11 Riparian Area Management

Water—a requirement for most if not all life. Free flowing or standing water is indeed required by many species. Many amphibian species need free water during at least part of their life to lay eggs that will hatch and develop into adults before the water evaporates (Figure 11.1). Other amphibians spend all of their lives in water, such as aquatic forms of Pacific giant salamanders. Waterfowl use lakes, ponds, streams, marshes, and swamps as places to feed and raise young. River otters, snapping turtles, and bullfrogs are all aquatic predators that use resources in both aquatic and terrestrial environments (Figure 11.1). Because so many species are associated with free water, the interface between the water and the land, that area known as a *riparian area*, is usually given special consideration during forest management.

Riparian areas are perceived by many ecologists as being particularly important for animal species due to several conditions:

- Free water is available near food and cover for many species.
- Because of the high latent heat of water, riparian and wetland areas can have more humid and stable microclimates than adjacent uplands.
- Edges are often formed between riparian and upslope vegetative communities, enhancing the number of niches for vertebrate species.
- Streams and riparian areas can provide corridors (or barriers) for animals moving across the landscape.
- Net primary production often is higher in riparian and wetland areas and food quantity and quality tends to be higher there for many species.

The availability of free water near the food and cover resources in the terrestrial environment is critical for a large number of vertebrate species. For example, mountain beaver occur near riparian areas (or in very moist forests) because their primitive uretic system requires a humid environment (Schmidt-Nielson and Pfeiffer 1970). White-tailed deer use water as a means of escaping predators in bottomland forests. Elk and deer will often use riparian areas as a cooler environment during warm weather. Because of the high latent heat of water (it takes 1 cal to raise 1 g of water 1°C), riparian and wetland areas can have more stable microclimates than adjacent drier uplands. Some species are able to take advantage of these more stable riparian conditions.

Edges are often formed between riparian and upslope vegetative communities, enhancing the plant species richness and vertical complexity of the forest (Naiman et al. 2000). Horizontal complexity in vegetation is also often high due to the dynamic nature of stream systems, creating canopy gaps and patches of shrubs and trees of various species and sizes, some of which are soft-mast producers (Naiman et al. 2000). This increased complexity provides a wide range of habitat element types, abundances, and distributions, thereby providing greater opportunities for more species to occur than in simpler systems.

Although riparian areas can provide many of the elements needed by some species, they also can provide corridors or barriers for animals moving across the watershed. A water shrew may find a fast moving river to be an excellent corridor, but a short-tailed shrew or Pacific shrew may find the same river to be a significant barrier. Indeed, even for some bird species, riparian areas >50 m wide can become barriers that they are reluctant to cross (Tremblay and St. Clair 2009). Again the function of the stream as a connector or barrier is species specific (Savidge 1973, Henein and Merriam 1990).

FIGURE 11.1 Species typical of riparian areas clockwise from top left: snapping turtles are found in slow-moving streams and ponds (photo by Mike Jones, with permission), spotted salamanders reproduce in vernal pools in the northeastern United States (photo by Mike Jones, with permission), cottonmouths are an aquatic pit viper of southeastern swamps and marshes, and beavers create ponds used by many other species.

Net primary production can be quite high, especially in slow-moving rivers and side channels, ponds, and lakes. Marshes represent one of the most productive ecosystems on Earth (Waide et al. 1999). Aquatic productivity is dependent on nutrient availability and sunlight in the water column. Nutrient-rich aquatic systems, referred to as *eutrophic systems*, can have very high levels of primary production through algal blooms, submerged vegetation, and emergent vegetation. But there is a price to pay for too much productivity. For instance, enriched streams with high levels of nitrogen and phosphorus from fertilizers can lead to algal blooms, which provide plant food for herbivores, but these plants can also deplete the water of oxygen. As plants photosynthesize, they return oxygen to the water, but in the evening they respire, using oxygen to survive while releasing carbon dioxide. Without adequate oxygen during the night many fish die from oxygen deprivation, reducing not only the fish fauna but also the food resources for their predators. So reducing nutrient loads is good, right? Perhaps, but again it depends on the species. Species that rely on a grazing-based energy acquisition by eating aquatic vegetation (e.g., carp) need nutrient-rich systems, while species that feed on aquatic insects associated with decaying leaves or with trees over the stream (e.g., trout) often do better in nutrient-poor (*oligotrophic*) streams.

ANIMAL ASSOCIATIONS WITH RIPARIAN AREAS

Animal species richness is often higher in riparian areas than in adjacent upslopes (Knopf et al. 1988), especially in arid environments. In arid environments, the availability of water not only provides the opportunity for evaporative cooling but also supports a richer and more palatable vegetative community than adjacent upslope areas. In moist environments, the importance of riparian areas to many species is much reduced (McGarigal and McComb 1992).

