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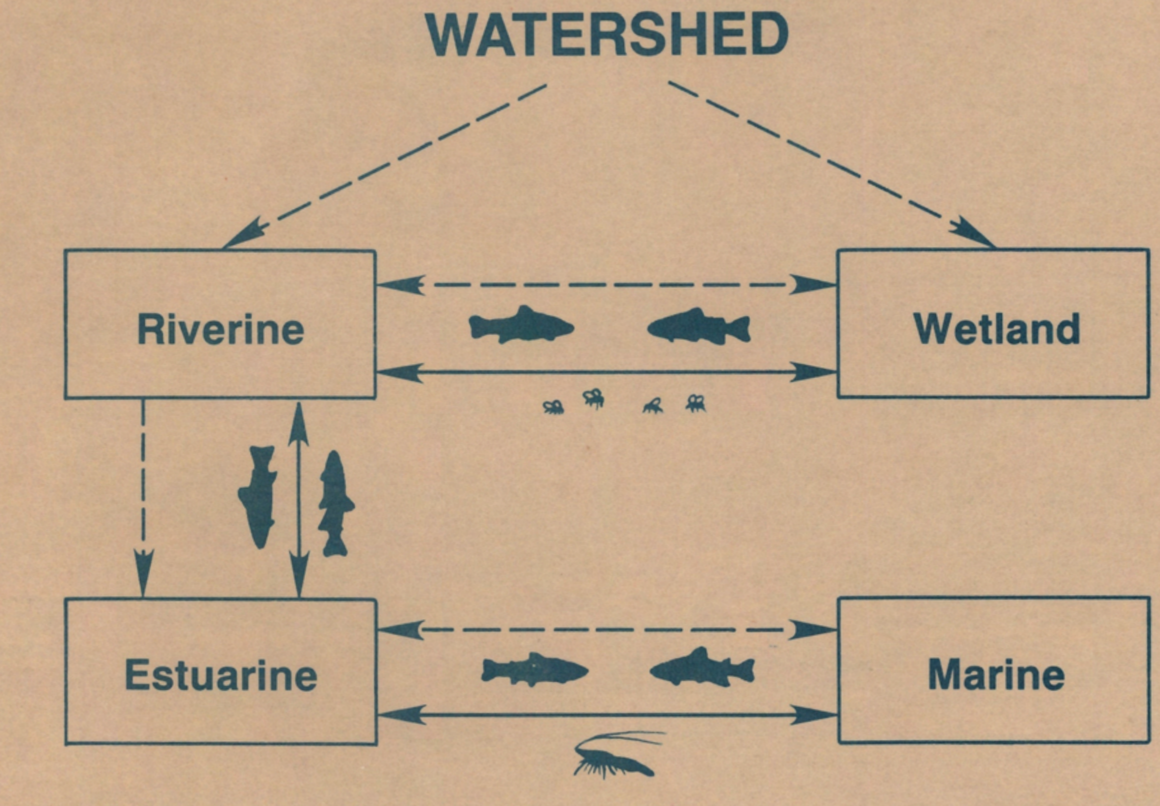

Fish and Wildlife Service

U.S. Department of the Interior

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RELATIONSHIPS BETWEEN PALUSTRINE WETLANDS OF FORESTED RIPARIAN FLOODPLAINS AND FISHERY RESOURCES: A REVIEW

by

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PREFACE

This report stemmed from a workshop held at Annapolis, Maryland, February 9-10, 1987, to identify priority information needs for nontidal, freshwater palustrine and riverine wetlands (exclusive of isolated wetlands). Participants in the workshop were primarily representatives of the U.S. Fish and Wildlife Service's Ecological Services Field Offices located at Annapolis, Maryland, and State College, Pennsylvania. A high-priority information need identified by the workshop participants was documentation of the values to fish of freshwater palustrine wetlands that are generally tree- and shrub-dominated floodplains of streams that flow to coastal areas of the eastern portion of the United States. The workshop participants concluded that a synthesis of the relevant literature should be the first step in addressing this information need. The participants also recognized that long-term field research will be required to determine more clearly the relationships between these selected palustrine wetlands and associated fisheries resources. Soon after a review of the relevant literature was initiated it became evident that there is sufficient evidence to support the hypothesis that palustrine wetlands of forested riparian floodplains are important to fishery resources. It also became evident that much additional research on this subject is needed for use in management and protection of these vital wetland resources and their associated fishery resources.

Wetlands are of national interest because of the many benefits they provide for society. Palustrine wetlands of forested riparian floodplains are notable because of the large areas they cover and because of the rapid rate at which they are being converted for timber production, agriculture, and human settlement. These wetlands are inextricably linked, directly or indirectly, to streams, estuaries, and upland watersheds. This report focuses on linkages between these wetlands, which flank many of the major streams that flow through the Piedmont and Coastal Plain to the sea, and their relationship to fishery resources. The draft manuscript was reviewed by six wetland ecologists for technical content and soundness of concepts. Some major changes in format and content of the draft manuscript along with other comments and recommendations by these six reviewers were incorporated where appropriate in the final manuscript.

Suggestions or comments relating to this report should be sent to the author at the noted address.

CONTENTS

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INTRODUCTION

At the functional level, wetlands moderate the effects of flooding, maintain and improve water quality, provide fish and wildlife habitat, support food chains, and have aesthetic and heritage values (Table 1). Wetlands also contribute to the stability of levels of atmospheric nitrogen, sulfur, carbon dioxide, and methane (Mitsch and Gosselink 1986).

Numerous laws and regulations have been enacted to protect and manage wetlands (Zinn and Copeland 1982; Kusler 1983; Mitsch and Gosselink 1986), but the area of wetlands in the lower conterminous United States declined from about 215 million acres in presettlement times (Roe and Ayres 1954) to about 99 million acres in the mid-1970's (Frayer et al. 1983). During the past 40 years, there have been significant losses of palustrine wetlands of forested riparian floodplains in the southeastern portion of the United States. A net loss of 4.5 million acres of palustrine forested wetlands occurred in the Mississippi Flyway alone during the 1950's-1970's (Frayer et al. 1983).

Until the second half of the twentieth century, the only functional value widely attributed to wetlands was that of providing habitat for wildlife, particularly waterfowl. More recently, wetlands have attracted significant attention related to other functions and values (Good et al. 1978; Greeson et al. 1979; Brinson et al. 1981a,b; Richardson 1981; Sather and Smith 1984; Strickland 1986; Mitch and Gosselink 1986).

At the population level, wetland-dependent fish, shellfish, furbearers, and waterfowl provide a valuable harvest and millions of man-days of recreational fishing and hunting. Commercial landings of wetland-dependent fish species had a landing value exceeding $700 million in 1976; and in 1975, recreational fishermen spent $31.1 billion pursuing wetland-associated fishes (Peters et al. 1979). About one-third of the North American bird species use wetlands (Kroodsman 1979), as do numerous aquatic invertebrates, amphibians, reptiles, fish, and mammals (Lambou 1965, 1984; Ziser 1978; Clark 1979; Fredrickson 1979; Schitoskey and Linder 1979; Brinson et al. 1981a,b; Frizell 1988). About 50% of the threatened or endangered animal species and 28% of the plant species are associated with wetlands, including 22 of the 41 species and subspecies of United States fishes listed as endangered or threatened (Williams and Dodd 1979; Niering 1988). The timber value of southern wetland forests was estimated to be $8 billion (Johnson 1979).

