

PENNSYLVANIA – DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES - BUREAU OF
FORESTRY-ECOLOGICAL SERVICES

White-Tailed Deer Plan

2013



EXECUTIVE SUMMARY

White-tailed deer (*Odocoileus virginianus*) are the official state mammal and are important to the Commonwealth for numerous reasons. Deer glimpsed in the woods have thrilled people with their grace and stateliness and venison has provided savor and sustenance for centuries.

However, the history of deer-human interaction in the last two centuries is one of overexploitation through unregulated hunting, followed by years of overprotection, population increase, and consequent habitat destruction resulting from overbrowsing.

The mission of the Bureau of Forestry, through sound ecosystem management, is to maintain a healthy, viable forest for many species of plants and wildlife. This includes conserving native wild plants throughout the state. White-tailed deer are considered keystone species for their ability to shape their community by selective browsing, especially where the species occurs in high numbers in relation to the available habitat. Pennsylvania's forested ecosystems have been altered by out of balance deer herds.

This plan provides the framework for the Bureau of Forestry's goals and responsibilities regarding white-tailed deer on state forest land.

This preparation presents 1) an identification of the goals targeted by the plan 2) the history of deer on state forest land, 3) an assessment of forest health conditions and theories on recovery 4) review of deer population management in Pennsylvania, DCNR's role in deer management, and DCNR's deer initiatives to meet our goals

To ensure steady progress toward maintaining a balanced white-tailed deer herd on State Forest land, every 5 years Bureau of Forestry staff will review the status of the white-tailed deer plan. Revision of the plan may be warranted if there are changes in threats, strategies or other pertinent information.

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WHITE-TAILED DEER GOALS ON STATE FOREST LAND

The Bureau of Forestry, through sound ecosystem management, manages the state forest system to ensure its long-term health, viability and productivity while providing suitable habitats for many species of plants and wildlife. The Bureau of Forestry has established terrestrial, wetland, aquatic/riparian, and cave habitats guidelines, which are implemented in normal operating plans on State Forest lands to ensure healthy habitats and communities. The Bureau of Forestry also creates specific management strategies for certain Special Management Areas, several species identified as keystone species, species of special conservation concern, and for species whose fragility is documented. White-tailed deer are considered keystone species for their ability to shape their community by selective browsing, especially when deer occur in high numbers in relation to the available habitat.

To meet the mission of DCNR in the stewardship of the State Forests, the following are the Goals of the Bureau of Forestry in deer management:

Goal 1: To improve forest regeneration and native plant abundance

Goal 2: To measure the progress of forest regeneration and plant abundance, and determine the best way to measure vegetation impacts in relation to deer

Goal 3: To provide access and opportunities for viewing and hunting on state forest land

Goal 4: To improve communications and education regarding deer on state forest land to the public

Goal 5: Utilize State Forests as a model for scientific forest and deer management across the Commonwealth of Pennsylvania

WHITE-TAILED DEER BIOLOGY AND ECOLOGY

White-tailed deer are ungulates, or hoofed animals, belonging to the family *Cervidae*. The *Cervidae* family also includes moose, elk, caribou and mule deer. White-tailed deer occur from southern Canada south through the United States and Mexico to Panama. Consequently, deer are found throughout Pennsylvania (Rosenberry et al. 2009).

The white-tailed deer's hair color and coat change throughout the year. During summer months the hairs are short, thin, straight and reddish brown. Their summer coat is shed in late summer or early fall and is replaced with thick, long, hollow hairs that are grayish brown. The hollow under hairs and wiry outside guard hairs provide additional insulation and protection during winter months. The winter coat is shed in mid to late spring. Hair color is alike in both sexes.

Fawns are born with white spots in the upper coat. This coloring provides excellent camouflage for the fawns. Their summer coats are molted during late summer or early fall and will assume the same coat colors as the adults in the fall.

Deer weights vary considerably, depending on age, sex, diet and time of year. Females tend to be smaller than males of the same age from the same area. Males typically lose weight as they expend energy during the fall breeding season. Breeding age bucks may weigh 25 to 30 pounds more at the start of breeding season than they do at its conclusion. This energy expenditure during the rut often predisposes males to have higher winter mortality rates than females (Owen-Smith 1993). Females tend to expend the most energy during the summer when rearing fawns. Due to the energy requirements needed for lactation, females spend more time feeding during summer months (Beier 1987).

Antlers generally begin to grow in March or April. A buck's first set of antlers begins to grow when a male is about 10 months old. Although antler growth is evident on male fawns, the buttons like protrusions are not prominent. On rare occasions, a female deer will grow antlers (Rosenberry et al 2009). The size of a buck's antlers will be influenced by nutrition, genetic characteristics of its mother and father, and age. Bucks will produce their largest antlers after reaching physical maturity around 4 to 5 years of age.

Antlers in March or April are covered by "velvet", a skin with soft hairs with blood vessels that supply nutrients to the growing antlers. Antler growth ceases by August or early September, followed by calcification, and shedding of velvet. To remove their velvet buck may rub their antlers on saplings, shrubs or rocks. Antlers drop any time from December through March and a new set of antlers begins to grow again in March or April, triggered by increasing daylight and hormonal cues.

