APPENDIX C

RIPARIAN ECOSYSTEMS: RESOURCE VALUES AND CONFLICTS WITH EMPHASIS IN THE MATANUSKA-SUSITNA BOROUGH

by
Dan Rosenberg

Alaska Department of Fish and Game
Habitat Division Region II
333 Raspberry Road

Anchorage, Alaska 99502

October 1983

TABLE OF CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

This report describes the values of riparian ecosystems and how these values are a result of complex interactions between riparian vegetation and aquatic systems. Impacts from land use activities and management practices can interrupt the functions of riparian ecosystems, diminishing their value. By understanding how and why riparian ecosystems are so valuable and using management practices that maintain these values, the public can continue to derive social and economic benefits from the riparian ecosystems.

Riparian ecosystems consist of a water body (river, stream, lake, etc.) and adjacent plant communities that are influenced by the presence of that water. Along rivers and streams riparian ecosystems, which include vegetation communities, streambanks, and the stream channel, are generally located within the riverine floodplain.

Ecological processes within riparian ecosystems result in high abundance, diversity, and production of wildlife. Floodplains, for example, provide important habitat for moose, birds, and furbearers. Overwinter survival of moose often depends on the availability of riparian vegetation, which also determines the quality of aquatic habitats for fish and functions as a buffer zone, providing a mechanism for flood control, pollution abatement, erosion control, streambank stabilization, ground water recharge, and the maintenance of water quality. Riparian lands attract and support many recreational, subsistence, and educational activities, including hunting, fishing, trapping, camping, and nature study.

Impacts from developmental activities (agriculture, grazing, settlement, forestry, oil and gas, mining, and road construction) alter ecological processes and have been responsible for degrading riparian and aquatic environments and reducing or eliminating existing resources and amenity values.

Soil erosion, water pollution, habitat loss, reduction in fish and wildlife populations, and loss of public recreational and private economic opportunities are often the consequences of developmental impacts. Development in or adjacent to riparian ecosystems has resulted in public expenditures of billions of dollars for water quality restoration, habitat rehabilitation, and disaster relief from flooding. Non-structural approaches (buffer zones) are the best managerial solutions for preventing riparian land and water degradation and maintaining a productive resource.

When river corridors come under multiple ownership, conflicts arise between landowners and public users. Trespass is the most serious riparian land owner-user conflict. Lack of public access results in overuse of the few available sites, increasing trespass, creating litter problems, and causing habitat degradation. Most riparian property owners oppose easements for regulating use and development, and they also oppose public agencies purchasing private riparian lands. In Alaska, many landowner-public user conflicts result from combinations of human population growth, changing landownership patterns, poorly marked access, limited or nonexistent access, and the absence of a clear definition of the rights and limitations of landowners and the public within access easements.

Conversion of floodplain forests and shrublands to alternate land uses has been responsible for making riparian ecosystems among the most severely altered landforms in the nation. In the contiguous 48 states, over 70% of the estimated original coverage of riparian ecosystems has been altered or eliminated. Recognizing the functions and important public benefits derived from riparian ecosystems, and alarmed over the rate of destruction, the federal, local, and state governments and private organizations have begun to exercise control over development in riverine corridors or to acquire private lands to protect riparian values and provide public recreational opportunities. Regulatory legislation, zoning, conservation easements, tax incentives, establishment of riverine corridors, and fee-simple acquistion of land are some methods currently being used to protect riparian ecosystems. Millions of dollars have been spent by Alaska, California, Oregon, Washington, and Idaho to purchase riparian lands for public access and fish and wildlife habitat protection.

INTRODUCTION

With an expanding population and ever growing demand for the use of Alaska's resources, the need for public awareness and planning in allocating resources is becoming increasingly important. This is especially so in Southcentral Alaska, the most rapidly developing area in the state.

Riparian ecosystems are one resource whose ecological, social and economic values to the people of Alaska must be recognized. In order to manage and maintain riparian river and stream ecosystems to best serve the public interest, the functions and values of the resource must be understood. It is the intent of this paper to develop an understanding of the relationships existing between river and stream ecology, riparian lands, fish and wildlife needs and the human uses and demands for these resources.

Riparian ecosystems are a highly productive public resource. They support a greater abundance and diversity of fish and wildlife than surrounding habitats. No ecosystem is more essential to the survival of the nation's fish and wildlife resources than riparian ecosystems (Council on Environmental Quality 1978). These high fish and wildlife values provide numerous recreational opportunities as well as jobs, both locally and regionally. The Council on Environmental Quality (1980) predicts that as travel becomes more costly, lakes and rivers near major population centers will provide even more important recreational opportunities. Any conflicting uses of riparian ecosystems must be weighed against the resource's inherent values and be designed to best maintain those values.

Allocating land and water in riparian ecosystems among various users and assessing the ecological, social, and economic impacts of such allocations are of great concern. How these resources are apportioned and managed will determine their future value to fish and wildlife productivity and its associated activities. Riparian ecosystems require only protection for them to yield consumables such as floodwater storage, water quality maintenance, and products from fish, wildlife, and timber.

Definition

Duff (1980) defines riparian ecosystems as wetland ecosystems that have a high water table because of proximity to an aquatic ecosystem such as a river or lake or to subsurface water. Plant species composition reveals the influence of the surface water (Franklin and Dyrness 1973).

Riparian ecosystems are distinguished by a linear band of distinct vegetation and soil characteristics situated between aquatic and upland ecosystems (Brown et al. 1978). Moisture requirements of riparian plant communities exceed those of adjacent upland ecosystems. Communities depend on high water tables or overbank flooding, which may vary from extended periods of seasonal flooding to periodic rises in subsurface ground water (Hirsch and Segelquist 1978). Plant communities may range from only a few meters wide along stream banks to several miles across in the floodplain of larger rivers. Riparian vegetation is usually dominated by trees or shrubs. The structure and function of these plant communities is primarily determined by the physical aspects of flooding, water flow, and the lateral transport of nutrients and sediments by the aquatic ecosystem.

Riparian communities are not restricted to river and stream systems. Thomas et al. (1979) divides riparian communities into standing water (lentic) habitats along the shorelines of lakes, ponds, and the periphery of bogs, and running water (lotic) habitats along rivers, streams, and springs. Lentic habitats often occur within the riverine floodplain.

For this report, the following definition will apply:

> Riparian ecosystems are composed of 1) plant communities along rivers and streams and around lakes, ponds, springs, or bogs, whose vegetative structure and function is primarily determined by influences from the adjacent aquatic system, including a high water table or overbank flooding, and 2) the adjacent aquatic system. Along rivers and streams, riparian plant communities are those located within or adjacent to the boundaries of the active floodplain.[1] These occur within or are often synonymous with the riverine corridor.

Vegetation types are not a good indicator of flood hazard (Miller 1982). The Soil Conservation Service has found that in most cases there are no measureable differences between plant life in the floodplain outside the three-to-five-year flood event. Vegetation in a floodplain that is flooded by a 10-year event will be the same as that flooded by a 25-year or 100-year flood.

Attributes of Riparian Ecosystems

The importance of riparian ecosystems to fish and wildlife and associated human activities cannot be overestimated. Riparian ecosystems maintained in a healthy condition should be recognized as a valuable natural resource and a legitimate land use. The following, modified from Duff (1980), lists several of the most important values of riparian ecosystems:

1.) Riparian vegetation regulates the nutrient input to aquatic ecosystems, thus determining the quality of aquatic habitat for fish resources.

2.) The structural diversity and complexity of riparian vegetation supports greater numbers and diversity of terrestrial wildlife populations than any other habitat.

3.) Riparian ecosystems support vegetative buffer zones that provide flood control, pollution abatement, erosion control, stream bank stabilization, ground water recharge and the maintenance of water quality;

4.) Riparian ecosystems attract and support many recreational, subsistence, and educational activities, including hunting, trapping, fishing, camping, photography, and nature study.

---

[1]Active floodplain: The flood-prone lowlands and relatively flat areas adjoining inland and coastal waters, including contiguous wetlands and floodplain areas of offshore islands; this will include, at a minimum, that area subject to a 1% or greater chance of flooding in any given year (100-year floodplain).

5.) Riparian ecosystems have a high aesthetic value due to the combination of water, land, attractive and unique vegetation types, and abundant fish and wildlife populations.

FUNCTIONS OF RIPARIAN VEGETATION

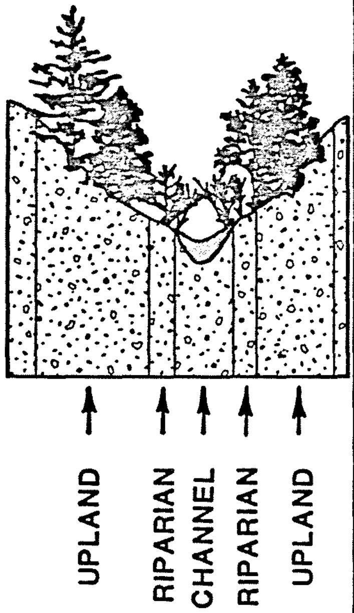
Fish Habitat

Fish habitat is directly related to and highly dependent on the conditions of the surrounding watershed, especially the adjacent riparian zone (Duff 1980, Merrit and Lawson 1978). The quality of the aquatic system is a result of the interaction between riparian vegetation, the stream/river channel, the water column, and the streambank (Platts 1982). By influencing water temperature, rate of flow and fluctuation in discharge, and available cover these determine the productivity of the fishery. Adverse alterations in riparian vegetation will affect the quality and quantity of fish habitat and may cause a decline in production.

The functions of riparian vegetation as they relate to the aquatic ecosystem are presented in Figure 1. Riparian vegetation reduces erosion and thus bedload sediment by controlling surface runoff and stabilizing streambanks. An increase in bedload sediment would interfere with intergravel waterflows and decrease oxygen available to incubating fish eggs and alevins. Stream bank erosion is a normal occurance but must be maintained in equilibrium with the buildup of new banks. Problems begin when this balance is upset. Vegetation slows overland water flow and traps sediment, building new stream banks and minimizing damage to the river channel and bank during periods of high flows. Burger et al. (1982) found that areas along the Kenai River, Alaska, with bank irregularities and overhanging vegetation resulted in higher catch rates of juvenile chinook salmon (Oncorhynchus tshawytscha). Greater numbers and higher frequencies of juvenile Coho Salmon (O. kisutch) were captured in the Susitna River in areas with emergent or aquatic vegetation and/or overhanging or deadfall cover (ADF&G 1983). Overhanging banks and vegetation provide fish with protective cover as do some submerged snags and boulders. Platts (1982) cites several studies that document the importance of cover to fish. Salmonid abundance declines as stream cover is reduced; as cover is added it increases. The removal of vegetation causes a reduction in bank irregularities and a tendency toward a smooth straight channel. Along with this goes an increase in water velocity and a reduction in cover and thus a loss of habitat.

By providing shade, vegetation maintains suitable water temperatures for fish, incubating eggs, aquatic plants, and invertebrates (Duff 1980). Hynes (1970) states that water temperature is one of the four most important abiotic factors in fish production. Temperature changes can affect the metabolic rate of fish, change the dissolved oxygen content in the water, and influence hatching success. Shaded streamside areas are a preferred habitat of juvenile salmonids (Platts 1982).

Riparian vegetation contributes to primary stream productivity by supplying the aquatic system with plant and animal detritus and nutrients that provide the basic components of the food chain (Meehan et al. 1977). Evidence suggests that organic detrital input into forested streams may support over 99 percent of the annual energy requirements for primary consumer organisms



RIPARIAN VEGETATION

SITE	COMPONENT	FUNCTION
above ground above channel	canopy & stems	1. Shade–controls temperature & in stream primary production 2. Source of large & fine plant detritus 3. Source of terrestrial insects
in channel	large debris drived from riparian veg.	1. Control routing of water and sediment 2. Shape habitat–pools, riffles and cover 3. Substrate for biological activity
streambanks	roots	1. Increase bank stability 2. Create overhanging banks–cover
floodplain	stems & low lying canopy	1. Retard movement of sediment water and floated organic debris in flood flows

Figure 1. Functions of riparian vegetation as they relate to the aquatic ecosystem. Adapted from Meehan et al. (1977).

(Fischer and Likens 1973). Organic debris supplies a food source to many aquatic invertebrates important in the diet of many fish. Riparian vegetation is also a supplier of terrestrial insects to the aquatic ecosystem. Vegetation along the Kenai River appears to supply food items to juvenile chinook salmon (Burger et al. 1982). Kennedy (1977) reports that 54 percent of the organic matter eaten by fish from the Missouri River is of terrestrial origin.

By its ability to absorb runoff, the riparian community can provide groundwater recharge to the aquatic system during periods of low flow, increasing available habitat to rearing fish. Absorbing surface runoff also mitigates high flows, reducing erosive forces.

Moose Habitat

Quality, quantity, and accessibility of riparian vegetation is absolutely essential for maintaining stable moose (Alces alces) populations. Good moose range consists of a complex of river bottomlands and adjoining lowlands and sub-alpine foothills (Alaska Department of Fish and Game 1973). For moose populations, riparian lands play a critical role in overwinter survival. During winter months, especially years of deep snow, subpopulations of moose travel distances up to 25 miles (40 km) from extensive areas to riparian communities along the Susitna River (Modafferi 1982). Here snow is less deep and food more accessible. During harsh winters river bottoms become yarding areas for high densities of moose. The areal extent and condition of riparian vegetation ultimately determine at what level moose populations will persist in a given area (LeResche et al., no date).

Numerous drainages in the Matanuska-Susitna-Beluga study area provide important winter habitat for moose (Table 1). On November 16, 1982, Bill Taylor (Alaska Department of Fish and Game, pers. comm.) counted 101 moose in riparian vegetation along Alexander Creek between the confluence of the Susitna River and Lower Sucker Creek. Aerial surveys flown between Mt. Susitna and Mt. Beluga reveal large numbers of moose in riparian drainages. Between Upper Sucker Creek and Bear Creek during the same years, early winter counts varied from 134 to 146 moose. Few other areas have been surveyed extensively.

While the number of moose in riparian communities increases markedly during winter months, year-round use is still significant. Along the Susitna River below Talkeetna, some moose use riparian areas for the entire life-cycle. A large majority (up to 90 percent) of the lower Susitna River moose are found between Montana Creek and Cook Inlet. Above Talkeetna, females migrate to riparian areas for calving (Modafferi 1982).

Movements between seasonal ranges often follow traditional migration routes. There are east-west movements of moose into the river valleys as well as movements parallel to the river corridor. Disruption of migration routes may cause a significant increase in mortality.

The natural seasonal variation in water flow, the frequency and magnitude of flooding, and ice and wind action create a shifting pattern of plant communities in the floodplain. This is most important in the creation and maintenance of primary and early successional plant communities such as willow shrublands. These, along with the understory vegetation of some later seral stages, provide important browse species. Horsetail-willow and horsetail-balsam poplar (cottonwood) plant communities provide substantial forage for moose, as do mature and decadent balsam poplar and birch-spruce stands. The extensive areal cover of the latter two communities makes them a major food resource for moose living in the floodplain of the lower Susitna River (McKendrick et al. 1982).

TABLE 1. Drainages that Provide Important Moose Wintering Habitat in the Matanuska - Beluga - Susitna Study Area. Additional Drainages may Provide Important Winter Habitat but no Information is Available.

