

## Landowner's Guide to Wildlife Abundance Through Forestry

*Peter T. Bromley, Wildlife Extension Specialist, Department of Fisheries and Wildlife Sciences, Virginia Tech*  
*James Starr, Chief, Forest Management, Virginia Department of Forestry*  
*Jared Sims, Assistant Chief, Wildlife Division, Virginia Department of Game and Inland Fisheries*  
*David Coffman, Environmental Programs Analyst, Virginia Department of Forestry*

### Wildlife and Forest Ecology

Your woodlands offer the promise of immediate and long-term benefits. Managed forests produce yields of timber and wildlife. Land with abundant game may be leased to hunting clubs for as much or even more than its taxes or provide the base for a hunting preserve business. Other recreation-based sources of income, such as camping or horseback riding, will be made more attractive on properties managed for wildlife. But economic considerations, though important, may not be your main reason for owning the land. To have a place where wildlife lives and can be enjoyed may be your primary desire. Land that has productive wildlife habitat is a pleasure to behold. The satisfaction of working with nature to increase wildlife abundance, and at the same time, of leaving to the next generation property of increasing economic and esthetic values can be yours through careful but decisive management.

If you want to really manage your woodlands for many considerations, especially wildlife, this publication has been written for you. We relate results of wildlife and forestry research that can enable you to make the best use of the ecological forces at work in your woods. Our goal is not to make you a professional wildlife manager and forester, but we aim to enhance your knowledge of wildlife and forest interactions. You may have the time, resources, and ability to put your plan into action yourself, or you may have to leave some or all of the technical operations to others.

Regardless of your personal ability to do forestry work, you will benefit from knowing in advance how forestry operations will influence wildlife on your land.

Ecology is the study of the interrelationships of living things with and within their environment. Forestry and wildlife ecology has received considerable attention from researchers over the past 50 or more years. A recent review of the literature located 642 research papers relating forestry to wildlife in the South. This growing body of knowledge increases understanding of our woodlands and how wildlife uses them.

Fundamental to all wildlife and forest resources are soil and water. Soil depth, fertility, chemical properties, and water content provide the base for plant life. In fact, the fertility of the soil and the availability of unpolluted water are reflected in the productivity and health of plants, trees, and wildlife. Care for soil and water is fundamental to good land stewardship.

The sun is another significant force at work every day. Light from the sun drives the plants to produce living material, without which there would be no wildlife. When you boil down all the technology of forestry and wildlife, you inevitably wind up dealing with the potential of the soil, the availability and quality of water, and the energy provided by the sun. Wildlife and forestry operations are successful when the soil and water resources are protected and plants are managed to make the best use of sunlight.

### Wildlife Habitats in the Forest

When we think of the forest, we usually visualize tall trees extending to the horizon. These forests still exist, but by far the majority of forest stands are measured in acres but not square miles. Eastern forests may be limited in size, but they are diverse in age. Some are mature, with old, dead trees in their midst, but most are

in stages of transition from seedlings to mature trees on cut-over land. (See Figure 1.) Streams, swamps, rivers, and ponds add diversity of plant and animal life to any woodland. Frequently, wooded properties are bounded by pastures or croplands. Sometimes these open areas are scattered about the property, providing forest/field edges that are interesting to look at and highly attractive to wildlife. These variations in plant cover, water resources, and topography determine much of the diversity and abundance of wildlife in forest habitats.

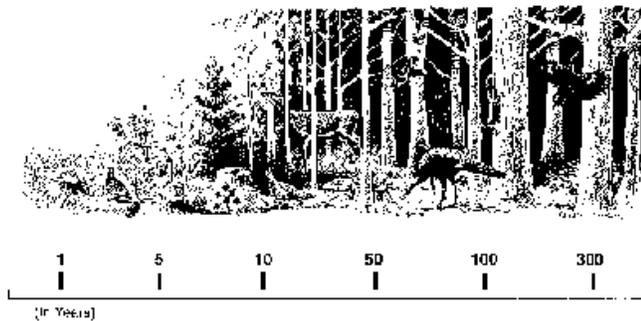


Figure 1. The succession of plants and wildlife from grasses and weeds to mature timber is a natural process that can be manipulated to reach both wildlife and timber objectives.

If you were to look at your property from the vantage point of an eagle, you would be able to evaluate the extent and relative positions of forest and crop covers that sustain wildlife. Such a view would help you understand the potential of your land for wildlife and it might stimulate thoughts about improving that potential. Fortunately, you do not have to fly over your property to gain this perspective. Your local Agricultural Stabilization and Conservation Service (ASCS) professionals have already done the job and they have photos for you to view. Other sources are your state Department of Transportation and your state Department of Forestry.

Chances are that back in the early 1900's at least some of your forested land was farmland. If time-lapse photography had recorded the events your land experienced year-by-year, you could see the fields changing to brushy places, the shrubby stands turning into stands of pole timber, and then see the large, dominant trees emerging to form mature stands. Ecologists term this progression of vegetation from barren ground to mature forest as "plant succession."

Plant succession is important to wildlife. Some depend on certain stages of forest succession for their survival. For example, quail must have seeds from weedy

plants. These plants occur in the early stages of plant succession. At the other end of the spectrum, pileated woodpeckers depend on dead and rotting mature trees for their food and nest sites. However, most kinds of wildlife, including the wild turkey, need more than one stage of plant succession to prosper. In the fall and winter, turkeys need mature timber stands for food and roost sites; but, in the spring and summer when they are young, they need openings in the forest or agricultural areas where insects are abundant. Similarly, deer need the cover provided by thickets, but they will feed extensively on acorns found under mature trees in the open woods and will also seek out green vegetation in agricultural fields.

This brings us to the point. The way to wildlife abundance on forest lands is to provide the right stage of plant succession or combination of stages in right amounts and distribution to satisfy the needs of the particular kinds of wildlife you desire. If you want to see woodpeckers and squirrels, then a mature forest stand is for you. If you want maximum quail, you will want the early stage of forest succession. However, if you want quail around for a long time, then you will have to provide young forest stands or specially managed agricultural lands on a continuing basis.

The conclusion we reach, when considering plant succession and wildlife abundance, is that to achieve most wildlife management objectives the landowner will want to provide a mix of stands of various ages and some openings. A landscape supporting timber stands in various age classes not only offers sustained wildlife production, but such an area is visually attractive, provides for soil and water conservation, and supports recreational activities. Accomplishing this will require an active forest and wildlife management plan. Also, the plan will project periodic income from forestry. Another benefit is that the good road system required for forest management will make your property accessible and easier to enjoy.