White-tailed deer may begin mating as early as September and continue into January. Breeding activity reaches its peak in November, and most adult females have been bred by the end of December. The age and health of a doe will influence her reproductive capacity. Does in farmland regions have a higher percentage of fawns and yearlings breeding than in forested regions where the food supply is less abundant. Adult females, 2.5 years and older, usually produce twins, and triplets are not uncommon.

In Pennsylvania, fawns generally have higher mortality rates than other age classes. The leading source of fawn mortality is predators, primarily black bears and eastern coyotes. Fawns are most susceptible to predation during summer months, during the fawn's first three months of life. Other sources of fawn mortality include starvation, disease, and infections (Vreeland et al. 2004).

Hunting is the most significant cause of mortality for deer at least 6 months of age in Pennsylvania (Vreeland et al. 2004). Deer-vehicle collisions are also a primary source of mortality, particularly during summer months for yearlings and adult deer. Predation typically accounts for approximately 1% of deaths of white-tailed deer at least 6 months old.

Deer are capable of recognizing nutritional differences and select food accordingly (Rosenberry et al. 2009). Consequently, although deer eat a variety of vegetative material, not all plants and plant parts are equally nutritious and palatable to deer. Therefore, a general listing of preferred and non-preferred foods could oversimplify the complex nature of the subject. Preferences should be considered in terms of availability in a particular area at a specific time.

White-tailed deer are adaptable and can be found in a variety of habitats. However, they are best suited to forested habitats where food such as buds, stems, leaves and herbaceous species are abundant. Forests are an important habitat for deer as they provide food and cover; however, different age forests can support varying numbers of deer. Mature timber stands can support a moderate number of deer, seedling/sapling stands can support the greatest number of deer and poletimber stands typically support few or no deer (Drake and Palmer 1991). This is why it is important to provide a mosaic of habitat age classes within a forested system.

HISTORY OF DEER IN PENNSYLVANIA FORESTS

The Early Days

Prior to European settlement, deer provided a staple for Native Americans who inhabited present-day Pennsylvania. Hunting by native peoples and predation by large carnivores kept deer populations in balance with what the habitat could support.

European settlement brought removal of large carnivores, land clearing for agriculture, and market and subsistence hunting that nearly extirpated deer from the state. The conservation efforts of the early 1900s following the complete removal of our forests and gave birth to the acquisition of the state forest system. With minimal deer browsing pressure, the land regenerated

vigorously, turning into rapidly growing trees and shrubs. At the same time, deer were being reintroduced across the state amid this sea of highly nutritious forage, and their populations expanded exponentially.

An Expanding Population

Early in the 20th century deer management was designed to protect does (female deer) and maximize population growth. By the 1930s, the deer herd had grown to the point of causing severe habitat damage across large portions of the northern range in Pennsylvania. Deer populations in many of these forests peaked in the 1970s and remained out of balance with forest habitat conditions for many years after.

Impacts of Too Many Deer

By the end of the 1900s and the early 2000s, as a result of over-abundant deer populations, the forest understory across vast areas of the state had been reduced to a diminished group of species not preferred by deer, such as beech, striped maple, hay-scented fern, and mountain laurel. Fewer deer are able to survive in this denuded habitat condition.

Tree species are also limited by deer. Recent federal data shows that only about a half of forest plots studied in northern Pennsylvania has enough new growth to replace the existing forest (McWilliams et al. 2004). Studies also show that overabundant deer populations reduce the populations of other wildlife species – both game and non-game—by limiting or eliminating their desired habitat (deCalesta 1994, Latham et al. 2005).

New Policies

Starting in 1999, the Pennsylvania Game Commission began outreach efforts to educate the public on the need to revise deer seasons and bag limits to restore a balance between deer and its habitat.

In 2003, the Game Commission created the Deer Management Assistance Program (DMAP) to give landowners a tool to better manage deer on their lands through site-specific antlerless deer permits. The program allows landowners to apply to the Game Commission for additional antlerless deer hunting tags to help manage deer numbers on their property. As the largest public lands manager in the state, DCNR has worked closely with the Game Commission to tailor DMAP to the state forest and park systems.

Finding the Right Balance: Where We are Today

Recent efforts to balance deer populations have helped improve forest habitat conditions in many areas of Pennsylvania. While there have been positive signs of forest recovery, many areas still

suffer from decades of deer impacts. These poor habitat conditions continue to threaten the forest ecosystem and the sustainability of the forest.

FOREST HEALTH CONDITIONS AND RECOVERY

DCNR has long advocated balancing white-tailed deer populations with forest habitat conditions. Recent efforts to manage the state’s deer herd in this manner, as well as new tools for landowners have yielded significant improvements in habitat conditions in some areas of the state. Other lower quality areas, however, continue to suffer from a lack of new forest growth, and habitat conditions and overall forest health remains poor.

