Wildlife Management Concepts and Terms

Wildlife management is both art and science that deals with complex interactions in the environment. However, it is critical to understand basic concepts about wildlife ecology and wildlife habitat requirements before management practices can be recommended to enhance habitat and manage populations for a particular wildlife species. Some of the basic concepts are described in this section. WHEP is based on these concepts, so it is important to understand them.

Definitions of various words or terms may be found in the **Glossary** at the back of this manual. Extension Wildlife Specialists, Extension educators, and local state agency wildlife biologists can provide clarification if needed. Additionally, wildlife management textbooks offer more in-depth reading and explanation.

Concepts and terms

- **Species, communities, ecosystems, and landscapes**
- **Plant succession and its influence on wildlife**
- **Habitat and habitat requirements**
- **Species richness and diversity**
- **Nonnative and invasive species**
- **Focal species and ecosystem management**
- **Edge**
- **Arrangement and interspersion**
- **Area-sensitive species**
- **Vertical structure**
- **Carrying capacity**
- **Compensatory and additive mortality**
- **Home range, movements, and migration**
- **Food webs**

Species, communities, ecosystems, and landscapes

A *species* is a group of individuals that can interbreed and produce viable offspring. A *population* is a group of individuals of the same species interacting and living in a given area. Populations of various species interact to form communities. Therefore, a biotic (living) *community* includes all the plant and animal populations living in a defined area. Communities interact with the abiotic (nonliving) resources (soil, air, water, and sunlight) to form what is known as an *ecosystem*. The size of the area involved when defining communities or ecosystems can vary. For example, the interacting communities of
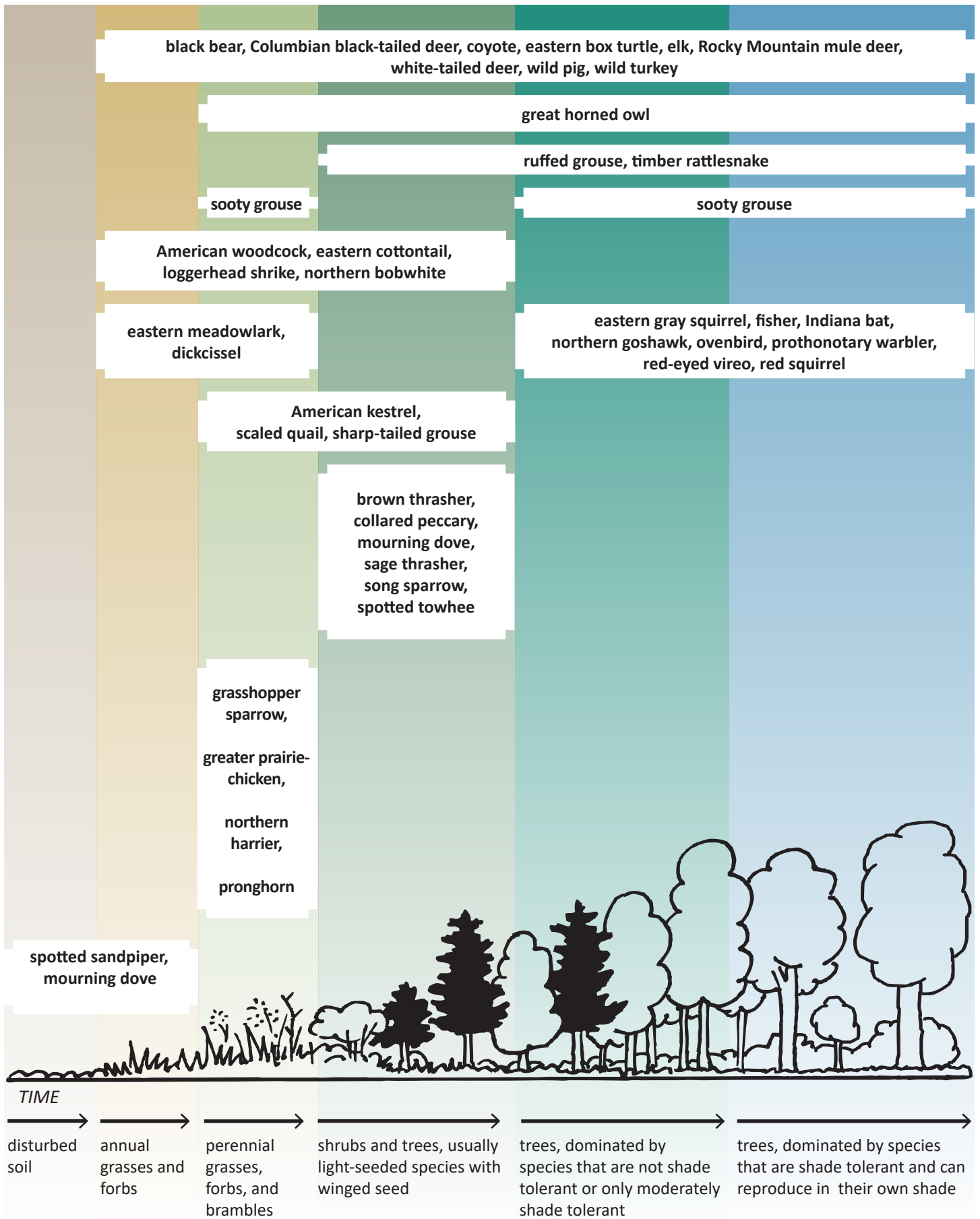
organisms associated with a decaying log or within an ephemeral pond may form an ecosystem. Likewise, this can be expanded to include all the communities associated with a forest ecosystem. The *landscape* is a larger area that composes interacting ecosystems.