## Forest Management Systems and Practices

Effective communication with a professional forester is easier when some of the major forestry concepts are understood. In this and the following section, the basic systems used to grow timber crops are discussed, along with frequently recommended management operations. Often, what appears to be assaults on wildlife habitat,

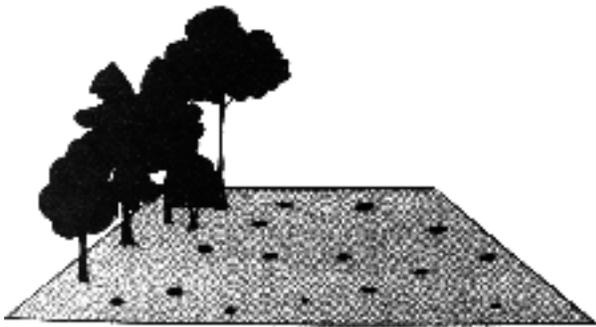
such as clearcutting or controlled burning, work in favor of certain desirable wildlife species but also work to the detriment of others. The landowner who understands forestry will recognize the trade-offs and can manage more effectively for both forest and wildlife resources.

Forest management systems can be described as being either even-aged or uneven-aged. Even-aged management systems result in creating a forest stand of trees of the same age. Uneven-aged management results in forest stands containing trees of all ages. To the casual observer, most hardwood stands appear to be uneven-aged because trees varying in size from big to small are present; however, casual observations are frequently wrong. The eight-inch-in-diameter oak is likely the same age as the sixteen-inch oak growing beside it. The smaller tree may not have grown as fast as the larger one because it received less sunlight. Most oak stands in Virginia are even-aged or contain two dominant age classes. There are few true uneven-aged stands.

## Even-Aged Management

### Clearcutting

Clearcutting is a method of final timber harvest. It is followed by regeneration efforts for the future forest. The size, shape, and distribution of cuts have major effects on many species of wildlife. Clearcuts are used to create loblolly pine plantations in the piedmont and coastal plain areas; and in the mountains, clearcuts are planted with white pines or allowed to naturally regenerate hardwoods, particularly oaks.



The size of clearcuts depends upon many factors, including wildlife species desired, the lay of the land, and economic considerations. In general, sale areas should have irregular shapes, be not more than 40 acres, and be separated by mature stands and open areas to create maximum variety of wildlife habitats. Cutting areas of less than 20 acres may not be of interest to timber buy-

ers, with the exception of firewood cutters.

Some wildlife species prefer the edges of clearcuts. Therefore, the forest planner should lay out sale areas with irregular boundaries to maximize forest edge. Where wildlife management is a major factor, 20-acre or smaller cutting units may be large enough. Small areas along roads, 5 acres here, 5 acres there, can be created by firewood cutting and result in excellent additions to overall forest habitat diversity. (See Figure 2.)

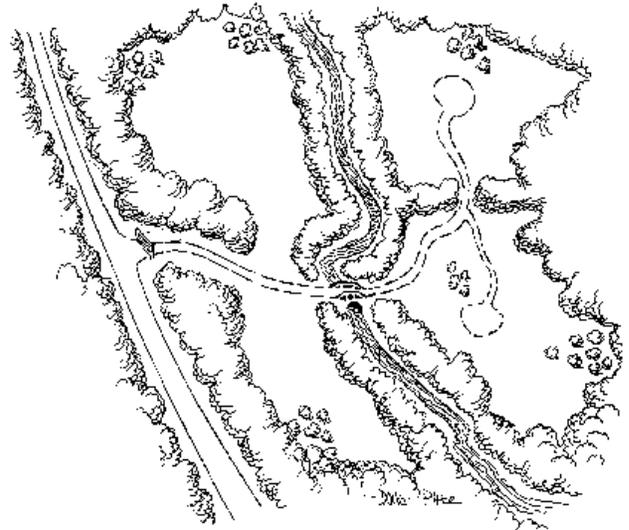


Figure 2. Timber cuts should be designed to protect streams, be irregular in shape, and provide corridors for wildlife to move into and through the area.

Strips of uncut timber 100 yards or more wide are used to separate cutting units. These are called "buffer" or "leave" strips. They provide habitat diversity, edge, travel lanes, den trees, and hard mast. Wild turkey nests have been found in or adjacent to leave strips. Leave strips along streams reduce the amount of silt entering streams and maintain cool water habitats for fish and wildlife and critical foraging areas.

Islands of uncut timber within clearcut areas, linked to the original forest by strips of mature trees, enhance wildlife habitat by providing for the production of mast, such as wild grapes and acorns, and by providing for the retention or development of den trees. A good island would be a one-quarter acre clump of mature, long-lived species such as white, chestnut, or red oak. A good candidate for retention in such a clump would be a very old oak tree with conspicuous cavities. These "wolf" trees have no timber value, but they do have great wildlife values. Extensions of mature timber into recent clearcuts result in greater wildlife use of the harvested areas.

Clearcutting may be the only practical way to enhance wildlife habitat in areas of poor soil fertility and dry conditions, such as those found in some areas of the Appalachian mountains. Under these conditions, clearcutting timber for firewood or pulp for paper mills is frequently the only economically feasible timber management system available to increase the amount of early- succession forest for wildlife habitat.

## Shelterwood Cutting

A shelterwood system is used to regenerate timber through a series of perhaps two to three cuts rather than making one final clearcut. Cuttings may be separated by as much as twenty years. Shelterwood cuts result in natural regeneration of shade-tolerant species, such as northern red oak from acorns. If stands of northern red oak are clearcut, shade-intolerant species such as red maple and tulip poplar will replace oaks. In addition to perpetuating timber stands that produce preferred wildlife foods, shelterwood cuts are used for visual aesthetic reasons on some properties.



## Uneven-Aged Management

In uneven-aged management, the timber stand is maintained by many growth stages, either by group selection cutting or by individual tree selection.

### Group Selection

Group selection is used in managing hardwoods, typically on superior growing sites. The forester identifies and harvests a group of hardwoods in an area from less than 1 to 2 acres, but the diameter of the opening is at least twice the height of the trees. The harvest cut resembles a small-scale clearcut. Group selection is usually done to produce high quality, veneer-grade hardwoods which bring top prices, particularly in international markets. This silvicultural system is used for hemlock, ash, and maples in northern areas; and, in southern areas, it is used in managing oaks and bot-

tomland hardwoods. Group selection cuts provide ideal pockets of young vegetation in the forest for grouse, woodcock, deer, and many songbirds. Additionally, some landowners may wish to scatter group selection cuts to produce firewood. The group selection system requires intensive management and excellent access to all parts of the tract. For these reasons, the system may be feasible only where the dollar value of the harvested trees is quite high.



### Individual Tree Selection



The most intensive silvicultural system, if done correctly, is individual tree selection. The forester marks trees that are ready for the market and low-value trees that are competing with future crop trees. Under this system, the forest can be made to produce timber on a continuing basis, with new seedlings constantly emerging to take the place of harvested trees. Individual tree selection appeals to many landowners, especially those concerned with the appearance of their forests.