Nonetheless in every forest system in North America, there is a suite of species that requires free water. These species are referred to as *riparian obligates*—you only find them near water. River otters, American dippers, beavers, and wood ducks are examples of riparian obligate species. Other species tend to be found more commonly near water but do not require the water directly for some aspect of their life. Yellow warblers, jumping mice, several species of myotis bats, and bald eagles are examples of *riparian associates*.

One group of riparian obligate species, pond-breeding amphibians, preferentially breed in isolated ponds and wetlands that hold water for only a part of the year. These *vernal pools* provide a predator-free (no fish) environment where the pond breeders can lay eggs and the larvae can feed on decaying vegetation, metamorphose into adults, and leave the pond before the pond dries out (Semlitsch and Bodie 1998). In some years, ponds dry out too soon, stranding the immature amphibians, while in other years the water lasts until after they have metamorphosed. Apparently pond-breeding species that reproduce in vernal pools have a selective advantage over those that use permanent fish-bearing water bodies where they face greater risks of predation. Animals must disperse from the ponds once they have metamorphosed, and there is evidence that at least some species may be adversely affected by forest management near vernal pools. Popescu and Hunter (2011) found that canopy removal and conversion of natural forest to conifer plantations in Maine may affect regional population viability of vernal pool breed amphibians by hindering successful dispersal of juveniles as they leave the vernal pool.

There are also some species that occur in forests that are not associated with riparian areas. They may obtain their water from condensation, rain, or their food. So although riparian areas are an important component of the forested landscape for many species, other upslope parts of the landscape are also important for additional species. Often forest management regulations focus on riparian areas due to the requirements to provide clean water, habitat for fish species, as well as habitat for terrestrial species, but may not consider the condition of the forest for other species some distance away from the riparian area. Such a focus on riparian areas can be to the detriment of other species not associated with riparian areas.

GRADIENTS WITHIN RIPARIAN ZONES

There are two dominant gradients of habitat elements associated with riparian areas, the intra-riparian and trans-riparian gradients. *Intra-riparian gradients* refer to the continuum of conditions from the headwaters to the confluence with larger water bodies, and eventually with the ocean at an estuary. Riparian areas are hierarchical systems constrained by a *watershed*, the area of the land that captures and routes water down hill (Figure 11.2). The upper reaches of a stream system are usually intermittent streams that flow only following rain or during snowmelt. Long considered somewhat irrelevant to the function of the permanent stream system, intermittent and headwater streams can provide important refugia for many species of amphibians (Sheridan and Olson 2003, Stoddard and Hayes 2005). These areas can also serve as conduits for transport of nutrients, sediment, and pathogens from upslope areas into the stream system (Naiman et al. 2000). If water temperature, sediment loads, or other pollutants are of concern downstream, then these intermittent streams deserve attention, in addition to meeting habitat needs for species associated with these areas (Wigington et al. 2005). Roadside ditches also often serve as conduits of sediments and chemicals into the stream system. Indeed road systems are the primary cause of excessive sediment loads in many forested stream systems (Reid and Dunne 1984).

Depending on the geology of the area, the upper portions of mountain watersheds usually support streams that have high gradients and deeply incised channels. The opportunity for the stream to move from side to side and develop a complex floodplain with side channels, pools, riffles, and glides are limited until the gradient declines somewhat and sufficient time has elapsed to lead to stream bank erosion, deposits of sediments, and expansion of the active channel (Figure 11.3). Within the middle part of watersheds, adequate stream volume usually leads to the development of a floodplain

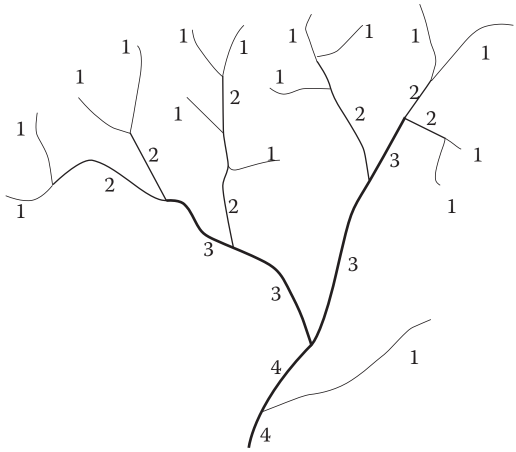

FIGURE 11.2 Hierarchical system of stream orders along an intra-riparian gradient. Note that two first-order streams form a second-order and two second-order streams form a third order, and so on.