Plant succession and its influence on wildlife

Plant succession represents the change in composition of the plant community in a particular area over time. Various plant species that typically occur together represent vegetation types. The sequence of plant communities that are possible and replace one another in progression on a given site is called a *sere*. These various plant communities represent seral stages, which also are commonly called successional stages. Each seral stage, or successional stage, may be represented by many vegetation types, which are indicative of that seral stage.

Climate, soils, and disturbance events determine which plant species (and therefore vegetation types) are found on a particular site. Climate, soils, and disturbance events (such as fire, wind storms, ice storms, flooding) are highly variable; thus, there are many vegetation types that can occur within any of the ecoregions represented in this manual. Examples of vegetation types include an oak-hickory forest; an emergent wetland dominated by cattails, sedges, and smartweeds; a stand of loblolly pine; a grassland dominated by blue grama and buffalograss; a thicket of regenerating aspen; or a fallow field of annual forbs, such as common ragweed, horseweed, and daisy fleabane.

Depending on climate in a particular ecoregion, there may be several or only a few successional stages that compose a sere. For example, in the Eastern Deciduous Forest ecoregion where annual precipitation typically averages 40+ inches, annual grasses and forbs represent the initial successional stage following soil disturbance. Perennial grasses, forbs, and brambles dominate by year 2 or 3 after soil disturbance and represent the second successional stage. Woody species, such as winged sumac, Virginia pine, winged elm, eastern redcedar, and persimmon might become prevalent within 5 or 8 years after disturbance and represent the third successional stage. Various oaks, hickories, yellow-poplar, red maple, blackgum, sourwood, sassafras, and other tree species may pioneer into the site and dominate the area within 20 years, representing the fourth successional stage. Without additional disturbance, such as fire, American beech, white pine, and sugar maple may eventually dominate the forest within 200 years and represent

black bear, Columbian black-tailed deer, coyote, eastern box turtle, elk, Rocky Mountain mule deer, white-tailed deer, wild pig, wild turkey

great horned owl

ruffed grouse, timber rattlesnake

sooty grouse

sooty grouse

American woodcock, eastern cottontail, loggerhead shrike, northern bobwhite

eastern meadowlark, dickcissel

eastern gray squirrel, fisher, Indiana bat, northern goshawk, ovenbird, prothonotary warbler, red-eyed vireo, red squirrel

American kestrel, scaled quail, sharp-tailed grouse

brown thrasher, collared peccary, mourning dove, sage thrasher, song sparrow, spotted towhee

grasshopper sparrow,

greater prairie-chicken,

northern harrier,

pronghorn

spotted sandpiper, mourning dove

TIME

DOMINANT VEGETATION

| disturbed soil | annual grasses and forbs | perennial grasses, forbs, and brambles | shrubs and trees, usually light-seeded species with winged seed | trees, dominated by species that are not shade tolerant or only moderately shade tolerant | trees, dominated by species that are shade tolerant and can reproduce in their own shade |

This chart is a general representation of ecological succession, depicting how the vegetation community may change over time and how various wildlife species are associated with various successional stages. Various wildlife species from several ecoregions are shown. Keep in mind succession does not advance this far in all ecoregions. For example, succession in the Shortgrass Prairie ecoregion stops with perennial grasses, forbs, and shrubs. Succession in the Hot Desert ecoregion stops with shrubs. Trees in those regions are limited to drainages where water is sufficient to support them.

the fifth successional stage. Thus, approximately 5 seral stages (or successional stages) can be expected to compose a sere on many sites within the Eastern Deciduous Forest ecoregion.