Susitna River
Little Susitna River
Alexander Creek and Sucker Creek
Talachulitna River
Yentna River
Skwenta River
Kahiltna River
Twenty-mile slough
Moose Creek, Deshka River, Kroto Creek, Twenty-Mile Creek
Lewis River
Theodore River
Beluga River
Tokositna River (between Home Lake and Bunco Lake)
Lake Creek
Talkeetna River
Oshetna River
Little Oshetna River
Little Nelchina River
Tyone River
Tyone Creek and tributaries
Mendeltna Creek
Watana Creek
Maclaren River
Nenana River
Coal Creek
Fog Creek
Sanona Creek
Brushkana Creek
Tsusena Creek
Goose Creek
Clear Water Creek
Jay Creek
Butte Creek
Deadman Creek
Kosina Creek

SOURCES: R. Modafferi, 1982, pers. comm.; J. Didrickson, 1982, pers. comm. D. Bader 1983, pers. comm. Adapted from ADF&G, Habitat Division, Comments on Proposed Cook Inlet Oil and Gas lease sale #40, 1982.

The major factors currently causing declines in study area moose populations are habitat-related; loss or alteration of riparian moose habitat will seriously exacerbate the situation.

Furbearers

Beavers (Castor canadensis), muskrats (Ondatra zibethica), mink (Mustela vison) and river otters (Lutra canadensis) occur throughout the Susitna River drainage along rivers, streams, and around lakes and ponds. All are dependent upon riparian ecosystems throughout their life-cycle. All being furbearers, they are sought by trappers for the value of their pelts.

Beavers. Beavers are restricted to freshwater aquatic habitat bordered by riparian vegetation. They are found throughout the Susitna drainage from sea-level to 3,100 feet (1,000 meters) (Terrestrial Environmental Specialists, Inc. no date). The extent of habitat use is a function of the rate of water flow, water depth, fluctuations in water depth, ice depth, ice scouring, and the characteristics of channel bottoms, streambanks, and riparian vegetation (Gipson 1983). Boyce (1974) found beavers in Alaska favoring lakes or slow-flowing streams bordered by sub-climax stages of shrubs and mixed coniferous and deciduous forests. Densities of lodges in Interior Alaska were positively correlated to habitats high in balsam poplar (Populus balsamifera) and willows (Salix spp.). Shifting river channels create an environment conducive to the natural regeneration and colonization of balsam poplar (Gill 1972) and willow. Beavers prefer a seasonally stable water level and abandon colonies when flows become too low (Collins 1976). Fancy (1982) considers the water depth under the ice to be the major limiting factor for beavers in the floodplain. Beavers are generalized herbivores (Jenkins 1975), but primary food is the bark of aspen (P. tremuloides), willow, cottonwood (P. trichocarpa), balsam poplar, birch (Betula spp.) and sometimes alder (Alnus spp.) (Konkel et. al. 1980). In Alaska, willow is the most stable food source, although not necessarily the preferred food (Murray 1961).

Boyce (1974) found beavers foraging up to 195 feet (60 meters) from the water's edge. Slough and Sadleir (1977) report beavers foraging up to 650 feet (200 meters) from water; 90% of all cuttings were done within 98 feet (30 meters) of the water's edge.

In modifying habitat through damming, beaver impoundments not only improve their own habitat but provide aquatic and riparian wildlife habitat for other species. Damming creates ponds that provide feeding, staging, and brood-rearing habitat for waterfowl (Hair et al. 1978, Yeager and Rutherford 1957), improves range for moose (Yeager and Rutherford 1957), and provides rearing habitat for juvenile salmonids. Hakala (1952) reports that extensive willow growth in the Susitna River moose range is the direct result of beaver activity. Beaver ponds also stabilize watersheds, reducing flooding and sedimentation.

Beavers are one of the major furbearers sought by trappers in the Susitna basin, including the Susitna River, its tributaries, and large lakes such as Stephan's Lake (Terrestrial Environmental Specialists, Inc. no date). Beavers are one of the few furbearers that readily provide for non-consumptive use such as viewing, photography, and nature study (Alaska Department of Fish and Game 1980).

The most significant factors affecting beaver populations are habitat destruction and overtrapping. Concentrated trapping efforts near settlements and along roads can result in depletions of local populations. In Southwest Alaska beavers are five times as abundant in remote areas compared to areas near villages (Alaska Department of Fish and Game 1980). From 1850-1900 beavers were almost eliminated from southeastern United States by the effects of overharvest and habitat loss due to clearing land for agriculture (Hair et al. 1978). Roads, railways, and land clearings invariably follow waterways and are a major limiting factor to beaver habitat suitability. Artificial water regulation with manmade dams can produce severe water fluctuations, decreasing the capability of many areas to support beavers (Slough and Sadleir 1977). Small streams are the most susceptible to change in flow rates, sedimentation, and alteration of riparian vegetation (Hair et al. 1978, Terrestrial Environmental Specialists, Inc. no date).

Mink. In the Susitna basin, mink occur along all major tributary creeks of the Susitna River below 4,000 feet (1,200 meters) (Gipson 1982). In Southcentral Alaska, mink are highly dependent on riparian plant communities and are most commonly found near streams, ponds, marshes, and fresh or saltwater beaches (Alaska Department of Fish and Game 1976). Movements are largely restricted to shoreline areas. Schladweiler and Storm (in Brinson et al. 1981) report the primary zone of activity is within 230 feet (70 meters) of a stream. Mink infrequently range out to 600 feet (180 meters) from a stream. Mink have large home ranges and may cover an area up to three square miles (7.7 km^2) (Banfield 1974, in Konkel et al. 1980).

There appears to be some correlation between the size of the mink population and the size of the salmon run for areas on the Kenai Peninsula (Alaska Department of Fish and Game 1976).

Mink do not construct their own dens but generally rely on vacated or appropriated dens of other furbearers, or they use naturally occurring cavities in channel banks, drift piles, or fallen trees (Konkel et al. 1980). Natal dens are generally located near water.

Human development along rivers may be detrimental to mink (Alaska Department of Fish and Game 1976). Disturbance by heavy machinery and recreational vehicles along streambanks causes damage to the denning habitat of mink (Burns 1964 in Konkel et al. 1980).

For more information on impacts to furbearers see Agricultural Impacts - stream channelization, page 12.

IMPACTS OF LAND USE ACTIVIES

Riparian zones occupy relatively small areas and are vulnerable to severe alteration. Past and continuing degradation of riparian ecosystems has resulted in conditions that are detrimental to fish and wildlife populations. Native fish and wildlife resources are dependent upon the maintenance of natural conditions. The removal of riparian vegetation, the debasement of both water quality and quantity, and the alteration of stream morphology will reduce fish productivity, resulting in economic losses to the commercial fishery, increase conflicts between sport fishermen and commercial fishermen, reduce sport fishing opportunities, cause a decline in wildlife populations, with a consequent loss of hunting opportunities, effect the loss of other water-associated recreational activities and of aesthetic and economic values. By 1983, approximately $275 billion will have been spent in an effort to clean up the nation's rivers (Warner 1982).

Because many of the state's fish and wildlife species are dependent on riparian areas or use them disproportionately more than other habitat types, and because riparian areas are a major recreational attraction, protection of these areas should be a high priority. "Habitat rehabilitation must never be viewed as a substitute for habitat protection" (Reeves and Roelofs 1982).

To effectively manage and protect riparian ecosystems, development-related impacts to these systems must be understood. The impacts of alternate land uses and related activities (agriculture, grazing, forestry, mining, settlement, oil and gas, roads) should be weighed against the existing values provided by riparian systems. By understanding the habitat needs of fish and wildlife and the impacts from development, management guidelines for a particular land use can be implemented that will allow development to occur in a location and manner having minimal effects on the existing natural resources. We must, however, be aware of the fact that an accumulation of relatively small impacts can severely weaken the ecological integrity of natural systems through interacting and cumulative effects (Karr and Dudley 1981).

The best management practice to protect riparian ecosystems is to leave a buffer strip of natural vegetation along or around a waterbody. This buffer strip should be retained in public ownership and be of sufficient width to protect water quality, and quantity, provide terrestrial habitat, including food and cover to a high diversity of wildlife species, and provide a variety of recreational and subsistence opportunities without causing conflicts among user groups.

Agriculture

The effects of agricultural development in Alaska are expected to be similar to those of other activities causing large-scale changes in vegetation and land use, e.g. timber harvest, residential development, mining, and oil and gas development. The same attributes, nutrients, soils, and water that make riparian lands productive for wildlife are also attractive to agriculture. As with many other developmental activities, the impacts of agriculture on riparian systems are often complex and subtle. The direct loss of wildlife habitat from large-scale land clearing is perhaps the most obvious impact. The impacts to the aquatic system, which are essentially secondary effects of land clearing, are at first much less apparent but have far-reaching consequences. The removal of riparian vegetation modifies stream flow rates, water temperature, water chemistry, and natural erosion rates. The closer to the stream channel the vegetation is removed, the more pronounced the effect from land clearing (Fig. 2).

Water quality. In the United States, cropland is the greatest single cause (contributor to) of excessive stream sediment (McCorkle and Halver 1982). Cropland yields four times more sediment to public water than any other erosion source (Clark 1977). Aldrich and Johnson (1979) report that in Interior Alaska, removal of ground cover increased erosion 18 times above that on forested lands. Wolf (in Cordone and Kelley 1961) considers siltation created by agricultural practices to be the real cause for the extinction of stocks of Atlantic salmon. The detrimental effects of increased sedimentation to populations of salmonids and the aquatic life of streams has been reviewed by Cordonne and Kelley (1961) and Hall and McKay (1983).

Sediment deposited in stream gravels may be detrimental to the survival of eggs, alevin, and fry. Sediment deposited in the streambed may decrease the permeability of spawning gravels and block the interchange of subsurface and surface waters. Egg, embryo, and fry survival may decrease because of oxygen depletion, fungal infection, and delayed and impaired emergence. Sedimentation may inhibit production of aquatic plants and invertebrate fauna. Eliminating habitat for aquatic insects reduces available food sources to rearing and resident fish.

Water pollution from agriculture is often diffuse (nonpoint) in nature and therefore difficult to identify and control (Clark 1977). Sixty-eight percent of the basins in the United States report water pollution caused by agricultural activities (McCorkle and Halver 1982). The use of fertilizers, insecticides, pesticides, and fungicides adds nutrients and toxic chemicals to the aquatic system. Carcinogens found in the drinking water of New Orleans, which draws its water from the Mississippi River, originated with industrial and agricultural pesticides (Tripp 1979). Feedlots, often located along rivers and streams, have for many years introduced untreated animal wastes directly into surface waters (Clark 1977). Rummel (1982) lists the potential effects of agricultural development on primary water quality in Alaska. These include

- changes in temperature;
- increased suspended load;
- increased sedimentation;
- decreased light transmission;
- changes in pH;
- decreased concentration of dissolved oxygen;
- increased concentration of specific compounds containing nitrogen and phosphorus (plant nutrients including nitrates);

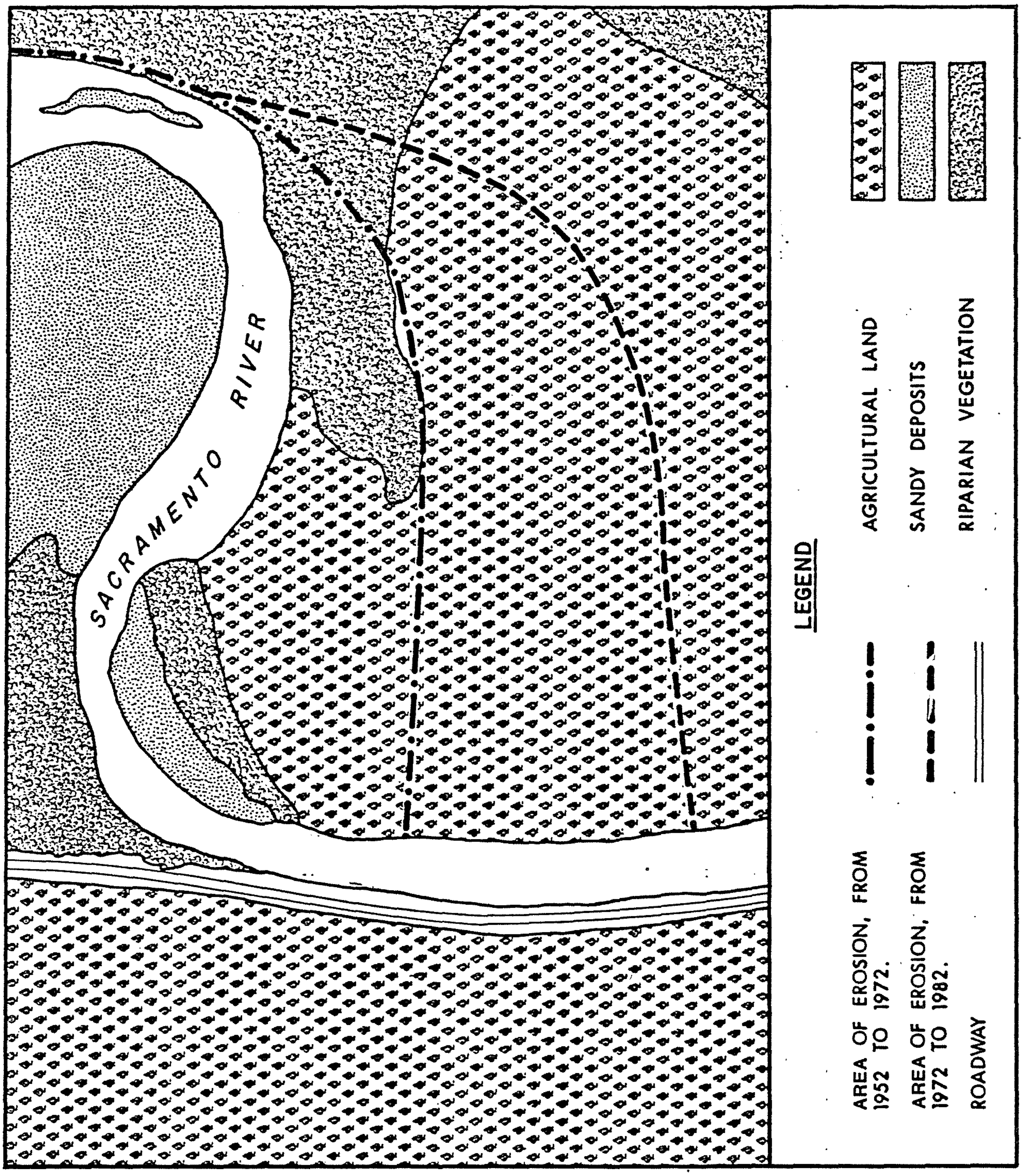


Figure 2. Extent of soil erosion from conversion of riparian forests to agriculture along the Sacramento River, California from 1952 to 1982. From McGill, 1975 and McGill (pers comm) 1983.

- introduction or increased concentration of pesticides, including herbicides, fungicides, and insecticides; and
- propagation of pathogens, as indicated by fecal coliform bacteria.

The Alaska Water Quality Standards (18 AAC 70) specify limits for primary water quality effects. Primary effects are responsible for secondary water quality effects, which cause changes in plant and animal communities, potability, and recreational potential (Table 2).