Many DCNR stakeholders, from hunters to wildlife watchers to wildflower enthusiasts to private forest landowners, often ask about “forest recovery” in light of more recently balanced deer populations. Forest habitat health and recovery is complex and involve many factors and variables.

Deer Impacts

Pennsylvania forests have sustained deer population densities high enough to cause impacts to forest vegetation since the 1920s (Leopold et al. 1943, Kosack 1995). Researchers have studied the effects of deer on forest ecosystems for many years, and the impacts of deer on the forest are well established in decades of scientific literature. How do deer impact the forest? Through selective browsing of native plants, shrubs and trees, they influence the vegetation that grows in the forest (Marquis 1974, Marquis and Brenneman 1981, Tilghman 1989, Horsley et al. 2003). By preferring certain species over others, they can effectively diminish the presence of the species in the forest while allowing less preferred species, such as striped maple, to thrive. In the most severe cases, deer can completely prevent the capacity of the forest to renew itself.

In some areas of the state, deer overbrowsing has eliminated the understory – the lower vegetation layer that includes young trees, shrubs and other plants. Deer feed extensively on many herbaceous plants such as wildflowers and other low-growing plants and even fungi (Latham et al. 2005). Some forest plants that deer prefer include large white trillium, bluebead lily, Canada mayflower, and numerous orchids (Balgooyen and Waller 1995, Rooney 1997, Miller et al. 1992). Because they never outgrow the reach of deer, plants that grow on the forest floor are continually vulnerable to deer impacts.



Forest Habitat Conditions

Pennsylvania's forests have benefited from recent efforts to balance deer populations with forest habitat conditions. Deer fencing on state forest land over the last two years (2009-2010) have been less than half of what they were five years ago. For the first time, fence dismantling equaled fence installation.

Despite recent gains in forest habitat health, in general, the forests of Pennsylvania are still in poor condition. According to USDA Forest Service Inventory and Analysis (FIA) data across all ownerships, approximately 43 percent of Pennsylvania's forests are adequately stocked with regeneration (FIA data 2005-2009)—the young trees and plants that will make up the future forest (Only inventory plots with sufficient sunlight to establish regeneration are counted in this inventory.) Only 48 percent of the sample plots in the north-central region were adequately stocked with tree seedling and sapling regeneration. These numbers indicate that only about half of Pennsylvania's forests would regenerate following an overstory disturbance such as a wind event, insect outbreak or timber harvest (McWilliams et al. 2004).

Legacy Impacts

Excessive deer impacts can alter the course of forest vegetation development with long-lasting consequences. Often referred to as “legacy impacts,” they can hamper forest recovery and habitat health for a long time. In some cases, such as the northern tier of Pennsylvania, legacy impacts can affect forest regeneration for decades.

Competing Vegetation

One type of legacy impact is the increase of “competing vegetation.” When deer selectively browse on vegetation, they not only reduce the occurrence of preferred species in the forest understory, but they also create conditions for unpalatable or resilient species to become so plentiful that they may suppress other plants by producing dense shade on the forest floor. Examples of competing vegetation in Pennsylvania include hay-scented fern, New York fern, and striped maple. In many areas of the state, the forest understory is completely dominated by these species—both an unnatural and unhealthy condition. FIA data indicates that nearly one-third of forest understory communities are dominated by this type of competing vegetation.



Competing vegetation not only provides poor habitat for deer and other forest wildlife, it also prevents the establishment of more trees and plants. Mats of fern and stands of shade-producing striped maple create poor conditions for many trees and plants to grow. Competing vegetation is

a significant problem across Pennsylvania that continues to impede forest recovery. Even in areas where deer populations are relatively low, competing vegetation can prevent or significantly delay the establishment of regeneration.

Reduced Seed Banks, Production, and Slow Growth Rates

A major impediment to the recovery of the forest is the lack of seeds and other means of reproducing where browsing has been a factor for long periods of time. In these areas there may be few local seed sources remaining. Also, most forest herbs do not have long-distance dispersal abilities. In addition to limited seed dispersal mechanisms, rates of seed production are often affected in deer-impacted forests. This occurs because deer often selectively remove the flowering or fruiting stem even though they do not consume the entire plant.



The combinations of these factors, as well as the abundance of non-preferred and browse resilient species in many areas, adds to a scarce seed bank. These issues will affect vegetation dynamics long into the future.

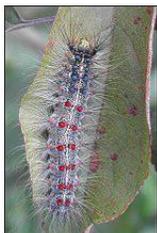
Other Factors

When managing forests and deer from an ecosystem perspective it is important to consider the myriad factors that may be affecting forest regeneration and other processes. Accounting for these factors is necessary in making sound predictions about recovery times following a reduction of deer browsing impacts.

Insects

Insect infestations are just one of the many factors reducing the number of seedlings that become established. However, they are occasionally severe enough to prevent the regeneration of tree species, especially when insect infestations occur in conjunction with other stressors.