FOCUS, SCOPE, AND PURPOSE OF THIS REPORT

There is no universal, correct, indisputable, ecologically sound definition for wetlands, primarily because of the diversity of wetlands and

Table 1. Summary of representative examples of functions of forested palustrine wetlands (adapted from Roelle et al. 1987).

Major functional categories	Specific functions
Hydrology	Flood storage Velocity reduction Groundwater discharge modification
Water quality	Sediment retention Erosion control Nutrient retention and transformation Contaminant retention and transformation
Fisheries and wildlife	Habitat for finfish Habitat for shellfish Habitat for wood ducks Habitat for wintering dabbling ducks Habitat for black bear Habitat for white-tailed deer Habitat for migrating passerine birds
Ecosystem processes	Maintenance of natural biotic diversity, cumulative level Maintenance of natural biotic diversity, site-specific level Food chain support Streamflow mediation Transforming and filtering (water quality)
Cultural/recreational/economic	Sensory experience Recreation experience Information storage Renewable harvesting

because demarcation between wet and dry environments lies along a continuum. However, several wetland classification systems impose boundaries on wetlands for the purposes of inventory, evaluation, and management (e.g., Martin et al. 1953; Shaw and Fredine 1956; Stewart and Kantrud 1971; Golet and Larson 1974; Zoltai et al. 1975; Millar 1976; Cowardin et al. 1979). Definitions of wetlands often depend on the objectives and field of interest of the user. I have chosen palustrine wetlands of forested riparian floodplains for the focus of this report. These wetlands are primarily forested and scrub/shrub classes of the palustrine wetlands system as classified by Cowardin et al. (1979). As used in this report, palustrine wetlands of forested riparian floodplains include only wetlands that are directly coupled to upland watersheds and to stream systems (generally higher order streams) which flow to estuaries along the mid- and south-Atlantic and the northern Gulf of Mexico coastal areas of the United States. Upslope, these wetlands are bounded by terrestrial habitat. They are coupled to riverine habitat via a "water bridge" during flooding (Figure 1). The water bridge is essential from a fishery functional value standpoint because during flooding it allows fish access to productive floodplain areas used for spawning, nursery, feeding, and cover. The water bridge also provides passage for fish to return to the stream channel during receding floodwaters. A stream corridor with palustrine forested wetlands located in its floodplain may also contain wetlands classified as Estuarine Intertidal Forested Wetlands, Riverine Lower Perennial Emergent Wetlands and Aquatic Beds, and Palustrine Aquatic Beds (Cowardin et al. 1979). These wetland habitats are also functionally important to fish that use the stream corridor and associated wetlands. However, such wetlands are not the focus of this report. Terms other authors have used to describe palustrine wetlands of special interest and which I consider to be generally synonymous to wetlands that are the focus of this report are listed in Table 2.

A recent survey by Abernethy and Turner (1987) showed that 57% of the forested wetland area in the United States is located in Alabama, Arkansas, Georgia, Florida, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, and Virginia. In this area of the United States, palustrine wetlands of forested riparian floodplains are commonly referred to as bottomland hardwoods. However, this term is used very loosely from an anatomical standpoint, since both hardwood and softwood tree species occur on floodplains of streams in these States.

LITERATURE REVIEW

USE OF FLOODPLAINS BY FISH

It is generally known that palustrine wetlands of forested riparian floodplains provide cover, spawning, and nursery habitat in situ for numerous fish species (e.g., Hinchee 1977; Hastings 1979; Welcomme 1979; Wharton and Brinson 1979; Chambers 1980; Wharton et al. 1981). It is generally known or assumed that such wetlands usually import, produce, store, recycle, and export biotic and abiotic materials that are used in food chains by fish in situ or at sites downstream (e.g., Day et al. 1977, 1980; Livingston and Loucks 1979; Conner and Day 1982; Taylor et al. 1984).

Most of the available information on the occurrence, population, and production of fish in forested floodplains has been reviewed and summarized by Wharton et al. (1981, 1982). It has been shown that 90 fish species use the wooded floodplains of the Atchafalaya River, Louisiana (Lambou 1965, 1984; Bryan et al. 1975, 1976). Of the 90 species, 51 used the overflow wooded areas for spawning or for rearing of young, while 53 species used these areas

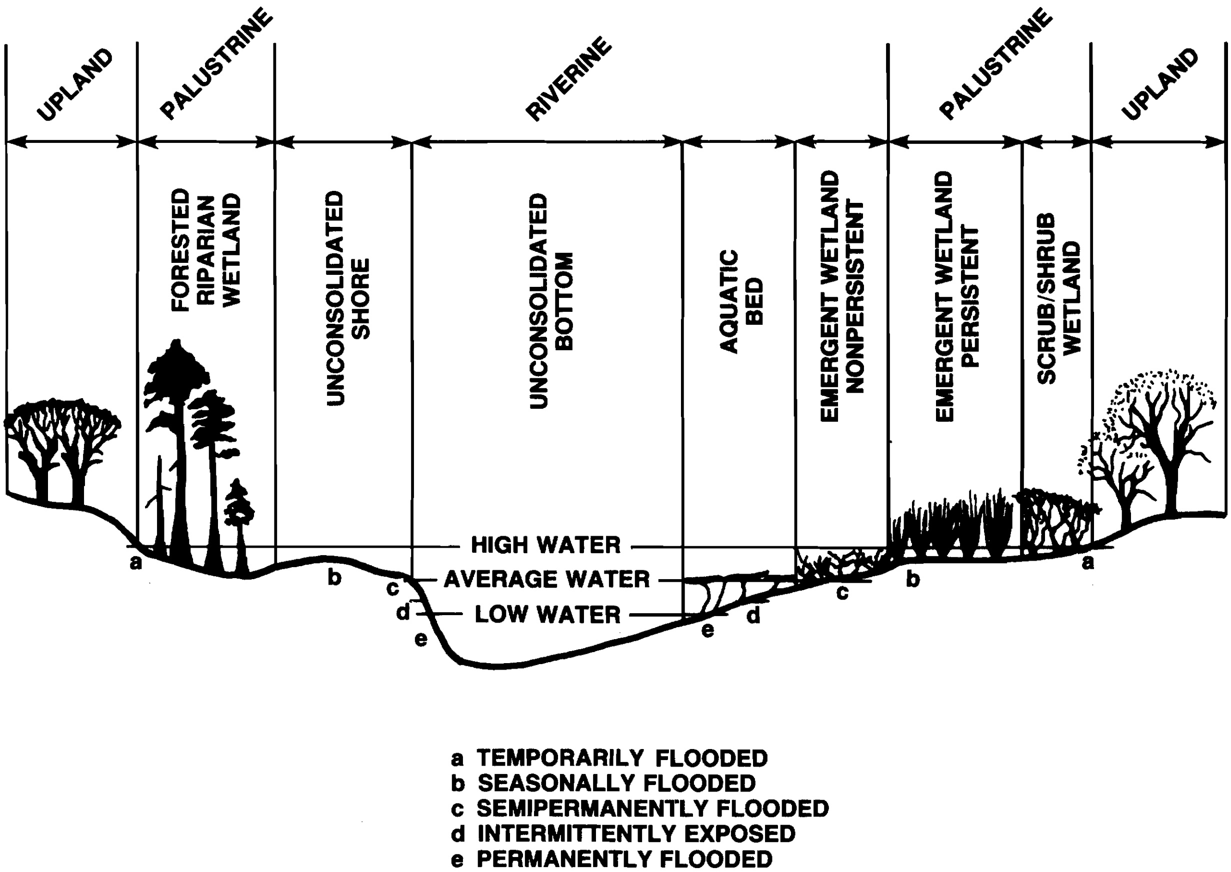

Figure 1. Simplified schema of a cross section of a stream corridor showing the proximity of a palustrine wetland in a forested riparian floodplain to upland, riverine, and some other palustrine habitats (adapted from Cowardin et al. 1979).