TABLE 2. Potential Primary and Secondary Water Quality Effects Resulting from Agricultural Practices in Alaska (adapted from Rummel 1982)

Primary Effects	Secondary Effects		
	Plant & Animal Communities	Drinking Water Supply	Recreational Potential
CHANGES IN TEMPERATURE	increased biological production to a limit; then decrease	--	warmer surface waters in summer
INCREASED SUSPENDED LOAD	interference with benthic invertebrates (fish food) and fish development	interference with water supply requiring filtration	--
INCREASED SEDIMENTATION	decreased reproductive success of anadromous fish from clogging of spawning beds	--	--
DECREASED LIGHT TRANSMISSION	decreased primary production; interference with food finding	--	muddy appearance of surface waters
CHANGES IN pH	some physiological effects	may require treatment of supply water	--
DECREASED DISSOLVED OXYGEN	decreased fish production; decreased growth in fish developmental stages	--	--
INCREASED NITROGEN AND PHOSPHORUS	increased growth of nuisance plants	contamination of water supplies from nitrates and nitrites	--
INCREASED CONCENTRATIONS OF PESTICIDES	wide variety of effects; from changes in behavior of aquatic organisms to developmental defects to death	contamination of water supplies	--
PATHOGENS	propagation of disease	propagation of disease	propagation of disease

Water quantity. Converting riparian forests to cropland or pasturelands leaves comparatively little vegetation or ground cover to intercept rainfall or retard surface runoff. Consequently, after rain or during snowmelt, floods will be more frequent and larger. As surface runoff increases, the relative amount of water that reaches underground reservoirs decreases. During low flows, streams are largely supplied with water from these subsurface resources. In addition, ground water modifies water temperature extremes, reducing ice thickness in winter and maintaining cooler temperatures in summer. Gosselink et al. (in McCorkle and Halver 1982) estimate that riparian forests of the Mississippi River alluvial floodplain historically had the capacity to store a volume of water equivalent to 60 days of river discharge. With land clearing, river channeling, and construction of levees this capacity has been reduced to 12 days. River stages are now higher for a given discharge during floods and lower during low water periods. Larger channels created during periods of high flow have an insufficient volume of water to fill the channel during low flows.

Agriculture is the largest single user of water in the United States. In the 17 western states, irrigation accounts for about 90% of freshwater use (McCorkle and Halver 1982). Withdrawals of water, whether directly from lakes and streams or indirectly from groundwater sources, will compound the problems previously discussed. Impacts will be greatest on small streams and lakes. Pumping ground water for crop irrigation has resulted in some streams losing their value for trout fishing (White, Hunter, in McCorkle and Halver 1982). The largest cause of losses of anadromous and resident fish in western streams is from lowered stream flows due to diversion of water for irrigation (National Wetland Newsletter 1982).

Stream channelization, impoundments, and dikes often accompany agricultural development. Following flood protection, farmers often remove riparian vegetation to plant more crops. Construction of flood control works and dams along California's Sacramento River System in the past 50 years has contributed significantly to the loss of riparian forests, and the number of king salmon spawning in the upper river has decreased by 50% (Burns 1978). The major consequences to aquatic systems from channelization include loss of spawning substrate, removal of instream cover, loss of instream vegetation, loss of streamside vegetation, loss of run-riffle-pool sequences, loss of overall stream length, increased gradient and velocity, draining of adjacent lands, physical and chemical changes in the stream, and decreased detrital input (Simpson et. al. 1982).

Stream channelization and its secondary effects decrease wildlife productivity and reduce populations appreciably. Alteration of streambanks is probably the most significant change affecting furbearers (Table 3). Gray and Arner (in Simpson et. al. 1982) found mink, beaver, and muskrat were all far more abundant along unchannelized stream segments than in channelized areas. After the Kissimmee River in Florida was channelized, the average duck harvest per day decreased from 374 to 50 (Montalbano, in Simpson et. al. 1982). Conversion of riparian vegetation to croplands will eliminate food and cover for moose in important wintering grounds, increase their susceptibility to predators, and eliminate travel lanes. Depredation by moose on agricultural crops may occur. Many of the major negative impacts to wildlife from agriculture, including loss of food and cover, wildlife depredation on crops or livestock, effects of agricultural chemicals on wildlife, and transmission of disease between domestic animals and livestock (Preston 1982), can be expected to be more pronounced in riparian areas because of the higher abundance and diversity of wildlife populations.

TABLE 3. Impacts on Furbearers Resulting from Stream Channelization Projects (from Singleton et al. 1982)

Effect of Channelization	Impact on Furbearers
Loss of woody vegetation (reduced diversity)	- Loss of bank cover - Reduction of roots and "nooks and crannies" for foraging - Decreases furbearer abundance
Bank composition and configuration	- Reduces available bank for foraging - Slope or sand and gravel deposition reduces den sites
Low water levels	- Underwater dens excluded
Reduction of channel snags and debris	- Reduces foraging areas
Reduction or loss of aquatic organisms	- Reduction or loss of food items

To reduce impacts from agricultural activities, setbacks or buffer zones should be required along all water courses to separate tilled land from waterbodies by a vegetated buffer area of specified width. A basic management goal should be that the higher the degree of development, the greater the vegetated buffer provided along water courses (Clark 1977). Depending on the amount of development within a watershed, additional buffer widths must be provided to offset the progressive effects of surface runoff associated with increasing development. Buffer widths required to remove contaminants and sediments from overland flows vary with soil characteristics, slope, climate, time of harvest, amount of cultivated area, type of farm operation, and type of vegetation in the buffer zone. Standard buffer strips for Maine's coastal zone vary between 50 and 110 feet, depending on slope (Table 4).

TABLE 4. Suggested Buffer Strip Widths to Control Sedimentation from Agricultural Practices for the Coastline of Maine (from Clark 1977)

Average Slope of Land Between Tilled Land & Normal High Water Mark (%)	Width of Strip Between Tilled Land & Normal High Water Mark [ft (m) along surface of ground]
0 - 4	50 (15)
5 - 9	70 (21)
10 - 14	90 (27)
15 and over	110 (34)

These are designed solely for purposes of sediment control. Guidelines for buffer zones developed for the United States Agricultural Research Service (Table 5) are also primarily for sediment control.

TABLE 5. Minimum Filter Strips for Cropland Water Quality Restoration Recommended to the U.S. Agricultural Research Service (from Clark 1977)

Slope (%)	Slight Erosion [ft (m)]	Moderate Erosion [ft (m)]	Severe Erosion [ft (m)]
0	30 (9)	35 (11)	45 (12)
10	55 (17)	65 (20)	80 (24)
20	80 (24)	95 (29)	115 (35)
30	105 (32)	125 (38)	150 (46)

Additional widths are required to provide for removal of nitrate and other agricultural chemicals. The minimum effective stream setback for nitrate removal covering most soil, slope, and vegetative conditions is 300 feet (91 meters) (Clark 1977).

Thompson et al. (1979) found that in a 118-foot (36 meters) buffer zone, nearly all of the manure-contributed nutrients present in runoff at the source were removed before reaching the stream. However, the quality and quantity of runoff is dependent upon the season of application, weather conditions, soil, and the amount of manure applied. Manure application in melting snow or just prior to rainfall represents the worst possible case for nutrient outflow.

Buffer strips are not a panacea for sediment control; persistent sediment sources will quickly overwhelm the absorptive capacity of the forest floor when surface pores are clogged by fine sediments (Chamberlin 1982). Buffer strips must also be designed for wind firmness and for providing wildlife habitat, including migration corridors. Therefore, widths recommend for sediment control represent a bare minimum and should be increased substantially to protect both aquatic habitat and terrestrial habitat.

Grazing

Since livestock are attracted to streamsides, overuse of the riparian zone by domestic livestock has often resulted in widespread stream degradation. In the western United States, livestock grazing is the single most important factor limiting wildlife and fisheries production (Platts 1979). Grazing has severely reduced riparian vegetation and altered stream geomorphology, adversely affecting fish and wildlife population. Behnke and Zarn (1976) identify livestock grazing as one of the principle factors contributing to the decline of native trout in the west. There are presently no range management techniques or guidelines short of fencing that can protect riparian vegetation from overgrazing by domestic livestock (Behnke and Raleigh 1978, Meehan and Platts 1978, Moore et al. 1979).

The consequences to fish habitat of changes, reductions, or elimination of riparian vegetation include the reduction of shade and cover, with subsequent increases in stream temperature, changes in stream morphology, and the addition of sediments through bank and off-site soil erosion. Stream-channel sedimentation caused by soil erosion on rangelands has long been recognized as a major problem.

Disturbance of ground cover and soil by livestock trampling has long been recognized as an important factor contributing to accelerated erosion and storm runoff in western forests and rangelands (Moore et al. 1979).

The sloughing and collapse of streambanks caused by improper livestock grazing is probably the greatest impact livestock has on fish populations (Platts 1981). This results in changes in stream morphology, including wider and shallower stream channels and the loss of undercut banks.

Other effects resulting from improper livestock grazing in riparian zones include decreased terrestrial food inputs because of loss of riparian vegetation, lowering of the water table, lack of regeneration of native trees and shrubs, loss of instream cover, and a reduction in fish populations (Behnke and Raleigh 1978, Platts 1981, Haugen and Duff 1982).

Interactions between wildlife and livestock, which may occur regardless of habitat, can be expected to have more pronounced effects in riparian lands because of the attraction of greater numbers of both wildlife and livestock. As determined from a literature review of over 1,200 references and conversations with biologists, Preston (1982) found loss of habitat, elimination of predators by livestock owners, disease transmission from domestic animals to wildlife, and competition for forage to be among the major impacts of grazing. Moose winter range could be severely affected by livestock grazing. In northeast Colorado, Crouch (1982) found significantly greater numbers of all game species in ungrazed bottomlands versus grazed bottomlands.

Settlement

Rivers, streams, and lakes are highly favorable areas for human settlement and frequently provide focal points for community aesthetics, recreation, commerce, and amenities. Nearly all phases of development in riparian areas, including residential developments, roads, airports, and commercial buildings, will affect river, stream, and lake habitat. The presence of native vegetation and the flow of water from the land are the primary factors controlling the condition of riparian ecosystems. Activities that degrade or remove vegetation also degrade the aquatic environment. Ultimately, not only does the local community environment suffer, but so does the environmental quality of downstream communities.

Poorly planned development will result in stream sedimentation. Erosion and run off from parking lots, housing developments, roads, and construction sites, and the use of natural drainages for storm sewers, dumping areas, and gravel extraction often produce high sediment loads. This degrades the capacity of freshwater habitats to support aquatic life. An appropriate level of soil erosion should, in most cases, be in the range of 0-3 tons/acre/year. Housing projects and other developments can produce up to 1,000 tons/acre/year (Johnson 1979).

Excessive nutrient input resulting from domestic sewage and soil erosion may produce large amounts of algae or bacteria in lake and streams. As algae decomposes, it decreases dissolved oxygen levels, promotes growth of bacteria, makes the waterbody less aesthetic, and reduces water quality.

Nutrient input is especially critical in floodplains, where wastes percolate rapidly into stream and groundwater. Public sewer systems often eliminate waste discharge; these are very expensive, however, and often increase the market value of land, offering strong economic incentives for land owners to sell. This often results in more development, thus increasing environmental problems in the long run (Palmer 1981).

Appropriations of water for domestic or industrial use often lower the capacity of freshwater bodies to support fish and wildlife populations. In addition, domestic water sources can become degraded when surface water stagnates and groundwater aquifers are depleted as a result of water withdrawals.

Increased settlement and development along floodplains brings increasing demands for flood control. As natural land surfaces are paved and developed, flood peaks increase and often arrive sooner after storm onset than under pre-developmental conditions (Anderson, in Platt and McMullen 1979). Impoundments, diversion structures, or stream channelization are often the solution. However, these reduce the productivity of both the terrestrial and aquatic system by eliminating habitat, and they encourage further settlement in the floodplain, destroying more wildlife habitat, blocking wildlife migration routes, and creating visual and noise disturbances to wildlife.

Encroachment upon floodplains in the belief they are "protected" sets the stage for heavy losses when floods exceeding the design capacity of flood control structures occur. Additionally, increased development in the floodplain diminishes its value as a natural water storage area, further increasing the magnitude of flood peaks and reducing baseflow water levels in rivers and streams.

The fragmentation of authority in floodplains when land is transferred to multiple owners makes integrated management difficult. Conflicts arise between public users and private landowners and between upstream development and downstream development. Fragmentation of landownership patterns along a river poses some of the most perplexing and least studied issues in floodplain management (Platt and McMullen 1979). Rapid conversion of rural lands to subdivisions has created problems for local governments that have only limited experience with large developments (Palmer 1981). The piecemeal evolution of year-round housing is hard to predict. Through a slow process of single lot development, the amount of building and settlement can become substantial, with impacts on water quality or wildlife habitat that were never expected initially.

Municipalities along the St. Croix River of Wisconsin and Minnesota require all new structures be set-back 200 feet from the normal high water mark. Additionally, no construction of buildings or alterations on slopes greater than 13% is allowed; no buildings are allowed in the 100-year floodplain, and buildings must be set-back 100 feet from bluff lines at the top of steep hills.

Because studies have shown unacceptable amounts of nitrate at distances of 150 feet from septic tank systems (Ketelle, Minear, and Patterson, in Clark 1977), a setback of at least 150 feet from the annual high water mark is required to minimize nitrate pollution. A setback of 300 feet should be required whenever possible because local soil and groundwater conditions may be unsuitable for nitrate removal (Clark 1977). Maine and Wisconsin require the absorption fields of septic tanks to be setback a minimum of 100 feet from surface waters. This allows for the removal of coliform bacteria and other waterborne pathogenic organisms from wastewater. Adequate soil purification removes organisms before they can reach and contaminate adjacent waterbodies.

Forestry

Timber harvest operations cause changes in water and land system processes, which in turn lead to changes in anadromous fish habitat (Chamberlin 1982) and terrestrial wildlife habitat (Tubbs 1980). The closer logging is to the riparian zone, the more severe the erosional impacts and the greater the danger of reducing water quality in the adjacent aquatic zones (Thomas et al. 1979).

Chamberlin's (1982) detailed review of how timber harvesting affects the aquatic habitat was used as a source document for much of this discussion. Gibbons and Salo (1973) have prepared an annotated bibliography with 278 references on the effects of logging on fish of the western United States and Canada.

Loss of vegetation and alterations in terrestrial habitat are a direct result of logging. The magnitude of these habitat changes to terrestrial wildlife depends on the extent and techniques of the logging operation. Habitat alterations can effect changes in bird populations in riparian communities (Stauffer and Best 1980, Tubbs 1980). Cavity-nesters and raptors are especially vulnerable to mature tree or snag removal. Beidelman (in Tubbs 1980) reported a four-fold decrease in spring species and a three-fold decrease in wintering birds in a highly productive eastern Colorado cottonwood-willow riparian community that was logged. Losses of thermal cover, hiding cover, and access to forage areas used by a variety of birds and mammals can result from logging practices (Thomas et al. 1979).

Alteration of vegetation in turn leads to changes in the aquatic system. Forestry, like other land-clearing processes, may substantially change

1) the distribution of water and snow on the ground; 2) the amount of water intercepted, transpired, or evaporated by foliage; 3) the rate of snowmelt; 4) the amount of water that can be stored in the soil or transpired from the soil by vegetation; and 5) the physical structure of the soil, which governs the rate and pathways of water movement to stream channels. Clearcutting can cause storm flow discharges of nine times those of undisturbed watersheds (Fig. 3) (Clark 1977). Impacts to the aquatic system include 1) introduction of surplus organic debris into streams; 2) acceleration of erosion and stream sedimentation; and 3) stream channel modifications.