following successive flood events that not only erode stream banks but also deposit sediments from farther upstream. These *alluvial* sediments often form terraces that represent different flood intensities and frequencies (Naiman et al. 2000). Intense floods that carry sediments and wood from the headwaters into the mid-watershed area spill over the banks of the active channel into the active floodplain. As the water slows along the flooded edges, it cannot carry the same sediment load and so it deposits the sediments in this floodplain. Frequent floods such as this allow the development of an active floodplain where tree species such as cottonwoods and willows may become established. Species such as these are well adapted to colonizing the exposed sediments when the water levels recede. They have seeds that are carried on wind and water, deposited on the sediments, and grow rapidly to claim the site. These mid-watershed areas often have braided channels as the stream velocity slows, depositing sediments (Naiman et al. 2000). Depending on the stream volume under high flows, the mid-watershed is also the portion of the stream system where beavers most often build dams, creating a staircase of ponds. The active floodplain also provides an opportunity for the stream channel to begin to meander and create a more complex stream channel system. Side cutting of the channel allows the formation of steep stream banks with bars, or areas of deposition on the opposite side of the stream (Figure 11.4). Steep stream banks provide places for belted kingfishers to nest and the bars provide nesting sites for spotted sandpipers and other shorebird species. Finally, as the stream approaches an estuary, water velocity slows further and is affected by tides causing sediment loads to further decline, forming a delta. These delta conditions can allow the formation of *marshes* (wetlands dominated by nonwoody vegetation) and *swamps* (wetlands dominated by woody vegetation). As the water flows into estuarine conditions, many tree and shrub species cannot tolerate the saline conditions and are replaced by grasses, sedges, and rushes to form a marsh.

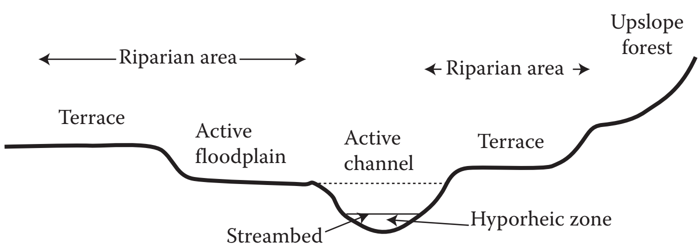

FIGURE 11.3 A schematic of a trans-riparian gradient from streamside to upslope.

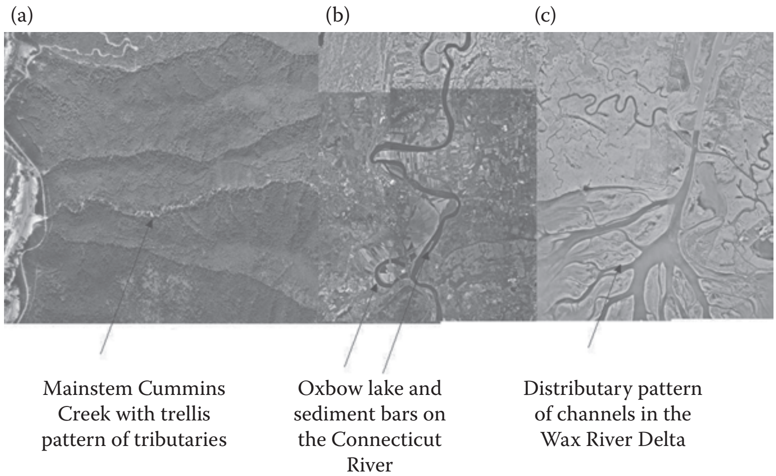

FIGURE 11.4 Three types of stream morphology in Cummins Creek, Coastal Oregon (a) with steep gradient and narrow valley floors; the Connecticut River Valley in Massachusetts (b) with broad floodplains and oxbow lakes; and the Wax River Delta in Bayou Vista Louisiana (c) with high sinuosity and delta formation. Note as floodplain width increases and gradient decreases, sinuosity and braided channels increase, leading to greater riparian complexity. (Images courtesy of TerraServer.com/DigitalGlobe. With permission.)

Swamps that often occur at the lower end of a watershed are frequently flooded forests dominated by species tolerant of being partially submerged for prolonged periods, such as baldcypress and water tupelo in the deep South of the United States. Because of the often nutrient-rich environments associated with these swamps, they tend to be highly productive areas for growth of trees and shrubs and as well as the animals associated with them. Louisiana's Atchafalaya Basin is the largest swamp in the United States at 241,000 ha (595,000 acres). Because this area and others like it along the Mississippi River and other large rivers produce nutrient-rich floodplain soils, many have been cleared for agriculture and more recently for urban expansion, despite the risks of repeated flooding.

Along the intra-riparian gradient, changes in the geomorphology of the watershed give rise to areas of different stream velocities and stream substrates. Continuously rushing water over boulders produces a cascade, which is excellent habitat for Harlequin ducks and tailed frogs. Where erosion-resistant rock or a log partially dams the stream, a pool can form both above and below the obstacle (Figure 11.5). The upstream pool collects water and allows sediment deposits to build up above the obstacle, aggrading the stream channel. As the water flows over the object, it forms a plunge pool. These areas provide places where beaver often initiate a dam (Leidholt-Bruner 1990). Both areas can add to stream channel complexity and hence provide conditions suitable to more species of aquatic and semiaquatic animals.

