indicated that ash (Fraxinus spp.) and American elm (Ulmus americana) may become more important in many of the silver maple forests and that pin oak forests may also replace them particularly in areas protected from flooding by levees.

Kozlowski, T.T.

1949

Light and water in relation to growth and competition of Piedmont forest tree species

Ecol. Monogr. 19:207-231

Pine seedlings exhibit a consistent increase in photosynthesis with increased light intensity. Hardwoods reach maximum photosynthesis at low light intensities. Growth of pine is reduced more by shading than is growth of oak. Oak exhibits greater capacity than pine for absorption of water at soil moisture contents less than field capacity. With decreasing soil moisture, photosynthesis of pine begins to decrease at higher moisture content than does the rate of oak. Shade-grown pine moved into the sun has a lower rate of transpiration than pine grown in full sun. Reserve foods were higher in oak than in pine seedlings of the same age at the end of the growing season. Reserve foods were higher in sun-grown pine than in shade-grown pine. In competition, pine and hardwoods differ in physiological processes because of hereditary differences. Effects of environment are interacting and interdependent. In the Piedmont, the critical threshold condition of low photosynthesis below which pine cannot maintain itself is correlated with the combined effect of decreased soil moisture and decreased light intensity under forest stands. Species studied: loblolly pine; shortleaf pine; white oak; overcup oak; yellow-poplar; and red maple.

Kozlowski, T.T.

1958

Water relations and growth of trees

Jour. of For. 56:498-502

1. Reduced growth of trees, early leaf fall, dieback, transplanting failures, sunscorch, and death of trees often occur as a result of an unfavorable internal water balance in trees.

2. Diurnal and seasonal variations in water contents of leaves and stems result primarily because water absorption lags behind transpiration. The absorption lag occurs primarily because of resistance to water movement across root cells.

3. Under prolonged drought leaves do not recover turgidity and become desiccated and scorched in summer. Winter injury also occurs widely when evergreens lose moisture and absorption cannot replace water in the leaves rapidly enough.

4. Growth of trees is checked by moisture deficits. Diameter growth appears to be more sensitive than height growth to variations in soil moisture supply during the growing season.

5. Water deficits in leaves check growth of trees by influencing carbohydrate supplies through direct and indirect effects on photosynthesis.

6. It appears therefore that photosynthesis can be decreased by too much as well as too little soil moisture.

Kramer, P.J.

1951

Causes of injury to plants resulting from flooding of the soil

Plant Physiology 26:722-735

A series of experiments was performed to learn how flooding the soil in which plants are growing causes injury or death of the shoots. Flooding is followed by a rapid reduction in transpiration and the water absorbing capacity of the roots and usually is followed by more or less wilting of the shoots. Within three or four days the lowest leaves begin to turn yellow and die, the middle leaves of tomato and yellow poplar show epinasty, and adventitious roots begin to develop on some species.

Injury to the shoots was found to be more severe when the pots were surrounded by soil and flooded than when they were simply submerged in water. Plants potted in soil were injured more than plants potted in sand. Tobacco was most injured by flooding, sunflower least, and tomato was intermediate in degree of injury. Those plants which produced adventitious roots most rapidly suffered least injury and showed the greatest degree of recovery.

While lack of water might explain the death of the leaves, it cannot explain such characteristic effects of flooding as curvature of the leaf petioles, hypertrophy of stems at the water line, nor development of adventitious roots. Flooding probably stops downward translocation of carbohydrates and auxin, and possibly their accumulation at the water line is responsible for hypertrophy and development of adventitious roots. Accumulation of auxin in the lower half of the stem might also be responsible for the epinastic curvature of the leaves and petioles. The injury and death of the leaves may be caused at least in part by toxic substances moving up from the dead roots or even from the surrounding soil.

It is believed that injury to the shoots of flooded plants is complex in origin and has several causes rather than resulting simply from interference with water absorption.

Kramer, P.J.; Bullock, H.C.

1966

Seasonal variations in the proportions of suberized and unsuberized roots of trees in relation to the absorption of water

Am. Jour. of Bot. 53:200-204

Growing root tips usually constituted less than 1% and mycorrhizal roots less than 6% of the total root surface under a 34-year-old pine stand. Growing root tips usually constituted less than 1% of the total root surface under a yellow-poplar stand, although one sample taken in May contained 9% of unsuberized roots. The water permeability of various types of roots was measured under a pressure gradient of 31 cm of mercury. It differed widely among individual roots, ranging from an average of 6.6 $mm^3/cm^2/hr$ for suberized pine roots 1.33 mm in diameter, to 36.6 mm^3 for suberized pine roots 3 mm in diameter, and 178 $mm^3/cm^2/hr$ for unsuberized roots grown in water culture. Water intake through a group of unsuberized roots grown in soil averaged 37.4 $mm^3/cm^2/hr$. The permeability of yellow-poplar roots varied even more, ranging from essentially zero to 30,000 $mm^3/cm^2/hr$. It is concluded that the major part of water absorption in pine occurs through suberized roots, some through mycorrhizal roots, and relatively little through growing root tips. Likewise, in yellow-poplar most of the water probably enters through suberized roots. Further study is needed of the role of suberized roots in water and salt absorption.

Kramer, P.J.

1969

Plant and soil water relationships: a modern synthesis

New York: McGraw-Hill

Krinard, R.M.; Johnson, R.L.

1976

Twenty-one-year growth and development of baldcypress planted on a flood-prone site

USFS Res. Note SO-217

Baldcypress is a good species to plant on sites where prolonged flooding is common and few other species can survive. When planted on a site where flooding had repeatedly killed cottonwood plantations, cypress survival at age 21 averaged about 41%; average diameter was about 6.1 inches. Some of the cypress was suppressed by other hardwoods such as ash and boxelder. Diameters of the best 10% of the cypress trees averaged 11.1 inches at age 21. Thus, mean annual diameter growth of these trees was 0.53—considerably more than the 0.32 inch per year estimated for dominant trees in natural stands during their prime development period.

Lacoursiere, E.; Pontbriand, P.; Dumas, J.P.

1976

The first stage in the ecological succession of the Ile aux Sternes, Quebec

Naturaliste Canadien 103 (1976):169-189

The vegetation, soils and avian fauna of Ile aux Sternes, an island in the St. Lawrence River, created in 1965 by dredging at Port Saint-Francois, were studied in 1970 to 1974. The 175 species of plants found on the island in these four successive years are tabulated, and vegetation groupings (mapped) are established using the methods of Braun-Blanquet. These include communities dominated by *Salix nigra*, *Salix interior*, and *Populus deltoides*. Altitude is an important factor in the vegetation pattern; the island is only 4-10 ft. above mean sea level and is completely submerged by the spring flood; most of the areas dominated by *Salix* and *Populus* communities is above the 6 ft. contour. The influences of the vegetation on soil characteristics on avian populations are discussed.

Larsen, Harry S.

1963

Effects of soaking in water on acorn germination of four southern oaks

For. Sci. 9:236-241

Greenhouse germination tests were run on acorns of Quercus falcata, Q. phellos, Q. laurifolia, and Q. lyrata. Q. falcata is typical of moderately dry upland sites, the others of southern bottomland types. Q. lyrata occupies the wettest sites. Acorns were pre-soaked in distilled water for four different periods at two different temperature levels to approximate normal ranges during winter and spring flooding. There were no conclusive effects on total germination; germination of treated Q. falcata and Q. phellos at 30 days was either unaffected or slightly reduced with no consistent pattern of soaking time-temperature effects but with poorest germination after the longest soaking period at the lower temperature level. Germination of Q. laurifolia at 30 days was, with an exception, either unaffected or slightly increased; maximum increase followed the longest soaking period at the highest temperature level. Germination of Q. lyrata was severely delayed by all treatments, which seems to be related to saturation of the spongy shells with consequent interference in gas exchange. If flooding is the principal factor preventing regeneration of certain oaks on wet sites it is most limiting after germination.

Lindsey, A.A.; Petty, R.O.; Sterling, D.K.; Van Asdall, W.

1961

Vegetation and environment along the Wabash and Tippecanoe Rivers

Ecol. Monogr. 31:105-156

The flood plains of the study extend along the Wabash and Tippecanoe Rivers for 430 mi of stream distance, and range through 230 mi of latitude. The glacial and post-glacial history of the region has been of major importance in determining present watershed characteristics. The coarser texture of Tippecanoe substrates, the much more regular stream flow, the much larger size of the Wabash River, and the climatic consequences of the latitudinal difference, provided the principal background for vegetational characteristics.

Definite range limits for 189 species and varieties of northern and southern plants were determined. Peculiar local aggregations were noted in the distribution of these limits, correlating with climatic expressions.

Long, F.L.; Daniels, J.M.; Ritchie, F.T.; Ellerbe, C.M.

1963

Soil moisture characteristics of some lower Coastal Plain soils

USDA Agri. Res. Serv. Publ. ARS 41-82. 22 pp.

No abstract available.

Lorio, P.L.; Hodges, J.D.

1968

Oleoresin exudation pressure and relative water content of inner bark as indicators of moisture stress in loblolly pines

For. Sci. 14:392-398

Diurnal patterns of oleoresin exudation pressure of *Pinus taeda* were related to changes in soil and atmospheric moisture. Single, early morning measurements were not closely indicative of soil moisture stress. Relative water content of inner bark reflected soil moisture status and diameter growth response, and apparently was affected by atmospheric moisture deficit. Trees continuously flooded eventually showed the most severe reduction in oleoresin exudation pressure and relative water content, and were successfully attacked by bark beetles.

Loucks, W.L.; Keen, R.A.

1973

Submersion tolerance of selected seedling trees

Jour. of For. 71:496-497

Seedlings (1 + 0 or 2 + 0) of ten species of trees commonly used in recreation areas were submerged in water in mid-April 1970 for 1, 2, 3, or 4 weeks. By May 1971, there had been no significant mortality in seedlings in the 1- or 2-week treatments: in the 3-week treatment, *Fraxinus pennsylvanica*, *Taxodium distichum*, *Populus deltoides*, and *Acer saccharinum* showed 100% survival, and the other species 44-67%; in the 4-week treatment, the most tolerant species were *F. pennsylvanica*, *T. distichum*, and *A. saccharinum*, the least tolerant (0-33% survival) were *Acer negundo*, *Ulmus pumila*, and *Juglans nigra*, and the intermediate species (55-75% survival) were *Carya illinoensis*, *P. deltoides*, *Gleditsia triacanthos*, and *Quercus macrocarpa*. The effects of the treatments on terminal growth are discussed: in general, longer submersion reduced terminal growth.

McAlpine, R.G.

1959

Flooding kills yellow-poplar

For. Farmer 19(3):9, 13-14

Yellow-poplar from four seed sources planted in overflow bottomlands along the Oconee river in Georgia suffered severe damage from flooding, many trees being killed. There were no consistent differences in mortality between the various seed sources. Sprouting from the root collars of trees, both living and dead, indicated that it was probably not damage to the root systems which killed the trees, but damage to the lower portion of the stems.

McAlpine, R.G.

1961

Yellow-poplar seedlings intolerant to flooding

Jour. of For. 59:566-568

Yellow-poplar seedlings were not affected by dormant season flooding, but mortality occurred after four days of flooding in May and after three days in June. All seedlings were killed after two weeks of flooding during the growing season.

McClurkin, D.C.

1965

Diameter growth and phenology of trees on sites with high water tables

USFS Res. Note SO-22. 4 pp.