Increased erosion and sedimentation in streams often results from timber harvests (Swanson and Dyrness 1975). The majority of severe sediment problems are related to road systems, especially where roads cross stream channels (Yee and Roelofs 1980). However, removing tree cover on steep slopes reduces slope stability and may accelerate the movement of soil and excess sediment to the stream.

Tree cutting adjacent to streams has the potential for introducing large amounts of debris. On steep slopes, residual debris can still be transported to main channels years later. Although stable debris contributes to channel stability and habitat variability for both fish and wildlife, excessive amounts impede fish and wildlife movements and in streams may reduce dissolved oxygen levels if fine organic particles accumulate in stream bottoms (Hall and Lantz 1969). Logging and skidding near or across small streams covered by snow or ice are particularly likely to result in fine debris accumulation because operators may be unaware of the stream's location. Debris accumulation also impedes fishing access and generally reduces recreational opportunities in a river. Buffers of vegetation between skid trails and streambanks are necessary to minimize sediment and organic debris accumulation in stream channels (Chamberlin 1982).

Of all riparian ecosystem components, streambanks and stream margins are the most susceptible to direct influences from logging activities. The breakdown and destruction of streambanks by felling and yarding are among the most persistent of direct harvesting impacts, and they are the most difficult to avoid when streamside felling or skidding and cross-stream logging occur (Chamberlin 1982). Tree falling and yarding along streambanks may reduce bank stability, eliminate streamside cover, cause streambank erosion, increase sedimentation, and widen channels. Avoiding logging activities in streamside areas is frequently the only alternative to bank destruction (Chamberlin 1982).

The principal water quality parameters influenced by forest harvesting are temperature, suspended sediment, dissolved oxygen, and nutrients. Removal of streamside vegetation usually increases summer water temperatures and decreases winter temperatures. The effects of temperature change are discussed on page 3.

Erman et al. (1977) reported that the changes to aquatic invertebrate populations in logged streams are similar to changes found in streams affected by sewage effluents, thermal discharge, and run-off from agricultural activities. Logging along streams without leaving vegetated

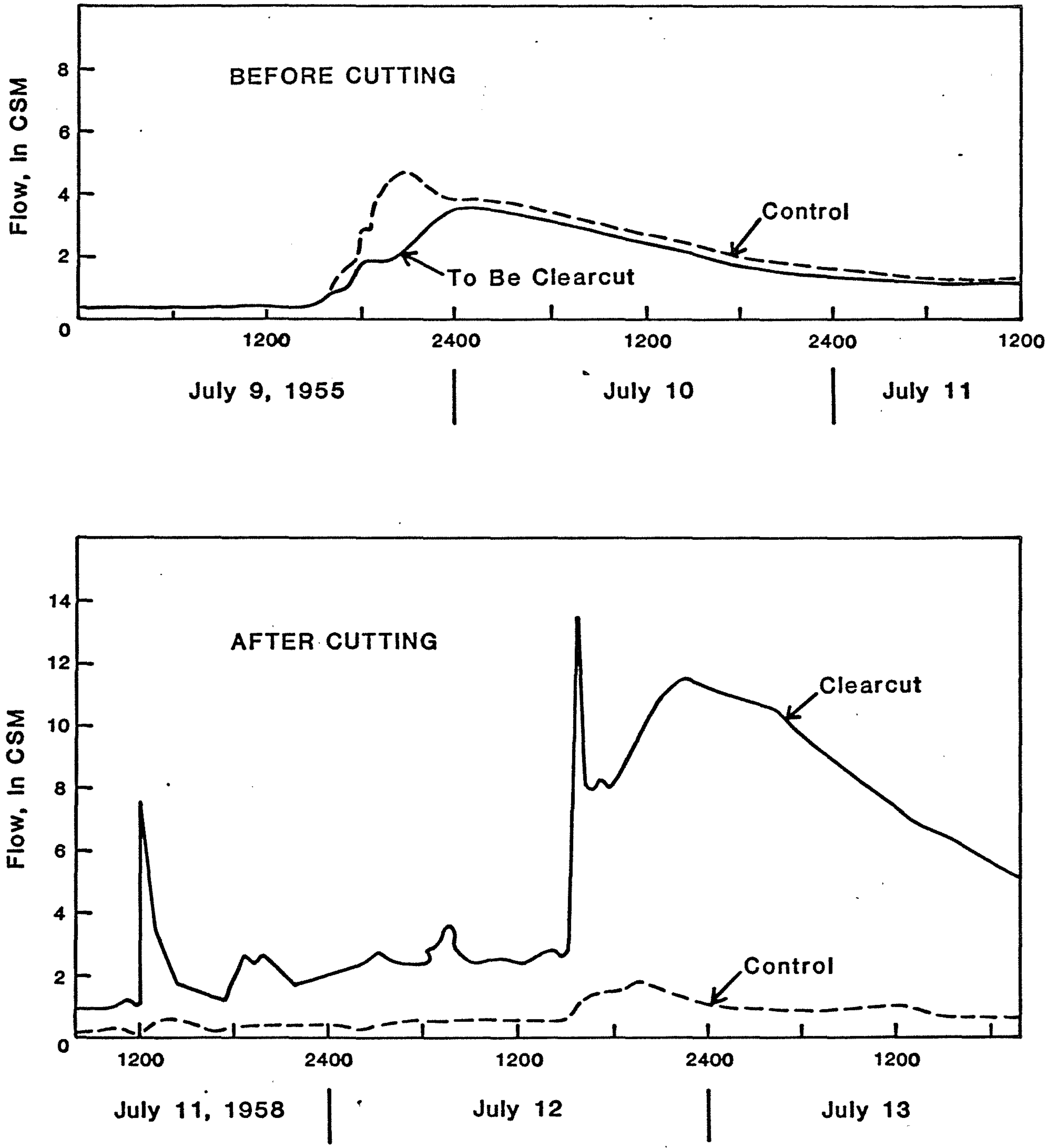


Figure 3. Sample storm hydrographs of clearcut and control watersheds before and after treatment. (Reinhart, Escher and Trimble 1963, in Clark 1977)

CSM = Cubic foot per second per square mile buffer strips caused a significant change in benthic invertebrates, compared with unlogged streams. While populations of some invertebrates increased, overall diversity was reduced.

Other forestry-related activities that can have significant adverse impacts on riparian vegetation and water quality are silvicultural treatments (Everest and Harr 1982); use of forest chemicals (Norris et al. 1983), including herbicides, insecticides, fertilizers, and fire retardants; and log storage (Schmiege 1980).

Erman et. al. (1977) found that buffer strips greater than 100 feet (30 meters) afforded protection for stream invertebrate populations at a level equivalent to unlogged streams. Streams with buffer zones less than 100 feet wide generally show the same impacts as streams without protective buffers, including changes in population abundance and reduction in species diversity.

The dimensions of a buffer strip depend on slope, wind exposure, rainfall, type of vegetation, location, and type of timber harvest. Trimble and Sartz (in Clark 1977) recommend a minimum buffer strip of 25 feet (7.6 meters) plus two feet (0.6 meters) for each 1% of slope between surface water and the logged area (Table 6).

TABLE 6. Recommended Widths for Filter (Buffer) Strips (Derived for Higher-slope Harvest Areas) (from Clark 1977).

Slope of Land (%)	Width of Filtration Strip (ft)
0	25
10	45
20	65
30	85
40	105
50	125
60	145
70	165

The United States Forest Service suggests the following formula for determining ideal buffer width: width = 4 feet (1.2 meters) X (percent slope) + 50 feet (15.2 meters) (United States Environmental Protection Agency in Clark 1977). Generally, if the terrain is steep, the potential for erosion moderate to severe, and large-scale clear cutting is to be used, the buffer strip must be substantially wider than the recommended minimum (Clark 1977). On the Delaware River, no logging is allowed within 100 feet without a permit (Palmer 1981).

Mining

Mining can cause severe pollution of aquatic environments by increasing bedload sediment and turbidity, changing pH, discharging heavy metals, and causing alterations in stream channel and streamflow (Martin and Platts 1981 Haugen and Duff 1982). Over 2,000 miles of major streams in Pennsylvania are polluted by drainage from coal mines (Palmer 1981).

Although there are many methods of mining (strip mining, open pit mining, dredge mining, hydraulic mining, underground mining), mining-related impacts in riparian wildlife habitats and the aquatic system can be divided into physical and chemical impacts (Haugen and Duff 1982). Examples of physical impacts resulting from mine operations include the following:

- Removal of riparian vegetation associated with stream channelization, road construction, culvert and bridge installation, direct mining activity, and tailing deposition.

- Increased rates of stream sedimentation resulting from vegetation removal, road and mine construction, tailing deposition, stream channelization and dredging, and erosion of overburden.

- Flooding of riparian areas for the construction of tailing pond or water storage reservoirs.

- Reduction of stream flows associated with decreases in ground water level or water diversions.

- Entrainment and/or impingement of aquatic organisms due to water diversion facilities and dredge mining activities.

Chemically related impacts associated with mining and related activities generally affect aquatic organisms directly without necessarily harming physical habitat. Examples of chemical degradation of water quality include the following:

- Introduction of toxic materials utilized in mining operations (petroleum products, flocculants, dispersants, etc.).

- Thermal shocks to aquatic organisms associated with the release of processing water.

- Release of acid mine waste into aquatic systems, thereby resulting in precipitation of ferric hydroxide and heavy metals.

- Reduction in dissolved oxygen from organic enrichment and increases in water temperature.

- Increased turbidity and suspended solids due to removal of ground cover.

To date, most of the mining impacts in Alaska have been from placer mining or gravel removal from floodplains. Habitat alterations include removal of riparian vegetation, processing of stream gravels, channelization, channel diversion, road construction in streams, high turbidity and sedimentation, litter, and barriers to fish movement. Placer mining adversely altered large areas of riparian vegetation and aquatic habitat in the Kantishna Hills area (Meyer and Kavanagh 1983). Singleton et al. (1978) cite low soil moisture-holding capacity, due to loss of soil fines during mining, and unfavorable post-mining topography as being responsible for slow revegetation following mining. Zemansky et al. (1976) provide numerous references indicating that increased total settleable solids and turbidity resulting from mining operations cause direct adverse effects on fish, including effects on fish reproduction and food supplies, and a reduction in fish populations. Heavy metals that are damaging to fish, including cadmium, chromium, arsenic, and selenium and sulfates are released into the aquatic system by placer mining (Metsker 1982).

The Alaska Department of Fish and Game (1982b) found that an increase in placer mining activity resulted in a reduction of recreational fishing.

Habitat alterations from gravel mining operations in flood plains are well documented, including resultant impacts to river hydrology, the aquatic biota, terrestrial biota, and water quality (Woodward - Clyde Consultants 1980).

Oil and Gas

Starr et al. (1981) review the impacts on fish and wildlife habitats from all phases of oil and gas development activities.

Impacts to wildlife habitat are associated with 1) any activity that removes, scars, or covers the surface vegetation and which, in turn, leads to increased erosion, permafrost degradation, or drainage changes; 2) oil well blowouts, spills, leakage, or release of other toxic materials capable of killing or damaging vegetation; 3) any activity that will increase the frequency or intensity of fires, such as a burning oil or gas well blowout; 4) degradation of the quality of land surface or water bodies by the disposal of solid or liquid wastes; 5) the creation of physical barriers, such as roads, pipelines, or other facilities, that separate large tracts of previously continuous wildlife habitat and that may lead to differential use of habitats by wildlife; and 6) any activity, such as gravel or sand borrowing or water withdrawal, that will result in the lowering of habitat quality for aquatic invertebrates, fish, waterfowl, and non-game birds and mammals. While many of these activities are not confined to riparian ecosystems, their occurrence in such areas will cause impacts of equal or greater intensity than in other habitats because of the high biological diversity and sensitivity of riparian zones.

Principal impacts to aquatic populations may occur from 1) blockages of fish passage (including those caused by pipeline or road crossings of waterways or accumulation of debris); 2) fish entrapment in borrow pits or reservoirs connected to waterways only during periods of high water; 3) channel, bottom, or current changes; 4) any activity that lowers the physical, chemical, or biological quality and, hence, the carrying capacity of the aquatic habitat (for example, oil spills, waste disposal, excessive winter water withdrawals, or siltation); 5) seismic operations through ice or adjacent to water bodies; and 6) increased harvest of fish and game due to increased access through new roads and airfields, higher incomes, and increased human presence.

In Texas alone, 23,000 cases of ground and surface water contamination caused by petroleum activity have been reported (Council on Environmental Quality 1980).

The effects on riparian fish and wildlife habitat from oil and gas operations and secondary developments (e.g., alterations to water quantity, water quality, and vegetation) are generally similar to other development-related activities discussed in this paper.

Road Construction

Road construction in riparian zones will reduce habitat suitability for many species, and probably has more critical and long-lasting impacts on riparian zones than any other activity (Thomas et al. 1981). Roads and their construction cause major increases in sedimentation to streams, remove riparian vegetation, alter stream channels (Haugen and Duff 1982), act as physical barriers to the movement of juvenile and adult fish, and increase human access to previously remote and isolated areas (Yee and Roelofs 1980). Burns (1972) observed a water temperature increase of 20°F (9°c) following riparian canopy removal during road construction. Gibbons and Salo (1973) concluded that during timber harvesting, forest roads are the primary initiator of erosion caused by human activities. Yee and Roelofs (1980) state that "poor culvert design and location can still be ranked among the most devastating problems for fish habitat in western forests." Road culverts can be barriers to migration, usually because of outfall barriers, excessive water velocity in the culvert, insufficient water in the culvert, lack of resting pools below culverts, or a combination of these conditions (Elliot 1982, Yee and Roelofs 1980).

Roads result in a direct loss of habitat and increased disturbance to wildlife from traffic (Thomas et al. 1981). Roads placed through major moose migration routes or wintering areas will result in wildlife fatalities from automobile collisions. Habitat use by deer and elk is adversely influenced by the presence of roads open to vehicular traffic. Effects are markedly influenced by type of road, location, and amount of use. Researchers have reported decreased use of areas adjacent to roads for distances ranging from .25 to .50 miles (.4 to .8 km) (Perry and Overly; Ward, in Thomas et al. 1979).

Little research has been done on the possible toxic effects of surface and subsurface runoff from oiled and chemically treated roadways. The potential exists for development of localized water quality problems that could affect fish and aquatic habitats.

Natural Hazards

Flooding. Flooding is a natural phenomenon occurring along rivers and streams. It is an important component in determining the nature of the riparian vegetation and other biological aspects of the stream and its floodplain. Land use management programs need to acknowledge the benefits and values of undisturbed floodplains, recognize the hazards of locating developments in floodplains, and realize that encroachments, obstructions, or alterations of floodways can reduce their floodwater carrying capacity, resulting in increased flood heights, velocities, and frequencies (French and Burby 1980). Building on floodplains increases flood damage for both private property owners and the taxpayers who pay for disaster assistance, flood control projects, and subsidized flood insurance.

Flooding of urbanized areas is currently the most widespread natural hazard in the United States. Flooding causes public and private property damage of $1.5 to $2 billion annually (French and Burby 1980). Federal and non-federal expenditures to reduce urban flood damage during fiscal year 1974 were $954.7 million (Goddard 1979).