Large logs falling into a stream or carried downstream from headwaters (often from landslides) can add significantly to channel complexity in many forested areas. Indeed, the transport of wood from the headwaters to the estuary provides opportunities for use by many species from salamanders to otters to salmonids to mollusks along its journey to the sea (Maser et al. 1988). This stream complexity contributes habitat elements and increases the potential number of species that use the variety of conditions that are created. The variability in flood frequency and severity adds complexity such as fine-scaled features of topography, which are strongly related to plant species richness and species composition (Naiman et al. 2000).

Trans-riparian gradients refer to the changes in conditions as you move from the edge of the stream into upslope forests, perpendicular to the gradient (Figure 11.3). Along the edge of a stream there often is the opportunity for emergent plants to become established, especially if there is adequate sunlight and the gradient is not too steep. Along the edge of a steep active channel, erosion and

FIGURE 11.5 Dead wood in a stream in the Berkshires of Massachusetts reduced stream flow and caused sediment deposition upstream and a plunge-pool downstream, adding to channel complexity.

deposition often prevents trees from becoming established, so water-tolerant herbs and occasionally shrubs dominate. Farther upslope, species of trees that are water tolerant begin to dominate in those areas that are flooded less frequently. Species such as red alder, cottonwoods, silver maple, water oak, and pin oak can be found here (depending on what region of North America you are in). As you move farther upslope, these species give way to others that are not so tolerant of saturated soils and more drought tolerant; eventually you are in an upslope tree community. We can see changes in plant species along the moisture gradient all the way to the ridge top. As these plant species change along this trans-riparian gradient, many animal species also change accordingly. In the northwest, we might find Pacific jumping mice and Dunn's salamanders in the floodplains near the stream and not find them farther upslope (McComb et al. 1993). On the other hand, we might find California red-backed voles upslope but rarely along the stream. Many species distribute themselves throughout a watershed in response to the moisture, soils, and vegetation seen along the trans-riparian gradient.

RIPARIAN FUNCTIONS

The function of a riparian area in providing energy, nutrients, and other resources to animals is heavily influenced by a set of processes linking streams to adjacent forests. Forested streams often produce cool, clean water; so it is not surprising that most public water is supplied from forested watersheds. Forests are the natural filter. Because they are clean, they tend to be low in nutrients. Low nutrient availability can limit the productivity of fish and invertebrates in the stream and hence can limit the abundance of their predators. Indeed, low availability of nitrogen, phosphorus, and carbon in streams of the Pacific Northwest has been suggested as a reason for poor productivity of salmon that once thrived in these streams. Because millions of salmon once spawned and then died in streams, the decomposing bodies provided a rich food source for native fish, including young salmon. Now that salmon runs are at 5% or less of historic levels, this source of nutrients for juvenile salmon is no longer present. In addition, there is evidence that these salmon-derived nutrients influence the function of the entire riparian area (Compton et al. 2006). As a way of giving these streams a boost in nutrients, some fisheries biologists have begun stocking dead salmon to enrich the stream (Compton et al. 2006). Not all forested streams have a natural source of anadromous fish carcasses; so they receive nutrients in other ways. Leaves from trees and shrubs are nutrient rich. Most nutrients in a tree are not stored in wood (except for carbon) but rather in leaves. When leaves and needles fall into a stream as *allochtonous* material, they decompose and provide an energy source for decay organisms. This material then serves as a source of detrital-based energy in nutrient-poor (oligotrophic) streams. Consequently, having a streamside forest ensures that the leaves that fall into a stream provide an important energy pathway (Figure 11.6). Litter fall into the stream provides a source of nutrients and food for aquatic invertebrates, which in turn are food for vertebrates. Streamside forests also provide root systems along the stream margin, stabilizing the streambanks and minimizing erosion and hence sediment loads. Sediment loads that are too high can cover cobble and gravel substrates important to many species of spawning fish (Kondolf 2000), as well as reducing habitat quality for species of salamanders that occur in well-aerated gravels. When trees die or are carried downstream, the wood increases channel complexity. Large pieces of wood are particularly important in large streams because they tend to move through the system more slowly than smaller logs. When a log falls into a stream, water flowing over and under it increases in velocity. Increased water velocity under the log leads to scour pools and the log forms a source of cover for fish and amphibians, as well as a place for otters to feed, muskrats to mark territories, and salamanders to survive in moist conditions.