for feeding (Table 3). Bottomland hardwood areas of the Henderson Lake area in the Atchafalaya floodplain are used by at least 37 fish species for spawning and nursery habitat (Pollard et al. 1983; Lambou 1984). The number of fish species that have been collected from other floodplains areas include: 13 in a cypress swamp in Florida (Carlson and Duever 1977), 16 from a blackwater creek floodplain in North Carolina (Walker 1980), and 20 from floodplain areas along the Savannah River in Georgia (Patrick et al. 1967). Numerous fish species use the floodplain along the Suwanee River in Georgia for spawning and nursery habitat (Wyatt and Holder 1969; Holder 1970; Holder et al. 1970, 1971; Germann 1973). Forested floodplains are used as spawning sites by hickory shad (Alosa mediocris) and blueback herring (A. sapidissima) in New Jersey

Table 2. Some terms used by various authors in discussing Palustrine Forested Wetlands and Scrub/Shrub Wetlands (Cowardin et al. 1979) and that are considered to be generally synonymous to palustrine wetlands of forested riparian floodplains.

Term	Author
Floodplain Floodplains of rivers	Welcomme (1979, 1985)
Forested wetlands Swamp forests	Conner and Day (1982)
Wetlands of bottomland hardwood forests	Clark and Benforado (1981), Roelle et al. (1987), Wilkinson et al. (1987), Lea (1988)
Floodplain swamps	Kuenzler et al. (1980)
Riparian ecosystems Riparian wetlands	Ewel (1978), Brinson et al. (1981b), Mitsch and Gosselink (1986)
Bottomland forests	Day et al. (1981), McKnight et al. (1981)
Bottomland hardwood-cypress forests	Langdon et al. (1981)
Lowland hardwood wetlands	Fredrickson (1979a,b)
Pine barrens Cedar swamps	Patrick et al. (1979)

(unpublished report cited by Hastings 1979). The blue crab (Callinectes sapidus), shrimp (Panaeus sp.), and several species of estuarine finfish were found to use freshwater forested floodplains in Louisiana (Hinchee 1977; Chambers 1980; Lambou 1984). Crayfish form a large percentage of the aquatic animal biomass on some floodplains (Holder 1971; Konikoff 1977) and are an important food source for the large predator fishes found on floodplains (Penn 1950; Holder 1971; Wharton 1977). Several species of freshwater mussels dominate the animal biomass of some floodplains (Parson and Wharton 1978). The glochidian stage of most freshwater mussels cannot survive unless they

Table 3. Summary of fish use of habitat types for a particular purpose in the leveed Atchafalaya Basin between Morgan City and Simmesport, Louisiana (adapted from Lambou 1984).

Habitat type and use	Number of fish species	Percent of total number (n = 90) of species
Used overflow wooded areas for spawning or rearing of young	51	53.7
Used overflow wooded areas for feeding	53	55.8
Spawned in marine waters and adults and subadults used overflow wooded and permanent-water areas for feeding	2	2.1
How extensively overflow wooded areas were used is not known	31	32.6
Used permanent-water areas with current, how extensive overflow wooded areas were used is not known	5	5.3
Mainly inhabited marine or estuarine waters, a few individuals invaded area during low-water periods	4	4.2

become attached to their host-specific species of fish. The average annual yield of finfish and shellfish from floodplains to man is largely dependent on the maximum area flooded (Bryan and Sabins 1979) and the amount of fishing effort. Yields may range from about 4,000 to 6,000 kg/km^2 of finfish (Welcomme 1979) to as high as 8,797 kg/km^2 of finfish and shellfish combined (Lambou 1984). Fish density and biomass in a cypress (Taxodium distichum) swamp in Florida ranged from 16 to 43 fish/m^2 and 1 to 3 g/m^2 respectively (Carlson and Duever 1977). The area of bottomland hardwood wetlands in the Mississippi River basin is likely an important determinant of the overall level of fishery productivity in that river basin (Risotto and Turner 1985).

STRUCTURE, FUNCTION, AND HYDROPERIOD OF FLOODPLAINS

A floodplain may be considered the part of a stream channel that is used to accommodate high flows (Brinson et al. 1981). Floodplains result from the combination of the deposition of alluvial materials (aggradation) and downcutting of surface material over a period of many years. In a review of the structure and function of riparian floodplains Mitsch and Gosselink (1986) pointed out that the importance of the stream to the floodplain and the floodplain to the stream cannot be overemphasized. If the stream or the floodplain is altered the other will surely change in time because streams and their floodplains are in continual dynamic balance between the building and removal of structure. Generally, there are four hydrological phases of a stream in relation to its floodplain (Figure 2).

The hydroperiod (Figure 3) defines the pattern of rise and fall of the floodplain's surface and subsurface water. The hydroperiod is unique to each stream and each floodplain and is the driving force which determines the floodplain's structure and function. Changes in the frequency, duration, and timing of the hydroperiod may prevent passage of fish between the stream and its floodplain, alter the age structure and species composition of the floodplain flora and fauna, and interfere with ecological processes that support food chains in the wetland and in downstream systems (Bedinger 1981; Kadlec 1987; Klimas 1988). The timing of flooding is particularly important because flooding during the growing season has a greater effect on floodplain productivity than does an equal amount of flooding during the nongrowing season (Mitsch and Gosselink 1986). Floodplain vegetation is dependent on inundation and drainage patterns that differentially influence the ability of various plant species to become established and compete on a given site (Klimas 1988). Timing and magnitude of floods are especially critical to fish species that use the floodplain for spawning. Migration routes may be blocked if flood levels are too low.

