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Riparian Habitat Management for Reptiles and Amphibians on Corps of Engineers Projects

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PURPOSE: This technical note is a product of the Ecosystem Management and Restoration Research Program (EMRRP) work unit titled "Improved Methods for Ecosystem-Based Habitat Management at Corps Projects." The objective of the work unit is to provide technology on managing wildlife and their habitats using ecosystem-based strategies. The emphasis is on methods that improve natural resources for a variety of animals rather than single species. The recent focus on ecosystem management and inclusion of nongame species in management plans has provided opportunities to improve the restoration and management of natural resources for additional important taxonomic groups such as reptiles and amphibians. This note provides an overview of the importance of riparian habitat at Corps projects for reptiles and amphibians, identifies riparian zone functions and habitat characteristics, provides examples of representative taxa and regional comparisons, and describes impacts of riparian habitat modification.

BACKGROUND: Ecosystem management is a primary issue on Federal lands throughout the United States. Riparian habitat and its associated diverse species represent an important component within ecosystem management. Herpetofauna (reptiles and amphibians) use riparian and wetland habitats primarily because of reproductive patterns. Amphibians are linked to water during their egg and larval stages and many reptiles are functionally tied to wetlands (Harris and Gosselink 1990). The majority of North American herpetofauna inhabit wetland habitats, including riparian areas (e.g., 60 percent in deserts of the Southwest); thus, amphibians and reptiles may be some of the best indicator species for riparian ecosystems (Lowe 1989, Wake 1991) (Figure 1). However, the value of riparian and wetland habitats for herpetofauna is not widely appreciated. The prevailing attitude towards this group of animals, as a whole, is not particularly positive. Some exceptions include: the harvestable species (e.g., terrapins and bullfrogs); the endangered or threatened species (e.g., American alligator); and the animals that are enjoyable to watch or have as pets (e.g., turtles and salamanders). Most other species of amphibians and reptiles are not widely admired and are viewed with indifference, disgust, or even fear.

Figure 1. Riparian areas provide essential habitat for a diversity of reptile and amphibian species

Numerous Federal and state agencies have become actively involved in both riparian habitat and herpetofaunal conservation management. According to participation lists for Partners in Amphibian and Reptile Conservation (PARC), these include the U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service, National Park Service, Bureau of Land Management, U.S. Army Corps of Engineers (USACE), Environmental Protection Agency, U.S. Geological Survey, all service branches of the U.S. Department of Defense, state parks, state wildlife departments, and state natural heritage commissions. Academia, scientific and conservation societies, and private organizations also continue to demonstrate active interest in riparian habitat conservation for herpetofaunal species.

RIPARIAN ZONE FUNCTION AND HABITAT CHARACTERISTICS

Biological Characteristics and Food Webs. Amphibians and reptiles are important components of many ecosystems. Ecosystem support roles of wetland herpetofauna include: (1) serving as links in food chains; (2) processing dead organic matter and making it available to detrital food chains; (3) physically modifying the wetland habitat so that it supports a more diverse or abundant fauna; and (4) controlling populations of nuisance organisms. Pauley et al. (1999) provide an excellent review of amphibian and reptile ecology in riparian habitats with species listings for riparian habitat types.

Frogs, toads, and salamanders use riparian and wetland habitats because of reproductive patterns. Though they may be somewhat terrestrial outside the breeding season, most species depend on water or moist ground for egg laying and maturation (Clark 1979). With few exceptions, the approximately 190 species of amphibians in North America north of Mexico require wetlands, at least for breeding purposes (Clark 1979, Conant and Collins 1991). Ponds, bogs, marshes, swamps, or other areas of still to slowly moving water are necessary for the success of most frogs and all salamanders, except those entirely adapted to life in moist soil.