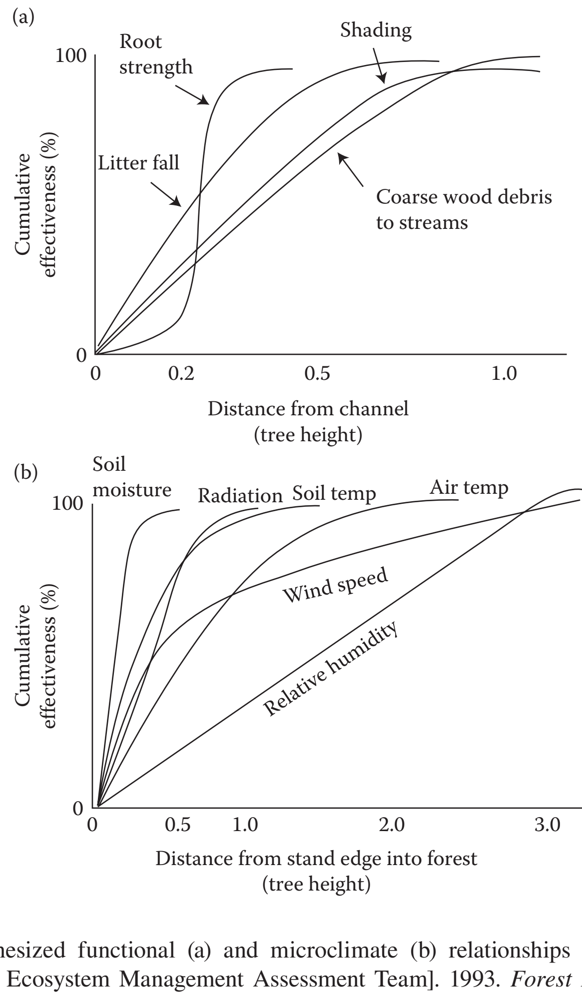

FIGURE 11.6 Hypothesized functional (a) and microclimate (b) relationships from streamside forests. (From FEMAT [Forest Ecosystem Management Assessment Team]. 1993. *Forest Ecosystem Management: An Ecological, Economic, and Social Assessment*. US Forest Service, US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, US Bureau of Land Management, Fish and Wildlife Service, National Park Service, Environmental Protection Agency, Portland, OR.)

Dead wood decay rates in water are usually less than on dry land because aerobic decomposition is decreased in water. Indeed, to store logs for long periods they are often submerged in log ponds prior to milling. Nonetheless, logs will eventually decay or move through the stream system; so a continual supply of logs is needed to ensure that these processes of developing channel complexity are maintained.

Tree canopies also provide shade to water and are especially important during the summer. Direct solar radiation striking a water surface can raise the temperature (Sinokrot and Stefan 1993) and increased temperatures can be deadly for some species. Tailed frogs in the western United States usually only occur in streams with water temperatures of 5–17°C. Many other species of amphibians and fish also are associated with cold water, and even American dippers, which feed on invertebrates in cascading mountain streams, are often associated with cold water. But some sunlight should enter streams. Sunlight allows photosynthesis to occur in the stream allowing the formation of periphyton on rocks, as well as other aquatic vegetation to grow (Welnitz and Rinne 1999). Periphyton and decaying plants provide energy to some animal species that support a food web. So a continuous riparian leaf cover, especially conifer cover, may not be ideal for most stream species. The manager often will strive to find a balance between providing enough leaf cover to maintain stream temperature but not so much that it inhibits photosynthesis in aquatic plants throughout too much of the system. The forest structure and composition along riparian areas all contribute to a set of microclimatic conditions that influence habitat quality for some species up to three tree heights from the stream edge, depending on the upslope forest condition (Figure 11.6). If the upslope forest is a recent clearcut or open rangeland, then the advantage of the microclimatic buffering to the riparian area may be critical to allowing some species to persist. On the other hand, if the upslope forest is similar in structure and to the streamside forest, then the stable microclimate can probably be realized over less than three tree heights. Height of mature trees, rather than a fixed distance, is often used as a guideline for maintaining riparian functions because many factors (e.g., shade, dead tree fall) relate more to tree height than to a fixed distance.

RIPARIAN BUFFERS

Most states and provinces in North America have regulations regarding stream protection (Figure 11.7). Often the rationale for these streamside management areas include protecting water quality (especially temperature and sedimentation) and providing habitat for "fish and wildlife." But by now you should be asking, which fish and which wildlife? Therein lies the conundrum.

These streamside management areas may be no-harvest zones, or they may allow harvest down to some minimum basal area, or they may be designed to meet specific needs. Typically a linear distance from the active channel is used to delineate the buffer strip width (Figure 11.7). Habitat for selected species of vertebrates will be provided dependent on the width and length of the buffer (riparian management area). Buffers that are narrow will likely only be used by species with small home ranges or those that have naturally linear home ranges (e.g., belted kingfishers and mink). The appropriate width will depend on the species and what it is being used for: a nesting territory, movement corridor, feeding, or resting. There is not a "one size fits all" prescription for these riparian management areas (Figure 11.8).