One forest type replacing another also is observed in other ecoregions that receive considerable precipitation. For example, Douglas fir forests may be replaced over time by western hemlock in the Pacific Coastal Forest ecoregion. In portions of the Northeast Mixed Forest ecoregion, stands of aspen are eventually replaced by spruce-fir. Development of the later successional stages in a sere is continual, but slow, as one successional stage gradually develops into the next. As a result, the process can be imperceptible to many people. Full development of some seres takes longer than the average lifespan of a human.

Descriptions of the successional process in different ecoregions of the U.S. can be found in the *Ecoregions* section of this manual. Successional stages can be difficult to identify or distinguish. Plant identification skills and some knowledge of plant community ecology are helpful.

The final seral stage that a site will transition to in the absence of disturbance is often called the climax seral stage and is dominated by species that can reproduce and replace themselves without additional disturbance. In ecoregions with sufficient rainfall (such as Eastern Deciduous Forest, Southeast and Northeast Mixed Forest, and Pacific Coastal Forest), early successional plant communities ultimately succeed to forests. In drier ecoregions (such as Great Plains Grasslands, Prairie Brushland, and Hot Desert), fewer seral stages compose the sere and vegetation communities of perennial grasses, forbs, shrubs, and cacti may represent the ultimate, or climax, successional stage. Disturbance events, such as fire, grazing, ice, wind storms, and flooding, continually set-back succession and the process starts over.

Although succession is set back through natural disturbances, many natural disturbance events have been disrupted by man. For example, levees have been built to prevent natural flooding, and great effort is expended to suppress and control fire. Also, extensive plantings of nonnative sod-forming grasses have unnaturally altered or interrupted succession in nearly every ecoregion of the country. Because of their dense nature at ground level, the seedbank is suppressed and response (thus succession) is suppressed. Suppressing succession is often called *arrested succession*. There are many nonnative invasive plant species that influence succession in most ecoregions.

Plant succession is an important concept for wildlife managers because as succession takes place vegetation composition and structure (density and height of vegetation) changes, which strongly infuences food and cover available for wildlife. **As vegetation structure and food availability change, the species of wildlife that may be found in an area change because different wildlife species have different food and cover requirements.** All wildlife species are associated with various plant communities or successional stages. Some species, such as wild turkey, white-tailed deer, and coyote, may use several successional stages to meet various life requirements. Others, such as grasshopper sparrow and ovenbird, may be found only in one or two successional stages. The fact that different wildlife species require different successional stages highlights the importance of having a diversity of successional stages if a diversity of wildlife species is a goal or consideration.

The compositional and structural changes of plant communities following disturbance events are fairly predictable within a given ecoregion. Thus, wildlife managers intentionally manage disturbance to provide the appropriate successional stage(s) for various wildlife species or groups of species. Wildlife management practices, such as prescribed burning, forest regeneration, selective herbicide applications, grazing, and disking, can be used in the absence or interruption of natural disturbance events. Alternatively, planting trees and shrubs and lack of disturbance will advance succession.

Differentiating successional stages can be difficult where

Plant succession involves a change in plant species composition over time. This field in east Tennessee is moving from the second successional stage (perennial grasses and forbs represented by broomsedge bluestem, goldenrod, and thoroughwort in picture) into the third successional stage (shrubs and pioneering trees, represented by winged sumac, sweetgum, and eastern redcedar in picture).

Oak or pine savannas represent early successional vegetation with scattered trees. However, without continued fire, savannas will succeed into forests.

grasslands, savannas, woodlands, and forests all occur. Grasslands are areas dominated by grasses and other herbaceous plants (forbs, sedges, and brambles) and few if any trees. Savannas and woodlands are areas with sparse to moderate tree cover and a well-developed groundcover of herbaceous plants. Forests are dominated by tree cover. In areas with abundant precipitation, grasslands, savannas, and woodlands will succeed into forests if not continually disturbed (usually with fire). When evaluating a savanna or woodland in these areas, it is not important to define the successional stage. Instead, evaluation of the structure and composition of the plant community and whether it provides habitat for the wildlife species under consideration is most important.