On a site where the water table always was within the root zone, thinning had little effect on diameter growth of white ash or sweetgum, but increased the growth of bald-cypress. Thinning did not extend duration of growth into the fall, nor was growth related to seasonal fluctuations in the water table. In ash and sweetgum, growth initiation seemed related to soil temperature; in baldcypress, to day length.

McDermott, R.E.

1953

Light as a factor in the germination of some bottomland hardwood seeds

Jour. of For. 51:203-204

Laboratory tests indicated that germination of river birch, sycamore, and American elm seeds was increased in percentage and speeded up by light treatments. Red maple, winged elm, and alder were apparently not sensitive to low light intensity.

McDermott, R.E.

1954

Effects of saturated soil on seedling growth of some bottomland hardwood species

Ecology 35:36-41

Seedlings of sycamore (Platanus occidentalis), river birch, American elm, winged elm, red maple, and alder that had just developed their first true leaves were subjected to saturated soil conditions of varying time intervals followed by intervals of soil moisture at and above field capacity under conditions of approximately one-half sunlight and high soil temperatures. Comparisons of height growth in ten-day periods after the most favorable soil treatment (days), and height growth in ten-day periods after the most stunting soil-saturated treatments were made. After subjection to a sustained saturated substratum with subsequent well-drained conditions, river birch and red maple seedlings recover very rapidly, sycamore rapidly, and American elm and winged elm at a moderate rate. The growth rate of alder seedlings is accelerated by short intervals of soil saturation, and their growth is not significantly changed by sustained saturation intervals up to 32 days. The relative degree of recovery from stunting induced by previously saturated soils of young seedlings of alder, river birch, sycamore, American elm, and winged elm, may be indicative of their successional relationships and ultimate stand composition in bottomlands.

McDermott, R.E.

1954

Seedling tolerance as a factor in bottomland timber succession

Mo. Agr. Exp. Sta. Res. Bul. 557. 11 pp.

In the successional sequence of bottomland timber species, an early shrub stage often characterized by alder is replaced by a stage in which sycamore and river birch may be prominent. This stage, in turn, is commonly replaced by a maple-elm-ash community. In general, it can be assumed that there is a shift from intolerant to tolerant species as this alder to sycamore-birch, to maple-elm transition takes place. To test this assumption, very young seedlings of alder, sycamore, river birch, American elm, winged elm, and red maple were grown in four sunlight intensities: full, one-half, one-third, and one-fifth.

On the basis of height growth and top-root ratios, it was found that alder and river birch are quite intolerant, American elm and winged elm moderately tolerant, and red maple tolerant. Contrary to expectations, sycamore seedlings are at least as tolerant as the elms. Thus, the fact that sycamore reproduction is lacking in sycamore stands, and that the tendency is commonly toward elm reproduction, is not primarily due to differences in light tolerance. The suggestion is made that as succession proceeds in bottomland timber areas, it appears that seedbed conditions become prohibitive for the sycamore stage and are improving for the elm stage.

McKim, H.L.; Gatto, L.W.; Merry, C.J.

1975

Inundation damage to vegetation at selected New England flood control reservoirs

Cold Regions Res. and Engr. Lab., Hanover, N.H. Special Rpt. 220. 49 pp.

The effect on vegetation of inundation caused by the regulation and impoundment of water at six New England flood control reservoirs during the June-July 1973 flood was assessed from color infrared photography and corroborative ground surveys. A large amount of reservoir storage was utilized during the two-week inundation period, resulting in extensive damage to vegetation. Four degrees of apparent vegetative damage were differentiated from color infrared photography based on color differences ranging from bright red or magenta for healthy foliage to cyan for unhealthy, damaged or dying vegetation. Correlative ground truth data showed that the deciduous trees, particularly silver maple and red oak, were least affected and that coniferous trees, especially white pine, were most affected by siltation and inundation. Much of the understory vegetation, i.e., poplar, basswood and hornbeam, lost all leaves after inundation but new buds and shoots reappeared by late September 1973. Generally, trees inundated for less than 90 hours were not extensively damaged.

McKnight, J.S.

1950

Forest management by old man river

Sou. Lumberman 181(2273):233-235

Describes the development of batture lands on the Mississippi River, and the growth of cottonwood and willow stands on these lands.

McKnight, J.S.

1968

Ecology of four hardwood species

LSU Proc. 17th Annual For. Symp., pp. 99-116

Eastern cottonwood, American sycamore, sweetgum, and cherrybark oak were chosen for discussion because of their importance in the ecology of southern lowlands and in plans for intensified silviculture in the southern bottomland hardwood region.

The principal problems in connection with sweetgum and cherrybark oak arise from the slow initial development of seedlings. Some successful plantations have been established, particularly where weed competition has been controlled in early years. Research is being directed toward genetically superior planting stock, control of mycorrhizal populations, superior ways of preparing nursery stock, and fertilization of young trees to hasten early growth.

Cottonwood ecology strongly indicates the need for intensive silviculture. Farming methods are essential for the establishment of a stand because of the extreme intolerance of the species to competition. Cottonwood reacts rapidly to adequate moisture and fertile soil, and this, together with a wide range of genetic variability, makes it possible to produce large yields on short rotations.

Sycamore ecology suggests a variety of possibilities. Three characters are of particular interest: (1) resistance to browsing by deer, (2) ability of seedlings to compete with grass and weeds, and (3) a sturdy young stem that grows through heavy vine competition.

McMammon, M.; Crawford, R.M.M.

1971

A metabolic theory of flooding tolerance: the significance of enzyme distribution and behavior

New Phytologist 70:299-306

The distribution and activity patterns of several enzymes of glycolytic and respiratory metabolism are considered in nineteen species of higher plants previously classified as tolerant or intolerant of experimental flooding. These results are combined with previous work on glycolysis, the inductive properties of alcohol dehydrogenase, and on tissue malic acid levels, to formulate a metabolic system of flooding tolerance. This system is based mainly on: (1) the control of glycolysis through the inductive and kinetic properties of alcohol dehydrogenase; and (2) a diversion from ethanol to malate accumulation, dependent upon the presence or absence of malic enzyme.

McReynolds, R.D.

1960

Mortality of newly germinated southern pine seedlings following inundation

USFS Tree Planters' Notes 43, pp. 23-25

A recent study at Oxford, Mississippi, tested the ability of newly germinated southern pine seedlings to withstand submergence lasting up to 20 days.

This exploratory study indicates that:

1. At ages of 15 or 20 days, loblolly and shortleaf pine seedlings have developed some resistance to flooding; most 25-day-old loblolly seedlings can survive 20 days of flooding, but shortleaf pine die off when flooded longer than 12 days.

2. Longleaf pine seedlings, 25 days old, are damaged by flooding of any duration and completely killed if flooded more than 12 days.

3. Slash pine seedlings begin to survive 10 days of flooding when 25 days old; up to 60% of seedlings of that age can survive 20 days of flooding.

4. Summer flooding is more damaging than spring flooding.

Maisenhelder, L.C.; McKnight, J.S.

1968

Cottonwood seedlings best for sites subject to flooding

USFS Tree Planters' Notes, p. 3

Cuttings rather than seedlings are generally used as planting stock of eastern cottonwood and are very successful on most sites. Research at the Southern Hardwoods Laboratory, however, shows that rooted seedlings may be preferable on areas likely to be flooded after cottonwoods are planted and before they begin height growth.

A study comparing the two types of stock was begun in 1964 on an area often flooded by Mississippi River backwaters. The planting stock consisted of unrooted cuttings, 20 and 40 inches long and set 15 inches in the ground, and 1-0 nursery seedlings with a top length of 25 inches. Immediately after planting the area was flooded from mid-March until late May.

The seedlings had a survival, at the end of the first growing season, of 87% as compared with 15-24% for the cuttings. Height measurements at the same time showed seedlings averaging 11.7 inches as compared to 7.3 to 10.8 inches for cuttings.

Cuttings are inexpensive to procure and easy to handle and also allow rapid expansion of genetic selections. Hence, they will undoubtedly continue to be preferred for most sites. Where floods are likely during late winter or in the early growing season, planters may have better results with seedlings whose tops are long enough to stay above high water. On such sites, as on all others, the plantation should be cultivated and weeds controlled when the soil becomes dry enough.

Marks, P.L.; Harcombe, P.A.

1975

Community diversity of coastal plain forest in southern east Texas

Ecology 56:1004-1008

Forests on the coastal plain of southern east Texas have high within- and between-habitat diversity for woody species. High shrub diversity is responsible for high within-habitat diversity; a long topographic-moisture gradient may be responsible for at least part of the between-habitat diversity.

Matjuk, I.S.

1953

Influence of soil conditions on the development of root systems of tree and shrub species

Pedology 5:24-30

Discussed with scale diagrams accompanied by profiles showing soil texture, the development of some root systems of trees and shrubs in mixed plantations (from 14 to 40 years old) in the chestnut-earth zone of Rostov province, based on studies made in 1952. The mixtures dealt with are _Pinus_ _sylvestris_/_Quercus_ _robur_, _P._ _nigra_ var. _caramanical_/ _Q._ _robur_, and mixtures of _P._ _sylvestris_ with one or other of the following--_Populus_ _nigra_, _Betula_ _verrucosa_, _Salix_ sp., _Rhus_ _continus_, _Caragana_ _arborescens_. Concludes that, in addition to the differences in rooting habit between species, there are marked differences in root behavior according to the texture of the various soil horizons, and considerable changes of root development occur in passing from one horizon to another of different texture. The correct choice of mixtures for plantations must therefore involve a study of both specific differences and behavior as regards soil texture throughout the profile.

Miller, W.D.

1974

An annotated bibliography of southern hardwoods, Vols. I and II

N.C. Agri. Exp. Sta. Techn. Bul. 176, 228

An excellent annotated bibliography of references on southern hardwoods covering a wide range of sources including monographs, journals, technical reports, and other serial publications.

Minckler, L.S.; McDermott, R.E.

1960

Pin oak acorn production and regeneration as affected by stand density, structure, and flooding

Mo. Agr. Exp. Sta. Res. Bul. 750, 24 pp.

Acorn production varies greatly from one year to another. Pin oak in pure even-aged stands produces plentiful acorns, at least as early as the range 25-35 years. During a good seed year, the production of sound acorns is abundant. Although dormant-season flooding did not decrease the production of acorns, it did adversely affect the production of new oak seedlings.

Minckler, L.S.; Janes, D.

1965

Pin oak acorn production on normal and flooded areas

Mo. Agr. Exp. Sta. Res. Bul. 898, 15 pp.

The effects of flooding and other stand treatments on pin oak acorn production, growth, and regeneration. This paper reports the approximate amounts and variability of pin oak acorn production after nine years of acorn collections, and discusses some of the elements that affect the size and quality of the acorn crops.

Minckler, L.S.; Woerheide, J.D.; Schlesinger, R.C.

1973

Light, soil moisture, and tree reproduction in hardwood forest openings

USFS Res. Paper NC-89

Light, soil moisture, and tree reproduction were measured at five positions in six openings on each of three aspects in southern Illinois. Amount of light received was clearly related to position in the openings, opening size, and aspect. More moisture was available in the centers of the openings, although 4 years after openings were made the differences between center and edge positions decreased considerably. The abundance of reproduction was not related to opening size, but height growth was best in the centers of larger openings.

Mitsch, W.J.

1975

Systems analysis of nutrient disposal in cypress wetlands and lake ecosystems in Florida

Ph.D. thesis, Univ. of Florida, Gainesville

Models, field measurements, and computer simulations were used to evaluate alternative systems of man's nutrient recycling using a freshwater lake and cypress swamps in Florida. Ecological characteristics, nutrient budgets, organic productivity, energy relations, and interfaces with man's economy were compared between the two ecosystems.