One example of an insect that has wreaked havoc on Pennsylvania forests is the gypsy moth. Gypsy moths were accidentally introduced into Massachusetts from Europe in the late 1860s and slowly spread to Pennsylvania where it began to cause heavy defoliations in 1969 (McManus and McIntyre 1981). When these insects move into an area they can kill large numbers of trees, especially hitting white oak and chestnut oak.



Gypsy moth outbreaks can have several effects on the natural regeneration of forests, particularly oak-mixed hardwood stands (Gottschalk 1988). One impact is the decrease in acorn production due to affected oak trees aborting undeveloped seeds and reducing subsequent crops. Acorn production is also reduced due to

direct mortality of oak trees of seed-bearing size (Gottschalk 1990). These dynamics affect the establishment of desirable forest regeneration even when deer impacts are low.

Acid Deposition

Acid deposition occurs when acid-forming substances are transferred from the atmosphere to the surface of the earth. The deposited materials include ions, gases, and particles typically resulting from power generation and heavy manufacturing (Driscoll et al. 2001).

Research has shown that acid deposition can cause slower growth, injury, or death of trees, particularly sugar maple and red spruce. It has been implicated in forest and soil degradation in many areas of the eastern U.S., particularly in high elevation forests. Acid deposition generally causes stress to trees by interfering with calcium and magnesium nutrition and the physiological processes that depend on these elements (Latham et al. 2005). Acid deposition does not usually directly cause mortality. Instead, it is more likely to weaken trees by damaging their leaves, limiting the nutrients available to them, or exposing them to toxic substances slowly released from the soil.

Quite often, injury or death of trees is a result of these effects of acid rain in combination with one or more additional threats. Other factors contribute to the overall stress of these areas, including air pollutants, insects, disease, overabundant deer, drought, or very cold weather. In most cases, in fact, the impacts of acid rain on trees are due to the combined effects of acid rain and these other environmental stressors.

The USDA Forest Service has been conducting a long-term research study (23 years) on the effects of broad-scale lime application on Susquehannock State Forest to mitigate impacts from acid deposition and improve regeneration. In this study, started in 1985, researchers treated stands with all possible combinations of liming, fencing and herbicide. The results indicate that fencing is by far the strongest predictor of good regeneration. Some less common species are positively affected by lime application or by the combination of lime and one of the other factors, but these effects appeared to be much subtler than the effect of controlling deer through fencing.

The Bureau of Forestry recognizes that there are many serious impediments to regeneration, and is supportive of studies to determine if liming should be more broadly used to mitigate the impacts of acid deposition.

Forest recovery in Pennsylvania is affected by a variety of factors. Some of these additional factors include invasive plant species, fire suppression in oak-dominated forests, diseases, and a



host of other issues. However, the consensus among biologists and natural resource managers remains that the most important factor affecting forest regeneration is deer browsing and legacy impacts.

Deer management on state forest lands focuses on the ecosystems in which deer are a part. Deer impacts in Pennsylvania need to be maintained at levels that will allow the restoration of full forest structure, diversity, ecological processes, and ecosystem function.

Forest Recovery: How long will it take?

The forests of Pennsylvania will most likely not return to the same conditions that existed prior to heavy browsing impacts of the twentieth century, even with reduced deer browsing pressure. There have been too many changes in the forest ecosystem due to introduced tree diseases, insect infestations, and invasive plants. Nevertheless, the return of a diverse native understory can be expected; however, this recovery will have varying time depending on local and regional conditions.

Forest recovery begins with the restoration of quick-responding understory species such as blackberries and raspberries. The abundance and height of woody and herbaceous species often preferred by deer will also increase. These signs of recovery can be reached relatively quickly in stands where deer browsing impacts occurred only for a relatively short time. In these areas, when deer densities are brought back into balance with the habitat, and there is enough light to reach the forest floor, partial recovery can be achieved within 10 years (Latham et al. 2005).

Full forest restoration occurs when a full suite of shrubs and herbaceous plants become reestablished in the understory. This kind of recovery can take more than 50 years in more severe cases (Latham et al. 2005). How long it takes for full recovery depends on the severity of deer impacts, legacy impacts such as competing vegetation, and other factors such as the site's logging history, soil chemistry, length of the local growing season, presence of introduced species, and seed sources.

State Forest Habitat Management Efforts

To sustain the forest and help improve forest habitat conditions, the Bureau of Forestry strives to accelerate forest recovery. The bureau harvests approximately 14,000 acres of state forest land each year, increasing sunlight to the forest floor and spurring new growth and creating early-successional habitat.

When timber harvests occur in areas where deer impacts are high on state forest land, fences are installed to increase the probability of



successful regeneration. Once deer browsing pressure is reduced, herbicide is often used to remove ferns and other competing vegetation that hinder seedling establishment and growth. In addition to herbicide, the bureau implements many practices designed to establish healthy new forests. In 2011 the Bureau of Forestry brush mowed 1155 acres to control woody vegetation, planted trees to augment natural seedlings on 4314 acres, scarified the seedbed to expose mineral soil on 411 acres, and implemented prescribed fire on 260 acres to control competing vegetation.