Unfortunately, proper applications of individual tree selection are rare. All too often, landowners contract with loggers for a diameter-limit cut of their woodland. Under this agreement, the logger cuts all trees greater than 16 inches in diameter, for example, and leaves the rest. In practice, trees that have saleable logs of cut and undesirable trees are left standing. Foresters call this high-grading. High-grading results in reduced timber and wildlife values and should be avoided.

## Thinning

Foresters prescribe thinning to increase the growth rate of the better trees in a stand. These trees grow better because they no longer compete for sunlight, soil moisture, and soil nutrients with the relatively inferior trees that were removed from the stand.

In concept, thinning is easy to understand, but in practice a trained eye is necessary to determine which trees to save and which to cut. This is particularly true in hardwood stands, where thinning is frequently termed "timber stand improvement" (TSI). In contrast, thinning in pine plantations can be the removal of every other row of trees. Generally, thinning increases sunlight penetration to the forest floor, which stimulates understory growth and creates more food and cover for some wildlife species, such as quail and rabbits.

The landowner concerned with wildlife will specify that from 2 to 4 den trees per acre be saved. Den trees, having one or more hollow chambers, are used by a variety of birds, mammals, and reptiles for nesting, roosts, and cover. Den trees can be as small as 5 inches or as large as 6 feet in diameter. The smaller trees may house chickadees, woodpeckers, screech owls, or flying squirrels, while the larger den trees may overwinter black bears.

Another consideration is encouragement of mast production. Hickory, beech, persimmon, serviceberry, blackgum, American holly, hawthorn, and dogwood do not bring top dollar on the timber market, but they produce nuts and soft mast favored by wildlife. Grapevines are particularly important for wildlife, but these vines can deform hardwoods, reducing their value. Foresters who mark stands for thinning need to know whether you want to save den trees and mast producers.

## Forest Management Operations

After you have determined wildlife, recreational, aesthetic, and economic objectives for your property, your next efforts will be toward developing a management plan and putting that plan into action. Time dedicated to planning with the help of professionals is well spent.

### Preparing Your Plan

The first step to successful forest and wildlife resource management is to work with professional natural resource managers, including both foresters and wildlife biologists, to develop a management plan. A directory

of the agencies willing to work with private landowners is provided at the end of this publication. Consulting foresters and wildlife biologists can be reached through the listed agencies. In general, professionals with public agencies help landowners get a good start, whereas consultants can be used to direct some or all of the technical operations. Professionals can assist you in defining your objectives, by inventorying your resources, helping you evaluate alternatives, developing a written plan, and by supervising the actual management operations. (See Figure 3.) It is in the planning stage that you will need aerial photos and maps of your property. This is when you decide on relative priorities of your objectives. Far too many plans are made and then discarded after a few years when priorities change. Planning is really a continuing process, in which results of your first operations are allowed to influence subsequent operations. The best strategy is to plan carefully in the beginning, but then to treat the plan as a living document, making changes for the future.



Figure 3. Planning for wildlife and timber management requires the desire to change things, consultation with professional natural resource managers, making written decisions, involvement with the land management operations, and keeping the plan current.

### Implementing Your Management Plan -- Conducting a Timber Sale

When you have decided on a management plan, the first action may be to sell some timber. Mark your boundaries clearly. Have a forester cruise the timber and estimate its volume and value. Offer the timber for sale to all reliable buyers in the area by sending them

an invitation to bid on your timber. A list of timber buyers is available at your local office of the Virginia Department of Forestry Sales managed by a reliable consultant forester, using sealed bids, usually result in the best prices. Use a written contract with the successful buyer, which includes provisions for monitoring the cutting and erosion control practices, known as forestry Best Management Practices (BMP's). A consultant forester can monitor the cutting for you, ensure BMP's are implemented, and advise on other specific provisions of the sale. A review of timber sale contract provisions is available from your local office of the Virginia Department of Forestry. Your attorney and forester working with you on the timber sale can help you develop a good contract. (See Table 1.)

## Locating and Constructing Forest Access Roads

Good access to your forest land is essential for conducting most forest management activities. Proper location, design, and construction of roads increases the value of forest property. Good drainage, construction, and the use of BMP's are recommended.

A practice that benefits both wildlife and forest management activities is called "daylighting." The trees bordering access roads are removed to allow sunlight to reach the road surface and banks for most of the day. This increases drying of road surfaces and improves the wildlife habitat by enhancing the growth of shrubs, browse, grasses, weeds, and insects. Essentially, day-

**Table 1. Forestry and wildlife services available.**

Activity	DOF	CF	IF	GAME	EXT	SCS	ASCS	DSWC
Forest-Wildlife Management Plan	T	T,C	T,C	T,E	E	T	F	
Mark property boundaries		T,C						
Mark timber sale boundaries	T	T,C	T,C					
Mark selective cut		T,C	T,C		E			
Cruise timber		T,C	T,C		E			
Timber sale		T,C			E			
Monitor cutting	T	T,C						
Reforestation Plan	T	T,C	T,C		E			
Area measurement for site preparation	T	T,C						
Site preparation	T,F,C	T,C	T,C		E		F	
Planting trees	T,F	T,C	T,C		E		F	
Planting for wildlife	T,F	T,C	T,C	T,E	E	T	F	F
Check survival	T	T,C	T,C					
Best management practices	T	T,C	T,C		E	T,F	F	T,F
Control undesirable vegetation in planting	T,F	T,C	T,C		E		F	

DOF - Department of Forestry Foresters

EXT - Cooperative Extension Agents and Specialists

CF - Consultant Foresters or

SCS - Soil Conservation Service Wildlife Biologists

ASCS - Agricultural Stabilization

IF - Forest Industry Foresters and Conservation Service

GAME - Department of Game and Inland Fisheries

DSWC - Division of Soil and Water Conservation

SCS - Soil Conservation Service Specialists

T - Technical assistance, ranging from advice to performance of tasks

F - Financial assistance, depending on practice and available funds

C - Charge or obligation

E - Educational programs

lighted logging roads function as long wildlife clearings and provide better year-round use. To maximize benefits to wildlife from the access road, make sure to fertilize, lime, and seed the road, roadsides, all log landings, skidder trails, fire lines, and other areas where the soil has been disturbed. A mixture of succulent grasses and legumes is recommended. Table 2 provides recommended seeding rates for eastern and western Virginia. Select from the clovers and lespedezas depending on cost and availability.

**Table 2. Seeding recommendations for disturbed soils in Virginia. Rates are given in pounds per acre. Plant one grass plus a mixture of one or more clovers and lespedeza. Plant in spring or fall, by September 15.**

Western Virginia Mixture	Eastern Virginia Mixture
orchard grass 10 lbs.	blackwell switchgrass 8 lbs. PLS*
white dutch clover 2 lbs.	Atlantic coastal panic 10 lbs.
medium red clover 2 lbs.	white dutch clover 2 lbs.
crimson clover 2 lbs.	medium red clover 2 lbs.
Korean lespedeza 7.5 lbs.	crimson clover 2 lbs.
brown top millet 5 lbs.	kobe lespedeza 7.5 lbs.
	brown top millet 5 lbs.