As a first approximation of the necessary width of a riparian buffer for a species consider its home range and the habitat elements that it needs. If it is a riparian associate and has a home range of 20 ha (50 acres), then the radius of that home range is 142 m (470 ft; $A = \pi r^2$). If the species is mobile and the stream does not represent a barrier to movement, then the width of the buffer should be 142 m on each side of the stream (Figure 11.8). If the stream is a barrier to movement, then the width would need to be 2 times as large or 284 m (940 ft) on each side of the stream. Managing for multiple species requires assessing buffer width for each species. The species requiring the largest buffer width sets the width for the others. So the appropriate buffer width for a small amphibian

FIGURE 11.7 Streamside buffer in a managed Oregon forest. These buffers are required by the OFPA. (Photo by Dave Vesely. With permission.)

with a home range of 0.2 ha would be 14 m (47 ft), correct? Well, maybe. If the species is associated with the riparian area due to the moisture needed for survival (a salamander or frog), then designing a buffer to support a suitable microclimate may be more appropriate. Vesely and McComb (2002) found that buffers probably need to be far wider than would be expected based on what is assumed to be a small home range for these species.

Another aspect of buffer width to consider is the land ownership pattern. Buffer strips may be very wide on some federal ownerships or where public drinking water supply is a primary use of the water. The adjacent private landowner may be required only to provide a buffer of 15 m (50 ft), and be able to harvest half of the basal area from it. The next landowner along the stream may be a dairy farmer who is not required to leave any buffer; so cows are allowed to graze to the stream bank. The ability for the stream to meet goals of the various landowners is inherently compromised by who is upstream of whom. Should the farmer own the upstream parcel and allow cows to use the stream,

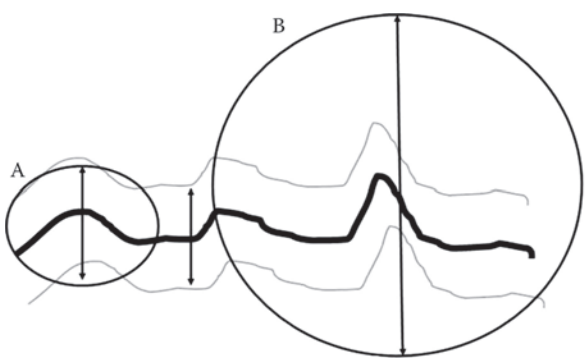

FIGURE 11.8 The width of a riparian management area is different for different species. Species A has a territory size that fits within the proposed buffer; species B has a territory size that would not be accommodated by the buffer.

then the south end of a north-facing cow (doing what cows will do) will contribute significantly to poor water quality on the downstream ownerships. It takes a cooperative community to manage clean water in a watershed.

Managing within Streamside Management Areas

Many landowners approach riparian areas as set-asides—areas not to be managed. Regulations certainly restrict management options (Figure 11.9). Within the limitations of what is allowed by law, the principles of managing habitat elements described in the previous chapters also apply to riparian areas. Depending on the species for which you would like to provide habitat in a riparian area, you can manipulate the vegetation to provide or produce those habitat elements. As mentioned many times already, managing for one species or set of species is managing against other species. Over the past 10–20 years in the Pacific Northwest, there has been an effort to restore conifer dominance to many riparian areas so that there is a continual supply of large dead wood to the stream (MacCracken 2002). This dead wood adds to channel complexity and habitat quality for salmonids and other species. At least two things must be kept in mind when trying to achieve this goal. First some species such as white-footed voles (Manning et al. 2003) and several species of myotis bats (Holly Ober, personal communication) select hardwood riparian areas over conifer-dominated riparian areas as places to feed. So some hardwood riparian areas should be retained. Second, dead wood not only comes from the stream side but also from the upslope areas during landslides; so streamside trees are only part of the source of dead wood to these streams. The conclusion drawn from this information is that there is not a single riparian management strategy that will meet the needs for all species, just as there is no stand or landscape management strategy that will meet the needs for all species.

For instance, if you wished to improve soft mast production along streamsides, then providing openings in the canopy would provide sunlight to fruit-producing plants and enhance production of soft and/or hard mast. But too much sunlight can raise water temperature and reduce habitat quality for some species. Balancing these conflicting goals is a social dilemma—what are the goals for the stream system? But when setting goals for riparian areas it is important to consider the context within which the riparian area resides. Is it an agricultural area with abrupt edges, a clearcut (Figure 11.7), a thinned stand, or an old-growth stand? How the riparian area will function as habitat