Mitsch, W.J.; Ewel, K.C.

1979

Comparative biomass and growth of cypress in Florida wetlands

Am. Mid. Nat. 101:417-426

Tree biomass and increase in biomass were determined for cypress (Taxodium distichum) in different systems in Florida. Ten trees were harvested to determine biomass regressions. Lowest biomass and tree growth rates were found in cypress-pine associations indicative of low water, in monospecific stands of cypress which are indicative of high water levels, and in a poorly drained cypress dome. Highest cypress tree growth rates were found in cypress-tupelo systems and cypress-hardwood systems. The latter are less dominated by cypress, however, so individual tree growth is greater. Cypress-hardwood associations are known to be generally better drained than cypress-tupelo systems. Two experimental cypress domes currently receiving treated sewage effluent and groundwater showed high individual tree growth.

Monk, C.D.

1966

An ecological study of hardwood swamps in north-central Florida

Ecology 47:649-654

The hardwood swamps of north-central Florida may be divided into two groups: (1) mixed swamps and (2) bayheads. The former is characterized by deciduous species and the latter by evergreen species. Mixed swamps occupy sites which are usually higher in calcium, magnesium, calcium/magnesium ratios, calcium/potassium ratios, pH, and depth of maximum flooding. Sabal palmetto, Fraxinus caroliniana, Ulmus floridana, and Taxodium distichum are more restricted to the mixed swamp habitat, while Gordonia lasianthus, l'ersca palustris, and Magnolia virginiana are more confined to bayhead. Quercus nigra, Acer rubrum, Liquidambar styraciflua, and Nyssa sylvatica occupy both habitats. Though several species link the two communities, the two habitats can be effectively separated by certain edaphic variables.

Nixon, E.A.; Willett, R.L.; Cox, P.W.

1977

Woody vegetation of a virgin forest in an eastern Texas river bottom

Castanea 42:227-236

The woody vegetation of a virgin forest on the floodplain of the Neches River in east Texas was analyzed. A total of 48 woody species was recorded, of which 17 occurred on ridge areas and 35 on low flats. Significant quantitative differences in vegetation existed on these sites even though elevational variation was generally less than 2 m. Ridge areas were dominated by American hornbeam (Carpinus caroliniana) and water oak (Quercus nigra), whereas Carolina ash (Fraxinus caroliniana) and silver bells (Styrax americana) were the most prevalent species on flats. The overall principal woody species were American hornbeam, Carolina ash, water oak, red maple (Acer rubrum), possumhaw (Ilex decidua), and silver bells. The successional status of this forest was discussed and we concluded that it was a topographic climax.

Nyboer, R.W.; Ebinger, J.E.

1976

Woody vegetation survey of a terrace forest in east-central Illinois

Castanea 41:348-356

A total of 47 woody species was found in the survey. Two distinct vegetational zones were recognized, a low terrace and a high terrace. The low terrace contained an average of 140 stems/acre (b.a. 125 sq. ft./acre); it was dominated by Aesculus slabra, Acer negundo, Celtis occidentalis, Platanus occidentalis, Acer saccharinum, Juslans nigra, and Ulmus americana. The high terrace contained an average of 126 stems/acre (b.a. 113 sq. ft./acre) and was dominated by Carya laciniosa, Acer negundo, Quercus alba, Fraxinus americana, Acer rubrum, and Ulmus rubra. Seedling density was lower on the low terrace, probably because of occasional flooding. Possible changes in the species composition of the two zones are discussed.

Nyestsyarovich, M.D.; Dzyaruhina, T.F.

1975

Growth of Russian elm and European ash seedlings depending on duration of flooding

Vyestsi Akad Navuk TSSR Syer Biyal Navuk 4:5-9

The effect of flooding for 15, 30, 60, 90, and 120 days on the growth of Russian elm and European ash seedlings was investigated. In the initial period flooding had no effect on plant development. Shoot growth began simultaneously in the control and flooded variants. Flooding for up to 60 days had little effect on the duration of shoot growth (82-88 days for elm and 67 days for ash). However, in this case there was a decrease in the average indices of the shoot length (78.8% for elm and 55.5% for ash in comparison with the control), plant height (by 21.1% for elm and 10.6% for ash), diameter of the trunks and root length. An increase of the flooding time to 90 and 120 days shortened the growth period of the shoots by 30-36 days for elm and 35 days for ash. Under these conditions the shoot length, trunk diameter, root length, and plant height decreased even more in comparison with the control.

Oaks, W.R.

1977

Banking on basket willow

Soil Conservation 42 (1977):16

Salix purpurea (introduced to the United States in colonial times for basket making) was successfully used in tests to control erosion of streambanks by floods and ice. Rooted or unrooted cuttings could be used. Plants reached a height of 4-5 ft. in 2 years and are expected to reach mature height (10-20 ft.) in 5-7 years.

O'Leary, J.W.

1965

Root pressure exudation in woody plants

Bot. Gaz. 126:108-115

A study was made of differences in amount and concentration of root pressure exudate from detopped root systems of several woody species. Root pressure exudation was exhibited by young grape plants and young seedlings of tulip tree, birch, and red maple but not by loblolly pine, white spruce, and sugar maple. The salt concentration of the root pressure exudate was always greater than that of the external solution. When solution was pushed through the root systems by applying a pressure of 1 atm to the solution surrounding the roots, the volume of exudate increased considerably and its salt concentration decreased. Nevertheless, the total amount of salt delivered per unit of time increased. An increase in solution temperature from 24° to 34°C. increased the yield of exudate from individual roots of pine and spruce more than seven times. The rate of exudation from single roots of grape and white spruce was decreased by sodium azide. Individual excised roots of loblolly pine that were completely suberized exhibited considerable exudation. In fact, after a 24-hour lag, the rate of exudation from these roots began to increase rapidly, soon surpassing the exudation rate from actively growing roots.

Olson, D.F.; Hoover, M.D.

1954

Methods of soil moisture determination under field conditions

USFS SEFS ES Paper 38

Lack of knowledge in the field of soil moisture can be attributed to a lack of adequate means of measurement rather than to a lack of interest on the part of investigators. It can be seen from the review of methods used that the ideal conditions for making soil moisture studies exist when nondestructive testing can be used, when moisture in the soil itself can be measured, and when the soil is undisturbed and free from unnatural influences. It is also a requirement that continuous records be obtainable in the range of soil moisture from air-dryness to saturation.

Of the methods available for use at this time, those employing fabric electrical resistance units most nearly approach the ideal. The use of radioactive materials, when further developed, will almost exactly match the ideal. Tensiometers are excellent devices for measurement in the wet range, and, used in conjunction with fabric units, provide records for the complete range of soil moisture.

One serious difficulty with all continuous measuring instruments, however, is that calibration in the field against gravimetric samples is not precise because of soil heterogeneity, uneven plant growth and root penetration, and uneven soil surface conditions. In sampling for calibration purposes, a certain portion of each experimental site is destroyed for further sampling.

As research continues, methodology of continuous soil moisture measurement in the field may be eliminated as a limiting factor, and then investigators can devote their energies exclusively to studies of the most dynamic of all soil characteristics—the soil water complex.

O'Neil, C.P.; deSteigur, J.E.; Korth, G.W.; Jennings, M.E.

1975

Trend analysis of vegetation in Louisiana's Atchafalaya
River Basin

Geological Survey, Bay St. Louis, Miss. EROS Applications Assistance Facility. Dept. of the Interior, Wash., D.C. Ofc. of the Asst. Sec. for Fish and Wildlife and Parks. Final Rept. 72 pp.

The objectives of this study were to conduct a trend analysis of forest vegetation in Louisiana's Atchafalaya Basin to: (1) determine trends of vegetation succession, (2) produce a current vegetation map of the Basin, and (3) develop a mathematical model capable of predicting changes in vegetation, based on changes in various hydrologic factors. Using time-lapse aerial photography from 1930, 1962 and 1973, four test strips of data covering 16% of the Basin were analyzed to determine trends in vegetation succession. During this 42-year time span, the areal extent of surface water decreased substantially. Sedimentation, responsible for the decrease in surface water, gave rise to extensive stands of willow trees. Natural levees increased in size as flats and strips were filled in by increased siltation which resulted in an increase in the extent of mixed hardwood forest types. Additionally, the sedimentation within swamp areas decreased the areal extent of the cypress and tupelo forest associations.

Parker, J.

1950

The effects of flooding on the transpiration and survival of some southeastern forest tree species

Plant Physiology 25:453-460

A study of the effects of flooding the soil in which a number of forest tree seedlings were growing showed a considerable amount of similarity in reduction of transpiration rate. There were, however, certain differences exhibited between species which ordinarily grew in widely different sites. Cypress seedlings showed an outstandingly high level of transpiration rate after flooding, although there was evidence that the roots did not grow as well in the more poorly aerated levels of the container as in the better aerated levels. Overcup oak showed a decline similar to the other oaks in the first few days of flooding, but unlike the other oaks, produced a second crop of leaves. Red cedar, red oak, loblolly pine, white oak, and swamp chestnut oak all showed a similar response to the flooding treatment.

Parsons, S.; Ware, S.

1978

Vegetation and edaphic factors in small stream swamps of the Virginia Coastal Plain

Paper presented at the 56th Annual Mtg. of the Va. Acad. of Sci., May 9-12, 1978, Blacksburg

Vegetational composition, soil texture, soil mineral content, soil pH, soil moisture content, and flooding levels were studied in 14 small stream bottoms in the central Coastal Plain of Virginia. High summer soil moisture levels, high Ca, high Mg, high N, and high pH were all found in stands dominated by Fraxinus pennsylvanica, Acer rubrum, and Ulmus americana. In stands of this type, which were frequently flooded, Taxodium distichum became an important associate. Stands with some dry periods in the summer were more variable in composition, but often had Carpinus caroliniana and Liquidambar as important species. Some stands of this more acid, low Ca, summer dry type had heavy flooding during the wetter parts of the year, and in these Quercus phellos was important. Duration of flooding and soil moisture between floods were far more important in controlling vegetation than frequency of flooding or depth of flooding.

Paul, B.H.

1966

Specific gravity variations in hardwoods of flooded delta areas

Sou. Lumberman 212(2634):14, 16-17

Trees subject to deep flooding were found to produce lighter-than-normal wood at their bases. This was especially true where buttressing occurred. Buttresses of water tupelo were found to have wood density only a little more than half that in the upper portions of the same trees. Flooded green ash also produced unusually light wood at the base. This is in contrast with the behavior of upland trees, which normally have the heaviest wood at the stump with a decreasing trend upward as far as the lower limits of their crowns. Flooded oaks show only a slight tendency to produce low-density wood near the ground level, or none at all.

The wood from water tupelo buttresses is often used as floats for fish-nets; it can be used for paper pulp but on a cord basis the yield is low. If forests are to be perpetuated on perennially flooded areas, some sacrifice in wood density may be necessary.

Penfound, W.T.

1952

Southern swamps and marshes

Bot. Rev. 18:413-446

Swamps are defined as woody communities and marshes as grass-sedge-rush communities occurring in areas with surface water for one or more months of the growing season. Fresh-water swamps are divided into deep-water swamps (two types), shallow swamps (six kinds), and peaty swamps (four types, including the bays, pine pocosins, cedar bogs and evergreen shrub bogs of other investigators). The salt water swamps include only two types, although two zonal (transitional) communities are described. The fresh-water marshes are divided into deep marshes (three types) and shallow marshes (variously called wet meadows, wet prairies, grass-sedge-bogs, pine barrens or savannahs by other workers). The salt marshes comprise only three marsh types, although two transitional communities are described. Also included are descriptions of succession.