Amphibians associated with bottomland hardwoods tend to use the lower zones for reproductive purposes but may exploit drier or seasonally flooded sites for other resources (Wigley and Roberts 1994). Though capable of migrating some distance, more terrestrial frogs and toads often stay close to their breeding ponds during the nonbreeding season and, therefore, require suitable habitat adjacent to the flooded area of wetlands. Many wetland-dependent salamanders are also terrestrial during most of the year. Because of their semi-terrestrial life strategies or their adaptations for surviving dry periods, many amphibians can exploit seasonally flooded habitats. Temporary ponds are also used by amphibians that do not migrate, but instead survive dry periods by burrowing beneath tree roots and in crayfish holes.

Many of the reptiles associated with riparian and wetland habitats in the United States — turtles, snakes, a few lizards, and alligators — are the opposites of amphibians in life history strategy. They differ by using these areas for food and cover, but move to the habitat edge or to drier land to deposit eggs (Clark 1979).

Indicator Species. Terrestrial amphibians and reptiles are excellent indicators of the relative amounts of microhabitats in ecosystems (Jones 1986). Aquatic amphibians and snakes are good indicators of the health of aquatic systems. These animals are especially sensitive to pollution and loss of aquatic habitat (Hall 1980). Herpetofauna are important in food chains and they make up large proportions of vertebrates in certain ecosystems (Bury and Raphael 1983). Information on amphibian and reptile abundance and diversity helps determine the relative health of ecosystems. For example, frogs, toads, and salamander abundance and diversity fluctuate directly with changes in the composition and amount of microhabitats. It may be that amphibians signal environmental stress earlier than do most other organisms.

Amphibians are good bioindicators of environmental health because of their unprotected, permeable skin, and a lack of long-range dispersal capability (Lannoo 1998). They inhabit both aquatic and terrestrial habitats, which means that they are exposed to both aquatic and terrestrial pollutants. They are particularly sensitive because of their highly permeable skin, which can rapidly absorb toxic substances (Blaustein and Wake 1990). The egg stage is extremely susceptible to chemical pollutants, and exposure in high concentrations can result in developmental abnormalities. The growth rates of frogs and toads may be significantly affected by even short-term exposure to acidic conditions, such as may result from acid rain or snow.

Reports of declining amphibian populations in many parts of the world are numerous, but supporting long-term census data are generally unavailable (Pechmann et al. 1991). Anthropogenic factors have been implicated in many of the reported declines and extinctions of amphibian populations, yet others have occurred in protected, seemingly pristine areas. One problem with documenting amphibian declines is that for regions and most species, there are no historical data with which to compare. A second problem is that amphibian populations fluctuate and environmental conditions vary (e.g., wet years favor reproduction whereas droughts do not) (Pechmann et al. 1991). What may look like an extinction could instead be a temporary absence because of hibernation or dormancy.

Reasons implicated for underlying amphibian declines are habitat loss, increased ultraviolet radiation, acid rain, global warming, pesticide overuse, introduction of nonnative predatory species (e.g., bullfrog, game fish, bait fish), overcollecting for biological supply companies, and overcollecting for human food consumption (Blaustein and Wake 1990, 1995; Wake 1991; Livermore 1992; Lannoo 1998). In France, disappearance of frogs in ponds and lakes has been attributed to released pet goldfish, which consume the eggs (Livermore 1992). Eurasian culinary markets for frog legs have severely impacted frog abundance (Blaustein and Wake 1995). The primary reason consistently given for amphibian declines has been habitat loss.

A world-wide decline of amphibians could have a huge impact on other organisms, including humans (Blaustein and Wake 1990). Amphibians are integral components of many ecosystems, often constituting the highest fraction of vertebrate biomass. Moreover, amphibians are top carnivores and are major consumers of invertebrates, especially insects. They are also eaten by predators such as fish, birds, mammals, and aquatic insects. Thus, the loss of amphibians in many ecosystems could profoundly affect the populations of the animals that they eat and the animals that eat them.