Overall, these practices are successful in establishing regeneration. However, because of their cost, they are usually only viable solutions on a small scale. Areas not as intensively managed will take much longer to establish healthy habitat conditions and recover from deer impacts.

A healthy forest will consist of young trees, shrubs, and a variety of wildflowers. The presence or absence of some wildflowers such as trillium, Canada mayflower, and Indian cucumber root can be key indicators of the level of deer impact on a given forest site (Korschgen et al. 1980, Knight 2004, Latham et al. 2005). Another reliable indicator of a healthy forest is an understory, the young trees and plants that grow in the lower layer of the forest. A well developed understory is an essential habitat element for many plants and animals, but it also indicates the forest's capacity to renew itself (Ristau and Horsely 1999, Rooney et al. 2004).

DEER POPULATION MANAGEMENT IN PENNSYLVANIA

Regulatory Authority and Responsibility

The Pennsylvania Game Commission (PGC), by the state Constitution and Game and Wildlife Code, is mandated to manage wildlife. This includes managing deer, as well as all wildlife and the habitat that supports their existence, for the benefit of all Pennsylvanians. The Department of Conservation and Natural Resources Bureau of Forestry is mandated to ensure sustainable forests and to conserve native wild plants.

Pennsylvania Game Commission Management Philosophy

The PGC manages deer and deer impacts for all stakeholders. Management decisions take into consideration future implications of actions. Therefore, they follow an adaptive management approach which establishes clear and measurable objectives. PGC deer management goals from 2009 to 2018 are to 1) manage deer for a healthy and sustainable deer herd, 2) manage deer-human conflicts at levels considered safe and acceptable to Pennsylvania citizens, 3) manage deer impacts for healthy and sustainable forest habitat, 4) manage deer to provide recreational opportunities, and 5) improve the public’s knowledge and understanding of deer and the deer management program (Rosenberry et al. 2009). A detailed description of the how the PGC manages white-tailed deer in Pennsylvania can be found in their “Management and Biology of White-Tailed Deer in Pennsylvania 2009-2018” plan (<http://www.portal.state.pa.us/portal/server.pt/community/deer/11949>).

Wildlife Management Units

The PGC divided the state into 22 Wildlife Management Units (WMUs) that represent the basic geographic divisions used for deer management. The WMUs were adopted to reflect differences in landscape features and composition, land use practices, landownership and human density (Rosenberry et al. 2009). These differences make each WMU unique in how many deer can be supported. The boundaries of each WMU are easily recognized roads and rivers and the size is also determined by how much deer population data can be collected to ensure adequate data for management recommendations.

Hunting Seasons and Bag Limits

Pennsylvania utilizes many techniques to manage the deer herd in Pennsylvania. Some of the seasons offered to harvest deer include a traditional firearms season beginning the Monday after Thanksgiving and continuing for two weeks, and an October muzzleloader and flintlock rifles season for antlerless deer. To further manage antlerless harvests, the PGC adjusts antlerless allocations within a consistent season structure (Rosenberry et al. 2009).

Deer Management Assistance Program (DMAP)

DMAP is a site-specific deer management program that increases a landowner's or hunt club's management options by allowing a more liberal kill of antlerless deer. DMAP gives public and private landowners the option of using hunters to manage deer on their property. Once enrolled in this program landowners can receive coupons for the harvest of antlerless deer, which are distributed to licensed hunters. Hunters can receive up to 2 permits per enrolled area.

BUREAU of FORESTRY'S ROLE IN DEER MANAGEMENT

The mission of DCNR, Bureau of Forestry is to ensure the long-term health, viability and productivity of the Commonwealth's forests and to conserve native wild plants.

To accomplish this mission, the bureau sustainably manages the 2.2 million-acre state forest system for many uses and values, including recreational activities such as wildlife watching and hunting. But the bureau's role in forest conservation, however, extends beyond state-owned lands. The agency is charged with protecting all of Pennsylvania's forests from wildfire and damaging agents, and conserving and managing the state's native, wild plant communities. The bureau also promotes the knowledge of resources and forest stewardship.



White-tailed deer are perhaps the most influential wildlife species in the forest ecosystem. Through selective browsing of native plants, shrubs and trees, they influence the vegetation that grows and the health of the forest. Deer also influence other wildlife species and other forest values, and can impact their own habitat.

To accomplish its mission of conserving Pennsylvania's forests, DCNR must manage deer on its own lands and promote sustainable deer management on all Commonwealth forest lands.

Forest Plants

When deer are out of balance with their habitat they can have negative impacts on forest vegetation. Overbrowsing by deer has eliminated the understory – the lower vegetation layer that includes young trees, shrubs and other plants – in many areas of Pennsylvania (Latham et al. 2005). Although primarily thought of as a shrub and small tree browser, deer also feed extensively on many herbaceous plants (such as wildflowers and other low-growing plants) and even fungi (Latham et al. 2005). Some forest plants that deer prefer include large white trillium (Anderson



1994; Augustine and Frelich 1998; Knight 2004), blue-bead lily (Balgooyen and Waller 1995), Canada mayflower (Rooney 1997), and numerous lilies and orchids (Miller et al. 1992). Plants on Pennsylvania's endangered and threatened list that have been negatively impacted by deer browsing include glade spurge, yellow fringed-orchid, showy lady's-slippers, and leafy white orchid (Loeffler and Wegner 2000). Because they never outgrow the reach of deer, forest floor wildflowers and other plant species are continually vulnerable to deer impacts.