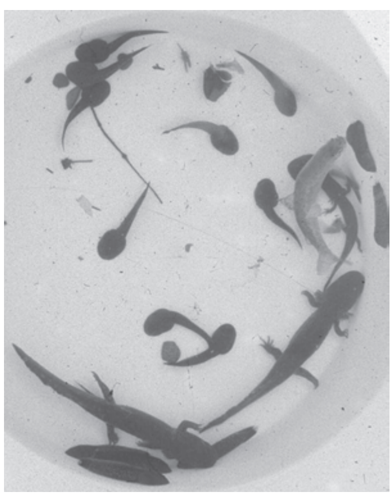

FIGURE 11.9 Two species of aquatic amphibians captured in a forest stream in Coastal Oregon, larval forms of Pacific giant salamander and tailed frog tadpoles, in addition to a cutthroat trout. State and federal riparian rules are designed to maintain water quality and protect species such as these. (Photo by Joan Hagar. With permission.)

for a suite of species will be greatly affected by these adjacent conditions. Although the goals for riparian areas may be different than for upland systems, the two systems are connected and should be considered part of a larger landscape or watershed, and not managed in isolation.

Several important principles have been provided by others for maintaining or restoring riparian conditions to meet a variety of riparian goals (Stanford and Ward 1988, 1999, Naiman et al. 2000):

- Restoring biophysical properties of riparian zones improves other natural resource values. Riparian zones allowed to respond to disturbance and regrowth may maintain a high level of complexity in plant species composition and structure used by a variety of animal species.
- Protecting interactions between surface flows and groundwater is essential to aquatic–riparian ecosystem integrity. This is particularly important relative to the *hyporheic zone*, the subsurface saturated sediments along the stream bottom.
- Allowing streams and rivers to migrate laterally is necessary for development of riparian habitat elements. This continual disturbance creates a mosaic of substrates and vegetation used by a wide variety of species.
- Incorporating natural flow regimes in regulated rivers promotes aquatic and riparian diversity and resilience. Many species are well adapted and indeed rely on the variability in flow rates in rivers and streams that have occurred for centuries prior to use of dams and levees.
- Modify human-imposed disturbance regimes to create and maintain a range of habitat conditions in space and time within and among watersheds that reflects the range of conditions to which desired species are well-adapted (Reeves et al. 1995). Humans like stability. Unexpected large-scale disturbances are considered catastrophes by many humans, but it is these events, over entire watersheds, that can influence changes in habitat availability for the full suite of terrestrial and aquatic species found in a region.
- Control invasive species that can simplify vegetation structure and composition. Aquatic and streamside vegetation that is invasive can exclude other *phreatophytic* (water-associated) vegetation from the site decreasing the vegetative structure and composition of the streamside area.

Beavers: The Stream Managers?

Busy beavers: they just love to stop water from flowing. Although not all beaver populations build dams (some live in dens in streambanks), most build quite impressive dams that flood large areas for long periods. In many respects, they are the streamside managers or destroyers—much depends on your perspective (see Chapter 1). Beavers cut trees and shrubs and use them to build dams, lodges (where they raise young), and as a source of food when they eat the bark from these plants. The openings that they create in streamside forests provide a flush of early successional plants along streams and provide habitat for a wide variety of early successional associated species (e.g., yellow warblers, jumping mice, and Carolina wrens) (Figure 11.10). Their dams create a *lentic* (lake-like) environment out of a *lotic* (flowing water) system, providing brood habitat for wood ducks and places for pond-breeding amphibians to reproduce (e.g., newts). These changes in vegetation and pool conditions give rise to different assemblages of animal species in the vicinity of beaver ponds than where beaver ponds are not present (Suzuki and McComb 2004). The dams cause ponds to capture sediments and if the pond is persists long enough, then it fills in with sediments over time and forms a wet meadow, which also is habitat for a completely different set of organisms. Because of their profound effect on riparian area function and ecological succession, beavers have been proposed as an umbrella species for which management could be focused in riparian areas (Stoffyn-Egli and Willison 2011).

To a forest manager trying to raise a commercial timber species near a stream or trying to develop forested riparian conditions for other species, beaver can be a problem (Bhat et al. 1993).

FIGURE 11.10 Beavers flood bottomland forests, creating snags, meadows and pools, markedly changing the composition of the riparian animal community in a stream reach.

They preferentially cut hardwoods over conifers and small trees over large ones (Basey et al. 1988). But they eventually cut nearly all trees around their pond. So planted seedlings are often cut, and mature trees may be cut as well, especially those close to the stream. In addition, their dam leads to flooding of low-lying areas causing tree death. And because culverts are easy places to block and flood a large area upstream of the culvert, damage to culverts and roads also becomes problematic (Jensen et al. 2001). Use of beaver deceivers, devices to allow water to flow through a dam, can help to reduce the damage caused by flooding (Nolte et al. 2001). Tree cutting, however, can only be reduced if trees are protected by wire mesh—an expensive proposition to a forest manager.

So at what point do beavers become a problem vs. a natural part of riparian area dynamics? Again that is a social decision. Since beavers do not respect property lines, decisions made by one landowner clearly influence the riparian conditions of her neighbor.