\*PLS - pure live seed

These seed mixtures will provide valuable areas of wildlife to graze, gather seeds, and pick insects. These open, grassy areas distributed throughout a forest provide valuable areas for turkey and ruffed grouse to raise their young. Professional wildlife managers call this type of habitat "brood range." Often, the private landowner can work out some arrangement with the timber operator to push-off or improve log landings and skidder trails for wildlife. Seed germination is best in spring and fall, which may require waiting to seed areas until the logging operations are completed. Your local office of the Soil Conservation Service will have information on the availability of seeds and shrubs for wildlife plantings. Seeding such areas also conforms with best management practices. Successful plantings usually require properly fertilized, limed, and prepared soil. Ask your local Extension agent for help with soil tests and recommendations.

It is also recommended that you restrict, or strictly regulate, motorized vehicular traffic on access roads.

By keeping disturbance to a minimum, wildlife species will fully utilize these seeded areas. It is most important to minimize vehicular disturbances on access roads from May 1st to October 15th to protect turkey poults, grouse chicks, and other young wildlife.

## Reforestation after Harvest

After the timber harvest is completed, professional assistance and financial incentives are available to start a new stand of timber, maintain erosion control practices, and improve wildlife habitat. Logging roads, fire lanes, and log landings should be stabilized to prevent erosion by planting wildlife foods. "Edge effects" are created along logging roads, fire lanes, log landings, and stream-side management zones. Pine plantation and hardwood regeneration areas can provide many wildlife benefits if properly planned and managed.

## Regeneration of Hardwoods

Unlike pines, hardwood stands regenerate without planting. Within a year or two there will be large numbers of young hardwoods, growing primarily from the recent stumps. Approximately 10-15 years after the cut, when the stand emerges from the shrub to the young tree stage, you may want to conduct a thinning or TSI operation. At this time, the highest value saplings are identified and saved for future crop trees. The rest are cut close to the ground. The cut trees can be piled to create better ground cover. TSI operations result in a second flush of ground level vegetation, which is beneficial to wildlife that feed at the ground level, such as grouse, wild turkey, and deer. TSI is labor-intensive, and at the 10-15-year stage, no immediate economic return is expected. Landowners who wait 20-25 years after cutting before conducting TSI, can use the thinned pole-sized trees for firewood. The wildlife benefits of this later thinning are not as great as earlier work. Although TSI can greatly increase the dollar value of the future hardwood stand, and there are currently no cost-sharing programs available to help pay for TSI. However, your local Virginia Department of Forestry forester will provide guidelines.

## Reforestation with Pine

If cost-share assistance is wanted for reforestation with pines, apply for assistance and receive approval before the project begins. The Virginia Department of Forestry accepts applications for Reforestation of Timberland (RT) assistance starting in April each year. In Janu-

ary each year, the U.S. Agricultural Stabilization and Conservation Service (ASCS) accepts applications for assistance starting in April each year. In January each year, the U.S. Agricultural Stabilization and Conservation Service (ASCS) accepts applications for assistance in the Federal Incentive Program (FIP) or Agriculture Conservation Program (ACP). (See Figure 4.)

## Site Preparation

Preparing the site for reforestation with pines can be accomplished in several ways. The most common are prescribed burning, drum chopping followed by prescribed burning, or bulldozing. Prescribed burning to clean up logging debris can be successful on some clearcut tracts. Most prescribed burning is done between mid-May and mid-October. However, burns made especially for wildlife are done in late winter.

## Planting

During the fall or winter, following site preparation, order pine seedlings from the Department of Forestry. During the winter or early spring, the Department of Forestry will, at the landowner's request, secure a planting crew, deliver the seedlings and, when the work is complete, inspect the planting. After the planting work is completed, the contractor will bill the landowner for the planting labor. If cost-share assistance has been approved, the landowner will receive a final cost-share payment from the RT, FIP, or ACP assistance program.

## Checking Survival

One year after the pine seedlings are planted, the Department of Forestry will check seedling survival and determine to what extent hardwood sprouts are competing with the planted seedlings. About one-third of the new pine plantations need to have hardwood sprout competition controlled if pine production is the top priority for the tract.

## Controlling Competition

The Virginia Department of Forestry provides a service, for a fee, whereby the hardwood sprout competition with planted pines will be controlled by spraying with a herbicide. The hardwood brush in pine plantations can be controlled by aerial or hand spraying of a herbicide onto the foliage of small brush in the summer or to the stems in winter. The herbicides recommended by forestry agencies have been selected carefully to insure that they are effective in reducing competition with pines and not toxic to wildlife. However, the use of herbicides is an important decision because by reducing hardwoods in the pine stand, the plant diversity and foods available to wildlife are also reduced. Once again, you are faced with a trade-off: maximum economic return from your forest stand versus reduced dollars but enhanced wildlife benefits. Professional assistance may help you recognize when competition from hardwoods is great enough to significantly reduce economic returns from pine plantations. The selection and timing of herbicide use may be managed to mini-

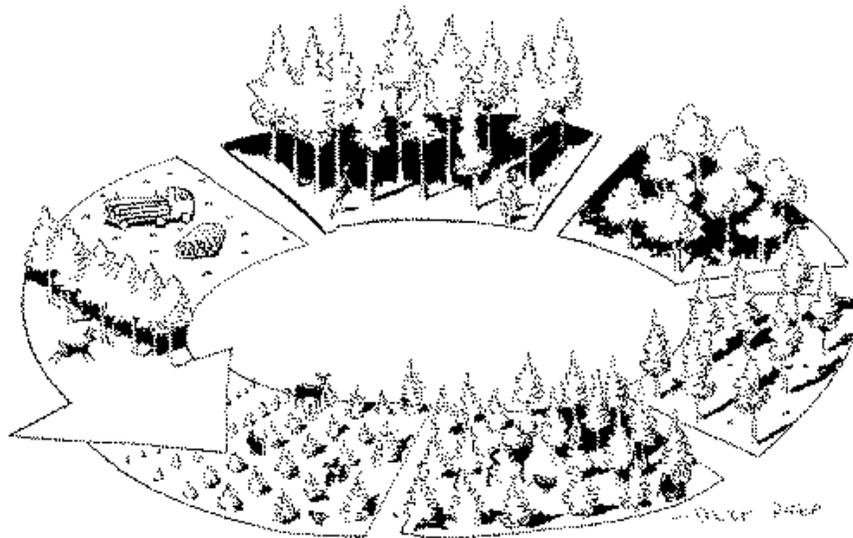


Figure 4. Pine Plantations can be managed with wildlife in mind throughout the harvest cycle. Frequently, strips of hardwoods are retained for wildlife travel corridors, to protect water quality, and provide food and cover for wildlife.

mize impact on wildlife. The landowner should identify areas on the tract such as wildlife plantings and hardwood leave strips where no herbicides should be used. Described below, prescribed burning may be a viable alternative to herbicides, once the pines have reached 15 to 20 feet tall.