In contrast to the major floods of the 1930's, an increasing proportion of flood losses today are caused by flash flooding along seemingly insignificant streams and creeks (Platt and McMullen 1979). Changes in flood patterns can be attributed to changing land use practice.

In Alaska, flood losses to public and private property will increase unless steps are taken to minimize development in floodplains. Miller (1982) reports on flood damage in Alaska. Throughout the summer of 1971, flooding in the Matanuska-Susitna Valley caused almost $6 million in physical damage. Damages to private homes and personal property were approximately $1.4 million. The breakout of Lake George in the Knik River drainage was a near-annual event until 1966. Since then, the Knik Glacier has not advanced to dam the lake, and development has occurred in the floodplain. In 1969 a lake dammed by the Skilak glacier released, causing the Kenai River to rise and fracture river ice. Ice blocked the river channel at Soldotna, causing backwater flooding of roads, homes, and businesses. Again in 1974 and 1977, glacial lake dumping caused flooding along the Kenai River.

In Fairbanks, the 1967 Chena River Flood took six lives and caused damage in excess of $85 million. To mitigate flood hazards, $243 million was spent in federal and state funds to build the Chena River Dam and floodway. Operation and maintenance costs are estimated at $763,000 annually.

By establishing greenbelts (buffer zones) along creeks, Anchorage has increased residential property values while combining protection from flooding with increases in recreational opportunities (Miller 1982).

PUBLIC ATTITUDES AND CONFLICTS

Public Attitudes

The public's view of riparian ecosystem management varies greatly with personal values, perceptions, and according to whether one is a landowner, a resource manager, or a public user. A few studies have attempted to quantify these attitudes in order to improve management of riparian resources and minimize conflicts among landowners and recreationists. Minimizing conflicts has become increasingly important as recreational use of rivers and lakes, especially those near population centers and those with access, has been rapidly increasing. This trend is expected to continue. At the same time, competition for land and water for developmental purposes will increase. Deciding the most appropriate allocations among many special interests will continue to be a topic of heated debate. Any land allocation system must recognize the attitudes and needs of the participants (landowners and public users) and promote cooperation while protecting public resources. Thus, understanding problems and attitudes among user groups and correlating these with ecological values, economics, and the legal system is essential for ensuring good management in the future.

A recent public opinion survey conducted in Alaska by the Dittman Research Corporation (1982) found that 70% of the public respondents strongly or moderately supported the "establishment of recreational waterway and trail corridors to provide hunting, fishing and other recreational opportunities through private land near the urban centers." These same people expressed willingness to "create a fund to purchase access corridors." Sixty-nine percent of the public strongly or moderately supported spending state money to buy private land necessary to establish a recreational waterway or trail corridor system.

In most states, landownership patterns are opposite those in Alaska, with most land in private ownership. Recognizing the need for access, the values of riparian land, and the prohibitive cost of acquisition, the public in these states has favored other alternatives for acquiring riparian lands. In Oklahoma, a public opinion survey on "public attitudes toward stream and streamside (riparian) fish and wildlife habitats" showed that "...large majorities favored enactment of state statutes which would allow protection of minimum stream flows and provide tax incentives to landowners who would agree to manage riparian habitat on their private land" (The Wildlife Society 1982).

In Wisconsin, Roggenbuck and Kushman (1980) found little understanding and support for the protection of riparian ecosystems among riparian landowners. While landowners supported adopting policies to protect the stream channel, they were in disagreement on how or if to protect the river corridor. Landowners with misconceptions outnumbered those who were well informed on policy towards use, development, or other activities on riparian lands adjacent to the river. Problems with recreationists, litter, vandalism, trespass, pollution, and inadequate law enforcement were much greater concerns to property owners than maintaining ecological values, including a decrease in wildlife. Seventeen eastern states identified trespass as the most serious landowner-user conflict along rivers and streams (Countess et. al. 1977). Lack of access results in overuse of a few sites, increasing trespass and litter, and leads to a degradation of the habitat. As a whole, riparian landowners opposed restrictions on development and land use practices (Roggenbuck and Kushman 1980). Only 33% of the private riparian landowners favored easements for regulating riparian use and development, and only 35% favored the state's purchasing land from willing sellers (Table 7). Most property owners identify easements as an unwarranted and unjustified encumbrance on their land (Countess et. al. 1977). Landowners oppose the state purchasing private riparian lands for three main reasons: 1) a fear of an influx of recreationists to the area; 2) a belief that condemnation would result on other lands once the government achieved partial ownership; and 3) a belief that property taxes would increase on remaining private lands (Roggenbuck and Kushman 1980). According to

TABLE 7. Riparian Landowners' Agreement With Alternative Techniques of Wild River Policy Implementation. Adopted from Roggenbuck and Kushman (1980).

Alternative	Agree	Neutral	Disagree
	Percent		
Revised or new laws to lessen present restriction on use and development	40	20	40
Increased participation by local residents in DNR decisions	76	8	16
Written agreements between the DNR and landowners to guide use and development	62	11	27
Tax incentives to encourage landowners to maintain their property in a natural condition	69	12	19
Zoning to guide use and provide protection to river	54	12	34
Easements to guide use and development	33	16	51
State acquisition of land from willing sellers	35	8	57
Condemnation of properties within the 400-foot zone along the rivers	14	5	81

Coughlin and Plaut (1978), however, if public access is required, in addition to achieving conservation objectives, public ownership is necessary as easements will not be sufficient. Not only are the terms of easements very difficult to enforce, but the administrative costs of enforcement over many years may far outweigh the initial cost difference between easement and fee-title purchase (Priesnitz and Harrison 1977). When landowners are willing to sell land for conservation purposes, they appear to prefer selling to private conservation organizations rather than to public agencies (Burns 1978). Landowners fear that public ownership will increase access and recreation, along with trespassing, littering, and vandalism, on nearby private lands.

Curtiss (1977) describes the problems, confusion, and conflicts that arise between and among landowners and public users when river corridors come under multiple ownership. Regulations become complex and often contradictory. The maze of federal, state, and local laws and private property rights leads to overlapping controls, confusion, and conflicts. These widen the dichotomy between user and landowner, and both sides, as well as the resource, bear the consequence. When this occurs, issues arise that must be resolved politically. The concerns of a local constituency and their political support may outweigh the benefits to the public-at-large. In California, a major obstacle to riparian land protection is the riparian landowner (Burns 1978). Protecting agricultural lands from flooding and erosion and protecting private property rights elicits a quick response from elected officials. Flood control projects are implemented that give little consideration to impacts on fish and wildlife populations.

Access Problems in the Matanuska-Susitna Borough

In the Matanuska-Susitna Borough, trespass and congestion around lakes and along streams has become a prevalent problem that continues to worsen. Conflicts arise both between public users (primarily sport fishermen) and private landowners and among public users. The problem is most severe where salmon streams cross the Parks Highway between Willow and Talkeetna and around lakes in the Matanuska Valley. Eastside Susitna River tributaries that cross the Parks Highway support excellent salmon runs and attract large numbers of anglers mostly from Anchorage and the Matanuska Valley. Along Willow Creek, Little Willow Creek, Sheep Creek, Kashwitna River, Goose Creek, Sunshine Creek, and Birch Creek, the only public access is by a state reserved 100-300 foot-wide highway right-of-way or by launching a boat from the highway. All other access is across private lands.

Conflicts result from a combination of increasing human population, changing land ownership patterns, poorly surveyed or marked access, limited or no access to some sites, and absence of clear definitions of the rights and limitations of landowners and the public within access easements. Wherever private property supports good fishing or recreation in the absence of nearby public lands and access, trespass becomes a problem.

When such situations arise, the public loses opportunities to utilize public resources, and enjoyment of recreational activities is greatly reduced. Meanwhile property owners feel their rights have been violated. Many landowners regret having granted easements because of the increases in public use and continued lack of management. Disrespect for both public and private property and lack of environmental awareness on the part of certain recreationists has often created or worsened existing problems.

Lack of public recreational areas near population centers leads to overcrowding at existing sites. Overuse at recreational sites and boat launch areas has resulted in environmental degradation and pollution, sanitation problems, public safety problems, and excessive noise and litter. Continued overuse of sites can result in loss of vegetation and lead to accelerated erosion, habitat degradation, or disruption of fish and wildlife populations.

Past land disposals have not adequately retained public lands that support productive fish and wildlife populations or provide ample access to these resources. In addition, in recreational areas sufficient public lands are needed for recreationists to disperse. The population of Anchorage is currently increasing at a rate of 2,000 residents per month. The state's population is projected to increase by approximately 17 percent in the next 10 years. An increased population with more leisure time will demand more access to and along public and navigable waters. Without proper planning, existing conflicts can only be expected to worsen.

Many examples of these problems can be found in the Matanuska-Susitna Borough. In addition, it often costs the state millions of dollars to rectify problems that were created by poor planning.

At Birch Creek (reached from the Talkeetna Spur road), access to an excellent salmon fishery has been blocked by a landowner who has erected a cyclone fence across the creek and shoreline at the outlet of Fish Lake. The fence blocks access to upstream areas. Conflicts have led to incidences such as smashed car windows. All access to Goose Creek has been denied to the public by a few private landowners. A public resource has become part of a private hunting and fishing club.

Recently, in an attempt to alleviate access problems and overcrowding, the state purchased land on both sides of Montana Creek between the Parks Highway and the Susitna River. The cost was $1.2 million. More purchases are still necessary to ease conflicts on upriver portions, where any public use involves trespass. One landowner attempted to physically block access across neighboring private lands that permitted public access. The landowner attempted to charge people $10.00 per day to park their cars on his land.

The state recently purchased five acres for $25,000 for access to Sheep Creek. While this may help alleviate the problem of reaching the creek, it does not relieve overcrowded conditions at the creek nor permit movement up and down the creek corridor. Both Caswell and Sunshine creeks have trespass and litter problems.

Since 1980, 11 AAC 53.330. has authorized the director of the Department of Natural Resources to reserve a minimum 50-foot easement to provide for public access along inland navigable or public water. "The director shall (also) reserve an easement or right-of-way to provide access to coastal or inland navigable public water in the conveyance of land adjacent to or containing that water... (of) at least 50 feet wide." Without a current status plat it is difficult at best for the public to know when land was disposed of and whether an easement pertains to specific parcels or to all the land in an area. Under 11 AAC 53.350, "the director may require as a condition of any sale, lease, grant or other disposal of State land that the purchaser, lessee or grantee survey, mark or survey and mark public easements..." In addition, 11 AAC 53.340. allows the director to publish a directory of navigable and public waters and of the easements that provide access to and along them.

To further complicate matters, conditions affecting easements on Native lands come under the Alaska Native Claims Settlement Act (ANCSA) and have different stipulations.

The Department of Fish and Game stocks 25 lakes in the Matanuska Valley. All have easements or rights-of-way for access to the lake, but access around the lake and activities allowed in this access zone are open to interpretation.

Both Rocky Lake and Finger Lake are stocked with fish at public expense. Both have public campgrounds. However, anglers without a boat are restricted to the campground area. Better fishing sites around the lake are privately owned. Florence Lake, east of Willow, has a section line easement from the road to the lake. Within this easement, a landowner added a porch onto his house. He then posted no trespassing signs in an attempt to block public access. Prater Lake and Memory Lake in the Matanuska Valley are other examples of lakes where access easements have created landowner conflicts with fishermen.

Because of limited and marginal access at Seymour Lake (Big Meadow Lake), the public is utilizing more than just the right-of-way and is disturbing adjacent landowners. Limited and poorly defined public use areas and lack of management have resulted in litter, noise, unattended fires, and tree-cutting on public and private lands.

The seven lakes in the Keppler-Bradley Lake complex near Palmer are all stocked. Because of public demand for recreational sites, the state spent $3 million to purchase land once held in the public domain. The main entrance to the area is still controlled by a private landowner who has entered into an agreement with the state to allow access.

As a result of various federal and state land disposal programs over the years, much of the land along the Parks Highway and in the Matanuska Valley was transferred to private interests, particularly through homesteading programs. After gaining title to the land, many landowners moved elsewhere or sold their land, often having it subdivided. In the past, with fewer fishermen and either absentee or consenting landowners, access to lakes and streams was not as significant a problem as it is today. Over the years, the population has increased, people have acquired more leisure time, and landownership patterns have changed. Gaining access and avoiding conflicts while traversing several parcels of private land becomes more difficult than crossing only one parcel. Many landowners are reluctant to grant access when it involves many individuals rather than a few, especially now that more of the land is developed for private housing. However, because historically access was available many recreationists continue to use land unaware or in spite of trespass violations.

LOSS OF RIPARIAN ECOSYSTEMS

The conversion of floodplain forests to alternate land uses has been responsible for making riparian ecosystems among the most severely altered land forms in the nation. In the contiguous 48 states, over 70% of the estimated original coverage of riparian ecosystems has been altered or eliminated. As of 1981, riparian communities comprised less than 2% of the total land area in the 48 states (Brinson et al. 1981).

The alteration and destruction of riparian ecosystems on a national level has been gradual but steady. Historically, elimination of riparian lands has essentially followed a consistent pattern, and the extent of riparian vegetation has been reduced by a substantial amount in every region of the country. The same qualities that are attractive and productive for vegetation and wildlife also attract human development. Impacts from water development, agriculture, grazing, settlement, and forestry have been the primary forces responsible both directly and indirectly for the loss of this valuable habitat. With this loss goes a decrease in fish and wildlife populations and a loss of recreational opportunities.

Riverine bottomlands were frequently the first areas homesteaded by newly arrived settlers. Rivers and their fertile valleys provided abundant fish, game, furs, and other easily harvested natural resources needed by early inhabitants. Rivers also served as transportation corridors, and water power was easily converted to an energy source. The same fertile soils and abundant water that supported diverse vegetation and wildlife also proved to support rich agricultural development. As development continued, more land was cleared, and greater demands were made on riparian resources. Growing human populations increased demands for transportation, economic development, homesites, water supplies for domestic, industrial, and agricultural development, as well as flood protection for homes and crops. While vegetation and wildlife are adaptable and resilient to many of the unpredictable forces of nature, human developments generally are not. Various combinations of dams, dikes, levees, drainage ditches, water diversions, alterations, and stream channeling were used to accomplish protective goals. These alterations lead to secondary losses of habitat. With improved protection from the natural forces of the river, human populations increased and placed more demands upon the riparian land. More land was cleared of native vegetation and converted to alternate uses. The cumulative impacts of increasing populations, continuous development, land use changes, and the resulting loss of vegetation and modification of hydrologic regimes have numerous adverse effects on fish and wildlife. Where modification of habitat has been most severe, certain species have become scarce. Of the 276 species of plants and animals listed as threatened or endangered by the U.S. Fish and Wildlife Service, 80 are directly or indirectly dependent on riparian ecosystems (Brinson et al. 1981).

Although the amount of riparian vegetation present before the arrival of Europeans to North America and the amount remaining today are often difficult to assess, there are many examples to indicate the startling loss that has taken place in many parts of the country.

In the 1850's along the floodplain of the Sacramento River, California's largest river, there existed an estimated 775,000 acres of riparian forests. By 1952, 27,000 acres remained, and by 1972 there were less than 18,000 acres of riparian forests along the river (Sands 1978). Of the state's remaining riparian lands, between 60 and 90% is privately owned (Warner

1982). As urban development and streambank erosion claim prime agricultural land, (Figure 2) additional riparian forests must be cleared for conversion to agricultural production.