Habitat and habitat requirements

Habitat represents the physical and biological resources (food, cover, water, space) required by a particular wildlife species for survival and reproduction. Although the general habitat requirements (food, cover, water, space) are required among all wildlife species, the specific resources required among wildlife species may be vastly different. That is, not all wildlife species require the same resources in the same amount or distribution. If those resource requirements are provided in a particular area for a particular wildlife species, then that area represents habitat for that species. Thus, there is no such thing as "suitable habitat"—the area either is or isn't habitat for a particular species. Habitat quality may range from excellent to poor, depending on resource availability, but if the minimum habitat requirements for a given species are not provided, then the area is not considered habitat for that species.

Habitat should not be confused with vegetation or vegetation types, such as a mature hardwood forest or a grassland. Some wildlife species may find all of their habitat requirements within one vegetation type. For example, an eastern gray squirrel may live its entire life within one mature oak-hickory stand. However, other species, such as white-tailed deer and elk, thrive in areas with considerable interspersion of vegetation types. Thus, habitat for these species usually includes several vegetation types and successional stages. Although the term "habitat type" is often used interchangeably with "vegetation type," it is confusing, technically inaccurate, and should be avoided.

Differences in habitat requirements among some species are subtle, whereas differences in habitat requirements among other species are dramatic. For example, habitat requirements for northern bobwhite and American kestrel are somewhat similar. They both require cover dominated by shrubs, forbs, and grasses, but bobwhites primarily eat various plants, seed, mast, and insects, whereas kestrels prey on other animals, including small mammals, lizards, and insects. Thus, even though bobwhites and kestrels may use the same vegetation type or successional stage, their habitat requirements are different. Habitat requirements for eastern gray squirrel and mourning dove are not similar at all. Although they may be found in the same ecoregion, they use different vegetation types and foods and have different space requirements.

Habitat requirements for various wildlife species often change through the year or life stage. Food and cover resources needed during one season or life stage for a particular species may be much different than what is required or available during another. For example, wild turkey hens and their broods spend the night on the ground where there is adequate groundcover until the poults are able to fly. During summer, wild turkey broods often use early successional areas with abundant forbs where they feed upon insects and are hidden from overhead predators. As young wild turkeys reach approximately 2 weeks of age, they roost in trees and shrubs, and as mast becomes available in the fall, wild turkeys are frequently found in mature hardwood forests where available.

Species richness and diversity

Species richness refers to the total number of different species present in an area. Species richness differs from diversity in that diversity not only accounts for the number of species present in an area, but also how those

species are distributed and how abundant each species is on that area. One goal in wildlife management may be to provide habitat for as many different species as possible, as contrasted to managing for a maximum number of individuals within a species or limited number of species. Generally, habitat requirements are provided for more wildlife species when a variety of vegetation types and successional stages are present in an area.

Nonnative and invasive species

Many plants and animals have been introduced, either accidentally or intentionally, into the United States from around the world. These species commonly are referred to as nonnative. Some nonnative species are most useful and have filled a need in our society. For example, wheat (native to southwest Asia) and soybeans (native to northeast China) are two nonnative plants that have provided high-quality foods for both humans and wildlife in the U.S. The domestic cow (ancestors native to Europe and Asia) and chicken (ancestors native to Asia) are examples of nonnative animal species that provide benefit for our society.

Some nonnative species have become naturalized. That is, they are able to maintain populations in the wild. Many of these species have not only become naturalized, but they have become competitive with native plants and animals, sometimes displacing native species. Some naturalized nonnative species are actively managed, such as ring-necked pheasants (native to China), brown trout (native to Europe), wild goats (western Asia), and white clover (native to Europe).

Often, nonnative species are successful because the climate is similar to where they originated and they do not have many natural pests or competitors that may have limited them in their native area. Some nonnative species are so favored by the conditions where they were introduced that they spread at incredible rates and controlling them can be very difficult. These species are both nonnative and invasive. Kudzu (native to Asia), cogongrass (native to southeast Asia), and Japanese stiltgrass (or japangrass, native to eastern Asia) are examples of nonnative invasive plants. Norway rats (native to Asia) and silver carp (native to Asia) are examples of nonnative invasive wildlife and fish.