Macrohabitat Components. The distribution and abundance of certain herpetofaunal species in wetland ecosystems is controlled by several macrohabitat factors including wetland size and location, relationship to adjacent terrestrial and aquatic systems, flooding regime, water quality, substrate, and vegetation structure (Pianka 1966; Clark 1979; Jones 1981) (Figure 2). Stream size determines the characteristics of the adjacent riparian zone and associated wildlife (Bury 1988). Along small headwaters the herpetofauna consist primarily of amphibians; as creeks and streams become larger, both amphibians and reptiles occur, with reptiles being found mostly along larger streams and rivers. Habitat structure is also known to influence amphibian and reptilian community structure. Abundance of amphibians and reptiles increases in streamside zones associated with a closed canopy and leaf litter ground cover (Dickson 1989; Rudolph and Dickson 1990).

Figure 2. Typical wetland habitat for amphibians and reptiles

Dickson (1989) demonstrated that medium (30-40 m) and wide (>50 m) streamside zones supported many more amphibians and reptiles than narrow (<25 m) zones in southern United States forests. Apparently, this difference was habitat-related. The medium and wide streamside zones had a distinct overstory, a shaded understory, and an accumulation of ground litter. The narrow streamside zone had little overstory and a dense understory. Streamside zones wide enough for a closed tree canopy, shaded understory, and a leaf litter ground cover provide adequate habitat for southern reptiles and amphibians.

Rudolph and Dickson (1990) similarly showed that streamside zone width significantly influenced the abundance of amphibians and reptiles within the streamside zones of southeastern United States pine (*Pinus* spp.) plantations. There were fewer amphibians and reptiles in narrow (0 to 25 m) streamside zones than in wider zones (30 to 95 m). The wider zones were characterized by an intact overstory and midstory, sparse shrub and herbaceous vegetation, and abundant leaf litter. In contrast, the narrow zones lacked these characteristics.

Microhabitat Components. Amphibians and reptiles are ectothermic; body temperatures are not derived from metabolic processes but rather from the surrounding environment. Therefore, behavioral adaptations and use of different microhabitats by amphibians and reptiles are diverse. Jones (1986) demonstrated that changes in microhabitats within a riparian ecosystem influence the distribution, abundance, and diversity of herpetofauna. For an unaltered riparian ecosystem, many microhabitats were more abundant and diverse, especially in regard to surface litter and trees. Herpetofauna are not nearly as common in riparian ecosystems with lower surface litter and fewer vegetation structures.

The most important factor affecting amphibian and reptile distribution and habitat use is horizontal and vertical habitat availability. Jones (1986) identified nine microhabitat components and attributes that are important determinants of amphibian and reptile abundance: lotic water, permanent lentic water, temporary lentic water, rock, litter/debris vegetation, live vegetation, dead vegetation, plant species, and soil. Microhabitat components are site-specific, physical entities that provide environmental conditions necessary for a wide variety of ecological functions such as reproduction, foraging, predator avoidance or escape, thermoregulation, and resting.

Litter (e.g., fallen logs, leaves), plant root structure, horizontal vegetation structure, substrate moisture, pH, light intensity, as well as soil depth, texture, and diversity are critical elements for amphibians and reptiles to utilize an area (Figure 3). Removal or reduction of microhabitats necessary for thermoregulation can detrimentally affect all other ecological functions because internal temperature regulation determines the intensity of activity (e.g., certain basking turtles can be wiped out from a pond if floating logs are eliminated). Removal or reduction of rotting logs and associated litter creates insufficient moisture for egg development and adult survival for many amphibian species. These microhabitat changes often result from land management practices such as bank clearing, snagging, logging, and clearcutting.

Figure 3. Fallen logs provide microhabitat for numerous reptile and amphibian species

Establishing native vegetation, especially trees, is often the focus of riparian restoration and management efforts in the arid Southwest (Jones 1988). Several techniques, such as planting live trees and tree poles, have been used on drainages with major water impoundment structures to improve reproduction and survival of trees such as cottonwoods (*Populus* spp.) (Swenson and Mullins 1985). Although these techniques generally increase nesting habitat for birds, they do not provide enough surface litter to support litter-dwelling species, such as upland herpetofauna. Surface litter is important in determining abundance and diversity of herpetofauna in riparian communities. Conservation of riparian ecosystems must emphasize protection of all habitat components including microhabitats such as surface litter. Lower species richness in highly modified riparian ecosystems appears to be a result of reduction in habitat diversity, which creates a more homogeneous and simplified environment.