The Role of Hydrology in Floodplains

The role of hydrology in maintenance of floodplain wetlands has been discussed by numerous authors (e.g., Conner and Day 1976; Gosselink and Turner 1978; Bedinger 1979, 1981; Carter et al. 1979; Wharton 1980; Brinson et al. 1981b; Gosselink et al. 1981; Klimas 1988). Gosselink and Turner (1978) developed a conceptual model of the role of hydrology in freshwater wetlands. Their model was adapted (Figure 4) to represent the role of hydrology in palustrine wetlands of forested riparian floodplains discussed in this report. This model shows that some climatic factors may have an overriding influence on the types of species that develop in wetlands of forested riparian floodplains. However, certain attributes of the hydrologic regime (i.e., water source, velocity, renewal rate, and timing) are of most importance to the biota, and especially to fish. The source of water strongly influences its ionic composition, oxygen saturation, and toxin load, each of which may influence the water quality suitability for fish. Water velocity affects turbulence and sediment transport and distribution, each of which may be determining factors for fish spawning and feeding habitat. The renewal rate or frequency of replacement of the water is dependent on volume and frequency of inundation and velocity. The renewal rate and the timing of frequency of

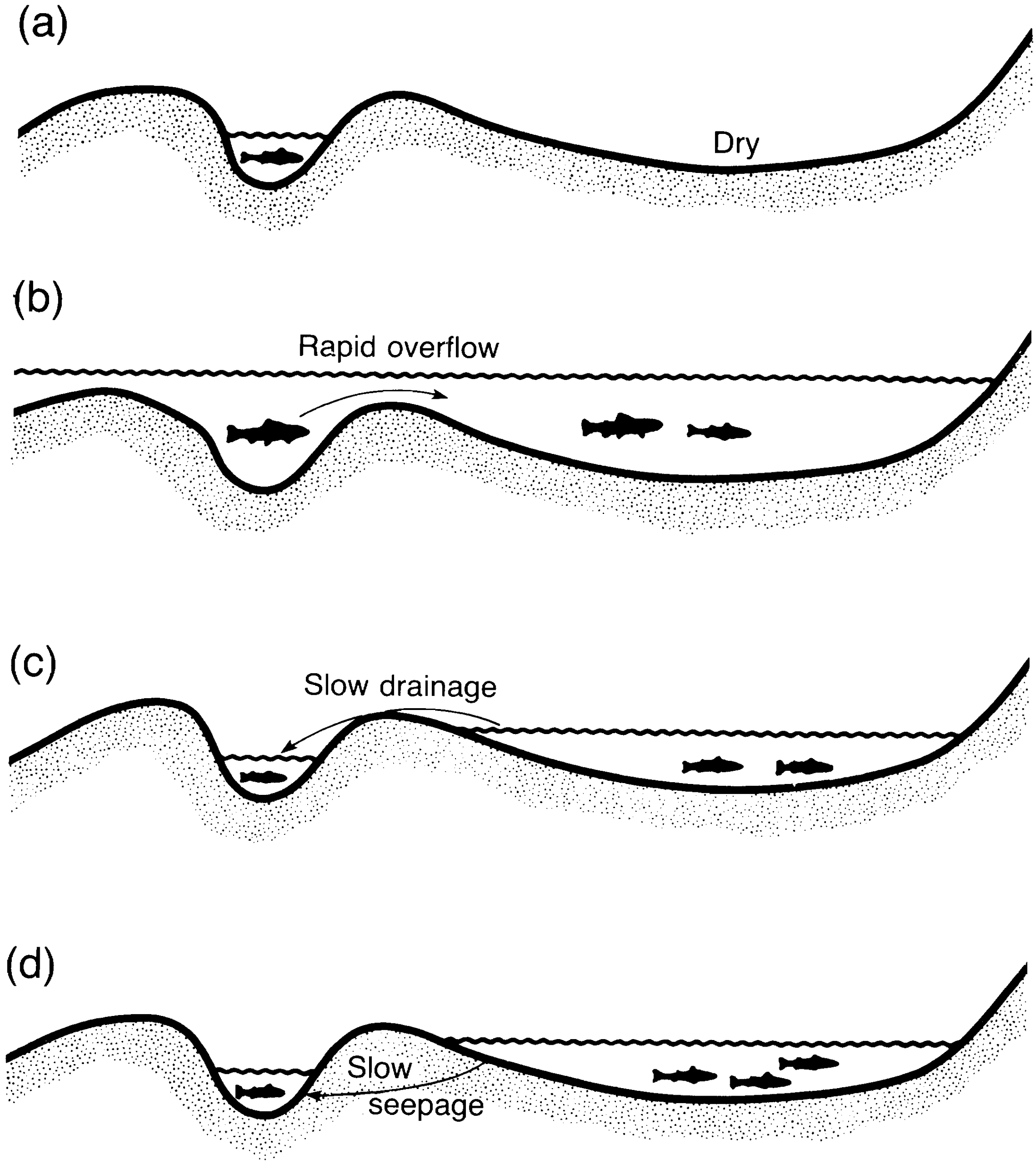

Figure 2. Schematic showing four of the hydrological phases of a stream in relation to its forested riparian floodplain: a, drought phase with the water level on the floodplain too low to support fish; b, flood phase when overbank flow from the stream channel contributes water to the floodplain allowing fish passage; c, post-flood phase with surface drainage from the floodplain to the stream, allowing fish passage; and d, normal channel-containeu streamflow which originates from floodplain seepage, precipitation, or lateral runoff from adjacent uplands. (Adapted from M.M. Brinson, H.D. Bradshaw, and R.N. Holmes, "Significance of floodplains in nutrient exchange between a stream and its floodplain," in T.D. Fontaine and S.M. Bartell, Dynamics of Lotic Ecosystems, pp. 199-221, with permission from Butterworth Publishers, Stonehem, MA.)