Pereira, J.S.; Kozlowski, T.T.

1977

Variations among woody angiosperms in response to flooding

Physiologia Plantarum 41:184-192

Effects of flooding on young *Populus deltoides*, *Salix nigra*, *Eucalyptus camaldulensis*, *E. globulus*, *Ulmus americana*, *Quercus rubra* and *Fraxinus pennsylvanica* plants were studied. Flooding variously induced several sequential physiological disturbances, with stomatal closure among the earliest responses. Subsequent responses included inhibition of root growth, alterations in root and stem morphology, formation of adventitious roots and leaf senescence. In amphistomatous species (*P. deltoides*, *S. nigra*, *E. camaldulensis*) flooding rapidly induced stomatal closure on the abaxial epidermis of *P. deltoides*, but not that of *S. nigra* or *E. camaldulensis*. In hypostomatous species (*E. globulus*, *U. americana*) flooding significantly induced stomatal closure on the abaxial surface within 3 days. Stomatal responses to flooding were not correlated with leaf water stress. In both long- and short-term experiments, flooding did not significantly increase plant water stress. These results deemphasized the importance of plant water stress in inducing plant responses to flooding. The importance of various hormones in inducing flooding symtoms is discussed.

Perry, T.O.

1962

Racial variation in the day and night temperature requirements of red maple and loblolly pine

For. Sci. 8:336-344

Plants from different geographic locales in the range of red maple were subjected to a number of day and night temperature treatments while the remainder of the environment was kept as uniform as possible. The night and day temperature required for optimum growth was different for each of the provenances of red maple and corresponded well with the day and night temperatures that normally prevail where the collections were made. The day temperatures required for optimum growth were higher than the night temperatures.

A parallel series of experiments with two provenances of loblolly pine revealed geographic variation in the day temperatures required for optimum growth. However, the loblolly pine provenances gave parallel and anomalous responses to the different night temperature treatments.

Pham, C.H.; Halverson, H.G.; Heisler, G.M.

1978

Red maple (Acer rubrum) growth and foliar nutrient responses to soil fertility level and water regime

USDA For. Ser. Res. Paper NE-412

Red maple seedlings were grown in a greenhouse using three treatments: two soil horizons, two soil moisture regimes, and three nutrient levels. Fertilization increased growth under moist conditions on the more fertile topsoil. Under dry conditions, fertilization had no effect on growth in subsoil, and slightly increased growth in topsoil. Without fertilization, growth was greater in the moist topsoil. Growth was most balanced when available soil N was 25 ppm, P was 25 to 75 ppm, and K was 75 to 100 ppm. Multiple regression equations relating growth to foliar nutrients were significantly different only for the subsoil.

211x

Phares, R.E.

1965

Growth and nutrition of hardwood seedlings on some Central States forest and old-field soils

Proc. Soc. Amer. For. 1964:46-47

Hardwood seedlings grown from seeds in pots of Lindley, Shelby, and Clarksville surface soils grew much better on forest than on non-forest soils, mainly because of differences in soil fertility and microbiology. Fertilizer treatments showed that all the soils were deficient in phosphorus and nitrogen for growth of red oak seedlings. Potassium was not limiting on any of the soils.

Phillips, J.J.; Markley, M.L.

1963

Site index of New Jersey sweetgum stands related to soil and water-table characteristics

USFS Res. Paper NE-6. 25 pp.

The authors developed a prediction equation based on percent of clay in the B_2 horizon, percent of fine sand in that horizon, difference in silt-plus-clay contents between the B_2 and A horizons, and the thickness of the B_2 horizon.

Phillips, J.J.

1966

Site index of Delaware-Maryland sweetgum stands in relation to soil characteristics

USFS Res. Note NE-48. 5 pp.

In 1963, Phillips and Markley published USFS Res. Note NE-6 describing the relationship between site index of New Jersey sweetgum stands and soil and water-table characteristics. The study was subsequently extended to Delaware and Maryland, where 25 suitable areas were located and plots installed.

It was found that alluvial soils were often very good sites for sweetgum, with site index generally between 85 and 95. Mature residual soils were moderate to good sites. Muck soils were normally low in productivity. But where drainage has been improved, sweetgum may have a relatively high site index — 85 on one study plot.

Phipps, R.L.; Ierley, D.L.

1978

Tree-ring response of loblolly pine to hydrologic change and climate

Paper presented at the 56th Annual Mtg. of the Va. Acad. of Sci., May 9-12, 1978, Blacksburg

Ring widths of loblolly pines (Pinus taeda) growing near a drainage ditch in the Great Dismal Swamp were analyzed and compared with climatic factors for periods prior to and following ditch construction. Results from regression analysis indicated that prior to ditching, growth was most limited by dry summers which followed dry summers. Relative to growth responses prior to ditching, growth after ditch construction was less strongly linked with precipitation and more strongly linked with temperatures. Climatic and prior growth factors in regression explained 87% of the variance of earlywood widths and 82% of the variance of latewood widths for the period prior to ditching. It was concluded that a change in hydrologic conditions following ditch construction resulted in rainfall and temperature having limited growth to different degrees.

Pierce, R.S.

1953

Oxidation-reduction potential and specific conductance of ground water; their influence on natural forest distribution

Proc. Soil Sci. Soc. Am. 17:61-65

Electrometric analyses of ground water were performed *in situ* by a portable equipment including a potentiometer, Wheatstone bridge, platinum and glass electrodes, calomel half-cell, and conductance cell. Results showed a close correlation between the natural distribution and growth rate of forest stands in lowland and peat soils and the properties of ground water, particularly its degree of stagnation and content of electrolytes estimated by the oxidation-reduction potential and specific conductance. Deficiency of dissolved O_2 and low values of the redox potential were unfavorable to the natural reproduction of most upland trees, but not of swamp species on organic soils. There was a successional trend from *Hypnum* to *Sphagnum* peat swamps on hydromorphic soils.

Pierce, R.S.

1957

Ground water; its nature, properties, and effects on forest growth

Diss. Abst. 17(10):2111

The investigation covered several broad geographic regions, including northern Ontario, Wisconsin, the Delta of the Mississippi River, and the Gulf Coast in northern Florida. For the general appraisal of the influence of hydrologic features on forest growth, the soils were classified as follows: (1) supraphreatic or upland soils not influenced by ground water; (2) phreatic soils underlain by a true ground water table; (3) vadose soils influenced by a perched or false ground water table; (4) periodically flooded soils of depressions and tablelands; (5) seepage soils of dip slopes influenced by the discharge of subterranean water; (6) alluvial soils subject to periodic inundation; (7) swamp soils permanently saturated with ground water. In every region studied these hydrologic soil groups exhibited pronounced differences in their floristic cover, rate of forest growth, quality of forest products, and capacity for natural regeneration.

Pirone, P.D.

1972

Tree maintenance

Oxford Univ. Press, New York

The author classifies the susceptibility of species to poor soil aeration as follows:

Most Severely Injured	Less Severely Injured	Least Injured
Quercus	Betula	Populus
Pinus	Carya	Salix
Liriodendron tulipifera		Platanus
		Quercus palustris

Ponnamperuma, F.N.; Martinez, E.; Loy, T.

1966

Influence of redox potential and partial pressure of carbon dioxide on pH values and the suspension efforts of flooded soils

Soil Sci. 101:421-431

Thirty-five air-dried, lowland rice soils were kept submerged for 16 weeks in pots in the greenhouse. Soil pH was determined weekly in a 1:1 slurry, in de-aerated water, of a small plug of soil taken from the bottom of the pot. Soil-solution pH and Eh were determined weekly in the solution drawn by gravity, with minimum of gas exchange, into an electrometric cell. The partial pressure of CO_2 in the soil solution was calculated from pH and HCO_3 activity. pH values of alkali and calcareous soils decreased while those of acid soils increased to a fairly stable value of 6.7-7.2 12 weeks after flooding.

Post, B.W.

1963

Effects of light, soil moisture, and mineral nutrient treatments on the growth of seedlings of certain deciduous tree species

Diss. Abstr. 24(1):13

Seedlings of sweetgum, northern red oak, and yellow-poplar were grown in sandy loam soil in pots with high and low levels of light, water, and mineral nutrients. The largest increases in height and dry weight of sweetgum and northern red oak seedlings were obtained with high soil moisture and high nutrients in full sun. Yellow-poplar made best growth when supplied with a high level of soil moisture and mineral nutrients and shaded. Within the range of conditions encountered in these experiments, soil moisture had the greatest effect on growth.

Preston, R.J., Jr.

1961

North American Trees

2nd ed., Ames, Iowa. 395 pp.

This manual covers the trees of North America with the exception of Mexico and the tropical species found in the southern fringe of the United States. Care has been taken to include all tree species native to this area (except for the 162 species of hawthorn and 20 usually shrubby willows), as well as naturalized or commonly planted exotic species. In all, 135 genera containing 568 species are treated. Drawings showing descriptive characters, distribution maps, and concise descriptions of botanical and silvical characters have been included for 232 species of trees which are either of importance or general interest, while an additional 336 less important species are either briefly described or included in the complete keys. Terminology has been kept as simple as possible without sacrificing scientific accuracy. A comprehensive glossary defines necessary technical terms. Nomenclature follows the International Rules.

Putnam, J.A.

1951

Management of bottomland hardwoods

SFES Occas. Paper 116. 60 pp.

Following a general discussion of sites, types, stand classes, timber and logging conditions, the bulletin takes up the essentials of early management and stabilized management. An appendix table lists silvicultural characteristics of 53 important bottomland species. (This bulletin is superseded by Putnam, Furnival, and McKnight, Management and Inventory of Southern Hardwoods, 1960.)

Ralston, J.

1955

The relative productivity of loblolly pine and sweetgum on forest sites in the lower Piedmont of North Carolina

MF thesis, N.C. State College. 40 pp.

Data collected on thirty one-fifth acre plots in the lower Piedmont region of North Carolina showed that loblolly pine volumes are 187% greater than sweetgum volumes for all positions (ridge, upper slope, lower slope, bottom). Site index for sweetgum was found to be higher than that of loblolly pine on bottoms.

Rand, P.J.

1972

A survey of the phreatophytic trees of the Republican River Valley, Nebraska

Water Resources Rsch. Inst., Lincoln, Neb. Completion Rpt. (Contract No. DI-14-31-001-3227) 77 pp.

The woody phreatophyte communities of the Republican River Valley were studied by means of 33 transects located at 4-8 mile intervals along the 205 miles of its course in Nebraska. Two principal types of communities are present and are located, respectively, on the west and east halves of the valley: (a) those in which cottonwood and peachleaf willow are the sole dominants and (b) those in which cottonwood and peachleaf willow have high importance values but in which there is a well-developed understory of mixed hardwood species. Thirteen species of trees were found in the transects and three others were seen in stands along the river.

Randall, W.K.; Mohn, C.A.

1969

Clone-site interaction of eastern cottonwood

Proc. 10th Southern Forest Tree Improvement Conf., pp. 89-91

Site quality for cottonwood in the lower Mississippi valley varies from excellent on loamy soils to poor on heavy clay soils. Tree breeders have found important clone-site interactions.

In the present study, 79 cottonwood clones were planted on two sites near Greenville, Mississippi. Thirty-nine clones were selected from preliminary clonal tests, and 40 were selected randomly. All clones came from the natural population along the Mississippi River near Greenville.

One plantation was established on Commerce silt loam, one of the best cottonwood soils in the Mississippi valley. The site index is 122 feet at age 30. The other plantation was established on Sharkey clay, which is considered poor for cottonwood; it has a site index of 91 feet. Both sites were planted in February, 1965. Measurements of height and diameter were made during the first four growing seasons.