CHARACTERISTIC HERPETOFAUNAL SPECIES

Representative Taxa. Bullfrogs (*Rana catesbeiana*) and green or bronze frogs (*R. clamitans*) are found in water or shore vegetation of permanently flooded wetlands during both breeding and nonbreeding seasons, but other members of the family Ranidae are terrestrial except during the breeding season and are able to survive in moist depressions during dry periods. Toads (Bufonidae) and tree frogs (Hylidae) are also terrestrial or arboreal outside the breeding season but generally remain close to their breeding ponds and, therefore, require suitable habitat near flooded wetlands (Figure 4).

Figure 4. The southern cricket frog (*Acris gryllus*) is a typical wetland species

Among the wetland-associated reptiles, turtles are probably the most diverse group. The degree to which turtles depend on water varies among species. Snapping turtles, mud and musk turtles, softshells, and some pond turtles are truly aquatic, leaving water only to lay eggs (Figure 5). Other species, such as box and wood turtles are largely terrestrial, eat fruit, berries, and other terrestrial plant materials in addition to worms and insects, and may enter water only to hibernate in the muddy bottom. Lizards are rare in freshwater wetlands. Skinks (*Eumeces*) and anoles (*Anolis*) are found near southern river swamps and floodplain forests but are also found in nonwetland forests.

Figure 5. The common snapping turtle (*Chelydra serpentina*) and the razorback musk turtle (*Sternotherus carinatus*) are true aquatic species

Although cottonmouths (*Agkistrodon piscivorus*) are frequently associated with wetlands of the central and southeastern United States, water snakes in the genus *Nerodia* are found in these habitats in higher numbers and biomass (Figure 6). Several other genera are also common: *Thamnophis* (garter snakes), *Regina* (queen snakes), *Farancia* (mud snakes), and *Seminatrix* (swamp snakes). Snakes depend on wetlands for food (e.g., fish, frogs, salamanders, and crayfish). Many snakes, including kingsnakes (*Lampropeltis*) and rat snakes (*Elaphe*), frequent wetlands but are not restricted to them.

Most notorious of all freshwater wetland reptiles is the American alligator (*Alligator mississippiensis*), which lives in swamps and marshes from North Carolina south through Florida and west to the Rio Grande. Its preferred habitats are river swamps, cypress domes, willowheads and sloughs of sawgrass marshes, and channels in the freshwater zone of mangrove swamps.