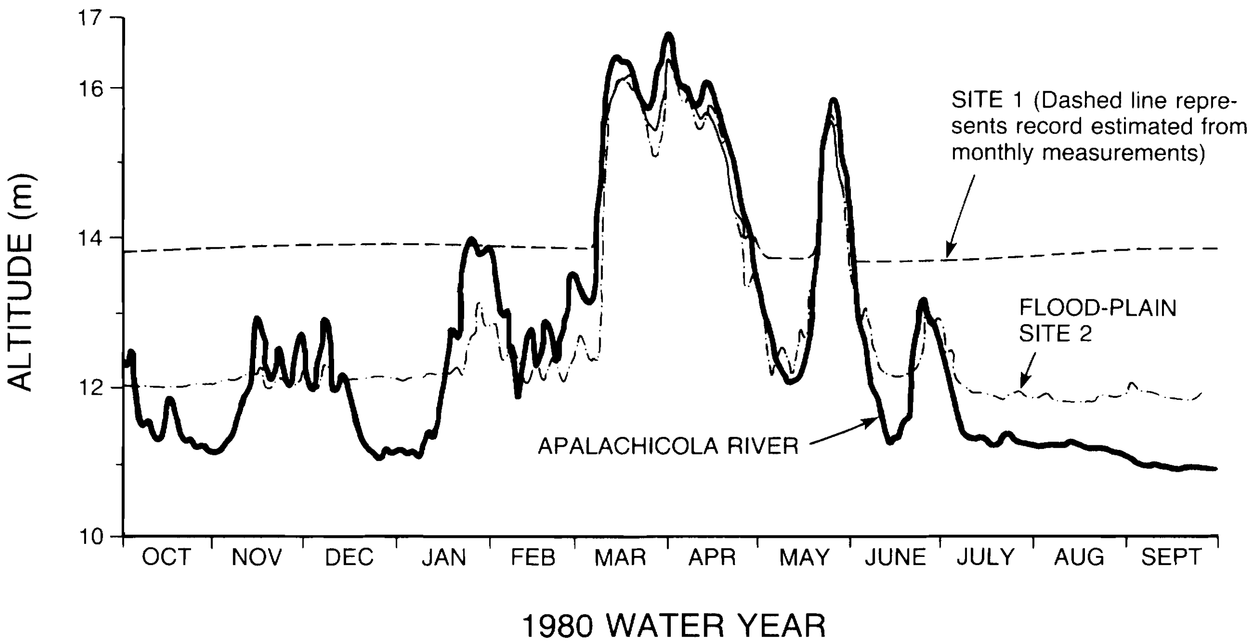

Figure 3. Example of hydrographs from the Apalachicola River, Florida (solid line) at river mile 86, and from two nearby floodplain sites along the river during the water year 1980. Floodplain site 1, (dashed line) was located one mile east of the river in a large tupelo-cypress swamp that was permanently ponded with 1-2 feet of water. Floodplain site 2 (dotted line) was located about 0.5 mile west of the river in a floodplain with high flow velocities during floods, but which was ponded during low flows (adapted from Leitman et al. 1984).

inundation and its regularity may limit the availability and use of the floodplain by fish and wildlife species. Water nutrients, toxins, and oxygen availability are key chemophysical properties of the floodplain's substrate and are strongly influenced by the hydrologic regime. Detailed discussions on the influence of the hydrologic regime on floodplain flora are found in Gosselink and Turner (1978).

Openness or coupling and primary productivity, secondary productivity and food chain support, and water quality characteristics of wetlands are known to respond to hydrology, which in turn determines the fisheries value of palustrine wetlands of forested riparian floodplains. These characteristics, their responses to hydrology, and their relationship to fishery resources are discussed in the following sections of this paper.

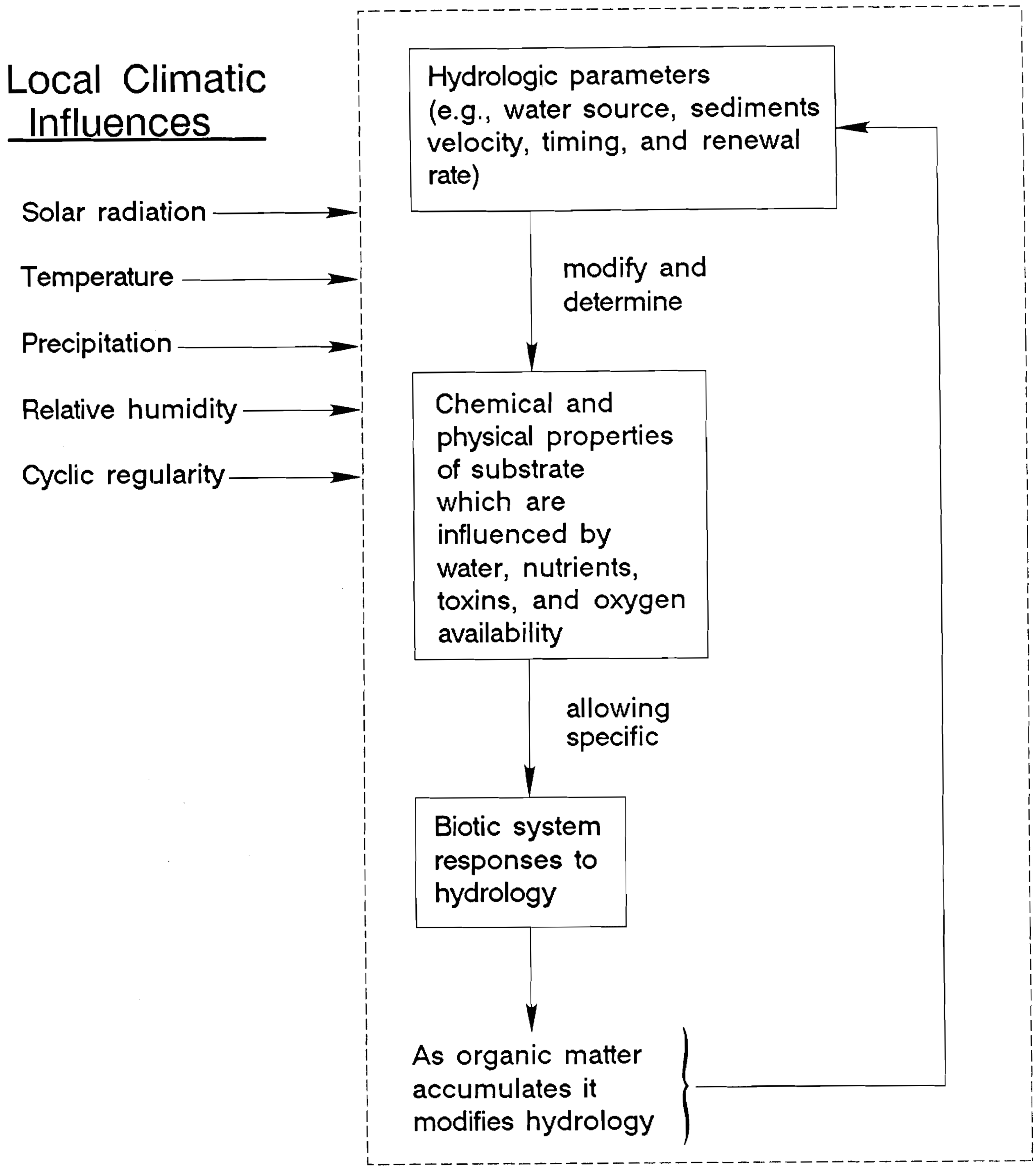

Figure 4. A conceptual model of the role of hydrology in palustrine wetlands of forested riparian floodplains. (Modified from Gosselink and Turner (1978). Original copyright 1978 by Academic Press, Inc. Modified and reproduced with permission from the publishers.)

Floodplain Coupling and Primary Productivity

Portions of the length of a stream corridor, including tributaries, have vital hydrologic and biologic attributes that couple a stream upstream and downstream, and laterally with its floodplain (Wharton and Brinson 1979). Palustrine wetlands of forested riparian floodplains are coupled directly or indirectly to upland watersheds, streams, and estuaries. By virtue of this coupling, gravity, the solubility and transport properties of water, and the mobility of various aquatic organisms, including fish, these wetlands are open systems accounting for exchange of materials among various components of the stream corridor (Figure 5). The functional aspect of this coupling depends on pulses of water flow which are vital to primary and secondary productivity in the floodplain and at downstream sites (Wharton and Brinson 1979).