Height and diameter differed significantly among clones, among replications, and between sites for all ages. Absolute differences were greater between sites than between clones. Mean diameter of all trees at age four was 5.7 inches for the plantation on Commerce silt loam and 2.8 inches for the plantation on Sharkey clay. The select clones had slightly larger diameters than the random clones.

The authors concluded that diameter-growth responses are probably more important than those in height in a selection program because small changes in diameter greatly influence volume.

Reddy, K.R.; Patrick, W.H.

1975

Effect of alternate aerobic and anaerobic conditions on redox potential, organic matter decomposition and nitrogen loss in a flooded soil

Soil Biol. and Biochem. 7:87-94

The effect of several cycles of varying length of alternate aerobic and anaerobic conditions on redox potential, organic matter decomposition and loss of added and native nitrogen was investigated under laboratory conditions in flooded soil incubated for 128 days. Redox potential decreased rapidly when air was replaced with argon for the short-time cycles, but decreased more slowly where the aerobic period was long enough to permit build-up of nitrate. The minimum redox potential reached during the anaerobic period was generally lower for the longer cycles, but in all cases was low enough for denitrification to occur. Rate of decomposition of organic matter was faster in the treatments with a greater number of alternate aerobic and anaerobic periods. The greater loss of N resulting from the 2 and 2 day aerobic-anaerobic incubation shows that, in soils where the redox potential falls low enough for denitrification to occur, increasing the frequency of changing from aerobic to anaerobic conditions will increase the loss of N.

Regehr, D.I.; Bazzaz, F.A.; Boggess, W.R.

1975

Photosynthesis, transpiration and leaf conductance of Populus deltoides in relation to flooding and drought

Photosynthetica 9(1):52-61

Single intact leaves of P. deltoides reached saturating irradiance at 1500 μeinstein $m^{-2}s^{-1}$ (61 klx). At 30°C the photosynthetic rate was 26 mg CO_2 $dm^{-2}h^{-1}$. Photosynthesis increased with increasing CO_2 concentration, reaching an asymptote at 1000 volumes per million. Complete inundation of the root system for 28 days reduced photosynthesis by 50%. Recovery occurred within 1 week after the end of flooding. The species is very sensitive to drought, with photosynthesis falling from maximum between -3 and -8 bar leaf water potential to near zero at -11 bar. Trends in transpiration rate and leaf conductance were similar to those of photosynthetic rate.

227x

Reicosky, D.C.; Ritchie, J.T.

1976

Relative importance of soil resistance and plant resistance in root water absorption

Proc. Soil Sci. Soc. Am. 40:293-297

No abstract available.

Rice, E.L.

1965

Bottomland forests of north-central Oklahoma

Ecology 46:708-714

The vegetation and selected edaphic factors of 47 stands of floodplain forest communities were examined in 10 north-central Oklahoma counties. Soil factors analyzed were pH; total nitrogen; total phosphorus; organic carbon; and percentage of sand, silt, and clay at the 0- to 6-inch and 18- to 24-inch levels. Normal precipitation in the study area varied from 28.0 to 37.5 inches. Ten types of communities were present, with *Ulmus americana* a dominant in six types and a dominant in 38 of the 47 stands sampled. *Celtis occidentalis* was dominant in only six stands. Other species which were dominant in at least one stand were *Sapindus drummondii*, *Carya illinoensis*, *Fraxinus pennsylvanica*, *Celtis laevigata*, and *Juglans nigra*. *Ulmus americana* occurred as a dominant throughout the entire area, whereas *Sapindus drummondii* occurred as a dominant in only the more xeric western counties and all other species occurred as dominants only in the central or eastern counties. The number of tree species increased markedly (11 to 23) and density increased slightly from west to east. No such trend was noted in basal area. The pH of the soil varied from above 8.0 in the west to 6.8 in the east. No consistent trends from west to east were evident in other soil factors analyzed. The best overall correlation appeared to occur between basal area and a combination of total nitrogen at the 18- to 24-inch level and normal precipitation. There were no apparent correlations between the type of plant community or the distribution of individual species and the soil factors analyzed.

Roberts, B.R.

1963

Effect of water stress on the translocation of photosynthetically assimilated carbon-14 in yellow-poplar

Diss. Abstr. 24( ):918

Three-year-old seedlings of yellow-poplar were subjected to various degrees of water stress and $C^{14}O_2$ was then supplied to a single leaf for one hour under artificial illumination. As expected, the relative quantity of radiocarbon in each seedling decreased with increased water stress. This condition was reflected by a decrease in the amount of $C^{14}O_2$ absorbed per unit of leaf area as well as by a reduction in the percentage of C^{14} translocated out of the exposed leaf. The most drastic change in radioactivity occurred between water deficits of 5-20%.

Roberts, S.W.; Knoerr, K.R.

1977

Components of water potential estimated from xylem pressure measurements in five species

Oecologia 28:191-202

Pressure volume curves were measured with a pressure bomb in leaves collected in the field from Ilex opaca, Acer rubrum, Liquidambar styraciflua, Liriodendron tulipifera, and Cornus florida. Water potential components were calculated from the curves. The species differed in the relationships measured. In all species the trends from summer to fall were toward lower (more negative) osmotic potentials, lower matric potentials, more rapid loss of turgor with increasing leaf water deficit, and the occurrence of incipient plasmolysis at lower values of leaf water deficit. Initial osmotic potentials ranged from -14.8 to -19.8 bars, similar to values reported in the literature for other mesophytic plants. These values, however, were much higher than those reported for halophytes and xerophytes. The fraction of leaf water which contributes to the osmotic potential ranged from 0.74 to 0.98 in this study. Values reported for other mesophytes and for halophytes and xerophytes all fall well within this range. Patterns of component water potentials are discussed in relation to potential growth rates and water flow in the total plant system.

Robertson, P.A.

1978

Comparisons of techniques for ordinating and classifying old-growth floodplain forests in southern Illinois

Vegetation 37:43-51

Comparisons are made among the responses of several ordination and classification techniques using a set of 136 plot samples from a diverse old-growth bottomland forest in southern Illinois. Of the ordination techniques evaluated (PO, PCA, GO and RA), RA provided the most interpretable ordering of species and samples. The RA plot ordination was divided into three segments which correspond to major vegetation units within the study area itself and more broadly within the Southern Floodplain Forest Region. Among the classification techniques used (MINFO, MDISP and CLUSTER), MINFO produced plot clusters and species groupings which are similar to those identified by RA. Discriminant analysis was used to interpret the plant groups using various environmental variables as predictors. This approach successfully provided an environmental interpretation of the group structure as identified by this and other classification techniques. The vegetation patterns in the old-growth woods at Horseshoe Lake appear to be influenced by a complex flooding-aeration gradient.

Robertson, P.A.; Weaver, G.T.; Cavanaugh, J.A.

1978

Species patterns near the northern terminus of the southern floodplain forest

Ecol. Monogr. 48:249-267

The bottomland forest on Horseshoe Lake Island, located on the Mississippi alluvial plain in Alexander County, Illinois, is comprised of 2 stands, one relatively undisturbed and the other which is recovering from disturbance in the late 1800s or early 1900s. In both stands vegetational structure, gradient relationships, diversity and size-class characteristics were studied. In the old-growth stand, 35 soil-site variables were measured or estimated for interpretation of vegetational patterns and species distributions. Both direct and indirect gradient analyses were evaluated for use in floodplain forest studies and ultimately the indirect approach with multiple regression interpretation was used to construct a gradient model of the vegetation. The important species on the ridge bottoms are Acer saccharum, Asimina triloba, Liquidambar styraciflua, Ulmus rubra, Quercus rubra and Tilia americana and are associated with well-drained soils and infrequent flooding. The transitional segment is dominated by Asimina triloba, Liquidambar styraciflua, Quercus michauxii, Quercus muhlenbergii and Ulmus americana with Quercus pagodaefolia and Quercus shumardii as associates on moderately heavy and poorly drained soils with intermediate flooding. The hardwood bottom sites are dominated by Acer rubrum, Fraxinus pennsylvanica, Liquidambar styraciflua and Ulmus americana and may be flooded for several months each year and have heavy textured, poorly drained soils. Multiple regression analysis with ridge regression revealed that Fraxinus americana and Acer saccharum have wider tolerance to flooding and poor aeration than previously reported. Importance Values of several species were related to duration and depth of flooding, soil mottling and soil texture indicating that distributions are affected by a site-inundation, soil drainage-aeration complex.

Schlesinger, W.H.

1978

Community structure, dynamics and nutrient cycling in the Okefenokee Swamp-Forest

Ecol. Monogr. 48:43-65

Aspects of community structure and nutrient circulation are described for the cypress (Taxodium distichum) forest in Okefenokee Swamp, Georgia. This bog environment is characterized by low nutrient availability and large peat accumulations.

The tree stratum of the forest is dominated by cypress, which is probably due to recurrent understory fires which eliminate other swamp species. In stands throughout the cypress forest, the density and total basal area of living stems > 4 cm diameter vary greatly, but mean values (1.465 stems/ha; 52 m^2/ha) are high compared to upland forests. Natural thinning appears to be unimportant. Abundant standing dead trees suggest that differences in density among stands are due to past differences in the frequency and intensity of forest fires during periodic droughts.

Schmelz, D.

1967

Kramer Woods: an old-growth stand on the Ohio River terrace

Proc. Ind. Acad. Sci. 77:184

The 212 acre stand is located in Spencer County, Indiana. In a full tally of 21 acres, 34 species with dbh over 4 inches were recorded; 2 more species with dbh over 2 inches were represented. Quercus shumardii contributed 17% of stand density and 30% of stand basal area. Density and basal area factors combined, Q. shumardii had an importance value of 23.5%, Carya ovata-laciniosa 13.5%, Quercus palustris 9.4%, Liquidambar styraciflua 8.4%, Ulmus americana 7.5%, Quercus bicolor 6.3%, and Fraxinus pennsylvanica 4.7%. The largest stems were those of the three Quercus species mentioned, one Q. shumardii measuring 51.5 inches dbh. Reproduction was predominantly C. ovata-laciniosa, F. pennsylvanica, and U. americana. The stand differed markedly from other Indiana bottomland stands in species composition, in higher average stem diameter, and in lower stand density; it was similar in stand basal area and in size-class distribution.

Schomaker, C.E.

1958

Two-year results of planting yellow-poplar in north Alabama

Jour. of For. 56:37-38

Preliminary indications are that yellow-poplar planting in north Alabama should be confined to the bottoms, lower two-thirds of the north aspects, and the lower one-third of the south aspects of upland draws. On moister but well-drained areas, planting may be safely done at higher levels on the slope. On drier sites, planting should be restricted to the bottoms and lower slopes of the north aspects, while south aspects should be avoided entirely.

236x

Schultz, R.P.

1968

Soil or foliar fertilization of well-drained and flooded slash pine seedlings

USFS Res. Paper SE-32. 8 pp.

One-year-old slash pine seedlings were grown for nine months under two soil-moisture and four N + P fertilization treatments. Flooding increased seedling mortality and decreased growth. Foliar fertilized seedlings did not grow better than unfertilized seedlings either under well-drained or flooded conditions. Under well-drained conditions, seedlings receiving soil fertilization or foliar plus soil fertilization had more than double the dry-weight increment and one-quarter more height growth than unfertilized seedlings. Under flooded conditions, soil fertilization or foliar plus soil fertilization did not increase height growth but increased dry-weight increment by 40 to 50% over unfertilized seedlings.