## Prescribed Burning

Prescribed burning in pine stands is a standard quail, deer, and turkey management tool throughout the South. In addition, prescribed burns reduce wildfire hazards and the costs of preparing recently logged areas for tree planting. A controlled burn involves running low-intensity, surface fires through a stand on a 1- to 4-year rotation, depending on fuel conditions. Burning during the winter kills woody vegetation on the forest floor, releases nutrients to the soil, and results in increased seed germination and herbaceous vegetation, particularly legumes and grasses.

Fire before the acorns fall also encourages the development of oaks in hardwood forests. Much of the predominantly oak forest present today in Virginia is the result of repeated burning during the past 200 years. A prescribed fire in a hardwood stand will kill undesirable thin-barked tree species, such as red maple, and give the oaks a chance to develop and dominate the stand. Researchers are exploring the role and benefits of a properly applied prescribed fire in hardwood stands to promote the sustenance of timber and wildlife.

The major difficulty that the landowner has in using fire is finding qualified people to conduct a safe and successful fire in accordance with state burning and air pollution laws. Fire can be very dangerous. Open air fires within 300 feet of woodlands are illegal before 4 P.M., March 1 through May 15, and open fires must be attended. Landowners are encouraged to seek help from professional foresters and wildlife biologists when considering use of fire.

## Management Tips for Selected Species

The general guidelines of forestry, with wildlife in mind, can be supplemented with special considerations for the particular kinds of wildlife desired. For this section, we have chosen those game animals and birds most frequently sought after in Virginia.

## White-tailed Deer

Once scarce in many areas of Virginia, the white-tailed deer is now so abundant that farmers complain about deer damage to crops, fruit trees, and Christmas tree plantations. Landowners who want more and bigger deer can take some valuable clues from neighboring farmers who have problems. Deer become nuisances because farmers grow protein-rich crops, such as alfalfa, peanuts, and clover--that deer find tasty and nourishing.

Each day, an adult deer eats about as much vegetation as you could cram into a basketball. That is a lot of leaves, grass, twigs, and fruits. However, it is quality, not quantity, that counts. The optimum protein content of forage for deer is about 16 percent. Availability of high quality food is critical in the early spring when pregnant does are carrying one or two fawns. The demand for excellent nutrition continues through the spring and summer when does produce quantities of rich milk for their fawns. Bucks and does utilize the best forage they can find through the growing season to replenish the losses in body condition suffered through the winter and to grow. In the fall and early winter, the diet of deer shifts to incorporate foods high in sugars and starches, such as acorns, grapes, and field corn. These high-energy foods are converted to fat. Fat stores laid up in autumn are used up during the winter when cold, wet weather forces the deer to burn more energy to keep warm than they generate from available food.

Buck deer do not reach full body size until they are in at least the second half of their fourth year. Furthermore, bucks do not develop their antlers fully until they reach 4 to 6 years of age. Careful research on the interplay of genetics and environmental influences has led some scientists to conclude that larger deer, including trophy bucks, are possible wherever the herd is kept below carrying capacity, the sex ratio of bucks to does approaches 50:50, bucks are permitted to attain ages of 6 years or more, and where there is ample, nutritious food.

Big-antlered, healthy deer are the product of genetics, good nutrition, and age. The manager has to add two more ingredients to complete the picture. First, thick, shady escape cover during the daytime hours needs to be present. Second, the extent of habitat under management needs to be sufficient to attract and support deer. Private landowners who control several thousand acres can manage both the habitat and the local population of deer. Because buck deer roam as much as 2 square

miles during the rutting season, only relatively large landholdings offer opportunities to control the harvest of bucks, permitting bucks to reach the age required for maximum antler development. An alternative for owners of smaller tracts is to engage in a cooperative venture with neighbors. This may seem unwieldy, but a second advantage in working with neighbors toward a trophy program is that the whole neighborhood will sustain fewer problems with trespass and other forms of uncontrolled hunting. Landowners who control sizeable acreages may want to participate in the Deer Management Assistance Program (DMAP). Contact your Virginia Department of Game and Inland Fisheries' wildlife biologist for information about DMAP.

Whether the landowner wants to attract and hold deer on 50 acres or 5,000 acres, the recommendations for habitat management are about the same. Deer management and intensive forestry go together exceptionally well. Clearcuts produce large volumes of palatable, nutritious forage during the first 10 years. From 10 years to about 30, clearcuts provide escape cover, with decreasing amounts of food. Mature hardwood stands produce nuts and fruits that deer use heavily in the autumn. Landowners who manage for top-grade hardwoods can enhance both the quality of their timber and food for deer and wild turkey through timber stand improvement. Timber stand improvement amounts to removing trees that compete for light and nutrients with trees selected to grow for sawlogs. The landowner who wants to get the best of both worlds needs only to select the trees that produce mast crops. Two trees that traditionally have both a high market value and produce favored nuts are white oak and northern red oak. Although beech usually does not bring top dollar, a few large beech trees can be left in the hollows.

Deer typically use open habitats at night, residing in thick places through the day. Buffer strips of hardwoods along streams and separating clearcuts, with strips of the original woods left intact, provide secure corridors for deer movement and mast-producing trees on the property. When leaving the hardwoods is combined with another Best Management Practice, revegetation of logging roads and log landings, it is clear why landowners who actively manage their forest lands for timber also benefit from increased deer populations.

Beyond strategic locations of clearcuts and the implementation of BMP's, you can really put the icing on the cake by planting food crops for deer. Plant about 5% of your property to high protein crops, such as alfalfa

or ladino clover. Fertilize, lime, disk, and seed logging roads and log landings as soon as possible after a logging job, but not during the heat of summer or the middle of winter. To control erosion on roads, it is a good idea to mix orchard grass with legume seed (Table 2). For new ground, planting winter wheat or annual rye along with a legume is suggested. Annual food plots tend to be more productive than perennial plots, but they are more expensive. Annual plantings of field corn or grain sorghum or particularly beneficial in anticipation of years when acorns are not produced in abundance. If perennial plots are created, plan on disking, liming, fertilizing, and replanting every three years. Also, perennial plots should be clipped or bush-hogged in the early fall. Crops do poorly when grown in the shade. Therefore, create openings at least 30 yards wide for permanent food plots. Where possible, orient the long axis of wildlife clearings to the south to capture the full benefit of the sun.