Studies have shown that primary productivity of forested floodplains depends on hydrologic and nutrient conditions (see summary by Mitsch and Gosselink 1986). Highest productivity results from wetlands that are neither too wet nor too dry but that have seasonal hydrologic pulsing (Brown et al. 1979; Brinson et al. 1981b; Conner and Day 1982) (Figure 6). Floodplain forests are among the highest in primary productivity of any ecosystem in the southeastern United States (Boyd 1976; Conner and Day 1976; Brown et al. 1979). Nutrient supplies from the watershed deposited during stream flooding provide resources necessary to sustain high rates of productivity. Trees are the floodplain's primary producers and the source of much of the detritus on the floodplain and in the associated stream (Wharton and Brinson 1979). Aboveground biomass varies widely, ranging from 10 kg/m² to 119 kg/m² (Brinson et al. 1981b). Some tree species commonly found on forested floodplains in the Southeast are bald cypress (Taxodium distichum), water tupelo (Nyssa aquatica), swamp tupelo (N. sylvatica), black gum (N. biflora), water hickory (Cara aquatica), overcup oak (Quercus lyrata), red maple (Acer rubrum), Atlantic white cedar (Chamaecyparis thyoides), and water ash (Fraxinus carolinians). However, tree species composition may vary greatly depending on hydrologic regimes, changes in floodplain elevation, and other factors (Conner and Day 1976; Wharton and Brinson 1979; Brinson et al. 1981; Larson et al. 1981; McKnight et al. 1981; Abernethy and Turner 1987).

One of the fundamental functions of primary productivity in forested floodplains is that of providing energy for detritus-based food webs, including fish food webs, in situ and at downstream sites. Detritus-based food webs add stability to ecosystems by making the energy that is seasonally fixed by primary production available to consumers over longer periods of time.

Secondary Productivity and Food Chain Support Related to the Floodplain

A review of the secondary production values of wetlands by Crow and Macdonald (1979) suggests that three distinct and significant wetland contributions to secondary productivity stand above all others. Two of these contributions relate to wetland trophic resources and one relates to nontrophic resources. Generally, food energy use in wetlands is of two types: direct and indirect consumption. Direct consumption is concerned with energy and matter transferred by means of grazing by consumers, including insects (Wallace and O'Hop 1985; Scott and Haskins 1987), waterfowl (Chamberlain 1959; Glasgow

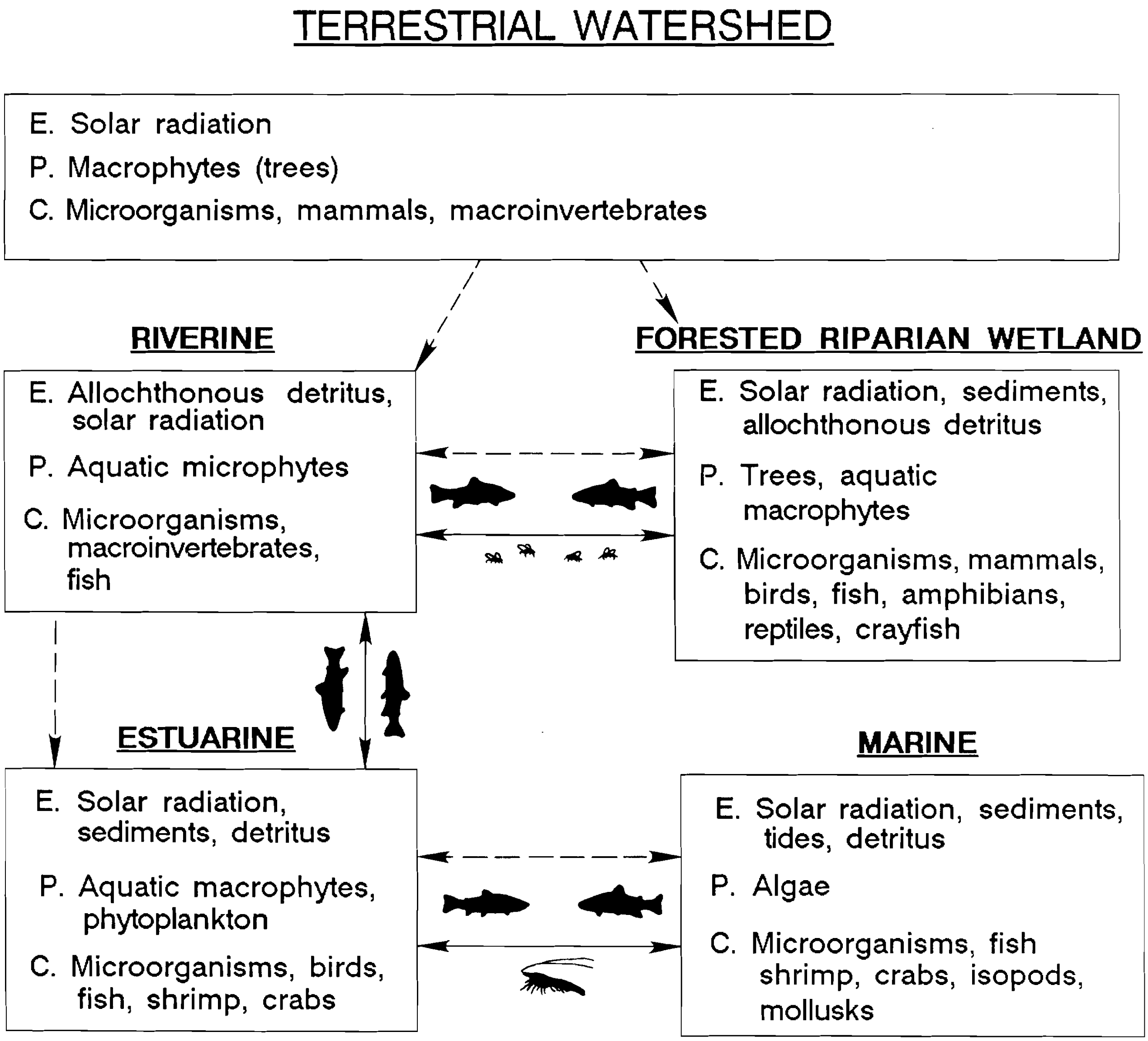

Figure 5. Schema showing the potential for transfer of materials between a palustrine wetland of a forested riparian floodplain and other systems linked directly or indirectly to the wetland. For each system (i.e., terrestrial watershed, riverine, forested riparian wetland, estuarine, and marine), examples are given of major sources of energy for the system (E), some major primary producers for the system (P), and some major consumers for the system (C). Arrows with broken line indicate direct linkage and direction of transfer of water, detritus, nutrients, and sediments. Arrows with solid line indicate direct linkage and direction of movement of fish and other primary consumers.