Forest Habitat and Wildlife

Overbrowsing can also alter habitat features important for forest mammals and birds, including deer. Direct effects occur when deer compete with other species for the same limited food source. For example, acorns and other tree nuts, known as mast, fluctuate greatly from year to year and are an important food resource for many forest mammals and some birds such as wild turkeys and blue jays (Martin et al. 1951). Competition for mast can cause a reduction in white-footed mice, deer mice, chipmunks, gray squirrels, and other small mammals, which can reduce predator populations that feed on them (Flowerdew and Elwood 2001), including owls, hawks, fishers and other carnivores (Latham et al. 2005).



Indirect effects occur when deer alter habitat features. Where overbrowsing has eliminated the shrub layer it has greatly reduced the diversity of forest-floor plant species (Latham et al. 2005). Therefore, vertical diversity (plant, shrub, and canopy layers) and horizontal diversity (the patches of different plant species across the forest landscape) are greatly diminished. Many wildlife species, such as Appalachian cottontail, snow shoe hare, and ruffed grouse, utilize the shrub layer and feed on forest-floor species. Some birds, such as ovenbirds and eastern towhees, nest and feed in the ground layer. Reduced cover increases nest predation and decreases the ability of birds to raise their young successfully (DeGraaf et al. 1991b, Leimgruber et al. 1994). Other species, such as eastern wood-pewee, indigo bunting, and black-and-white warbler, which use the middle layer of forest vegetation, have declined in heavily browsed forests (deCalesta 1994).

Impacts to Forest Growth and Development

Forest disturbances, such as timber harvests, wind events, insect outbreaks and fires, have profound effects on deer populations. Populations tend to increase in response to these types of disturbance that allow more light to reach the forest floor and trigger new growth. This only occurs where deer impacts are low enough to allow this new growth to establish and flourish and competing vegetation such as ferns do not interfere.

Typically, the growth response from these disturbances is short-term, subsiding as the crowns of the canopy trees rapidly expand to fill their new growing space. Excessive browsing by deer during understory growth can suppress certain tree species. This selective browsing also promotes the expansion of unpalatable or resilient species, such as hay-scented fern, and

American beech or striped maple seedlings and saplings that may slow or prevent the later regeneration by trees and other plants. By exhausting major food sources and fostering conditions that obstruct its regrowth, deer in high numbers can cause a forest's ability to support deer populations to decline.

Impacts to Forest Management

A deer population out of balance with its habitat impedes the practice of sustainable forestry in all forest types in Pennsylvania. On state forest lands, DCNR has specific goals for regenerating forests with many types of trees and creating a diversity of habitat across the landscape. Since our forests regenerated after the widespread clear-cutting that occurred in the early 1900s, many are approximately the same age—between 80 and 120 years old. Establishing young forests enhances the mix of forest habitat and is good for wildlife and overall forest health. Out-of-balance deer populations, however, can frustrate efforts to establish healthy young forests. Often, deer exclosure fences are required to encourage new growth.

Deer populations, when out of balance with habitat conditions, can impact forest health and many forest uses and values. DCNR is responsible for conserving the Commonwealth's forests and native plant communities. Science-based deer management that factors in habitat conditions is necessary to ensure healthy and sustainable forests.

BUREAU OF FORESTRY DEER MANAGEMENT INITIATIVES to ACHIEVE GOALS

In recent years the Department has undertaken measures to regenerate the forests using Regeneration Funds established by the legislature in 1995 (10% of the timber revenues are earmarked to pay for regeneration-related costs). These steps include fencing of areas to ensure regeneration and other measures such as mowing and herbicide treatments. All are costly and limited in scope, allowing the treatment of only a small portion of the State Forest lands. Other measures the Bureau has begun implementing to meet our goals include utilizing DMAP, increasing hunter access, supporting research, increasing communication and public education, habitat monitoring, and advocacy for continued adaptive change.

Goal 1: To improve forest regeneration and native plant abundance.

Strategies:

I. Deer Management Assistance Program on State Forest Lands

Many State Forests and State Parks in Pennsylvania have been severely overbrowsed for up to 70 years. The DMAP program allows DCNR to promote forest regeneration by

targeting the most vulnerable and severely impacted tracts for additional antlerless deer harvests.

DMAP Placement

DCNR foresters and biologists determine where to place DMAP areas based on numerous criteria. Currently, DCNR foresters collect forest health data using plots located across state forest land. Deer impact data is composed to determine if our objectives are being met. The following measures are collected: a) % plots with seedlings, b) Presence of indicator species (specific to each district) are increasing, decreasing or stable, c) % plots adequately stocked, d) % of species browsed. The foresters review these data as well as other information such as whether fences are needed in certain areas, current and future management opportunities, how long an area has been enrolled, the sale of tags and the harvest success for an area that has been enrolled in DMAP before a final decision is made (see figure 1).