There are two reasons why plans to create food plots often fail. To be successful, the creation of a food plot in the forest requires mastery of agricultural practices. This is why we recommend strongly that the landowner who is not experienced in growing field crops get help from the local Extension agent. Cost is the other reason why food plots for wildlife fail. In the mountains, the cost to convert a clearcut area to one that can be worked with farm machinery and then planted with crops is approximately \$800 per acre. The reason for this high cost is that about two days of bulldozer time per acre is required to push out the stumps and level off the ground for tractor work. It costs about \$125 per acre each year once the food plot is established to maintain the plot in productive condition. These cost estimates include charges for labor as well as machine time. These start-up and annual costs have forced the Department of Game and Inland Fisheries to put increasing emphasis on managing recently logged areas by seeding the roads and log landings, rather than creating permanent wildlife clearings.

Recently, a new compromise between the permanent food plot and simply reseeding logging roads has been started. This involves selecting sections of logging roads that can be economically enlarged to create temporary wildlife clearings. These clearings will be rejuvenated some 10 years later when another timber sale is conducted off the road. An active timber management harvesting program will often suffice for providing browse for deer, brood range for turkeys and grouse, and soft mast for many wildlife species.

## Wild Turkey

Once thought of as a bird of the mature hardwood forest only, the wild turkey has surprised professional biologists, foresters, hunters, and landowners by adapting to pine plantations and restricted hardwood stands in agricultural areas. Wild turkey flocks need secure roosting areas, open lands for brood rearing, and several miles of suitable terrain over which to find food and cover during the different seasons and from one year to the next. Other critical ingredients in turkey range are protection from free-ranging dogs, illegal hunting (poaching out of season, exceeding legal bag limits, and the taking of hens during the spring), and motorized vehicles. Research has shown that turkeys avoid roads open to motorized vehicle activity, but turkeys will use roads that are gated to restrict access.

Forestry practices resulting in mature hardwoods favor wild turkeys. Rotation ages of 125 years or more are recommended to maintain mast production from hardwoods. One approach is to restrict harvest to 8 percent of a prime oak stand, cut in 10- year intervals. When oaks are managed to produce top-grade sawlogs, the result is a forest that will produce large amounts of acorns in good years. Such practices as timber stand improvement can be used to benefit both the economic and wild turkey yield of the hardwood stand. If the landowner has chosen to cut a mixed hardwood-pine forest and replant it to pine, wild turkeys will not necessarily abandon the property if cutting units are 40 acres or less and BMP's are employed. A key to retaining wild turkeys on large holdings, especially pine plantations, is to insist on maintaining strips of hardwoods along all streams and between cutting units. Watersheds can be connected over steep ridge tops by leaving hardwoods. These wet and steep areas are not good growth areas for pine, so the landowner loses little in return for the chance that wild turkeys will continue to be on the property. Restricting use of herbicides to control hardwood competitions to application only on the hardwoods that are in the immediate vicinity of the pines may be desirable. This, however, is more expensive than aerial applications over the entire stand.

In forested areas where pastures and crop fields are not common, the number of wild turkeys is likely to be limited by shortage of brood range. Wild turkey poults, as well as quail and grouse chicks, depend on insects, spiders, and other invertebrates during the first month of life. These energy and protein-packed foods are most abundant in openings. Convenient ways to provide critically important brood range are to daylight logging

roads and to plant logging roads and log landings with grasses and legumes (Table 2). A valuable fall planting mixture for turkeys is one comprised on winter wheat and annual clover (crimson clover). During the late winter and early spring, adult turkeys will feed on the lush green forage provided. During the late spring and early summer, adult turkeys and young poults will feed on the wheat seedheads as well as the abundant insect life found in these plantings.

The landowner who wishes to regenerate hardwoods following clearcutting should leave strips of undisturbed woods along the streams, spring seeps, moist hollows, and bottoms. Removal of individual trees is permissible, but destruction of these corridors of timber reduces the value of the whole tract to wildlife and fish. Allow at least some grapevines to grow to maturity when the new stand develops. These vines may result in deforming some hardwoods that would be crop trees, but grapes are a very important and dependable fall and winter food for wild turkeys and other wildlife. Grapes that hang on after the frost fall to the forest floor when the winter wind blows, providing food when other mast crops are unavailable.

## Quail

The keys to quail abundance are thick, weedy cover, scattered thickets, and bare ground within the cover. In the old days of self-sufficient farming, the hedgerows joining fallow fields and small grain fields fit the needs of quail perfectly. Today, fields that have been retired from crop production and planted to pines or to grasses and perennial plants that do not produce a thick thatch can be great quail producers. Some of the highest populations of quail are found in young pine plantations adjacent to soybean fields.

However, you do not need to create a new forest from abandoned crop fields to generate productive quail habitat. Especially in the piedmont and coastal plain, clearcut forest lands that are planted to pine, following drum-chopping and burning, attract and produce quail. Burning the duff following the logging releases nutrients and creates conditions necessary for sprouting of legume seeds that are in the soil. From the first growing season and for several years following, these legumes produce large amounts of seeds needed by quail.

Clearcutting is recommended for forest landowners who desire quail. There are ways to make clearcuts even more attractive to quail. One is to supplement the

natural legume production by planting all logging roads and prescribed fire lines to clover and Korean lespedeza (see rates in Table 1). Another way to enhance the clearcut for bobwhites is to plant strips of seed-bearing plants where the soil can be worked. A plant worth considering is the bobwhite soybean. This plant produces good ground cover, its seeds are small and sought after by quail, and it reseeds itself with a light disking in the spring. Other valuable plants worth considering for planting for quail are shrub lespedeza, partridge pea, perennial cowpeas, grain sorghum, soybeans, dove proso millet, brown top millet, Egyptian wheat, sesbania, and buckwheat. The millets and annual lespedezas make excellent planting materials for seeding fire lines which would serve as long linear food strips.

Clearcuts are attractive to quail from years 1 to 8 following the cutting operation, but hunters have difficulty getting through the cover much past year 4. There are three ways the landowner can extend the time quail can be enjoyed. The first is to space pine seedlings to 10' x 15' or 15' x 15'. This expanded spacing will have no negative impact on the dollar value of the stand if it is held to saw-timber size, but you will lose the opportunity for a thinning at 20 years. In recent years, thinning has not been very profitable. The second is to establish annual feed patches in borders surrounding and through the cut and in strips along logging roads through the cut. The third approach to maintaining quail on the property is to schedule clearcuts on adjoining tracts at approximately 5-year intervals.

Though common in Virginia, tracts of pine are managed for quail in more southern states by maintaining pine stands at low stand densities and burning them in the late winter every other year. This style of management is feasible for loblolly stands in the southern Piedmont and coastal plain of Virginia.

## **Ruffed Grouse**

This forest gamebird depends on thickets and young forests. In Virginia, the most productive grouse habitats are above 2,000 feet of elevation. In lower altitudes in the foothills, grouse prefer damp, north-facing slopes and hollows. Traditionally productive grouse habitats are abandoned mountain farms. These special places have orchards, scattered patches of open ground interspersed with shrubs, briars, and tangles of grapevines.