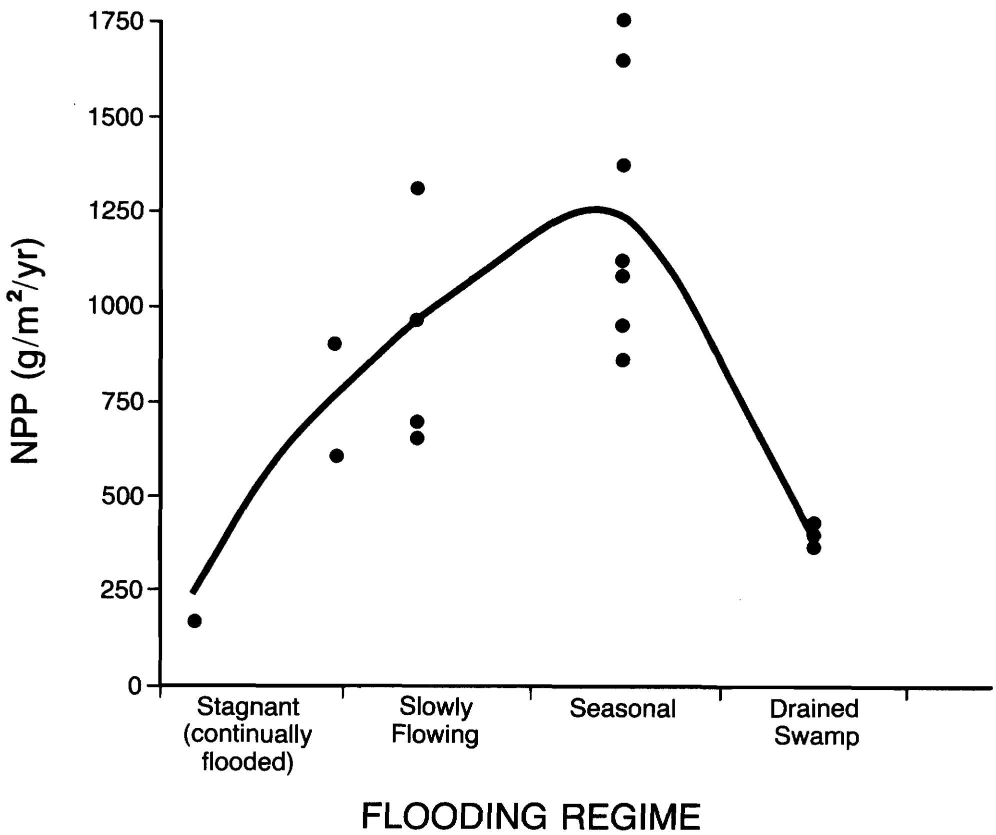

Figure 6. Net primary productivity (NPP) of various swamp areas classified as to their flooding regime (Conner and Day 1982).

and Bardwell 1962), and mammals (Lowery 1974). Indirect consumption involves energy transfer associated with altered states of the wetland products under essentially three conditions: (1) food chain predator-prey transfer, (2) energy associated with wetland plant detritus, and (3) energy derived from dissolved organic carbon that may be leached from wetland plants, or excreted by wetland dependent organisms (Crow and Macdonald 1979). In addition to its own nutritive value, detritus provides a rich substrate for the growth of diatoms, bacteria, and other microorganisms (Kaushik and Hynes 1971; Melchiorri-Santolini and Hampton 1972). Thus, wetland-derived detritus and its associated microbiota is exported downstream, recycled through omnivores and herbivores, and reinoculated with microbiota, and likely supports major food webs that include commercially important fish and shellfish. The third principal contribution of wetlands to secondary production involve nontrophic resources (Crow and Macdonald 1979). Palustrine wetlands of forested riparian floodplains provide habitat for various life stages and activities of numerous species of fish, birds, and invertebrates. A summary of models of energy transfer, resource use patterns, and temporal use patterns for wetland secondary productivity are given in Table 4.

Table 4. Wetland secondary productivity: summary of models of energy transfer, resource use patterns, and temporal use patterns (Crow and Macdonald 1979). (Reproduced with permission of the American Water Resource Association.)

Modes of energy transfer	Resource use patterns	Temporal use patterns
	TROPHIC RESOURCES:	
Direct consumption of primary producers	Direct grazing Onsite detritus use Offsite detritus use	Permanent wetland populations
Food web predator-prey transfer	Cycling of bacteria-rich detritus and fecal matter	Seasonal wetland use by local populations
Detritus export	Predator-prey interactions	
	NONTROPHIC RESOURCES:	
Dissolved organic carbon leachates from plants, excretion from animals	Breeding sites and nursery areas Flight staging areas	Seasonal wetland use by populations Occasional wetland visitors from adjacent habitat
Export of larvae and juveniles	Resting areas Refuge from predators	

One of the reasons for high fish productivity in the Atchafalaya River floodplain (Lambou 1984) was attributed to the short, efficient aquatic bacteria-detritus-based food chain involving only two or three transfers of energy, i.e.:

bacteria → detritus → crayfish → man
↓
→ large finfish → man

as compared to:

phytoplankton → zooplankton → insects
↓
→ small fish → larger fish → man

Water Quality and the Floodplain

The role of forested wetlands in the southeastern United States in maintaining water quality was reviewed by Winger (1986). Good water quality enhances the quality of fish habitat. The quality of water entering or leaving the floodplain and exported downstream may be affected by the nutrient content of surface water or ground water from the watershed. In the past two decades, concerns have increased that the use of agricultural fertilizers and pesticides may result in contamination of surface and ground water and increased nutrient loading to streams (Kemp 1949; Scheuler and Kemp 1979; Kuenzler and Craig 1986). Gilliam et al. (1974) found ground water nitrate concentations to be higher under cultivated and fertilized fields than from unfertilized woods. A study in four watersheds of the Little River in the Georgia Coastal Plain (Lowrance et al. 1985) showed that two watersheds with more agricultural land had consistently higher loads of N, K, Ca, Mg, and Cl in streamflow, and had NO_3-N loads 1.5 to 4.4 times higher than loads from two less-agricultural watersheds. Agricultural nonpoint sources are a major contributor to nutrient loading to some stream systems (Kemp 1949; Scheuler and Kemp 1979; Kuenzler and Craig 1986).

Forested floodplains can be effective filters for nutrient materials in lateral runoff and ground water. A 50-m-wide riparian forest in an agricultural watershed near the Chesapeake Bay in Maryland removed about 89% of the nitrogen and 80% of the phosphorus that entered the forest from upland runoff, ground water, and bulk precipitation (Peterjohn and Correll 1984). Correll (1987) concluded that protection and proper management of riparian forest buffer strips between cropland and urban areas along the first order streams in the watershed of Chesapeake Bay would prevent most of the nitrate from these watershed sources from being discharged into the bay. Kuenzler et al. (1980) reported a significant retention of phosphorous by a coastal plain floodplain swamp in North Carolina. Other studies have provided evidence that forested riparian floodplains reduce sediment and phosphorous loads in adjacent streams (e.g., McColl 1978; Schlosser and Karr 1981a,b). The same general conclusion that forested floodplains effectively reduce levels of nutrients from agricultural lands to receiving waters has been reached as a result of numerous studies (e.g., Lowrance et al. 1983, 1984a,b,c; Correll et al. 1984, 1986; Cooper et al. 1986; Peterjohn and Correll 1986; Schnabel 1986; Gilliam et al. 1988; Correll and Weller, in press).