Nonnative invasive plants contribute to loss of habitat for native wildlife and fish species and can lead to population declines of both native plants and wildlife species. Nonnative invasive wildlife and fish often outcompete native wildlife and fish and cause population declines of native species. Nonnative invasive species (both plants

and animals) pose a considerable challenge for natural resource managers. Many nonnative invasive species are extremely difficult to control or eradicate. Herbicide applications, prescribed fire, mechanical removal, and biological control are commonly used to limit the impact of nonnative invasive plants on native plants and animals. Not only do nonnative invasive species impact native wildlife and plants, they also impact agricultural production, water resources, municipal capacity, and even human health and safety. Every effort should be made to prevent the introduction of nonnative species that may become invasive.

Focal species management and ecosystem management

Wildlife management generally is practiced with a focal species approach or an ecosystem management

The ecosystem management approach involves managing for a healthy, functioning ecosystem without focusing specifically on one or more wildlife species. This approach is most often used in an effort to restore imperiled ecosystems on large tracts of land.

Most landowners identify focal species when managing their property for wildlife because not all species benefit from the same wildlife management practices.

approach. The focal species approach involves managing specifically for one or few select wildlife species. The ecosystem management approach involves managing for a healthy and functioning ecosystem, such as the longleaf pine or shortgrass prairie ecosystems, and allowing the associated wildlife species to respond. Most landowners have specific objectives or concerns about a particular species. Once the species is determined, resources that may be limiting (such as cover, food, or water) for that species on that property can be identified and the appropriate wildlife management practices can be prescribed. Occasionally, the focal species may be totally incompatible with the area under consideration and management goals and objectives must be changed.

It is best to select wildlife management practices that provide or improve the habitat requirements most lacking and thus are limiting the population (limiting factors). For example, if a species requires trees for cover with water nearby, and the area being evaluated has plenty of trees but no water, a management practice that will supply water will improve the area more effectively than planting trees.

Wildlife management practices that improve habitat for some wildlife species may be detrimental to other wildlife species. It is impossible to manage an area for any one species or group of species without influencing other species in some way. For example, if a mixed hardwood stand is clearcut to benefit ruffed grouse, then wild turkey, white-tailed deer, and eastern cottontail also may benefit. However, species, such as ovenbird, wood thrush, and eastern gray squirrel, which prefer mature deciduous forest, will be forced to use another area.

Edge

An edge is formed where two or more vegetation types or successional stages meet. An obvious example is where a field meets a forest. A less obvious example is where a mature stand of aspen meets a spruce-fur forest. An even less obvious example is where a 40-year-old mixed hardwood stand meets an 80-year-old mixed hardwood stand.

The transition in vegetation types or successional stages can be abrupt or gradual. An example of an abrupt change would be where a hayfield meets mature woods. This type of edge has high contrast and is called a *hard edge*. A more gradual change would be where a 40-year-old forest meets an 80-year-old forest. A much more gradual change is where an overgrown field with native grasses, forbs, and scattered shrubs blends into a brushy thicket or a 3-year-old regenerating hardwood stand. This type of edge has low contrast and is called a *soft edge*. Sometimes the edge or transition between two vegetation types is so gradual, characteristics of both are evident in a relatively wide zone, called an ecotone. A common example of an ecotone is where an upland hardwood stand meets a bottomland hardwood stand. Species transition occurs gradually with the elevation change as the upland blends into the bottomland.

The concept of edge is important in wildlife management. If there is increased edge, then there is increased interspersion of vegetation types or successional stages. This may be beneficial for a particular wildlife species *if*:
- both vegetation types are usable by the species and provide some habitat requirement;
- the arrangement of the vegetation types is suitable for the focal species (see **Arrangement and interspersion** on page 23).

The abrupt change in species composition and structure (left) is typical of a hard edge. Allowing native grasses, forbs, and brambles to grow into the field from a woods edge is typical of a soft edge and increases the amount of usable space for many wildlife species by providing suitable cover and food resources.

For those wildlife species considered "edge" species, the physical edge presented where two vegetation types or successional stages meet is not as important as the actual structure presented within a vegetation type or successional stage.

Some species do not require much space to live. An eastern gray squirrel or eastern box turtle might spend their entire lives on only a few acres. Other species, however, require considerable area. Grasshopper sparrows, for example, are rarely found in grasslands smaller than 100 acres.