Schwintzer, C.R.; Williams, G.

1974

Vegetation changes in a small Michigan bog from 1917 to 1972

Am. Mid. Nat. 92:447-459

Quantitative descriptions of the vegetation and maps of the pool of Bryant's Bog are available for several years since 1917 providing an opportunity for direct observations of bog succession. The vegetation advanced into the bog pool in an irregular manner at an average rate of 2.1 cm/year. In 1972 the pool was 76% of its extent in 1926. The vegetation changed in a successional series from the chamaedaphne association of 1917 to the high bog-shrub association in the dry years of the 1920s to a bog forest which was well-established in the late 1960s. It regressed in the early 1970s when many of the trees died and the chamaedaphne association appeared to be re-establishing itself. The most probable cause of tree mortality was flooding caused by exceptionally high water levels due to natural weather cycles. Tree mortality was also found in Hoop Lake Bog—which, like Bryant's Bog, lacks aboveground drainage—while none occurred in bogs with aboveground drainage.

23Sx

Scott, A.D.; Evans, D.D.

1955

Dissolved oxygen in saturated soil

Proc. Soil Sci. Soc. Amer. 19:7-12

The polarographic method of measuring dissolved oxygen in saturated soil was used in the laboratory to determine what happens to dissolved oxygen in saturated soils with no plant growth. Air-dry soils in a glass cylinder were flooded with air-saturated distilled water and the dissolved oxygen content was recorded. It began to decrease immediately after the soil was flooded and had disappeared within 10 hours. More oxygen was added to the same saturated soils by flushing them with oxygen-laden solutions. This added oxygen disappeared even more rapidly. Oxidation-reduction potentials were measured in situ with platinum electrodes to determine the relationship of these potentials to the dissolved oxygen present. The potentials measured were not a reliable index of the dissolved oxygen present. The systems used are not entirely analogous to those in the field, but results give preliminary information about changes in dissolved oxygen in saturated soils. Redox-potential measurements show that reduced conditions that develop in a soil in the absence of oxygen are not readily removed by the addition of oxygen. There was a rapid increase in redox-potential when dissolved oxygen was first added to reduced soil, but later the soil was re-oxidized very slowly. It is possible that the effects of waterlogging on plant growth may persist for some time after the soil is drained, and even temporary flooding may be injurious to plant growth.

Sharitz, R.R.; Gibbons, J.W.; Gause, S.C.

1973

Impact of production-reactor effluents on vegetation in a southeastern swamp forest

In Thermal Ecol. Conf.-730505, proc. of a symp. held May 3-5, 1973, Augusta

The discharge of heated reactor effluents into streams entering the Savannah River plant swamp has resulted in tree mortality throughout two-thirds of the swamp. In the deltas of the tributary streams, water temperatures may be as high as 25°C above normal. The release of reactor effluents not only elevated the water temperatures in portions of the swamp but also raised the water level throughout much of the swamp. Portions of the stream deltas in which both extensive flooding and silt deposition occur comprise more than half the area of total tree kill. The studies include determination of the flooding and thermal tolerance levels of the various species, of the effects upon species composition and diversity, and of the alteration of the competitive interaction among the species.

240x

Shima, L.J.; Anderson, R.R.; Carter, V.P.

1976

The use of aerial color infrared photography in mapping the vegetation of a freshwater marsh

Chesapeake Sci. 17(2):74-85

Spring and fall vegetation maps were prepared from a freshwater marsh on the Patuxent River, Maryland. Low altitude, color infrared (IR) aerial photos were correlated with data obtained from field surveys. The vegetation units mapped refer to areas of homogenous color on the photos. These areas of homogenous color represent species associations or monospecific stands which produce a distinctive tonal signature. Color fluctuations within an area having a distinctive tonal signature are primarily caused by a quantitative variation of plant species but are also related to the growth habit, vigor of the plant species, and environmental conditions which affect the vegetation and in turn the color of the recorded image. Changes in the color over the growing season reflect plant successions.

Sigafoos, R.S.

1961

Vegetation in relation to flood frequency near Washington, D.C.

U.S. Geol. Surv. Prof. Paper 424-C. Short papers in the geological and hydrological sciences. Art. 238

Vegetation along the Potomac River, near Washington, D.C., is being studied to determine the relationship between the form and distribution of plants and the magnitude and frequency of floods.

The study area, upon which this report is based, is a small section of the flood plain of the Potomac River at Little Falls, a few hundred yards upstream from the Washington, D.C.-Maryland boundary, between the Chesapeake and Ohio canal and the left bank of the low water channel. The flooded area is for the most part a bedrock surface, which near the canal is covered with alluvium of undetermined thickness. The forest is composed of typical flood plain species. Twenty-four wood species were identified in the plots.

The three types of vegetation that occur on the flood plain of the Potomac River in the study area are thus flooded at different frequencies, and the vegetation at lower elevations is flooded at greater depths. The form and species composition of these types are related to the magnitude and frequency of flooding.

Silker, T.H.

1948

Planting of water-tolerant trees along margins of fluctuating level reservoirs

Iowa St. Coll. Jour. Sci. 22:431-437

A thorough sampling was made of 1,100 acres of water-tolerant tree plantations, 5-12 years old, along the margins of fluctuating reservoirs on the lower Tennessee river. Data on survival, height, and adaptation of trees of changing water-tables and to soil and ground-cover conditions were obtained for Taxodium distichum, Quercus nigra, Q. phellos, Fraxinus pennsylvanica var. lanceolata, Liquidambar sytraciflua, Nyssa aquatica, Chamaecyparis thyoides, and Platanus occidentalis. Results are presented for two kinds of reservoir-margin sites:

(1) Reservoir surcharge zone plantations, 1-15 ft. above normal pool level and infrequently flooded during the dormant season, have been more affected by inherent soil moisture than by water surcharge levels. Surcharge water covering some areas 2-7 ft. deep throughout the dormant season has caused no apparent damage, e.g., T. distichum, N. aquatica, and L. styraciflua plantations flooded by 2-4 ft. of 'trapped water' throughout June of the third growing season. These plantations averaged 11-90% survival and 3.5-14.3 ft. total height growth after five growing seasons.

(2) Growth of 9-to-12-year-old plantations of T. distichum, N. aquatica, and C. thyoides in the upper drawdown zone intermittently covered by 1-3 ft. of water is as good as, or better than, that of upland plantations of fast-growing conifers or hardwoods. Sites made unfit for agricultural use because of water-level fluctuation offer considerable promise for timber production. Results show that: N. aquatica should be planted on seepage areas or sites intermittently flooded during the growing season; T. distichum and C. thyoides are adapted to the same sites as N. aquatica, but can be planted at higher elevations on all but the drier and poorer terrace soils; F. pennsylvanica var. lanceolata is adapted to all sites except those subject to prolonged flooding during the growing season; Q. nigra and Q. phellos have not been subjected to intermittent flooding during the growing season, but offer promise for wildfowl cover, and food on all but the drier and poorer terrace soils; L. styraciflua and P. occidentalis are the better species for planting on the better soils in the upper part of surcharge zones.

Sipp, S.K.; Bell, D.T.

1974

The response of net photosynthesis to flood conditions in seedlings of <u>Acer saccharinum</u> (silver maple)

For. Res. Rep. 74-9 (1974), Dept. of For., Univ. of Illinois. 2 pp.

This study describes laboratory experiments which study the effect of simulated flood conditions on photosynthesis. Net CO_2 assimilation rates after 10 days were reduced to 75% of the normal rate in seedlings on continuously saturated soil, and to 25% in seedlings completely inundated. The growth reductions caused by reduced photosynthesis under flood conditions are discussed.

Solomon, C.E.

1977

Bottomland forest ecology

Proc. Forest Management-Water Quality Sem., Feb. 16-17, 1977, Univ. of Missouri, Columbia

No abstract available.

Southeastern Forest Experiment Station

1957

Effect of flooding on survival and growth of yellow-poplar seedlings

Ann. Rpt. 1957:8

Tanks with about 20 yellow-poplar seedlings per tank were flooded in January and May, and the seedlings completely covered with water for periods of 1, 2, 3, 4, 7, and 14 days. The dormant-season flooding had no effect on survival and growth. In the May series, the survivals were 100, 100, 90, 50, 30, and five percent.

Steinbeck, K; McAlpine, R.G.

1966

Inter- and intra-specific differences in the root respiration rates of four hardwood species

For. Sci. 12:473-476

In this investigation of the causes of the differences in tolerance to flooding, four species were chosen for study: yellow-poplar, which is intolerant to flooding; red maple, which grows on flood plains as well as on slopes; weeping willow and black willow, which grow chiefly on flood plains. Sprouts of the first two species were rooted and then transplanted to clay pots filled with sand and decomposed sawdust; current branches of the two willows were rooted directly in the clay pots.

All comparisons of root respiration rates of two species showed significant differences, with the exception of that between red maple and weeping willow. Yellow-poplar, intolerant to flooding, had the lowest root respiration rate, red maple was intermediate, and the willows had the highest rates.

Steward, E.H.; Powell, D.P.; Hammond, L.C.

1963

Moisture characteristics of some representative soils in Florida

USDA Agri. Res. Serv. Publ. ARS 41-63. 53 pp.

No abstract available.

Straka, W.F.; Tramer, E.J.

1976

Effects of subsurface drainage on tree growth and forest succession

Proc. Central Hardwood Forest Conf., 1st, 1976, pp. 203-219

In 1969, subsurface drains were installed in one-half of an oak forest to permit development of an industrial park. Subsequent abandonment of the project permitted comparisons of growth rates of dominant trees and shrubs on drained and undrained plots, correlation of those growth rates with soil moisture fluctuations, and some insights to the possible long-term effects of drainage on forest succession.

Where differences in growth were statistically significant, species on the drained site grew less. Drainage did not affect leaf production, but did cause early loss of foliage. Generally, it appears that the typical response to moisture stress is an increase in terminal stem growth at the expense of lateral stem growth. The present structure of the forest will remain the same, although white oak's relative abundance in the canopy may decline and the shrub, blueberry, may eventually be replaced as a result of its poor growth.

Teskey, R.O.; Hinckley, T.M.

1977

Impact of water level changes on woody riparian and wetland communities. Vol. I: Plant and Soil Responses to Flooding

Fish and Wildlife Ser., Ofc. of Biol. Ser. Rpt. 77/58

A comprehensive literature review of general plant physiological responses to managed or natural changes in water levels (i.e., submersion, flooding, soil saturation) and on plant tolerance mechanisms involved in water level changes is presented. The major effect of flooding is the creation of an anaerobic environment surrounding the root system and the maintenance of proper root functioning is the factor which determines tolerance to flooding. Physical tolerance mechanisms involve processes designed to increase oxygen content in the roots either by transport of oxygen from the stem or from parts of the root system where oxygen is more available. Metabolic mechanisms enable the plant to utilize less toxic end-products. Tolerant species are able to maintain root systems with a minimum of stress by incorporating a variety of tolerance mechanisms. Soil factors may ameliorate or accentuate the problem caused by flooding on physiological changes. Soils which are flooded show a decrease in oxygen concentration which leads to changes in soil chemistry (pH and redox potential) and nutrient availability. Five water level factors—time of year, flood frequency, duration, water depth, and siltation—are considered critical in determining a plant's physiological responses.

Teskey, R.O.; Hinckley, T.M.