Riparian vegetation along the Colorado River has been cleared at a rate of about 3,000 acres per year. Additionally, water management practices and overgrazing have encouraged the replacement of native plant species by introduced exotic species that provide poorer wildlife habitat (Anderson et al. 1978).

According to David E. Morine, Director of Land Aquisition for the Nature Conservancy:

> When originally acquired, the Louisiana territory contained over 50 million acres of bottomland (riparian) hardwoods. Currently there are less than 3.5 million acres left in America (48 contiguous states) and these are being destroyed at a rate of 300,000 acres per year. Seven out of every eight acres of bottomland forest has been drained and cleared.

For the Mississippi River floodplain, the rate of clearing has averaged about 2% per year over the past 20 years (Brinson et al. 1981). A study published by the U.S. Fish and Wildlife Service estimates that since 1937 over 6.6 million acres of bottomland hardwood in the Mississippi River delta have been cleared and converted to soybean production. The report estimates that by 1985, 86% of the original bottomland forests will be destroyed. Of the remaining bottomland forests in this region, only 700,000 acres are in public ownership (National Wetland Newsletter 1982). As with Alaska's riparian lands, those in the southeast United States support an abundance of fish and wildlife and provide excellent hunting, fishing, and recreational opportunities. This tremendous loss of habitat has occurred in a region where a larger proportion of the people hunt and fish than any other portion of the country and the commercial and sport fishing enterprise constitute a multi-billion dollar industry (National Wetland Newsletter 1982).

As previously mentioned, several factors have combined to severely alter or eliminate riparian forests in the lower 48 states. Most of these habitat losses have come at considerable expense to the taxpayer. Most are the result of secondary habitat losses, after initial settlement is established. The effects of local or regional projects, however, often extend far beyond the intended target area. Among these are federal and state spending for water resource developments such as flood control and drainage projects, stream channelization for agricultural soil conservation programs, government subsidies and price supports for crops, and preferential tax policies.

CURRENT PROGRAMS FOR PROTECTING RIPARIAN ECOSYSTEMS

Increased recognition of the important public benefits and functions of riparian ecosystems and the extent to which they have been altered has resulted in efforts by the federal government and some states to exercise some control over development in riparian corridors and acquire riparian lands for public use.

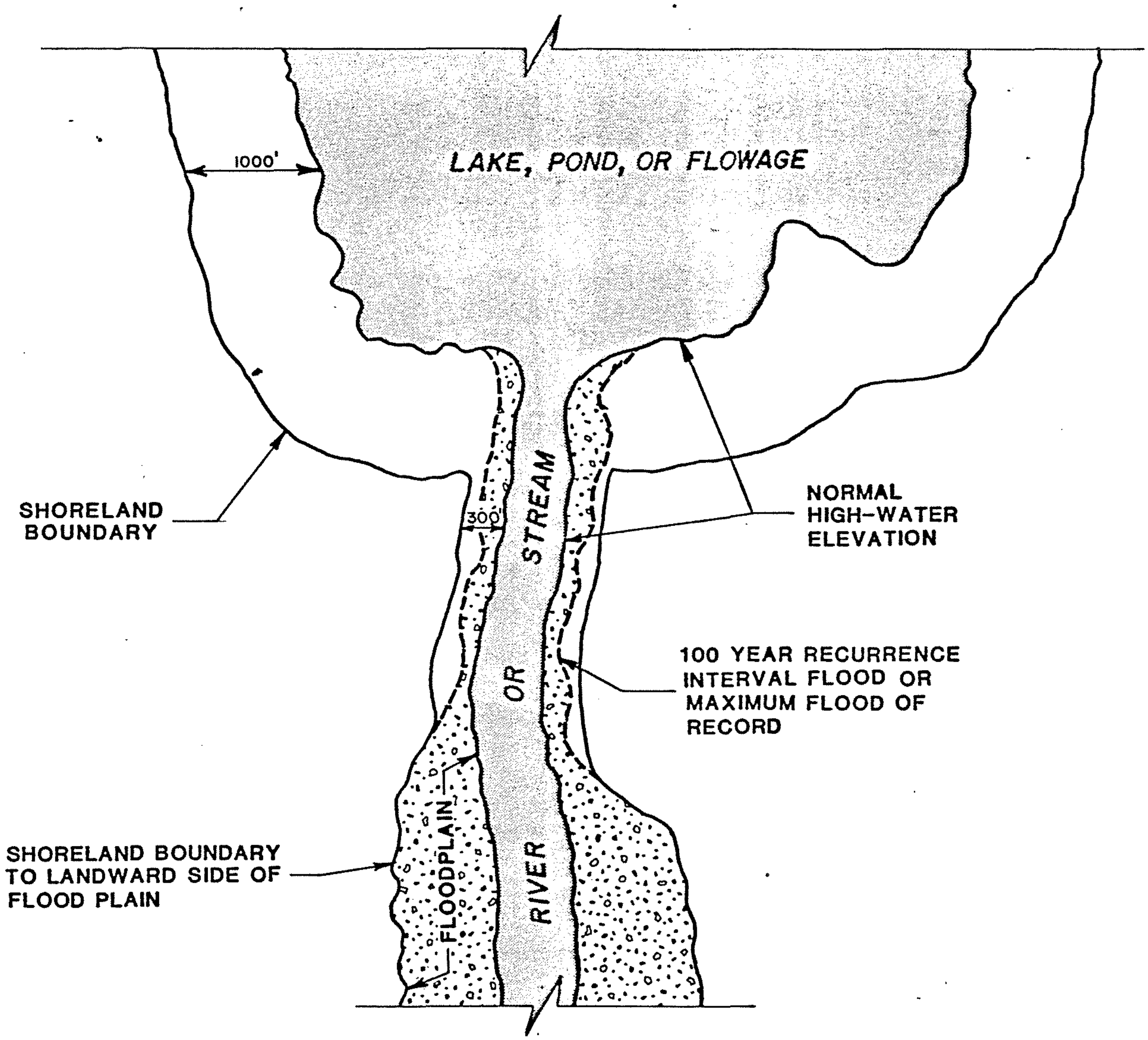
State Programs

Numerous alternatives for protecting riparian lands from future alteration or destruction are being utilized in various parts of the country. These include acquisition by fee simple and less-than-fee simple interest, acquisition of easements, leasing, direct government regulation, economic incentives, and management through compatible use. The Alaska Department of Fish and Game endorses a policy of maintaining riparian ecosystems in public ownership, especially when these lands are already held by the state. Examples from other states that have recognized the need for riparian land protection illustrate the high cost to the taxpayer of reacquiring these lands for public use. As a result, most programs are a case of too little, too late, or a second-best alternative. Acquisition of only a portion of the floodplain or stream segment does not assure adequate protection because disturbances in upstream areas or adjacent habitats can have downstream impacts extending far beyond the immediate area. However, many states are attempting to rectify past policies in land management, and the following discussion will present some examples of on-going programs.

Six states have adopted special legislation for the protection of inland shoreland areas: Maine, Vermont, Washington, Wisconsin, Minnesota, and Michigan (Kusler 1980). All six states define shoreland in relation to the high water mark of rivers and lakes. Depending on the state, distance from the high water mark to the shoreland boundary varies from 200 feet in Washington to 1000 feet in Michigan and Vermont. In addition, some of these states regulate river shorelands up to 300 feet from the high water mark or to the landward side of the 100-year floodplain. This minimum distance varies from 200 feet in Washington to up to 300 feet in Wisconsin and Minnesota. In general, one of two main approaches has been used to classify shoreland areas. The first method classifies specific riparian lands individually, such as particular wetlands around individual lakes. The second approach classifies lakes and streams in their entirety as "natural environment" or "recreational development" or "general development." These classifications then determine minimal standards.[1]

Wisconsin's shoreland zoning act (WIS. STAT. ANN. 144.26,59.971) has been in effect since 1965. It requires all counties to adopt zoning regulations for the protection of shoreland corridors in unincorporated areas. Shorelands are defined as lying within 1,000 feet of the highwater mark of a lake, pond, or flowage, or within 300 feet of a river or stream or to the landward side of a floodplain (Figure 4). The Wisconsin Department of Natural Resources is responsible for establishing a comprehensive plan for navigable waters and their shorelands. Different-use districts are designated. Enforcement of the zoning ordinances has been difficult (National Wetland Newsletter, 1980). No development is permitted in the shoreland-wetland zone except for minor structures associated with hunting, fishing, hiking, wild crop harvesting, and sustained yield forestry. In

[1] A more detailed description of state shoreland programs can be found in B. Berger, J. Kusler, and S. Klinginer, Lake-Shoreland Management Programs: Selected Papers, Univ. of Mass. Water Resources Research Center, Publ. No. 69, Technical Report, Amherst, Mass. (1976).



Figre 4. Wisconsin,s shoreline delineation.
(From Kusler, J., 1980)

1982 the state legislature enacted Assembly Bill (AB) 839, which requires protective zoning of shoreland wetlands in cities and villages. Wetlands to be zoned must be five acres or more in size.[2]

All shoreland regulatory programs apply state standards for local adoption of zoning, subdivision controls, and, in some instances, sanitary codes. Minimum standards include pollution control, wildlife protection, preventing land use conflicts, reducing flood and erosion hazards, wetland protection, and protecting aesthetic and recreational values.

Twenty-four states have adopted legislation for the protection of wild, scenic, or recreational rivers (Table 8) (Kusler 1980). State-designated rivers may be included in the National Scenic and Wild River Program. Inclusion in the federal program protects the rivers from federal water resources projects. In general, acts provide that wild, scenic, or recreational rivers are distinguished, based upon their "extraordinary" "unusual," or particular "water conservation, scenic, recreational, or wildlife values." (Kusler 1980). Some states impose tight controls on structures within rivers, such as dams, but do not regulate shoreland areas. Minnesota and Michigan authorize a state standard for local regulation in corridors up to 1,320 feet and 400 feet wide, respectively. Regulatory objectives include preserving water quality and free-flowing river conditions, protecting natural scenic beauty, vegetation, wildlife, and recreational values. Secondary objectives include minimizing alternate user conflicts, controlling access, protecting health and safety, and reducing flood damage. The Oregon Supreme Court sustained shoreland regulations for a one-fourth mile wide corridor along the Rogue River (Kusler 1980).

In Florida, the 1981 Save our Rivers Act created a fund to enable the state's water management districts to acquire lands needed for water management. Another act (FLA. STAT. Section 259) created in 1979 established the Conservation and Recreation Lands Program. This program authorizes state selection and purchase of lands containing Florida's most valuable conservation and recreational resources. Under this act, a trust fund was created to acquire lands. Money comes from severance taxes on the mining of minerals and oil and gas.

---

[2] For further information on this legislation, contact Wisconsin Wetlands Association, 2 South Fairchild Street, Madison, Wisconsin 53703; (608) 256-0565, or Editor, Environmental Law Institute, Suite 600, 1346 Connecticut Ave., N.W. Washington, D.C. 20036.

TABLE 8. Summary of State Wild and Scenic Rivers Programs.

State	System or Program	How Established (date) Legislative	Admin.	Number of Rivers
Alabama	System		1969	1
Alaska	None			
Arizona	None			
Arkansas	None			
California	System	1972		9
Colorado	None			
Connecticut	None			
District of Columbia	None			
Florida	Program		1972	0
Georgia	System	1969		0
Hawaii	None			
Idaho	None			
Illinois	None			
Indiana	System	1972		2
Iowa	System	1970		1
Kansas	None			
Kentucky	System	1972		8
Louisiana	System	1970		43
Maine	System	1966		1
Maryland	System	1971		9
Massachusetts	Program	1971		0
Michigan	System	1970		6
Minnesota	System	1973		4
Mississippi	None			
Missouri	None			
Montana	None			
Nebraska	None			
Nevada	None			
New Hampshire	None			
New Jersey	None			
New Mexico	None			
New York	System	1973		61
North Carolina	System	1971		2
North Dakota	System	1975		1
Ohio	System	1968		8
Oklahoma	System	1970		5
Oregon	System	1971		8
Pennsylvania	Program	1972		0
Puerto Rico	None			
Rhode Island	None			
South Carolina	System	1974		0
South Dakota	Program	1972		0
Tennessee	System	1968		11
Texas	None			
Utah	None			
Vermont	None			

TABLE 8. (Continued)

Virginia	System	1970		2
Washington	None			
West Virginia	System	1969		5
Wisconsin	System	1965		3
Wyoming	None			
Total		24	2	190

Source: Bureau of Outdoor Recreation, Wild and Scenic Rivers, Outdoor Recreation Action, No. 43, U.S. Department of Interior, Bureau of Outdoor Recreation, Washington, D.C., Spring 1977.) Adapted from Kusler (1980).

Due to the shortage of public funds and the high cost of land acquisition an alternative method of riparian land protection has been established in Oregon. The Oregon state legislature passed a bill (S.B. 397) that grants property tax exemptions and income tax credits to private landowners who voluntarily dedicate their riparian lands to wildlife uses. The bill states that "the legislative assembly declares that it is in the best interest of the state to maintain, preserve, conserve and rehabilitate riparian lands to assure the protection of the soil, water, fish and wildlife resource of the state for the economic and social well-being of the state and its citizens."

In Oregon's approach to riparian land protection the emphasis is placed on local administration and self-management by landowners. The program was attractive to landowners interested in more monetary incentives and less regulation. It is too early to evaluate the effectiveness of this legislation in achieving goals, such as increased salmon production, stream bank stabilization, and increased late-season streamflows.[3]

This type of program does not necessarily allow access; landowners are not committed to the program over a long time frame, and agreements must be renegotiated with a change of ownership. Further, a program of this type is no guarantee for protection of large continuous tracts of land necessary to support populations of highly mobile species such as moose. Such a program does not provide incentive to protect critical habitats such as moose wintering grounds, and it has not been in existence long enough to have been tested for effective enforcement. It must also be determined what acceptable level of economic gain is necessary to encourage a landowner to participate in such a program. Clearly, such a program remedies only some of the symptoms created by past practices and does not solve the underlying cause of the problem.

The Oregon State Department of Fish and Wildlife has spent an average of over $500,000 per year for the last 15 to 20 years for the purchase of private land for public access, recreation, and habitat protection (Dick

[3] For futher information on this legislation, contact Water Resources Analyst, Metro Office, Oregon Wilderness Coalition, 2637 S.W. Water St., Portland, Oregon 97201.

Scherzinger, pers. comm.). Some of these costs include money for development and maintenance. In one of its larger projects, the state recently purchased 17 miles of river frontage along the Deschutte River. Money came from the Department of Fish and Wildlife, State Parks, and public contributions. Total cost equalled $1.6 million. Another major state purchase of riparian lands involved buying 11 miles of river frontage along the Middle Fork of the Malheur River. Purchased in the late 1970's, this cost $750,000 (Dick Scherzinger, pers. comm.).

In 1947, the California legislature passed the Wildlife Conservation Act (chapter 1325, statutes 1947). Section 1 of the act states:

> It is hereby declared that the preservation, protection and restoration of wildlife within the State of California is an inseparable part of providing adequate recreation for our people in the interest of public welfare; and it is further declared to be the policy of the state to acquire and restore to the highest possible level, and maintain in a state of high productivity those areas that can be most successfully used to sustain wildlife and which will provide adequate and suitable recreation. To carry out the aforesaid purposes, a single and coordinated program for the acquisition of lands and facilities suitable for recreational purposes and adaptable for conservation, propagation and utilization of the fish and game resources of the state is hereby established.