Increased interspersion also can lead to increased species diversity, as more vegetation types are available, and can potentially provide habitat requirements for a larger number of species. It is important to realize the presence of edge is not always beneficial for any wildlife species. If the vegetation types or successional stages present do not provide any habitat requirement for the species in question, the interspersion and resulting edge is not beneficial. Thus, looking at an aerial photo and counting the number of times different vegetation types or successional stages meet should not be used to measure of habitat quality for any species. Also, some species may actually avoid edges and seek areas that are more similar.

Furthermore, some species often found along an edge have been relegated to use the edge because the interior of the adjacent vegetation type is unattractive or does not provide any habitat requirement. For example, wild turkey and northern bobwhite broods might be found along the edge of a field dominated by tall fescue or bermudagrass. The reason the birds are not in the interior of field is not because they necessarily like the edge, but because there is not suitable cover or food resources in the field, or the structure of the vegetation in the field is so thick at ground level the birds cannot walk through it. Thus, if the composition and structure of the vegetation in the field was improved to provide mobility and adequate cover for quail and turkeys, there would be as many birds in the opening as along the edge. As a result, there would be additional habitat for the birds and the carrying capacity of the property would be increased (see **Carrying capacity** on page 25). In summary, the edge is not what is necessarily important, but rather the composition and structure of the vegetation.

Arrangement and interspersion

How different successional stages or vegetation types are situated in relation to each other is often referred to as arrangement or juxtaposition. Some wildlife species may obtain all of their habitat requirements from only one vegetation type or successional stage (such as crissal thrasher, eastern gray squirrel, gopher tortoise, sharp-tailed grouse, or ovenbird). Other species require (or greatly benefit from) more than one successional stage to provide all their habitat requirements (such as bobcat, northern bobwhite, white-tailed deer, wild turkey, American woodcock). For example, ruffed

The arrangement of vegetation types and successional stages directly influences animal movements and home range size. Here, cover for nesting and brooding, and escape cover are arranged in close proximity (juxtaposed) to favor habitat requirements for northern bobwhite.

grouse may forage on acorns in mature mixed-hardwood stands during fall and winter, but use young forest stands with high tree-stem densities for escape cover. Required successional stages should be close to each other to better allow safe travel to and from those areas. Proximity is especially important for species with limited movements and relatively small home ranges.

Interspersion is the frequency of occurrence of different vegetation types. Increased interspersion generally leads to increased "mixing" of vegetation types and often supports a greater diversity of wildlife. However, the vegetation types present and the quality of cover and food resources present in those vegetation types are more important than whether or not there is much interspersion. As interspersion increases, so does the amount of edge. However, as discussed in **Edge**, increased interspersion is not necessarily beneficial to all species. Interspersion is easily viewed on aerial photos or satellite images. However, habitat quality cannot necessarily be assessed by viewing aerial photos or satellite images. It is true that where there is increased forest cover, the amount of habitat for eastern gray squirrel likely is increased, and where there is increased grassland cover, the amount of habitat for grasshopper sparrow likely is increased. However, the composition and structure of the vegetation in fields, shrubland, and forests greatly influence habitat quality for many species, and that fine-level analysis is not possible by viewing photos. Thus, walking over the property and taking a closer look is necessary when evaluating habitat for most species.

Area-sensitive species

Fragmentation is the disruption of vegetation types either by man or by natural processes. All wildlife species do not respond to fragmentation the same way. For some, the edge between a young forest and an older forest may fragment their habitat, whereas others may not respond to fragmentation except under extreme circumstances such as an interstate highway bisecting a forest or prairie or suburbia creeping into a rural area. Some species need large, unfragmented areas in a certain successional stage to provide some or all of their habitat requirements. Such species are referred to as area-sensitive. For these species, large areas in one successional stage are desirable. Unfragmented habitat of at least 100 acres is considered the minimum requirement for many area-sensitive species. Some species, such as the grasshopper sparrow, may require a minimum of 1,000 acres of relatively unfragmented habitat to sustain a viable population. Others, such as the greater prairie-chicken, may require 30,000 acres of relatively unfragmented

The vertical structure in this mature oak/hickory forest provides cover and food resources for a suite of forest songbird species that otherwise would not be found here.

habitat.