1977

Impact of water level changes on woody riparian and wetland communities. Vol. II: The Southern Forest Region

Fish and Wildlife Ser., Ofc. of Biol. Ser. Rpt. 77/59

A description and documentation of the natural plant ecoregions (communities) occurring in the Southern Forest Region as affected by flood inundation are presented. The four ecoregions described are: southern mixed forest, southern floodplain forest, beech-sweetgum-magnolia-pine-oak forest, and bluestem prairie. Within each ecoregion, site characteristics for dominant species are followed by lists of the associated species arranged in order of increasing site-soil moisture. In addition, the climate, soils, general physiography and bottomland successional patterns for each ecoregion is developed. A table summarizes information from existing literature regarding mature tree and seedling survival in 66 species under three water conditions: total submersion, partial submersion, and soil saturated. The information is also divided into flood periods during the growing season, the dormant season, and year-round. Associated with this table is a ranking of relative tolerance to flooding of these species.

Teskey, R.O.; Hinckley, T.M.

1977

Impact of water level changes on woody riparian and wetland communities. Vol. III: The Central Forest Region

Fish and Wildlife Ser., Ofc. of Biol. Ser. Rpt. 77/60

A description and documentation of the natural plant ecoregions (communities) occurring in the Central Forest Region as affected by flood inundation is presented. The three ecoregions described are: oak-hickory forest, oak-hickory bluestem parkland, and oak-bluestem parkland. Within each ecoregion, site characteristics for dominant species are followed by lists of the associated species arranged in order of increasing site-soil moisture. In addition, the climate, soils, general physiography and bottomland succession pattern for each ecoregion is developed. A table summarizes information from existing literature regarding mature tree and seedling survival in 53 species under three water conditions: total submersion, partial submersion, and soil saturated. The information is also divided into flood periods during the growing season, the dormant season, and year-round. Associated with this table is a ranking of relative tolerance to flooding of these species.

Teskey, R.O.; Hinckley, T.M.

1978

Impact of water level changes on woody riparian and wetland communities. Vol. IV: The Eastern Deciduous Forest Region

Fish and Wildlife Ser., Ofc. of Biol. Ser. Rpt. 78/87

The purpose of this review is to consolidate existing information on the effect of water level changes on woody plants found in riparian and wetland communities. These plants are normally exposed to high groundwater levels as well as periods of excess water due to flooding. It is the effect of too much water rather than a water deficit which is often the cause of stress to the plant. This stress can result in decreased growth and even death, since a plant's response to flooded conditions depends on many factors, including the plant species, water level, duration of flooding and time of year. Available information for each species has been listed separately in a tabular format.

This volume of the series covers the important woody plant species in the Eastern Deciduous Forest Region, which encompasses the area from southern Minnesota eastward to the Appalachians.

Teskey, R.O.; Hinckley, T.M.

1979

Impact of water level changes on woody riparian and wetland communities. Vol. V: The Northern Forest Region

Fish and Wildlife Ser., Ofc. of Biol. Serv. Rpt. In press.

Teskey, R.O.; Hinckley, T.M.

1979

Impact of water level changes on woody riparian and wetland communities. Vol. VI: The Plains Grassland Region

Fish and Wildlife Ser., Ofc. of Biol. Ser. Rpt. In press.

Thieret, J.W.

1971

Quadrat study of a bottomland forest in St. Martin Parish, Louisiana

Castanea 36:174-181

A forest on the Mississippi River floodplain "second bottoms" in St. Martin Parish, Louisiana, was studied by the quadrat method. The dominant tree of the overstory was hackberry; subordinate were green ash, sweetgum, and baldcypress.

Thiman, K.V., ed.

1958

The Physiology of Forest Trees

New York: Ronald Press, 1958

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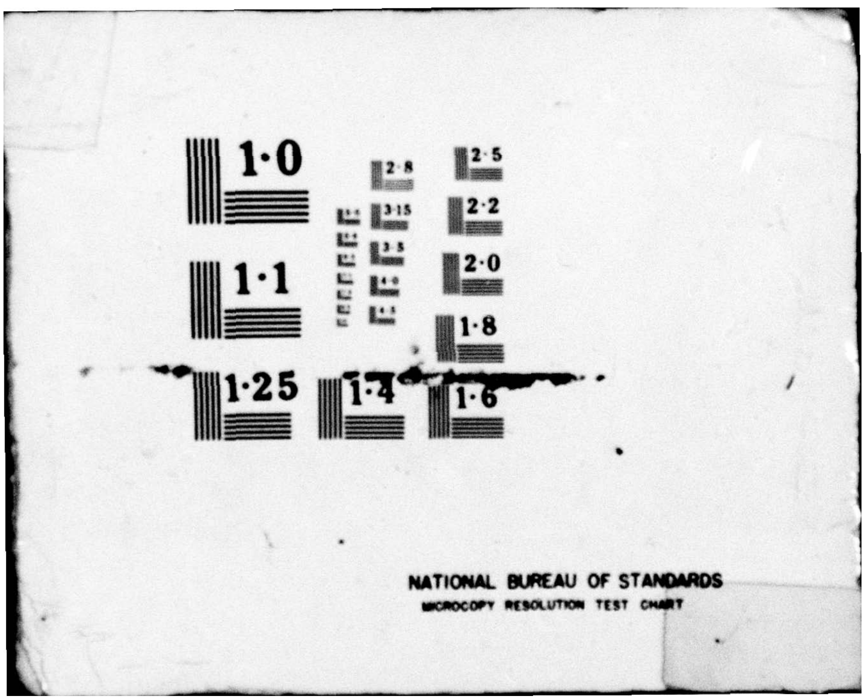
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Thomson, P.M.; Anderson, R.C.

1976

An ecological investigation of the Oakwood Bottoms Greentree Reservoir in Illinois

Proc. Central Hardwoods Forest Conf., 1st, 1976, pp. 45-64.

The vegetation of the Oakwood Bottoms Greentree Reservoir, Jackson County, Illinois, which is under the management of the U.S. Forest Service, was examined using the quadrat method. A total of 27 stands were sampled on this bottomland area, and the data obtained was used to delineate community types. The following communities were recognized: shagbark hickory, pin oak, black willow, pin oak - cherrybark oak, and pin oak - red maple. Pin oak is the dominant species over most of the area; however, its successful reproduction is limited to more open stands. In stands with more than 18.4 m of basal area/ha (80 sq. ft. of basal/acre), green ash, slippery elm, and American elm dominate in the reproductive strata. A synthetic moisture gradient was developed using selected indicator species, and success of herbaceous species and tree seedlings examined across the gradient. The presettlement vegetation was examined using the Government Land Office Records and compared with existing vegetation.

Trousdell, K.B.; Hoover, M.D.

1955

A change in groundwater level after clear cutting of loblolly pine in the Coastal Plain

Jour. of For. 53:493-498

Groundwater observation wells were dug in adjacent compartments of the Bigwoods Experimental Forest located in Hertford County, North Carolina, in June 1950. Soils and topography are similar in the two compartments, and the wells are approximatley 350 feet apart. The soil is Bladen silt loam. In July 1952, the loblolly pine-hardwood timber around one group of wells was clearcut. As a result of this cutting, the water table rose to higher levels for the remainder of the growing season than it did where a forest stand was left. This same relationship was maintained during the 1953 growing season.

The results of these studies may have a practical significance in developing silvicultural systems for the poorly drained soils of the Coastal Plain and throughout the flatwoods, where surface drainage is extremely slow. Heavy cutting may conceivably create soil conditions unfavorable for successful seedling establishment. If this proves to be the case, other systems of cutting that will have less immediate effect on soil moisture and groundwater levels may be needed in particular areas.

Tyree, M.T.; Cheung, N.S.; MacGregor, M.E.; Talbot, A.J.B.

1978

The characteristics of seasonal and ontogenetic changes in the tissue-water relations of *Acer*, *Populus*, *Tsuga* and *Picea*

Can. Jour. of Bot. 56:635-647

The Scholander-Hammel pressure bomb has been used to measure ontogenetic and seasonal changes in the osmotic pressure of the symplasm at zero water potential, the osmotic pressure of the symplasm at incipient plasmolysis, the bulk clastic modulus near maximum turgor, and a number of other water relations parameters in single leaves of *Acer saccharum* and several species of *Populus* and in shoots of *Tsuga canadensis* and *Picea abies*.

Van Camp, J.C.

1961

Tolerance of trees to soil environment

Proc. Nat. Shade Tree Conf. 37:5-19

The tree species normally associated with flood plains and lowlands in nature appear to show better survival, better growth rates, and better condition when planted along city streets and in parks than do the upland species. The bottomland species, such as sycamore, pin oak, elm, soft maple, poplar, swamp white oak, cottonwood, red maple, willow, river birch, box elder, and cypress, while certainly not all recommended species for planting, all possess varying degrees of inherited tolerance to low rates of diffusion of soil air. The author believes the tolerance these trees exhibit is a fundamental tolerance to faulty soil aeration rather than a specific tolerance to excessive soil moisture. Therefore, to these and to other bottomland species, it makes little difference whether the faulty soil aeration is caused by a layer of water, a layer of concrete, or a layer of severely compacted soil. They can tolerate those conditions and continue to live when their upland cousins such as the oaks: white, bur, red, black, scarlet, and chestnut along with tulip-poplar and most evergreens would show their intolerance to poor soil aeration in symptoms of yellow leaves, small, stunted foliage, and gradual dieback in the crown over a period of years. This intolerance to inadequate soil aeration as expressed by upland oaks is most obvious in former natural woodlands converted into park use.

Vanlear, D.H.; Hosner, J.F.

1967

Correlation of site index and soil mapping units poor for yellow-poplar in southwest Virginia

Jour. of For. 65:22-24

Ninety 1/5-acre plots of well-stocked, pure or nearly pure yellow-poplar were located in southwestern Virginia. These plots were found to be in five different soil-mapping units: Clifton loam, Chewacla silt loam, Watauga silt loam, Chester-Clenelg loams, and Tusquitee loam. Evidence in this study indicates little, if any, usuable correlation between soil-mapping units and the site index of yellow-poplar.

Wagner, K.; Kurz, H.

1954

Cypress: Root and stem modifications in relation to water

Florida State Univ. Stud. 13:18-47

Cypress survival was studied in three types of basins: Dead Lake and Cascades, Florida, and Reelfoot Lake, Tennessee. Survival in continuous deep water for long periods is attributed to adventitious roots which may be of three kinds: extensions of buttress beads, outgrowths from the sides of the buttress, or brush-like protrusions rising vertically from the roots at the floor of the lake. At Reelfoot, the critical depth for cypress is nine to ten feet. At Cascades, Florida, cypress often endures 14 to 16 ft. of water. However, the duration of high water at Cascades is much shorter than at Reelfoot. The aero-hydroperiod, as herein defined, determines the ultimate buttress and knee height. Active cypress knees contain chlorophyll in sufficient quantity to give positive starch tests. Cypress knees will grow into rotting cypress stumps. When the stump is entirely gone, the pattern of the knees often outlines the area covered by the buttress of the former tree.

Walker, L.C.

1961

Flooding and drainage efforts on slash pine and loblolly pine seedlings

For. Sci. 7:2-15

Slash and loblolly pine seedlings planted in a plastic clay loam soil were continuously flooded to ± 0, 4, and 8-inch depths; continuously drained to 4 and 8 inches below ground level; and flooded to a depth of three inches at 3-week intervals with subsequent drainage at 1/8, 1/4, and 1/2-inch per day coefficients.

A supplemental study tested survival ability of slash and loblolly pine seedlings planted on waterlogged soil immediately after drainage, but subjected to subsequent 2-, 4-, and 8-week periods of inundation to 8 inches.

Walker, L.C.