This act established the Wildlife Conservation Board (WCB). The purpose of the WCB is to acquire and develop lands and waters for wildlife conservation and related recreational purposes for the State Department of Fish and Game (DOF&G).

In 1951, the WCB began land acquisitions. Prior to 1951 all lands were acquired directly by the DOF&G. Information prior to 1951 is not available.

Between 1951 and December 31, 1982, the WCB has spent approximately $22.3 million[4] acquiring land in riparian habitats (pers. comm., John Wentzel, WCB). This includes purchases and easements for the purpose of access to freshwater fishing sites, fish habitat protection, and protection of river and stream riparian wildlife habitat. In addition, land valued at $676,000.00 was donated to the state through the WCB. Donations are tax deductible.

The WCB has spent approximately $33.5 million in acquiring coastal fishing access, freshwater and coastal wetlands, hunting access, deer winter and summer range, bighorn sheep range, and lands acquired for the protection of threatened and endangered plants and animals. Some of this undoubtedly includes riparian lands but has not been included in the above dollar value for riparian acquisitions. A large percentage of this money goes to acquiring wetlands and state waterfowl management areas.

---

4 $7,354,000 included in the $22.3 million was acquired with State Water Project (California Aquaduct) funds for mitigation of damage to wildlife habitat during construction. I do not know how much of this cost was used for riparian land acquisition.

A breakdown by primary recreational use of each acquisition is difficult, as many of the areas provide several recreational opportunities and also protect valuable habitat.

Much of this land was purchased prior to the recent inflationary spiral, and present costs and future costs will be much higher.

Other municipal, county, state, and federal agencies are also responsible for acquring land for access, recreation, and habitat protection. The amount acquired and costs incurred by the WCB is probably a relatively small percentage of the total for riparian land acquisitions within the state.

The Riverine Corridor concept in California was first implemented on the American River. Sacramento County has purchased 4,100 acres along a 23 mile stretch of the American River at an average cost of approximately $4,000 per acre; this amounts to a total cost of roughly $16 million (Walt Veda, pers. comm.). The county still has plans to purchase another 800 acres but is hindered by rising costs and lack of funds. Additionally, the county has purchased small tracts of 0.5 to 4.5 acres along the Sacramento River for public access to fishing. There was a proposal (as of 1979) to establish a Sacramento River Parkway (corridor) with a length of over 300 miles and a width of 300 feet on each side of the river. Land acquisition costs were estimated at $165 million (Warner 1982). The high cost of acquisition made enancting this proposal an impossibility. Although funds are often available for acquisition, purchase of important riparian tracts is not assured. Both the Wildlife Conservation Board and the Department of Parks and Recreation have been unsuccessful in acquiring fee title or easements to important riparian lands (Burns 1978). Other counties have similar programs and are competing for federal and state money. Because of the high costs involved in purchasing land, emphasis is being placed on zoning to protect riparian ecosystems (Ross Henry, pers. comm.).

In California, legislation (AB 3147, 1978) provided funding for a two year Department of Fish and Game study to survey California's remaining riparian lands and make recommendations for action by the legislature. California Fish and Game established a riparian task force to develop programs and procedures for the maintenance, protection, and restoration of the state's riparian resources.

Idaho is similar to Alaska in that a high percentage of land within the state is owned by the federal government. Yet, despite the large amount of public land and the fact that the U.S. Forest Service and Bureau of Land Management have retained some riparian lands, there is still a big demand for public access to rivers and lakes (Gene deReus, pers. comm.). In addition, development of private lands has interfered with the migration routes of big game. As a result, the state has been spending public money to purchase private lands, acquire easements, and lease lands to provide public access to the state's waters.

Since 1965, the Idaho Department of Parks and Recreation has spent approximately $13.3 million (combined state and federal money) purchasing riparian land from private landowners (Dale Christiansen, pers. comm.). With $2.00 received from the sale of every hunting and fishing license the

Idaho Department of Fish and Game spends $450,000 per year for land acquisition, easements, and leases for the purpose of "sportsmen access" to rivers and lakes and for habitat protection (Gene deReus, pers. comm.).

In the State of Washington the Interagency Committee for Outdoor Recreation (ICOR) oversees land acquisitions for state resource agencies. Between 1965 and 1981 the ICOR has assisted the State Game Department in purchasing 273 parcels of land. Of these, 218 (80%) have included riparian fish and wildlife habitats. During this 16 year period, 37,385 acres of riparian lands were purchased for the Department of Game at a cost of nearly $6.2 million (Ronald Taylor, pers. comm.). According to Mr. Taylor, this is not the total sum but represents the majority of the riparian land acquisitions. Money comes from the Federal Land and Water Conservation Fund and the State Capital Budget. The Department of Game also acquires land with money made available through the Pittman-Robertson Act. Additionally, the ICOR has funded another 1,500 projects by state and local agenices for the purchase of recreational lands. Due to financial constraints, land acquisition projects have been reduced in the past few years, although demand for public recreational lands and access to them is still high.

Private Programs

Not all projects and programs for the protection of riparian lands are initiated by public agencies. The private sector as it begins to understand and recognize riparian values is also contributing time and money to protect riparian resources. Some of the best examples come from work done by the Nature Conservancy, a national conservation organization committed to preserving natural diversity.

The conservancy also enters into cooperative programs with state agencies. In 1974, the Mississippi Game and Fish Department, with the Assistance of the Nature Conservancy, drafted legislation to create the Mississippi Wildlife Heritage Committee. The goal of the committee is to create and implement a state-wide comprehensive natural resources program to guarantee the preservation of the state's most important wildlife habitats through acquisition or other means. Many of these habitats are in riparian ecosystems. In another effort in the Southeast, the Nature Conservancy, with a grant of $15 million and by raising matching funds, is attempting to purchase key tracts of land to protect six major river systems. The conservancy's goal is a total gain of 350,000 acres of river habitat. The purchase price of this land is over twice the original cost for the entire Lousisiana Territory, an area of over 525,911,680 acres.

Another strategy used by the Nature Conservancy for protecting habitats is acquisition of conservation easements. Along nine miles of the Brule River in northern Wisconsin, the conservancy has negotiated easements with private landowners for protecting the natural character of almonst 5,000 acres. The conservation easements are parcel specific but contain some common provisison. Mining, alteration of topography, alteration of water courses, filling or removal of gravel, sand, topsoil, rock, or other materials, and dumping trash, noncompostable garbage, or other offensive materials are prohibited. Also prohibited are commercial development, access to commercial development, billboards, mobile homes, off-road vehicles, grazing, shooting within one-quarter mile of raptor nests, application of herbicides and pesticides (except in home gardens), and introduction of non-native species. A conservation easement is a legally enforceable restriction that attaches to the land in perpetuity and is recorded at the register of deeds office. In addition, the landowner is entitled to a charitable contribution deduction on his federal income tax, equal to the amount of the reduction in the value of the property.

Federal Programs

The federal government has also recognized the values and special mangement needs of riparian ecosystems. The Environmental Protection Agency and the U.S. Forest Service (1978) published a cooperative report describing a survey of streamside management zone laws, ordinances, and regulations on state and private lands in all 50 states, some counties, and local jurisdictions. At least 209 laws are applicable to riparian areas (Duff 1980). Thirty-one percent of these laws have been enacted since 1980.

Executive Order 11988, May 24, 1977, Floodplain Management (42 FR 26951), requires that federal agencies all "take action to reduce the risk of flood loss, to minimize the impact of flood loss, to minimize the impacts of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains." This is an important act because many riparian areas have been adversely affected by federally funded projects for development of agricultural lands, flood control projects, water diversions, and road construction.

Executive Order 11990, May 24, 1977, Protection of Wetlands (42 FR 26961), may also be applicable, as riparian ecosystems are considered wetland ecosystems by many authors (Duff 1980, Brinson et al. 1981). This order calls for "action to minimize the destruction, loss or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands." It requires each federal agency to determine how its activities affect wetlands and to revise regulations to minimize adverse impacts on wetlands. As with EO 11988, this applies only to federal projects.

The National Wild and Scenic Rivers Act of 1968 (Public Law 90-542:82 Stat. 906, et sef.) can be applied to entire watersheds to ensure better management of water quality and land use. Of the seven national and wild scenic rivers in Alaska, not counting those in national parks or wildlife refuges, none are within the boundaries of the Matanuska-Susitna-Beluga Study Area.

The Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500, Sec. 208; Stat. 816 et sef.) are intended to "restore and maintain the sociological integrity of the nation's waters." Section 208 requires water pollution controls for both point and non-point sources, including soil erosion. This may be interpreted to have great significance for requiring better managerial practices to protect riparian vegetation. This legislation is being implemented through federal, state, and regional water quality plans.

The Federal Fish and Wildlife Coordination Act (16. USC 661 et sef.) requires federal agencies to give wildlife conservation equal consideration with other features of water resource develomental programs. This includes "aquatic and land vegetation upon which wildlife is dependent." While the act gives wildlife managers the opportunity to comment and make recommendations, the acceptance of these recommendations is not mandatory.

A possible federal alternative to Oregon Riparian Bill is the recently introduced Conservation Land Sale Tax Incentive Bill (HR 6465). Introduced into the U.S. House of Representatives by Rep. Robert Lagomarsino (R-CA) and 43 co-sponsors, the bill would give landowners a tax incentive for selling or exchanging real estate to "qualified organizations" for conservation purposes, instead of to developers. Qualified organizations include federal, state, and local agencies and private non-profit conservation organizations. The conservation purposes must be protected in perpetuity and may include 1) preservation for education or public recreation, including hunting and fishing; 2) protection of fish, wildlife, and plant habitat; and 3) land acquisition to carry out federal, state, or local conservation programs.

Current legislation can go only so far in mitigating damages to riparian systems. Another method commonly used, and among the most desirable methods for long-term protection, is through direct federal or state acquisition of riparian lands. Riparian lands have been purchased by agencies often with money made available by the Land and Water Conservation Fund Act (16 U.S.C. 4601-4 to 4602-11). This act established the Land and Water Conservation Fund. The fund provides money for purchase of fee and easement interests in lands designated for protection of fish and wildlife and other ecological values.

Alaska's Programs

The State of Alaska has few programs, laws, or policies that specifically recognize and protect the functions and values of riparian ecosystems. Those provisions most applicable to riparian ecosystems are contained in the Alaska Administrative Codes (ACC) and the Alaska Statutes (AS). The Standards for Resources and Habitats (6 ACC 80.130) defines rivers, streams, and lakes as habitat types in coastal areas subject to the Alaska Coastal Management Program (ACMP). Section 6 AAC 80.130 c (7) states that rivers, streams, and lakes will be managed to protect natural vegetation, water quality, important fish and wildlife habitat, and natural flow. In addition, Section 6 ACC.80.130 b (7) provides that rivers, streams, and lakes shall be managed so as to maintain or enhance the biolgical, physical, and chemical characteristics of the habitat that contribute to its capacity to support living resources.

The standards of the ACMP are implemented in three ways: 1) through local coastal management plans; 2) through the ACMP's "state consistency" provisions, which require state agencies to carry out both planning and regulatory actions that affect the use of coastal resources in a manner consistent with both the ACMP standards and any local coastal management programs; and 3) through the state's review of federal actions for consistency with the state program.

The only statewide authority applicable to riparian areas is AS 16.05.870. This authorizes the Alaska Department of Fish and Game to regulate activities proposed for streams supporting anadromous fish. The statute states that the approval of the commissioner of the Department of Fish and Game is needed to, use, divert, obstruct, pollute, or change the natural flow or bed of a river, lake, or stream, specified as important to the spawning or migration of anadromous fish. Alterations of riparian vegetation may change the natural flow of a river if these alterations are severe enough or encompass a large area.

Legislative designation of state game refuges, sanctuaries, and critical habitats can be used for the protection of riparian lands or riverine corridors. Under AS 16.20.220, the legislature can designate certain lands and waters as "Fish and Game Critical Habitat Areas" to protect and preserve habitats especially crucial to the perpetuation of fish and wildlife and to restrict all other uses not compatible with that primary purpose.

Curran and Dwight (1979) review existing state water use laws and their administration. For a review of wetlands management in Alaska and the legal authorities pertaining to it, see State of Alaska (1981).

Two recently introduced bills to the Alaska State Legislature also address the need for better management of the state's rivers and streams. Senate Bill No. 9, introduced in January 1983 by Vic Fishcher and Joe Josephson (later withdrawn), included provisions for establishing state historical, recreational, and wilderness waterways.

House Bill No. 278, introduced in March 1983, by Fritz, Malone, Szymanski, and Bussell recognizes that "Alaskan rivers are among the most important of the State's natural resources and that they must be protected and preserved for the maximum benefit of all Alaskans." To solve problems endangering fish and wildlife habitats, increasing erosion, causing overcrowded, unpleasant conditions, and causing a fragmentation of management jurisdiction, this act would establish an Alaska Rivers Commission.

Already in Alaska demand for acquiring recreational access and public recreational lands is much greater than the money available for purchase (Russ Redick, pers. comm.). Lakes, rivers, and streams are the lands most sought by recreationists. Due to the state's demographic patterns, demand for recreational access and conflicts over land use are increasing, especially on the Kenai Peninsula and in the Mat-Su Borough. In response to public demands, the State Division of Parks has spent over $2 million buying back private riparian lands once held in the public domain along rivers and creeks in the Kenai Peninsula. Land purchases were targeted for areas receiving heavy recreational use (Jack Wyles, pers. comm.). In 1982, the legislature appropriated $3 million to buy back lands for access in the Kepler-Bradley Lake System in the Mat-Su Borough. Land acquisition in the Nancy Lakes area has cost the state over $565,000. To provide access, the state recently spent $1.2 million to purchase land along Montana Creek and $25,000 to purchase land adjoining Sheep Creek (page 27). These costs have been incurred because past land disposal systems did not consider future population patterns and recreational needs, nor needs to protect natural resources.

Another example of the public's need for Alaska's riparian lands and the high cost to the taxpayer of "buying back" this land can be found in Anchorage. The municipality has been purchasing "greenbelt" tracts along Fish Creek, Chester Creek, Ship Creek, and Campbell Creek. The municipality is in the process of trying to acquire land along Little Campbell Creek and Rabbit Creek, but with the rapid growth in Anchorage over the past few years, demand for developable land has made land very expensive. Between 1976 and 1981, the municipality has spent $3.2 million to buy 60.4 acres along Campbell Creek (Diane Reusing, pers. comm.).

LITERATURE CITED

Alaska Department of Fish and Game. 1973. Alaska's wildlife and habitat. Juneau, Alaska. 144 pp.

______________. 1976. A compilation of fish and wildlife resource information for the State of Alaska. Vol. 1, Wildlife. Anchorage, Ak. 425 pp.

______________. 1980. Alaska wildlife management plans - species management policies. Juneau, Ak.

______________. 1982. Aquatic habitat and instream flow studies. Susitna Hydro Aquatic Studies. Phase II: Basic Data Reports. Vol. 4., Part II. Anchorage, Ak.