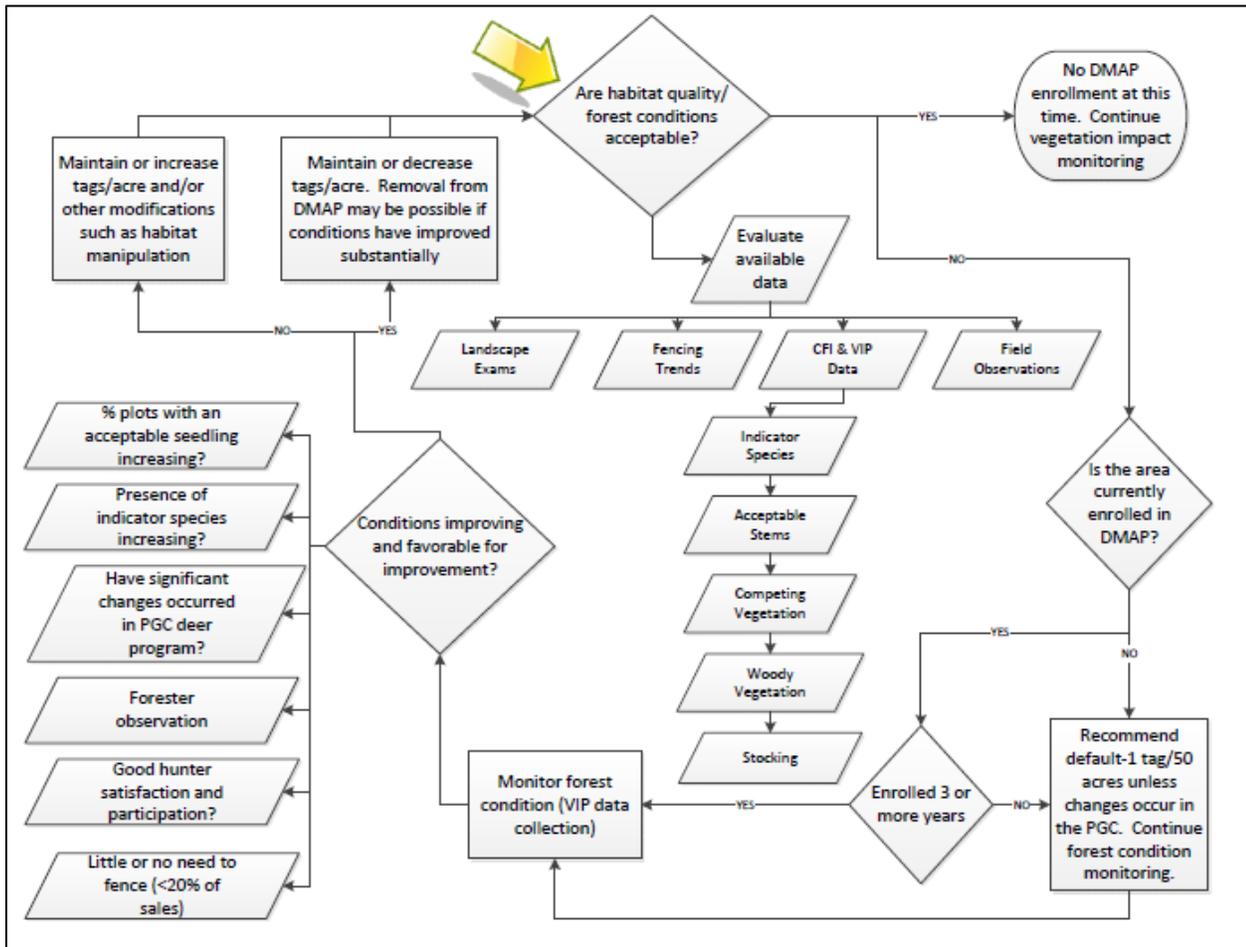


Figure 1. DMAP Decision Tool for State Forest land

Length of DMAP Enrollment

DMAP areas need to be enrolled long enough for changes in vegetation to be detected. Forest recovery will depend on the current habitat, past browsing history, and other factors. Typically, DMAP areas are enrolled for at least 3-5 years in order to see changes in vegetation. Often, areas are enrolled for longer than 5 years if browsing and other factors have significantly impacted regeneration.

Deer Abundance in DMAP Areas

DMAP areas may not necessarily have more deer than other areas. In fact, frequently DMAP units are in areas of the state where deer overbrowsing has eliminated the understory or fern is the dominating vegetation. Some of these locations may not provide the healthiest food sources for deer and therefore, any regeneration trying to become established is more sensitive to deer impacts. These areas may need to maintain a low carrying capacity in order for regeneration to become established, which is why it was placed into DMAP.