Vertical structure

In most vegetation types, there are distinct layers of vegetation. In a grassland, there is often a litter layer with one or two layers of grasses and forbs. In a forest or woodland, there may be three distinct layers of vegetation. The understory is composed of those plants growing near the ground, up to 4.5 feet tall. The understory may be very diverse and include grasses, forbs, ferns, sedges, brambles, vines, shrubs, and young trees. The midstory is represented primarily by shrubs and trees more than 4.5 feet tall yet below the overstory canopy. The overstory is made up of those trees in the canopy.

How the different layers of vegetation are arranged in relation to each other is important to many wildlife species. For example, some birds require more leaf litter in a grassland than others and some like taller grasses, whereas others prefer shorter grasses. Some birds may require a herbaceous understory for foraging in the forest, but nest in the overstory. Vertical structure may vary dramatically from site to site, even within a given field or forest type. For example, one mature oak-hickory forest might have a well-developed understory and midstory with visibility of no more than 30 feet, whereas another has very little understory vegetation and no midstory at all. Although they are the same forest type, these two forests would not necessarily provide habitat for the same wildlife species. The structure could be manipulated on these sites depending on the objectives. Thinning and prescribed fire are two management practices that are commonly used to influence understory and midstory structure in forests and woodlands.

Any area is only able to support a certain number of animals before available food and cover resources are depleted. Here, overabundant white-tailed deer have exceeded the carrying capacity of the area. Chronic overbrowsing has eliminated the forest understory and thus negatively affected many other wildlife species that require understory vegetation for nesting, feeding, roosting, or escape cover.

Carrying capacity

There are only so many animals that can live in an area. The concept of carrying capacity is related to the number of animals that can exist in an area. Biological carrying capacity refers to the maximum number of animals, within a given species, an area can support before that species or another species is negatively affected. The quantity and quality of food, cover, water, and space determines the carrying capacity. The requirement that is in shortest supply, called the limiting factor, determines carrying capacity. Increasing the requirement in shortest supply can increase the area's biological carrying capacity.

Biological carrying capacity varies from season to season and often from year to year. For most species, it is usually greatest from late spring through fall when food and cover are most abundant. This time of year is when young of most species are born, which helps ensure adequate nutrition and cover are available for growth and survival. With the coming of winter or summer drought, food and cover gradually diminish.

More animals are produced each year than will survive. Surplus animals are lost to predation, starvation, competition, or disease. Young wildlife and animals in poor health experience the highest mortality rates. Hunting and fishing remove some animals and may help prevent over-population for some species (see **Compensatory and additive mortality**).

In suburban areas, humans often demand the density of certain wildlife species be lower than the biological carrying capacity because of wildlife damage issues. For example, white-tailed deer populations can thrive in suburban areas where the biological carrying capacity is relatively high because deer have adapted to feed opportunistically on ornamental plants. However, homeowners generally have low tolerance for deer feeding on expensive landscape plants. Thus, the deer population must be reduced to limit damage. In this case, the cultural carrying capacity (determined by human tolerance) is lower than the biological carrying capacity.

Compensatory and additive mortality

Annual mortality is the rate at which animals die per year. The mortality rate for a species often is estimated by biologists to help determine management efforts for that species. Animals die from many causes, including predation, diseases, malnutrition, weather, hunting, accidents, fighting, and others. All of these factors may contribute to the annual mortality rate for a particular species. For example, each of those factors contributes to the annual mortality rate of white-tailed deer in Minnesota each year. However, the number of deer that die from each of these causes of mortality is not the same, and the number of deer that die from each cause in Minnesota may differ greatly from the number that die from each cause in Tennessee in any given year.

The number of animals that die from one cause of mortality often influences the number that may die from another cause. For example, increased harvest of deer by hunters in October and November leaves fewer animals in the population that winter. Thus, more food is available per animal and the likelihood of deer dying from starvation decreases. Thus, mortality from hunting and mortality from malnutrition can act in a compensatory manner. As the mortality from one cause is increased, the mortality rate of another is decreased. To relate this to the WHEP contest, *Increase Harvest* may be recommended to lower white-tailed deer populations so that food availability is increased per animal and fewer animals are susceptible to winter starvation.