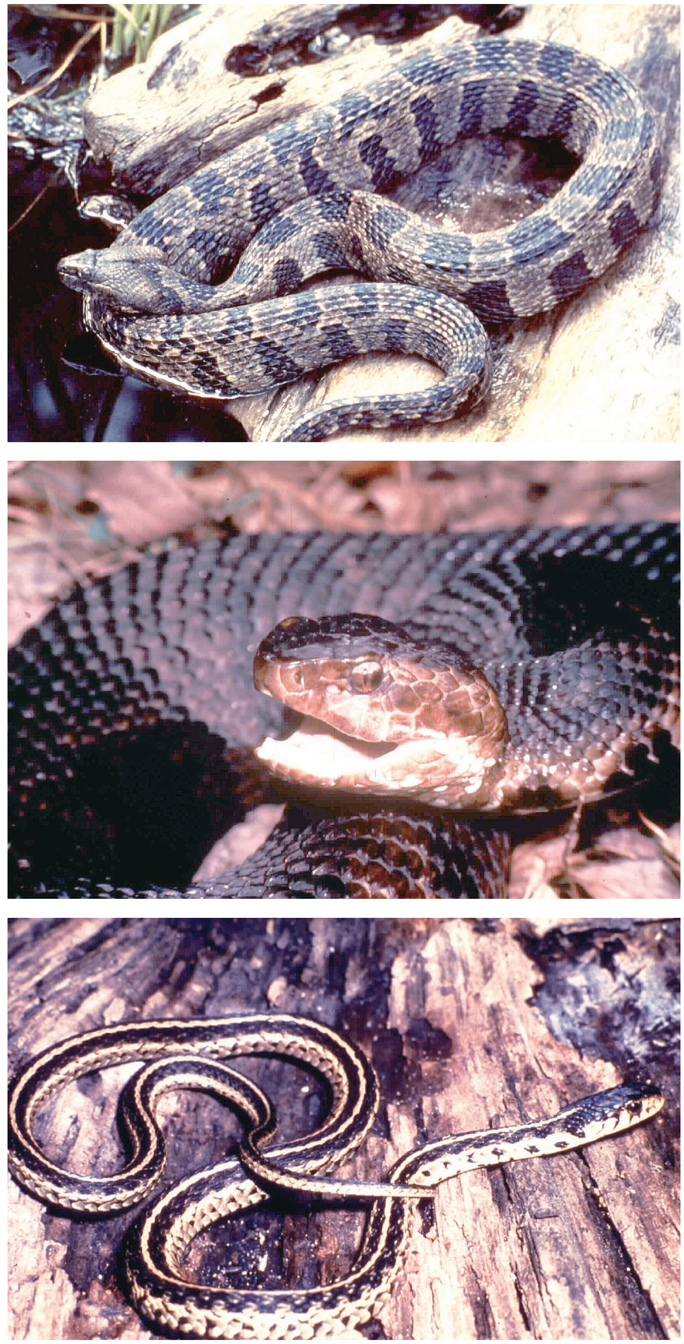

Figure 6. The diamondback water snake (*Nerodia rhombifera*) (top), cottonmouth (*Agkistrodon piscivorus*) (center) and garter snake (*Thamnophis sirtalis*) (bottom) are all common wetland species

Regional Comparisons. Because the majority of North American herpetofauna inhabit riparian/wetland habitats, they may be the best indicator species for these ecosystems (Lowe 1989, Wake 1991). Of the North American amphibians, 190 species are dependent on wetlands for breeding (Clark 1979, Conant and Collins 1991). The diversity of wetland amphibians varies with latitude and annual rainfall (Clark 1979). Species richness is very high in southern swamps, even in temporary ponds, and decreases to the north and west.

In the southwestern United States deserts, 60 percent of herpetofauna inhabit riparian and wetland areas (Lowe 1989). In California, riparian ecosystems provide habitat for 83 percent of the amphibians and 40 percent of the reptiles known from that state (Brode and Bury 1984). In the South, reptiles and amphibians constitute as much as 45 percent of native fauna, excluding fish (Vickers, Harris, and Swindel 1985).

Amphibians and reptiles are often abundant in aquatic and streamside zones in the Pacific Northwest, and most have distinct habitat preferences. Bury (1988) showed 30 to 60 percent of the Pacific Northwest herpetofauna associated with riparian zones of small streams. Amphibians are important components of aquatic and riparian habitats associated with first- and second-order streams in this area (Bury and Corn 1988). In many headwater reaches, amphibians can be the dominant vertebrate predators.

Threatened and Endangered Species. The effects of continuing habitat loss and fragmentation in wetland and riparian habitats are further exemplified by the high proportion of threatened or endangered species that depend on forested wetlands. Although wetlands compose only 3.5 percent of the land area of the United States, 35 percent of all rare, threatened, and endangered wildlife species occur there or depend on these ecosystems for survival (Kusler 1977). As an example, 18 percent of all Florida amphibians and 35 percent of all Florida reptile species are considered to be in a category of concern (rare, threatened, or endangered) (Harris and Gosselink 1990). These percentages are much higher than those for birds, mammals, and fish.

IMPACTS OF HABITAT MODIFICATION

Environmental Disturbance. Factors controlling herpetofaunal abundance and diversity include climate, wetland size and location relative to other wetlands, wetland setting, substrate, vegetation structure, flooding, and water quality, as well as competition and predation (Clark 1979). Anthropogenic activities primarily attributed to environmental disturbances to these factors include but are not limited to the following:

Flooding pattern and substrate alterations. Flooding patterns in a riparian area may create isolated “island” situations, which subsequently reduce herpetofaunal abundance and distribution (Szaro and Belfit 1986). For these situations, the potential for ecological replacement of disturbed riparian herpetofauna, particularly in regard to nonmigratory species, might require more than a simple increase in vegetative complexity. The lack of invasion by typical riparian species probably results more from isolation factors than from structural and physical conditions. The reintroduction of riparian species might be necessary, particularly in such isolated “island” situations.