CASE STUDY: RIPARIAN AREA MANAGEMENT IN A PATCHWORK OWNERSHIP

To illustrate the conundrum associated with riparian area management, consider the pattern of riparian management areas along streams in western Oregon where the Bureau of Land Management (BLM) manages public forest land. During 1866, Congress created the Oregon and California railroad lands as alternating square miles of land in western Oregon and providing an incentive for the railroads to build infrastructure into the region. Congress revested or pulled these lands back into public ownership in 1916 and eventually gave the BLM the responsibility for managing them, mandating that a portion of the timber receipts go to the counties to support schools. The BLM now manages a checkerboard of lands across much of western Oregon. Intervening lands, many of which are forested but some of which are agricultural, are privately owned.

For years, the BLM followed the Oregon regulations with regards to streamside protection, but when concerns arose regarding endangerment of spotted owls, marbled murrelets, and coho salmon, a new management strategy for all federal lands in the region emerged as the Northwest Forest Plan (NWFP) (FEMAT [Forest Ecosystem Management Assessment Team] 1993). A stream passing across this landscape has three predominant land uses: federal forests designed to provide habitat for late-seral species, state and private forest lands that are largely timber producers, or private

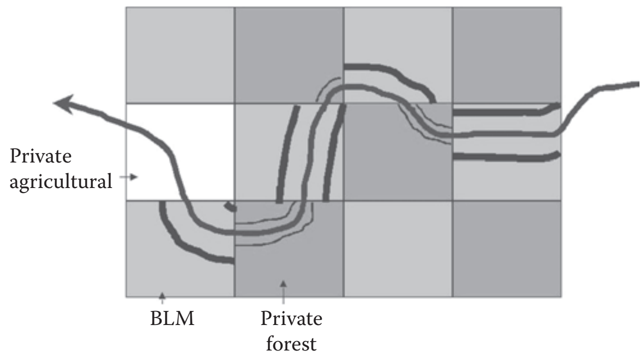

FIGURE 11.11 Schematic of possible riparian management area widths along a stream passing through three types of land ownerships.

agricultural lands for crop and livestock production. Each land use has its own standards and guidelines for riparian management area (Figure 11.11).

Under the NWFP, buffers along nonfish-bearing streams are one site-tree height in width, and along fish-bearing streams they are two site-tree heights in width. A site tree is the height of the dominant trees in the region—45 m (150 ft) in many of these watersheds. So, in this example, buffers on fish-bearing streams would be 90 m (300 ft wide) and on nonfish-bearing streams they would be 45 m. These buffers could be adjusted up or down depending on the results of a watershed analysis, a process where the functions of the riparian area are more completely considered before additional management is allowed (Montgomery et al. 1995).

On private forested lands, the Oregon Forest Practices Act (OFPA) prescribes streamside management areas that vary depending on stream width and whether they are fish-bearing streams (Figure 11.11). Typical OFPA buffers might be 8–33 m (25–100 ft) in width, with some timber removal allowed within them if canopy cover and basal area guidelines are met. On private agricultural lands, buffers or other management actions are not required, unless the stream is listed as "impaired" under the Clean Water Act (Hill and Blair 2005). Impairment may be caused by many things, most often by increased temperature, sediment, nutrients, or pesticides compared with standards set by state environmental quality offices.

Now consider a stream passing through a set of these ownerships (Figure 11.11). What imprint does land ownership have on the ability of a stream to maintain certain functions? If the stream passes through agricultural land causing the water to become too warm and the stream reach to be listed as impaired, and that warm water flows through an adjacent forest owned by someone else, then the downstream neighbor inherits the problem. And we all live downstream. We see similar inconsistencies in streamside protection in forested regions across the country. Is there a more thoughtful design? Clearly there is, but a more thoughtful design makes regulation of policies very difficult. The challenge is to provide incentives to encourage a more thoughtful and cooperative streamside protection strategy that allows streams and other water bodies to meet habitat, clean water, recreation, and other goals.

SUMMARY

Riparian areas are adjacent to and influenced by a body of water, typically a stream, lake, pond, or wetland. Some species are riparian obligates, those that only occur in or near water and the associated streamside conditions. Other species may not require water but are riparian associates and are found in riparian areas more frequently than in upslope areas. The distribution of habitat elements is influenced by the intra-riparian gradient, from the headwaters to the ocean, and the trans-riparian gradient, from the streamside to the ridge top. Contributions of matter and energy to stream systems is often a function of the distance from the stream edge upslope several tree heights. Delineating and managing streamside areas as habitat for a species can be constrained by regulations or influenced by desired ecosystem services and functions. Buffer strip width appropriate to meet a species needs is dependent not only on the home range size of the species being managed, but also on the energy and microclimatic conditions needed by the species. Buffer regulations are highly variable, and current state and federal policies in the United States can lead to highly inconsistent riparian area management strategies across a mixed-ownership landscape.

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