Mortality can be additive. For example, rainfall commonly influences northern bobwhite populations in portions of Texas and Oklahoma. In years with little rainfall, there is less groundcover to provide cover and food and, as a result, fewer quail survive through summer and fall. Thus, the bobwhite population going into winter may be quite low because of malnutrition, predation, and heat stress through the summer. If the population is at a critically low level, additional mortality from hunting through winter may be *additive*, especially if hunting pressure is equal to

that in normal years. As related to WHEP contests, if the population of a nonmigratory game species has declined for some reason and is considered too low to sustain the level of mortality experienced recently by regulated hunting or trapping, **Decrease Harvest** may be warranted.

Hunting is not the only mortality factor that could be additive. Using the scenario above with relatively few bobwhites surviving through summer and fall, there still may be sufficient numbers of quail to replenish the population when the breeding season begins. However, a late winter storm that dumps unusually deep snow and persists for a while can limit food availability even further. Thus, more quail die. In this situation, mortality is *additive* from the snowfall. Regardless of whether the population was high or low, a significantly high percentage of the population would have been affected by the weather event.

Thus, it is important for biologists to monitor mortality rates for various species, especially those that are hunted, and be prepared to adjust regulations and management practices to better manage for a particular species. Adjusting regulations and management practices as conditions change and additional information becomes available is termed *adaptive management*.

Home range, movements, migration, and corridors

A home range encompasses the area in which an animal lives. Home range size is related to habitat quality. Daily movements include those for normal day-to-day activities. In higher-quality habitat, home ranges tend to be smaller than in lower-quality habitat because movements necessary to meet life requirements are reduced. A seasonal home range is the area an animal uses in a particular season of the year. A seasonal movement, or migration, is made when an animal moves from one seasonal home range to another. Migration may represent movements to and from wintering and nesting areas (such as waterfowl and songbirds) or wintering and calving areas (for caribou and some elk populations). Migration also can involve movements from higher elevations to lower elevations each spring and fall as food availability varies with the seasons (seen with elk and some species of grouse).

Migration distances may be short or very long, depending on the species. Long migrations for some species require habitat along the route (to stop and rest and eat). Thus, wildlife managers must consider this in landscape planning for various species, which means habitat

conditions might have to be considered across states, countries, or even continents.

Corridors are areas that do not restrict movement and allow various wildlife species to move from areas within their home range or during migration. The type of vegetation within the corridor and the size (both width and length) of the corridor needed varies depending on the species. An example of a corridor might include a stream or river with trees and shrubs along both sides (the riparian zone) cutting through a large grassland. The wooded, riparian corridor facilitates movement for squirrels, deer, wild turkey, and other species that require or otherwise seek the security of wooded cover to cross a broad open area. A smaller version of such a corridor would be a hedgerow traversing a large field. Other examples of corridors might include valleys between mountain ranges for migrating mule deer, or underpasses facilitating black bear movement under interstates and major highways.

Food chains and food webs

Food chains are the step-by-step passage of material and energy (food) through an ecosystem. A network of interconnected food chains is called a food web. In terrestrial ecosystems, plants are primary producers in a food chain because they supply food at the lowest level of the food chain. In aquatic ecosystems, phytoplankton (microscopic algae) is the base of the food chain. It takes an enormous number of individual plants (or amount of phytoplankton) to support the other parts of a food web. At the next level of a food chain are primary consumers, plant-eating animals or herbivores. Primary consumers include rabbits, mice, deer, and certain other mammals; some insects and fish; and dabbling ducks, geese,

Alan Windham

Predators, such as this red-tailed hawk, are necessary to buffer populations of various prey species. For most predators, when one prey species begins to decline, other prey species become more prevalent in the diet.

and various other bird species. In aquatic ecosystems, zooplankton and aquatic insects feed on phytoplankton.

Primary consumers are eaten by secondary consumers, or carnivores (meat-eaters). This group includes predators, such as birds of prey, snakes, foxes, cats, and people. In aquatic ecosystems, zooplankton and aquatic insects are eaten by small fish. Small fish are eaten by larger fish. Secondary consumers are eaten by tertiary consumers, which may be predators or scavengers, such as turkey vultures, crabs, and sometimes people. Note these categories are very broad and general. Many animals fit into more than one group, and there are more complex levels of a food web. An example is an omnivore, which is an animal that eats both plant and animal matter.

Any of the food web components mentioned above can be broken down by decomposers—organisms such as bacteria and fungi that reduce dead plant or animal matter into smaller particles. A decaying plant, for example, will be broken down into nutrients that enrich the soil. This process supports the growth of more plants and thus, more animals.