Wetland substrates can be easily altered to the detriment of aquatic herpetofauna by draining, dredging, filling, and performing a variety of human activities (inside or outside the wetland) that cause sedimentation. Water depth, hydroperiod, and timing of water level changes are major factors controlling wetland faunal abundance and diversity. Seasonal changes in water levels additionally serve as environmental stimuli for life cycle activities of some wetland herpetofauna. In southern river swamps, dropping water levels may initiate dormancy in some aquatic snakes and salamanders, whereas rising water levels are suspected of initiating breeding activity in some species.

Channelization. Amphibian and reptile abundance decreases when channelization destroys important habitat features such as meanders, pools, and overhangs, and reduces the frequency and duration of flooding (Barclay 1980). Water impoundment structures eliminate periodic flooding and can significantly reduce stands of cottonwoods and willows (*Salix* spp.) along major drainages, which may reduce mesic conditions important to amphibians and reptiles in downstream riparian systems (Jones 1988). Removal of coarse woody debris from streams has detrimental effects on various herpetofaunal species as well as other stream biota and their habitats (Harmon et al. 1986).

***Bank clearing and snagging*.** As watersheds are cleared, especially as the stream-edge floodplain forests are cleared, erosion increases and stream water quality degrades. The first effects on native biotic diversity due to cumulative bottomland hardwood forest loss are felt by individual species, which suffer abnormalities in reproduction, range restriction of sensitive species, and loss of genetic heterogeneity (Harris and Gosselink 1990).

Logging and clearcutting. About 57 percent of forested wetland acreage occurs in 12 southeastern states, which indicates a dramatic decline in bottomland hardwood areas (Harris and Gosselink 1990). Approximately 50 percent of the 1940 area was lost by 1985 with only one-fifth of the natural forested wetlands of the Lower Mississippi River Valley remaining (Harris and Gosselink 1990). Selective logging and other past forestry practices have degraded internal stand quality and created fragmentation of the remaining areas into small, disjointed, and sometimes isolated patches.

Rudolph and Dickson (1990) found few amphibians and reptiles in riparian zones affected by timber harvesting and clearcutting. These areas had open overstories, dense shrub layers, dense herbaceous vegetation, and little leaf litter. Clearcutting in pine-hardwood stands results in higher soil temperatures and more evaporative water loss from the soil and understory (Raymond and Hardy 1991). Clearcutting also reduces herpetofaunal species richness due to loss of some arboreal snake and lizard species (Enge and Marion 1986, Wigley and Roberts 1994).

Agriculture. Grazing-caused reductions in debris heaps within riparian habitats result in serious declines in herpetofauna that use these microhabitats as their principal source of food and cover. Szaro, Belfit, and Aitkin (1985) showed reduced populations of *Thamnophis elegans* (garter snake) in riparian habitats as a result of grazing impacts. Reductions in overall lizard abundance and species diversity from livestock grazing were associated with changes in structural composition of a given vegetative community (Bury and Busack 1974, Jones 1981). Additional agricultural impacts include aquatic and terrestrial pollutants and toxins from pesticide overuse and runoff.

Other human activities. Habitat destruction in riparian zones includes off-road vehicle use and road construction. The intentional or accidental introduction of nonnative species results in predation or competition to displace, reduce, or eliminate native species. Overcollecting of particular species for consumption, scientific specimens, or pet trade significantly reduces or eliminates populations.

Inventory and Monitoring. The primary difference between inventory and monitoring of amphibians and reptiles and their habitats is the objective established by the biologist. Both may involve similar data collection methods; however, inventories usually verify what is there and how habitat resources are being used. Monitoring determines how individual species or communities change as a result of specific types of land use. Before initiating any sampling, the required scientific collecting permits should be obtained from state and/or Federal regulatory agencies.