______________. 1982b. Placer mining issue paper. Fairbanks, Ak. 2 pp.

Aldrich, J.W., and R.A. Johnson. 1979. Surface erosion sedimentation associated with forest land use in Interior Alaska. University of Alaska, Institute of Water Resources, Report No. IWR-99. Fairbanks, Ak. 87 pp.

Anderson, B.W., R.D. Ohmart, and J. Disano. 1978. Revegetating the riparian floodplain for wildlife. In R.R. Johnson and J.F. McCormick (Tech. Coord.), Strategies for the protection and management of floodplain wetlands and other riparian ecosystems. United States Department of Agriculture, Forest Service General Technical Report WO-12. Washington, D.C.

Behnke, R.J., and R.F. Raleigh. 1978. Grazing and the riparian zone: impact and management perspectives. In R.R. Johnson & J.F. McCormick (Tech. Coord.) Strategies for protection and management of floodplain wetlands and other riparian ecosystems. United States Department of Agriculture, Forest Service General Technical Report WO-12. Washington, D.C.

Behnke, R.J., and M. Zarn. 1976. Biology and management of threatened and endangered western trouts. United States Department of Agriculture, Forest Service General Technical Report RM-28. Fort Collins., Colo. 45 pp.

Boyce, Mark S. 1974. Beaver population ecology in Interior Alaska. M.S. Thesis, Univ. of Alaska, Fairbanks. 161 pp.

Brown, S., M.M. Brinson, and A.E. Lugo. 1978. Structure and function of riparian wetlands. Pages 17-31 in R.R. Johnson and J.F. McCormick (Tech. Coord.), Strategies for protection and management of floodplain wetlands and other riparian ecosystems. United States Department of

Agriculture, Forest Service General Technical Report WO-12. Washington, D.C.

Burger, C.V., D.B. Wangaard, R.L. Wilmot, and A.N. Palmisano. 1982. Salmon investigations in the Kenai River, Alaska, 1979-1981. U.S. Fish and Wildlife Service, Anchorage, AK. 178 pp.

Burns, J.W. 1972. Some effects of logging and associated road construction on northern California streams. Trans. Am. Fish. Soc. No. 101(1), pp. 1-17.

Burns, J.W. 1978. Planning for riparian vegetation management in the Sacramento River, California. In R.R. Johnson and J.F. McCormick (Tech. Coord.), Strategies for protection and management of floodplain wetlands and other riparian ecosystems. United States Department of Agriculture, Forest Service General Technical Report WO-12. Washington, D.C.

Chamberlin, T.W. 1982. Influence of forest and rangeland management on anadromous fish habitat in western North America. 3. Timber Harvest. United States Department of Agriculture, Forest Service General Technical Report PNW-136. 30 pp.

Clark, J.R. 1977. Coastal Ecosystem Management - A Technical Manual for the Conservation of Coastal Zone Resources. John Wiley and Sons, New York, New York. 927 pp.

Collins, T.C. 1976. Stream flow effects on beaver populations in Grand Teton National Park. Pages 349-352 in R.L. Linn ed., First Conference on Scientific Research in National Parks. USDI NPS. Trans. Proc. Series 5. Vol. I. New Orleans, La.

Cope, O.B., ed., 1979. Proceedings of the Forum - grazing and riparian/stream ecosystems. Trout Unlimited Inc., Washington, D.C. 94 pp.

Cordone, A.J., and D.W. Kelley. 1961. The influences of inorganic sediment on the aquatic life of streams. California Fish and Game 47(2):189-228.

Coughlin, R.E., and T. Plaut. 1978. Less-than-fee acquisition for the preservation of open space. AIP Journal, October, pp. 452-462.

Council on Environmental Quality. 1978. Environmental quality (Annual Reports). Washington, D.C. 599 pp.

________________. 1980. Environmental Quality (Annual Reports). Washington, D.C. 497 pp.

Countess, M.L., W.L. Criley, and B.R. Allison. 1977. Problems and conflicts associated with river recreation programming and management in the east. Pages 147-150 in Proc.: River Recreation Management and contingency table analysis. Oecologia 21: 157-173.

Johnson, R. 1979. Why do we need a national riparian initiative. Pages 1-8 in R.E. Warner ed., Proceedings of a workshop on fish and wildlife resource needs in riparian ecosystems. U.S. Fish and Wildlife Service, National Water Resources Analysis Group.

Karr, J.R., and D.R. Dudley. 1981. Ecological perspective on water quality goals. Environ. Manage. 5(1):55-68.

Kennedy, C.E. 1977. Wildlife conflicts in riparian management: water. In R.R. Johnson and D.A. Jones (Tech. Coord.). Importance, preservation and management of riparian habitats: a symposium. United States Department of Agriculture, Forest Service General Technical Report RM-43. Washington, D.C.

Konkel, G.W., L.C. Shea, K.E. Bulchis, L.C. Byrne, D. Penquilly, K. Stenehjem Lourie. 1980. Terrestial habitat evaluation criteria handbook - Alaska. U.S. Fish and Wildlife Service, Anchorage, Ak.

Kusler, J.A. 1980. Regulating sensitive lands. Environmental Law Institute. Ballinger Publishing Company, Cambridge, Massachusetts. 248 pp.

Le Resche, R.E., R.H. Bishop, and J.W. Coady. Distribution and habitats of moose in Alaska. Alaska Department of Fish and Game, Fairbanks, Ak. No date.

Martin, S.B., and W.S. Platts. 1981. Influence of forest and range management on anadromous fish habitat in western North America. 8. Effects of Mining. United States Department of Agriculture, Forest Service. General Technical Report PNW. 119 pp.

McCorkle, C.O., Jr., and J.E. Halver (co-Chairman). 1982. Impacts of emerging agricultural trends on fish and wildlife habitat. National Academy Press, Washington, D.C. 303 pp.

McKendrick, J., W. Collins, D. Helm, J. McMullen, and J. Koranda. 1982. Alaska Power Authority, Susitna Hydroelectric Project. Environmental Studies, Subtask 7.12:Plant Ecology, Phase 1 Final Report. University of Alaska, Agricultural Experimental Station. Palmer, Ak.

Meehan, W.R., and W.S. Platts. 1978. Livestock grazing and the aquatic environment. J. Soil and Water Conservation 33(6):274-278.

Meehan, W.R., F.J. Swanson, and J.R. Sedell. 1977. Influences of riparian vegetation on aquatic ecosystems with particular reference to salmonid fishes and their food supply. Pages 137-145 in R.R. Johnson and D.A. Jones (Tech. Coord.), Importance, preservation and management of riparian habitat: a symposium. United States Department of Agriculture, Forest Service General Technical Report RM-43. Washington, D.C.

Merritt, R.W., and D.L. Lawson. 1978. Leaf litter processing in floodplain and stream communities. Pages 93-105 in R.R. Johnson and J.F. McCormick (Tech. Coord.), Strategies for protection and management of floodplain wetlands and other Riparian ecosystems. United States Department of Agriculture, Forest Service General Technical Report WO-12. Washington, D.C.

Metsker, H. 1982. Toxicity of certain heavy metals on fish in the aquatic environment. United States Fish and Wildlife Service. Anchorage, Ak. 10 pp.

Meyer, S.C. and R.C. Kavanaugh. 1983. Fish resources and the effects of mining activities in the Kantishna Hills, Denali National Park, 1982. USDI, National Park Service. Anchorage, Ak. 150 pp.

Miller, C.L. 1982. Floodplain management for Alaskan communities. Alaska Department of Community and Regional Affairs. Anchorage, Ak. 68 pp.

Modafferi, R.D. 1982. Susitna Hydroelectric Project Phase 1 Final Report. Big Game Studies, Volume II, Moose - Downstream. Alaska Department of Fish and Game. Anchorage, Ak. 114 pp.

Moore, E., E. Janes, F. Kinsinger, K. Pitney, and J. Sainsbury. 1979. Livestock grazing management and water quality protection (State of the art reference document), United States Environmental Protection Agency. Seattle, Washington. EPA 910/9-79-67. 147 pp.

Murray, David F. 1961. Some factors affecting the production and harvest of beaver in the upper Tanana River Valley, Alaska. M.S. Thesis, Univ. of Alaska, Fairbanks. 103 pp.

National Wetland Newsletter. 1980. Vol. 2, No. 4. July - August 1980. Environmental Law Institute, Washington, D.C.

_______________. 1982. Vol. 4, No. 6. Environmental Law Institute, Washington, D.C.

Norris, L.A., H.W. Lorz, and S.V. Gregory. 1983. Influence of forest and rangeland management on anadromous fish habitat in western North America. 9. Forest Chemicals. United States Department of Agriculture, Forest Service General Technical Report PNW-149. 95 pp.

Palmer, T. 1981. Local protection of high quality streams. Environmental Planning Information Series Report No. 6. Department of Environmental Conservation. Harrisburg, Pa. 79 pp.

Platt, R.H., and G.M. McMullen. 1979. Fragmentation of public authority over floodplains: the Charles River response. Water Resources Research Center, University of Massachusetts, Amherst, Massachusetts. 112 pp.

Platts, W.S. 1979. Livestock grazing and riparian/stream ecosystems - an overview. In O.B. Cope, ed., Proceedings of the Forum - Grazing and riparian/stream ecosystems. Trout Unlimited. Vienna, Va.

Platts, W.S. 1981. Influence of forest and rangeland management on anadromous fish habitat in western North America. 7. Effects of livestock grazing. United States Department of Agriculture, Forest Service General Technical Report PNW-124. 25 pp.

Platts, W.S. 1982. Vegetation requirements for fisheries habitats. United States Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. Boise, Idaho. 4 pp.

Preston, D.J. 1982. The impacts of agriculture on wildlife. Alaska Department of Fish and Game. Project No. W-21-1. Fairbanks, Ak.

Priesnitz, M.F., and J. Harrison. 1977. Managing corridors in multiple ownership. Pages 183-186 in Proc.: River Recreation Management and Research Symposium. U.S. Department of Agriculture. General Technical Report NC-28.

Reeves, G.H., and T.D. Roelofs. 1982. Influence of forest and rangeland management on anadramous fish habitat in Western North America. 13. Rehabilitating and enhancing stream habitat: 2. Field Applications. United States Department of Agriculture. Forest Service General Technical Report PNW-140.

Roggenbuck, J.W., and K.G. Kushman. 1980. Riparian landowners' attitudes toward a state wild river program. Journal of Forestry. Vol. 78. No. 2. 3 pp.

Rummel, B.W. 1982. Agricultural practices and water quality effects. Alaska Department of Environmental Conservation. Anchorage, Ak. 82 pp.

Sands, A. 1978. Public involvement in riparian habitat protection - a California case history. Pages 216-227 in R.R. Johnson and J.F. McCormick, (Tech. Coord.), Strategies for protection and management of floodplain wetlands and other riparian ecosystems. United States Department of Agriculture, Forest Service General Technical Report WO-12. Washington, D.C.

Schmiege, D.C. 1980. Influence of forest and rangeland management in anadromous fish habitat in western North America, 11. Processing Mills and Camps. United States Department of Agriculture, Forest Service, General Technical Report PNW-113. 17 pp.

Sheridan, W.L., and W.J. McNeil. 1968. Some effects of logging on two salmon streams in Alaska. J. Forestry 66(2):128-133.

Simpson, P. W., J.R. Newman, M.A. Keirn, R.M. Matter, and P.A. Guthrie. 1982. Manual of stream channelization impacts on fish and wildlife. United States Fish and Wildlife Service/OBS-82/24. Washington, D.C. 154 pp.

Singleton, G.A., O.A. Steen, K. Weagle, and D. Weir. 1978. Fish and wildlife habitat recovery in placer mined areas of the Yukon. Hardy Associates, Ltd., Calgary, Canada. 131 pp.

Slough, B.G., and R.M.F.S. Sadleir. 1977. A land capability classification system for beaver. Canadian Journal of Zoology. 55(8):1325-1335

Starr, S.J., M.N. Kuwada, and L.L. Trasky. 1981. Recommendations for minimizing the impacts of hydrocarbon development on the fish, wildlife and aquatic plant resources of the Northern Bering Sea and Norton Sound. Alaska Department of Fish and Game, Habitat Division. Anchorage, Ak. 525 pp.

State of Alaska. 1981. Wetlands management in Alaska: a report to the Alaska Coastal Policy Council. Office of Coastal Management, Juneau, Ak. 119 pp.

Stauffer, D.F., and L.B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. Journal of Wildlife Management. 44(1):1980.

Swanson, F.J., and C.T. Dyrness. 1975. Impact of clearcutting and road construction on soil erosion by landslides in the western Cascade Range, Oregon. Geology 3(7):393-397.

Terrestrial Environmental Specialists, Inc. No date. Susitna Hydroelectric Project Feasibility Report. Vol. 2 Sec. 1-4. Anchorage, Ak.

The Wildlife Society. 1982. Stream and streamside (riparian) fish and wildlife habitats - a report on the results of a public opinion survey in Oklahoma. Oklahoma Chapter, Broken Arrow. 48 pp.

Thomas, J.W., C. Maser, and J.E. Rodiek. 1979. Riparian zones. Pages 40-47 in Wildlife habitats in managed forests - the Blue Mountains of Oregon and Washington. United States Department of Agriculture, Forest Service Agriculture Handbook, No. 533.

Thomas, J.W., C. Maser, and J.E. Rodiek. 1981. Wildlife habitats in managed rangelands - the Great Basin of Southeastern Oregon. Riparian habitats. United States Department of Agriculture, Forest Service General Technical Report. PNW-10. 18 pp.

Thompson, D.B., T.L. Loudon, and J.B. Gerrish. 1979. Animal manure movements in winter runoff for different surface conditions. In R.C. Loehn, ed., Best Management Practices for Agriculture and Silviculture. Proceedings of the 1978 Cornell Agriculture Waste Management Conference. Ann Arbor Science, Ann Arbor, Michigan. 740 pp.

Tripp, J. 1979. Who are our constituents and the decisionmakers. Pages 9-14 in R.E. Warner, ed., Proceedings of a workshop on fish and wildlife resource needs in riparian ecosystems. U.S. Fish and Wildlife Service, National Water Resources Analysis Group.

Tubbs, A.A. 1980. Riparian bird communities of the Great Plains. In

R.M. De Graff (Tech. Coord.) Proceedings: management of western forests and grasslands for non-game birds. United States Department of Agriculture, Forest Service, General Technical Report. INT-86.

Warner, R.E. 1982. Proceedings of a workshop on fish and wildlife resource needs in riparian ecosystems. National Water Resources Analysis Group, Eastern Energy and Land Use Team, United States Fish and Wildlife Service, Washington, D.C. 53 pp.

Woodward-Clyde Consultants. 1980. Gravel removal studies in arctic and subarctic floodplains in Alaska. United States Department of the Interior, United States Fish and Wildlife Service, OBS-80/08. Anchorage, Alaska. 401 pp.

Yeager, L.E., and W.H. Rutherford. 1957. An ecological basis for beaver management in the Rocky Mountains region, Pages 269-300. Trans. 22nd North American Wildlife Conference.

Yee, C.S., and T. Roelofs. 1980. Influence of forest and rangeland management on anadramous fish habitat in western North America. 4. Planning forest roads to protect salmonid habitat. U.S. Department of Agriculture. Forest Service General Technical Report. PNW-109. 26 pp.

Zemansky, G.M., T. Tilsworth, and D.J. Cook. 1976. Alaska mining and water quality. Institute of Water Resources, University of Alaska, Fairbanks, Alaska. 82 pp.