Fortunately, ruffed grouse are not restricted to abandoned farms. These fine gamebirds respond to the dense

vegetation that results from timber cutting. When shrubs and saplings are 5-15 feet in height and have densities of at least 2,000 stems per acre, the habitat usually provides the cover and food grouse need. Grouse will use clearcuts from a few acres to hundreds of acres, but cuts of 5-20 acres are favorable. The prime grouse years for cut-over lands are from 8 to 12 years, with some use through 20 years. A checkerboard pattern of scattered, small, 1- to 5-acre firewood clearcuts through the property can be scheduled to have new thickets developing perpetually. Planting roads, roadsides, and log landings to a mixture of clovers, or Korean lespedeza, and orchard grass provides areas for grouse chicks to find insects (Table 1). Landowners may wish to leave a few logs, at least one log per 5 acres, that have little commercial or firewood value in the clearcut for drumming logs. Drumming logs are typically located on slight elevations within a thicket. Another fine-tuning touch for cut-over lands for grouse is to leave tree tops in piles. Timbercuts that are burned in preparation for regeneration provide little cover in the undergrowth after about 8 years. The productive span for a clearcut can be extended by conducting timber stand improvement cuts at about 12 years after the cut.

In addition to creating thickets and brood range, private landowners can increase the attractiveness of their properties to grouse by increasing fruit production. Grouse feed heavily on fruit in the late summer and autumn. Natural sources of fruit include dogwood trees, viburnums, sumac, greenbrier, wild grape, hawthorns, serviceberry, wild plum, wild cherry, and black gum. Grouse also eat apples and crabapples. Fruit production can be stimulated by removing trees that compete with producers, as well as fertilizing and pruning selected trees and vines. This will encourage the growth of valuable and soft mast shrubs, trees, and woody vines. Grouse will also seek out the smaller nuts, such as the acorns produced by white, pin, scarlet, and bear oaks and chinquapin. Mast producers should be near brushy cover if grouse are to use them. Numerous kinds of soft mast producers can be planted on your land. Contact your local wildlife biologist for a list of recommended species.

In the winter and early spring months, grouse in the southern Appalachians feed heavily on tender, green vegetation. Typically, these favored green plants produce new leaves or sprout from seeds in the fall and are located in damp hollows or at the edges of fields. Grouse, and other wildlife species, heavily utilize damp hollows, wet bottoms, and spring seeps. These areas

should be recognized as important areas and protected by sparse cutting. We recommend a minimal disturbance zone of 50 feet along spring seeps. When brushy cover is present in damp hollows, these areas can be preferred winter habitats. Scattered thickets of white pines or red cedars are also characteristic of good winter cover for ruffed grouse in the southern Appalachians.

A final note on productive grouse covers. With a few exceptions, cattle and horses in the woods ruin grouse habitats. Livestock destroy the cover that is necessary for grouse to escape predators.

## **Woodcock**

Woodcock are generally more likely to migrate through Virginia than to nest and rear their young in the Old Dominion. However, woodcock have been reported to reproduce along the northern coastal plain, along the Blue Ridge, and in the mountains along the West Virginia border. Woodcock feed on earthworms by probing in moist soil with their flexible bills. This feeding habit depends on good, moist topsoil and relatively thick shrubby cover. Even more than the ruffed grouse, the woodcock depends on low, wet, moist, and wooded thickets. The typical woodcock feeding area is an alder thicket or swamp. Abandoned beaver ponds grow back into ideal woodcock thickets. Low, woody stands of many shrub and tree species that provide overhead protection and sparse ground cover will also attract woodcock. Stands of dogwood, hawthorn, viburnum, crabapple, and multiflora rose provide suitable woodcock habitat. Another prerequisite for woodcock in the spring is open, grassy areas used for singing grounds. In the early 1900's, woodcock became quite abundant in North America due to the vast acreages of abandoned farms. In recent years, more and more of these one-time rich woodcock covers have grown into mature forests and are no longer suitable for woodcock.

The essential management scheme for promoting woodcock involves cutting down forested areas to create thickets where moist soil conditions exist. Cuts designed particularly for woodcock are laid out in rectangular shapes, with the long axis of the rectangle cutting across wet places. Several cuts are laid out side by side. One or more blocks are cut annually to provide a diversity of age classes. Singing grounds must be at least 0.5 acre. Within these areas, maintain two to three 200-300-square-foot areas by mowing. When the timber is cut, burn or remove the slash so that a grassy area develops. Grassy areas can be maintained

by bushhogging, treatment with herbicides to prevent woody shrubs from shading out the grassy areas, or by prescribed burning. Woodcock roost at night in fields, preferably at least 3 acres in size. Recently clearcut areas qualify as roost habitats. Some managers burn roost cover to maintain the low vegetation needed by woodcock. Alternatively, fields mowed in strips provide ideal roosting cover and earthworm populations. Woodcock do, however, use moist, rich, mature, hardwood bottoms for daytime cover.

The practical woodcock manager will use firewood cuts to generate cover for woodcock. As the cover matures, first the woodcock and then the grouse will use it. There will be an overlap of several years when both the woodcock and ruffed grouse can be found in the same cover.

## **Landscapes that Attract Wildlife for Enjoyment**

Throughout this publication the emphasis has been on managing forested lands for game species. The same practices that create habitats for game birds and animals also produce opportunities for songbirds, hawks, owls, reptiles, amphibians, small mammals, and many kinds of invertebrates. Everyone who devotes time, effort, and resources to manage for wildlife wants to see results. That is what this section is about. Here, we want to present concepts of landscape management and tips on getting close to wildlife.

### **Landscaping for Wildlife**

When timber cuts, logging roads and decks, ponds, wetlands, and wildlife plantings are planned on an aerial photograph of your property, you can create habitats and movement corridors that do more than increase wildlife abundance and diversity. You can channel wildlife movements so that you can see them. This aspect of planning, though based on ecological relationships and verifiable by scientific measurements, approaches art. There are infinite variations in topography, soils, history of human use, and diversity of wild and introduced species of plants and animals. Furthermore, each landowner has a personal mix of aesthetic, economic, and recreational objectives. We present some proven ways to encourage wildlife to come near you: however, your application of these ideas will be tailored to your property. Professional foresters and wildlife biologists can help you decide how to apply these ideas in effective, economical ways.

Wildlife biologists want edges, the longer the better, and good corners. By "good" is meant two or more desirable forest or land-use types adjoining. A hemlock stand adjacent to a corn field produces a good edge because the combination provides both food and cover. A fallow field adjacent to a pond also produces a good edge. The junction of two similar forest types together, such as red oak and white oak, is better than a solid stand of either because a greater variety of foods and cover is provided throughout the year, but this combination is not as good as, for example, a pine forest adjacent to an oak forest.