1962

The effects of water and fertilizer on loblolly and slash pine seedlings

Proc. Soil Sci. Soc. Amer. 26(2):197-200

Slash pine and loblolly pine seedlings in a Bladen clay loam soil were treated for 2 years with water at 4 levels, from 4 inches above the ground to 4 inches below. Superimposed on these water treatments were 3 fertilizer levels to determine if fertilization in the presence of adequate and excessive moisture may result in growth responses and if fertilization may aid seedlings to overcome deleterious effects of high water tables. Survival, height growth, needle length, foliage color, and foliar N, P, and K were influenced by both water and fertility levels. Draining these plastic soils of the Southeastern Tidewater area to depths of 4 inches below ground is recommended. Growth of both species during their first 2 years was increased appreciably by a spring application of 1,000 lb./A. of 8-8-8 plus 100 lb./A. of a mixture of trace elements.

Walker, L.C.; Watterston, K.G.

1972

Silviculture of southern bottomland hardwoods

School of For., Stephen F. Austin State Univ., Nacogdoches, Tex., Bull. 25. 78 pp.

This bulletin contains an excellent and concisely presented overview of the effects of flooding on the bottomland tree species.

266x

Wenger, K.F.

1952

Effect of moisture supply and soil texture on the growth of sweetgum and pine seedlings

Jour. of For. 50:862-864

This study compares the growth of 1-year-old potted sweetgum and pine seedlings during one growing season in soils of three different textures and under three levels of moisture supply. Although the sweetgum seedlings produced more dry matter and developed larger root systems, the growth in length of leaders and branches was less than that of the pines under all conditions of the experiment.

White, E.H.; Carter, M.C.

1970

Properties of alluvial soils supporting young stands of eastern cottonwood in Alabama

USDA For. Ser. Res. Note SO-111. 4 pp.

Eight pure young natural stands of cottonwood, greater than two acres in area and representing a range of site quality, were selected in the floodplains of the lower Alabama and Tombigbee Rivers. Their ages ranged from 6 to 9 years.

Soil samples were collected from soil pits by 6-inch depths to 2 feet and by 12-inch depths to 3 feet. For each sample, the following values were determined: pH, texture, content of phosphorus, potassium, calcium, and magnesium.

Examination of the data showed that one stand deviated greatly from the regression line of site index over soil potassium. The soil under this stand was extremely sandy and also low in potassium. The stand was surrounded on three sides by the river and a slough, and was influenced directly by a semi-permanent high water table which may have supplied nutrients for the trees.

When this stand was omitted from the computation, a regression equation of height growth over soil potassium was secured accounting for 94% of the variation in height. This is in agreement with European experience indicating that Populus spp. have a high requirement for potassium.

Average soil pH over all soils and depths sampled was 6.4. This is well above the value of 5.5 indicated by other reports as the minimum for adequate growth of Populus.

Wilde, S.A.; Youngberg, C.T.; Horind, J.H.

1950

Changes in composition of groundwater, soil fertility and forest growth produced by the construction and removal of beaver dams

Jour. of Wildlife Mngmt. 14:123-128

The residual effects of flooding and subsequent drainage were investigated on several typical beaver flowages in Marinette County, Wisconsin. The extremely low negative oxidation-reduction potential of the surface and ground water samples indicated that the removal of the dam drains the flowage only superficially, but not internally. The analyses of submerged soils revealed several unfavorable changes produced by impounded water, namely: saturation of soil with H_2S, accumulation of ferrous Fe, and fixation of P. Greenhouse trials showed that prolonged inundation destroys mycorrhizal fungi. The lack of these microorganisms appears to be one of the obstacles retarding the re-invasion of forest trees on drained flowages. The detn. of annual increment on strip sample plots proved that a rise of the ground water table depresses the growth of forest stands on neighboring lowlands.

Wilkum, D.A.; Wali, M.K.

1974

Analysis (a North Dakota gallery forest: vegetation in relation to topographic and soil gradients

Ecol. Monogr. 44:441-464

The relations between vegetation, topography and soils were studied in forest stands on slopes and on a floodplain in northeastern North Dakota. The forest was less than 100 years old, dominated by Quercus macrocarpa, Tilia americana and Fraxinus pennsylvanica var. subintegerrima; it contained 109 species of vascular plants, 10 mosses, and 15 lichens (listed, by layers). Forty plots were studied. Correlation analyses were made between community characteristics of the vegetation (coverage values, etc.) and topographic factors (slope, aspect, etc.). Principal-component analyses and Swan-Dix-Wehrhahn ordination were used to establish five abstract community types. Soil factors (chemical and water) were measured and used with the topographic factors for step-wise elimination multiple regressions to develop predictive equations for the distribution of plant species. The mathematical techniques (exemplified in detail) gave results showing species and community patterns resembling those obtained by stand ordination.

Williston, H.L.

1959

Inundation damage to loblolly pine seedlings

USFS Tree Planters' Notes 36, p. 13

No abstract available.

Williston, H.L.

1959

Inundation damage to upland hardwoods

USFS Notes SO-123

Of six upland hardwood species flooded during the summer of 1958 by a flood-control detention reservoir near Oxford, Mississippi, all yellow-poplars flooded for as long as 19 days died, and those flooded for as long as ten days were damaged. Other species flooded were red oak, white oak, blackgum, sweetgum, and red maple.

272x

Williston, H.L.

1962

Loblolly seedlings survive twelve days' submergence

Jour. of For. 60:412

One-year-old loblolly pine (Pinus taeda) seedlings in north Mississippi survived 32 days of submergence in the dormant season but only 12 days during the growing season.

Tests were conducted with potted 1-0 seedlings in February and May of 1958 and 1959, and in May of 1960.

These studies suggest that during their second growing season, loblolly pine seedlings can survive 12 days' submergence; that approximately 50% will survive 21 days; and that one month underwater will kill almost all seedlings. During the dormant season 1-year-old loblolly pine seedlings can undergo complete submergence for at least 32 days without loss in survival.

Williston, H.L.

1962

Pine planting in water impoundment area

USFS Notes SO-137

In tests in Mississippi, all loblolly and shortleaf pine seedlings submerged for 6-7 months in the winter after (spring) planting died, and all shortleaf submerged for 3½ months; 79% of loblolly survived 1 month's total and 3 months' root submersion. Height after 3 years was reduced by flooding.

Wilson, R.E.

1970

Succession in stands of Populus deltoides along the Missouri River in southeastern South Dakota

Am. Midl. Nat. 83:330-342

Studies on five different-aged communities of Populus deltoides adjacent to the Missouri River in southeastern South Dakota were carried out in 1964-65. In this geographic region newly barren shore lines and sand bars are commonly first stabilized by Salix interior. After stabilization, P. deltoides usually dominates these communities, and S. nigra and S. interior are present as subordinate species. After approximately 20 years of P. deltoides growth these communities change from sites of dry sandy surface soils supporting little undergrowth to sites with moist soil surfaces that support an abundance of shrubby species. Reproduction by P. deltoides is seemingly halted in these communities after 15-25 years of cottonwood growth. With the decline of P. deltoides, species such as Fraxinus pennsylvanica, Ulmus americana and Acer negundo take on added importance in these floodplain communities.

Wistendahl, W.A.

1958

The floodplain of the Raritan River, New Jersey

Ecol. Monogr. 28:129-153

1. The floodplain of the Raritan River is derived from diverse geologic materials, since the river flows over three of New Jersey's four geologic provinces.

2. Flood waters deposit the finer particles of alluvium at a greater distance from the river than the coarser particles. This results in the development of a floodplain which has a greater percentage of sand on the river bank than it has farther from the river. The dynamics of such deposits were apparent in a soil profile on the natural levee or outer floodplain at Raritan Landing.

3. Floods on the Raritan River are unpredictable and range from none to about 16 days of flooding a year. The more recent trend as interpreted from existing records seems to be toward higher annual average temperatures, lower precipitation, and fewer floods. Monthly records show that March has the most floods, although the greatest average monthly precipitation is in summer when temperatures are high, plant cover dense, and floods scarce.

4. The floodplain forest at Burnt Mills is composed of a large number of species. Within this forest several plant communities are evident: the outer floodplain with mesophytic species, the diverse inner floodplain forest, and the sugar maple dominated terrace. River banks and islands show successional trends on newly deposited alluvium which reflect the dynamics of stream action.

Wolfe, C.B.; Pittillo, J.D.

1977

Some ecological factors influencing the distribution of *Betula nigra* in western North Carolina

Castanea 42:18-30

A phytosociological and edaphic study was made of 3 stands of river birch, and of 4 communities lacking this species, in the floodplains of the Little Tennessee River System, North Carolina. River birch populations have a scattered distribution in this region. Analysis of the data showed that the river birch stands were correlated with a high total clay content in the soil. It is suggested that river birch may not only be able to tolerate soils of high m.c., but may actually require soils that can maintain a near field-capacity m.c. throughout the year.

Wood, B.W.; Carpenter, S.B.; Wittwer, R.F.

1976

Intensive culture of American sycamore in the Ohio River Valley

For. Sci. 22:338-342

In 1971 American sycamore plantations were established on a terrace and a floodplain site along the Ohio River near Hawesville, Kentucky, to study short rotation yields. Three spacings and three fertilization treatments were tested. After 3 years highest above-ground yields on both sites occurred with the closest spacing and N fertilization.

Wood, B.W.; Wittwer, R.F.; Carpenter, S.B.

1977

Nutrient element accumulation and distribution in an intensively cultured American sycamore plantation

Plant and Soil 48:417-433

Biomass and nutrient uptake under various spacings and fertilizer treatments were measured by total tree analysis techniques for Platanus occidentalis seedlings grown on either a floodplain or a terrace site in western Kentucky. Stands were planted as 1+0 stock and harvested after 3 growing seasons. Nutrient element concentration was affected by site and fertilizer but not by spacing. Branches and foliage contained 45-70% of nutrient elements present in above-ground tree parts. Consideration of the soil nutrient cycle suggests that removal of all above-ground tree parts could reduce soil P concentration, but that other soil nutrients would be unaffected.

Wuenscher, J.E.; Kozlowski, T.T.

1971

Relationship of gas-exchange resistance to tree seedling decay

Ecology 52:1016-1023

Net photosynthesis and transpiration of intact leaves of seedlings of live species of forest trees were measured under a range of light intensities and leaf temperatures. Leaf transfer resistances to water-vapor loss and CO_2 uptake were calculated. The species tested included *Quercus macrocarpa*, *Q. velutina*, *Q. alba*, *Q. rubra*, and *Acer saccharum*, which occur in southern Wisconsin along an ecological gradient from xeric to mesic. Stomatal resistance and water-use efficiencies, the ratio of water-loss resistance to CO_2 uptake resistance, decreased along the gradient from xerophytic to mesophytic species. Mesophyll resistances showed a corresponding increase. Variations among species in transfer resistances help explain the success of different species at various points along the ecological gradient and appear to be an important factor in determining species ecology.

Yeager, L.E.

1949

Effect of permanent flooding in a river-bottom timber area

Ill. Nat. Hist. Survey Bul. 25: article 2. Ill. Dept. Registration and Ed. 65 pp.

The effect of flooding on timber was studied over an 8-year period (1939-46), on an area of 2200 acres at the junction of the Mississippi and Illinois rivers. About 600 acres of this were flooded permanently by the Alton Dam impoundment. Within eight years almost all trees were killed in the areas that were actually flooded; with most species, flooding to a depth of 20 in., enough to cover the root collar, was fatal. Pin oak was the most susceptible species, all trees dying within three years. White ash proved the most resistant, trunk sprouts appearing on some individuals eight years after inundation.

SECTION IV

GENERAL BIBLIOGRAPHY

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