SUMMARY AND CONCLUSION

Palustrine wetlands of forested riparian floodplains were defined as freshwater wetlands that are coupled to upland watersheds and to adjacent streams. Coupling between the floodplain and the watershed forms a continuum. Coupling to the associated stream is via a "water bridge," at least during flooding and generally during the growing season. The associated stream forms a continuum to downstream aquatic systems. This openness of a stream corridor ecosystem strongly suggests that a systems approach be taken in the examination of the relationship between wetlands of forested riparian floodplains and fishery resources. Numerous studies show that many species of fish and several species of shellfish use palustrine wetlands of forested riparian floodplains, but few studies have been made to quantify the value of these wetlands to fisheries production. Fish yields to man by many of the major river floodplains of the world have been estimated to be 4,000 to 6,000 kg/km^2/year/maximum area flooded (Welcomme 1979). In the United States, few if any floodplain fisheries are fully exploited, and fish production on floodplains has not been adequately quantified. The average annual harvest of fish and shellfish from floodplains in Louisiana has been estimated to be as high as 8,797 kg/km^2 (Lambou 1984).

It is generally known, but not sufficiently quantified or substantiated, that palustrine wetlands of forested riparian floodplains import, store, produce, and recycle materials used in food chains _in situ_ by numerous organisms, including many species of fish. In most, if not all of these wetlands, some residual materials are exported to downstream aquatic systems where the materials are available for use in food chains of fish. Thus, palustrine wetlands of forested riparian floodplains may be used by fish for feeding, spawning, nursery and rearing habitat, or as a source of materials used in food chains at downstream sites. This openness emphasizes that one of the fundamental functions of wetland primary production is providing energy flow to detrital food webs. Detritus-based food webs add stability to aquatic systems by making the seasonally fixed photosynthetic energy available to fish, shellfish, and other consumers over longer periods of time and at sites remote from where the detritus was produced.

All wetlands exist as a result of hydrologic regimes. Food chain support, openness, productivity, species diversity and structure, and nutrient cycling are some of the important characteristics of forested floodplains that respond to hydrologic regimes. Buffer strips of forested riparian wetlands effectively reduce levels of nutrients and possibly levels of pesticides from agricultural lands reaching receiving waters. The importance of the relationship between the stream hydroperiod and floodplain is undeniable. If either is altered the other will surely change. For example, stream channelization or stream impoundment may or may not reduce wetland area on the adjacent floodplain, but either activity may drastically alter the quality and quantity of the wetland by altering its hydroperiod. Timing, magnitude, and duration of flooding are the primary determinants of floodplain structure and function. We have gained a considerable amount of insight on how palustrine wetlands of forested riparian floodplains function. However, more information is required to help ensure that these wetlands are managed in a manner that provides the greatest benefits to society. Three research topics that need immediate attention are (1) trophic relationships between fish communities of the wetland and associated streams and estuaries, (2) relationships between watershed land use and the wetlands, and (3) the effects of hydrology (i.e., timing, extent, duration, and frequency of flooding) on ecological processes (i.e., productivity, nutrient cycling, food chain support, and species diversity and structure) in the wetland. Research in each of these areas should lead to better guidelines for protecting and managing palustrine wetlands of forested riparian floodplains and the fishery resources that these wetlands sustain.

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16. Abstract (Limit: 200 words)

This literature review should help fishery, wetland, and water resource managers focus on management approaches and research for the identification and mitigation of wetland impacts and on the importance of wetlands to fisheries. Wetlands and their attendant fisheries exist as a result of hydrology. Productivity, species diversity and structure, and nutrient cycling are wetland characteristics that respond to hydrologic regimes. Anthropogenic changes often appear subtle but can result in ecological catastrophes. Deterioration of hydrologic regimes of these wetlands is likely to reduce habitat quality or quantity and may block fish access. Wetland-related fishery resources should be given high priority when regulated stream flow, channelization, diking, and watershed practices are being evaluated.

17. Document Analysis a. Descriptors

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b. Identifiers/Open-Ended Terms

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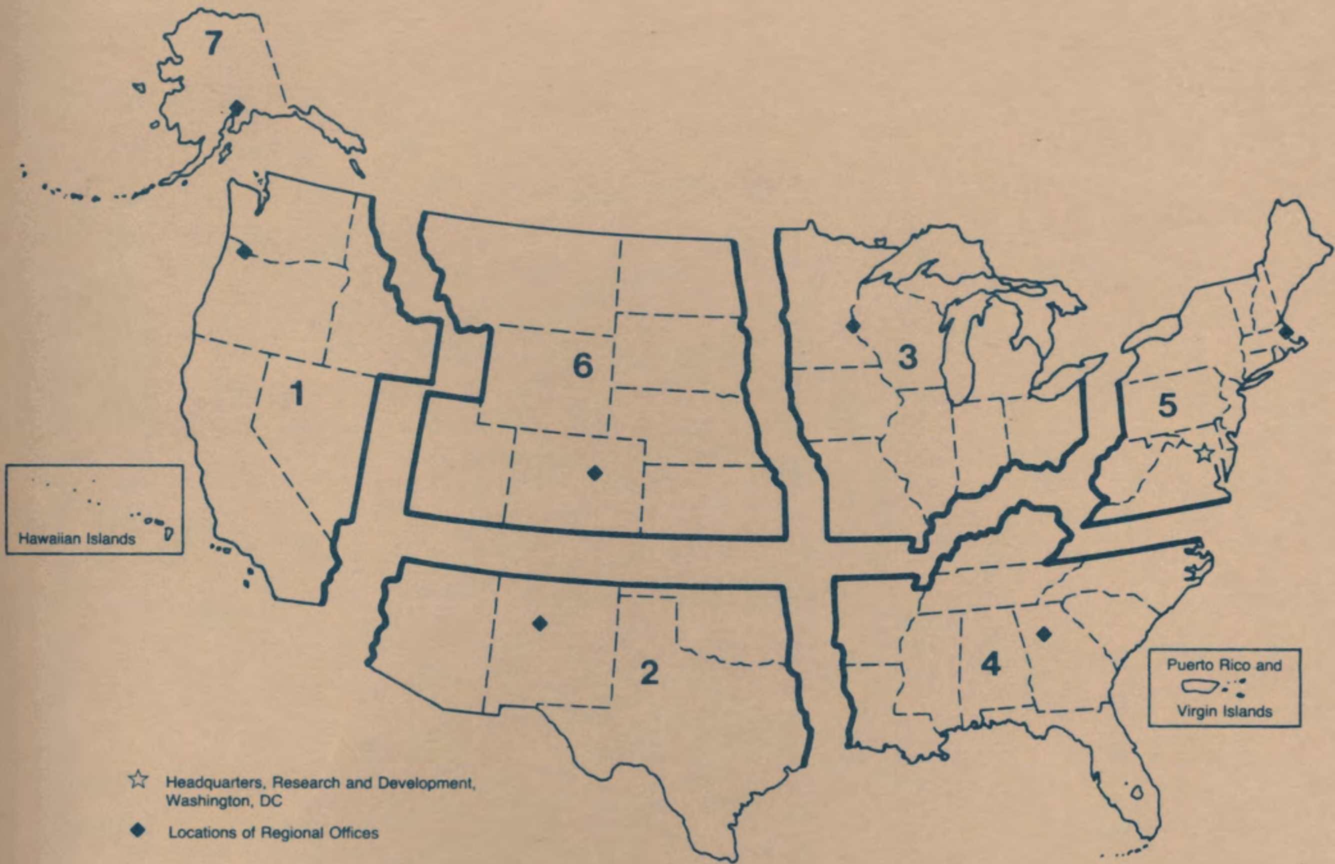

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