Further complicating the problem, but a way to wildlife management success, is to produce good corners. The concept is to join three desirable cover types for a particular species. Food plus cover plus water is a good combination. Autumn acorns, spring insects, and summer woodland variety is also a good combination. The way to get the most such 3-factor combinations is to have fields and stands in hexagons. The smaller these hexagonal units are, the better. A rule of thumb for timber cuts is that the units must be at least 25 acres to be economically attractive.

Firewood cuts of 5 acres or more may be feasible, depending on the local market for firewood. Of course, variations in topography, soils, and existing vegetation make creating a mosaic of hexagonal habitat units virtually impossible and economically unfeasible. But, you can plan your timber cuts and wildlife plantings to attain a surprising number of junctions of different habitat types. Furthermore, these junctions can be located near places where you live or have easy access.

Another way to enhance chances of seeing wildlife is to establish wildlife corridors that pass by or coverage at your home. A strip of mature hardwoods 50 yards wide that extends through plantations of pine, annual wildlife plots, or other distinctly different cover and leads from a large hardwood stand to a source of water or crop fields will be heavily used by wildlife. Deer will routinely use the hardwood strip in the morning and evening. Songbirds characteristic of the deep woods as well as those of open areas and edges will use the corridor and its edges.

Special plantings of seed-producing annual plants like winter wheat or millet or fruit-producing trees and shrubs near the home and close to good wildlife cover are the equivalent of placing a bird feeder between your back window and a hedge. Wildlife feel comfortable as

long as cover is nearby. These food plantings will be used heavily in years when oaks and other mast producers do not bear.

The presence of wetlands on any property guarantees increased wildlife abundance and diversity. Beaver swamps are preferred habitats for wood ducks and several varieties of fishes, amphibians, and reptiles. Also, you can create wetlands for wildlife. Shallow ponds that are wet during the fall, winter, and spring, but dry in the summer are most productive. Such areas can be built with planning assistance from the Soil Conservation Service so that they can be drained in late June and flooded in early October. Erection of wood duck nest boxes and planting annual seed-producing plants, such as the one of the millets, near the pond further increase wildlife use.

A landscape for wildlife must be dynamic because the forest stands grow each year. For example, an untended 25-acre clearcut that supports a covey of quail this year will not have quail in 10 years because their habitat will be overgrown. Forest growth and its associated economic, recreational, and aesthetic products make landscaping for wildlife an interesting challenge.

## **Tips on Observing Wildlife**

By strategically employing the preceding ideas, many kinds of wildlife will be living near or moving by your woodland home. You will see wildlife from your windows frequently. You can add another sense to your perception by being outside with the wildlife. The sounds produced by birds, amphibians, and mammals add a rich addition to what is seen. There are two essential ways to see more wildlife. One is to move slowly and noiselessly through their habitats and the other is to move not at all.

The American Indians were masters of stealth. They wore soft moccasins and silent buckskins. They knew how to slip along game trails and how to use trees and rocks to hide their movements. You can train yourself to move with deliberate care and you can wear clothes to help blend with your background. Boots with soft, gum rubber bottoms and leather uppers are available at sporting goods stores. There are several excellent camouflage patterns of clothing to get close to wildlife. You can clear, and mow where necessary, trails through your property to make your walks more pleasant.

The alternative to sneaking through the woods is to

hide in strategically placed blinds. The vast majority of striking wildlife photographs are taken from blinds. The blinds can either be permanent or portable. Outdoor catalogues list camouflage netting and easily assembled frames for blinds. The complete blind has one or more comfortable seats and several ports to facilitate viewing. Although blinds can be placed anywhere, the best locations are near travel corridors, water sources, or places of abundant food. The blind should be inconspicuous and set up or constructed at least a few days before use. Place the blind so that the sun will be at your back. Plan to be in your blind before light in the morning and well before dusk in the evening. You may wish to locate blinds for both morning and evening observations.

While stalking through your woods or sitting in your blind, you may be able to interact directly with wildlife by using calls. There are game calls available for deer, wild turkey, quail, squirrel, ducks, and predators. Along your paths, you can work the soil up or place piles of sand a few feet in diameter in which to capture animal tracks.

Your observations of wildlife will no doubt reward you richly for your planning and hard work. To make the reward even greater, consider buying field guides to the birds, mammals, reptiles, amphibians, insects, flowers, shrubs, and trees. Binoculars and a telescope on a tripod are useful. In addition to photography, a diary of your observations will sharpen your memory and add to the value of your forests and wildlife. The diary or journal should contain careful records of dates and time spent on the property, detailed actions taken according to your plans, and include data on wildlife observed, game animals taken, and thoughts on how your management operations are working or could be improved.

We encourage you to contact professional natural resource managers in the agencies listed below to help you develop and put into action a management plan tailored to your desires and the potential of your property.

## **Public Agencies Offering Assistance**

Virginia Department of Game and Inland Fisheries  
P.O. Box 11104  
Richmond, VA 23230-1104  
(804) 367-1000

Virginia Department of Forestry\*  
P.O. Box 3758, University Station  
Charlottesville, VA 22903  
(804) 977-6555

Local Extension Offices or  
Virginia Cooperative Extension\*  
Virginia Polytechnic Institute and State University  
Blacksburg, VA 24061  
(703) 231-5299

Virginia Department of Soil and Water Conservation\*  
203 N. Governor Street, Suite 206  
Richmond, VA 23219  
(804) 786-2064

USDA Soil Conservation Service\*  
400 N. Eighth Street  
Richmond, VA 23240  
(804) 771-2458

USDA Agricultural Stabilization and Conservation  
Service\*  
400 N. Eighth Street  
Richmond, VA 23240  
(804) 771-2591

\* Designates agencies with offices in counties. Local  
phone numbers are in the blue pages of the telephone  
book.

## **Sponsored by**

Virginia Department of Forestry

Virginia Department of Game and Inland Fisheries

Virginia Cooperative Extension

Tennessee Valley Authority

Virginia Wild Turkey Foundation

Virginia Quail Unlimited

Ruffed Grouse Society

## **Acknowledgements**

The authors thank the Tennessee Valley Authority, Virginia Department of Forestry, Virginia Department of Game and Inland Fisheries, Virginia Cooperative Extension, Virginia Wild Turkey Foundation, the Ruffed Grouse Society, Virginia Quail Unlimited, and the Department of Fisheries and Wildlife Sciences at Virginia Tech for supporting this publication. Helpful reviews of the manuscript were provided by James A. Bowman, Kent Burtner, Steve Capel, James N. Cranor, Robert H. Giles Jr., Louis A. Helfrich, James E. Johnson, Rodney D. McClanahan, Gary Norman, W.B. (Chuck) Stanley, Creed B. Taylor, Chris Wheaton, and James F. Williamson. The cover illustration and the line drawings are by Doug Pifer. The original publication was desugbed by Creed B. Taylor. Without the support and assistance of these agencies, organizations, and individuals, this publication could not have been completed.