Biologists should be aware of several factors that may affect results when sampling amphibians and reptiles. The largest problem in assessing amphibian and reptile populations is that behavior and reproduction vary with natural environmental fluctuations, such as precipitation and temperature (Gibbons and Semlitsch 1981, Vogt and Hine 1982). Caution should be taken when interpreting cause and effect data because observed differences may result from natural fluctuations in weather.

Other major factors affecting amphibian and reptile sampling are differences in species morphology, physiology, and behavior such as activity patterns and movement. Daily, weekly, and yearly fluctuations in amphibian and reptile activity also affect verification of species occurrence in an area. There may also be daily and seasonal differences in movement between different ages, size-classes, and sexes. Other life history limitations may also affect the interpretation of sampling data (e.g., differences in reproductive strategies). Provided species life histories and sampling limitations are clearly understood, relatively accurate samples can be obtained for individual species or entire amphibian and reptile communities.

There are generally two ways to collect species information: direct and indirect. Direct sampling of amphibians and reptiles involves observation of animals occurring on a sample site. Indirect sampling involves obtaining species information of a sample site without observing the animal. Microhabitat specific searches are generally used to verify and collect data on the abundance of a few species. If used for verification only, this method can be quick and easy. When relative abundance or density is needed, this method is considerably more time-consuming.

Broader, more extensive surveys of entire amphibian and reptile faunas in a variety of habitat types do not allow for intensive study of individual species. In a community survey, biologists attempt to determine species composition of each major habitat type and some rough estimate of abundance; and, if possible, species' uses of microhabitats. By being aware of macrohabitat conditions, biologists will better understand causes of microhabitat variables, and how and where to set up sampling.

Because individual amphibian and reptile morphology, behavior, and ecology vary, biologists should use several censusing methods for determining herpetofauna community composition. Attempts should be made to use sampling combinations such as opportunistic observations, transects, pitfall and funnel traps, drift fences, and road riding for deriving more complete species lists (occurrences) within specific areas or habitats.

Monitoring generally requires sampling over several years so that species and community health can be accurately estimated. Multi-year data collection helps determine which population trends are due to naturally fluctuating environmental conditions and which ones are due to land use practices.

If funds prohibit complete community sampling, decisions should be made as to which species or habitat will produce the most useful information for the money. Most agency budgets will not permit long-term, intensive, multi-year sampling of individual species or entire communities. To offset budget limitations, biologists should concentrate on long-term changes in species richness and important microhabitats, especially when losses are involved. To determine these changes, studies involving only species verifications, habitat measurement techniques, or sampling of indicator species may be the most cost-effective. In selecting indicator amphibians and reptiles, the sampling methods and species life history limitations must be clearly identified. Two general types of indicator species are amphibians and reptiles that represent species assemblages that use habitats in similar ways (species guilds) and species that use specific habitat components. Although very time-consuming, systematic search procedures in defined areas are generally used to assess accurate estimates of population density for special status amphibians and reptiles such as Federally threatened and endangered species.

SUMMARY: The majority of North American reptiles and amphibians are functionally tied to riparian or wetland habitats either as obligate or seasonal inhabitants. Both macrohabitat components (wetland size and location, relationship to adjacent terrestrial and aquatic systems, flooding regime, water quality, substrate, and vegetation structure) and microhabitat components (lotic water, permanent lentic water, temporary lentic water, rock, litter/debris vegetation, live vegetation, dead vegetation, plant species, and soil) should be considered in riparian habitat management for reptiles and amphibians. Anthropogenic activities primarily attributed to disturbances of the macrohabitat and microhabitat components include: flooding pattern and substrate alterations, channelization, bank clearing and snagging, logging and clearcutting, agriculture, road construction, and off-road vehicles. Project field studies for establishing comprehensive inventories of reptiles and amphibians can be labor-intensive and costly. Techniques that utilize typical indicator species (amphibians) may provide cost-effective monitoring and evaluation of management practices in riparian habitats.

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