DMAP Goals and Objectives

DCNR's goal for each DMAP area is that the program assists in promoting a diverse, healthy natural habitat. The objectives of the program are: a) Address deer impacts on habitat, b) Provide additional hunting opportunities, c) Assist in maintaining regeneration to support sustainable forestry practices with minimal need for fencing, d) Assist in maintaining a forest with healthy, native wild plant species.

In order to meet these objectives we have determined a set of strategies to determine our success. These strategies include: a) Find threshold levels of native plant species for each forest district that can be indicators of a balanced or unbalanced deer population in regards to habitat, b) Determine whether the number of regeneration sample plots adequately stocked is acceptable to successfully regenerate our forests in case of a disturbance, c) Maintain good hunter participation, d) Determine the number of acceptable seedlings present and find an acceptable threshold for each forest district, e) Reduce the need for fences to be necessary for successful forest regeneration

DMAP Success

Healthy habitat is DCNR's primary indicator for success. Continued, systematic monitoring of forest vegetation indicators provides valuable data to assist field managers in making decisions on the effectiveness of individual DMAP areas.

II. Forest Management

When timber harvests occur in areas where deer impacts are high on state forest land, fences are installed to increase the probability of successful regeneration. The Bureau of Forestry



maintains approximately 40,000 acres of fencing, which has cost the Bureau approximately \$16 million in installation costs alone since 1995. However, fence installation has been slowly decreasing. In 2010 fence dismantling, for the first time, equaled fence installation.

Once deer browsing pressure is reduced, herbicide is often used to remove ferns and other competing vegetation that hinder seedling establishment and growth. In addition to herbiciding, the bureau implements many practices designed to establish healthy new forests. In 2011 the Bureau of Forestry brush mowed 1155 acres to control woody vegetation, planted trees to augment natural seedlings on 4314 acres, scarified the seedbed to expose mineral soil on 321 acres, and implemented prescribed fire on 260 acres to control competing vegetation. Overall, these practices are successful in establishing regeneration. However, because of their cost (\$1.7 million in 2011), they are usually only viable solutions on a small scale. Areas not as intensively managed will take much longer to establish healthy habitat conditions and recover for deer impacts.

Goal 2: To measure the progress of forest regeneration and plant abundance, and determine the best way to measure vegetation impacts in relation to deer.

Strategies:

I. HABITAT MONITORING

Conducting and maintaining accurate and current forest resource inventories is critical to implementing ecosystem management and achieving sustainable forestry. As part of its resource planning and management strategy, the Bureau of Forestry conducts and maintains many inventories that provide information on various levels, including statewide, eco-region, individual state forest, landscape, and forest stand level.

Forest Inventory Analysis

Collecting credible information on Pennsylvania's forests is essential to understanding the condition of this important natural resource. A comprehensive set of variables that consistently tracks and describes the forest through time is needed to accurately inform policies, guide management decisions, examine trends, chart trajectories, and formulate critical research questions. The Northern Research Station's Forest Inventory and Analysis (NRS-FIA) unit is uniquely positioned to provide pertinent data and information about Pennsylvania's forest to help achieve these and other objectives.

Therefore, in 2000, the NRS-FIA and the Bureau of Forestry implemented a new annual system for monitoring Pennsylvania's forests, completing full inventories every five years. This system incorporates measurements of forest health, forest regeneration and understory conditions across the state. Every five years a complete set of the results of

the annual inventory measurements and represented in a report for the Bureau of Forestry.

Continuous Forest Inventory

The purpose of this inventory is to provide basic biological data on plants, shrubs, trees, tree growth and mortality, forest stand structure, volume, and change on state forest lands. The Resource Inventory and Analysis Section conducts this inventory, which is a continuous process to provide data for developing periodic updates to resource management plans, as well as for long range planning and monitoring. Although this data is not collected specifically to look at the effects of deer, the data is collected within and outside fence enclosures and we are currently beginning to incorporate this data into our DMAP decision process.

The inventory cycle is five years with approximately 300 plots visited every year. Following a completed cycle the Resource Inventory and Analysis section will analyze and summarize the data on statewide, ecoregion, and district levels.

Landscape Examination Process

The landscape Examination is the primary planning tool intended for each forest district to be able to verify management zoning and vegetation typing, identify landscape features and opportunities, and for identifying candidate areas for management activities in implementing the State Forest Resource Management Plan.

The landscape examination is designed to collect basic silvicultural, ecological, recreation and cultural information to facilitate long-term planning for each of these opportunities and to monitor changes occurring at the landscape level.

Transects

Regeneration and browse data are also collected by each district to determine areas to be enrolled in DMAP. Currently, indicators/measures are collected using transects with plots (6 foot plot radius) located every 100 ft. Pellet data, constituting the total number of plots and pellet groups, and the relative abundance of sign between plots, is taken at every plot. Deer impact data, including information on acceptable seedling presence, the number of adequately stocked plots, browsing impacts, competing vegetation and site limitations, are taken every other plot or every 200 feet.

Forest Impact Protocol

The Bureau has also begun a pilot project for a new vegetation monitoring protocol, Vegetation Impact Protocol, to improve our data collection and decision making process for DMAP. The new protocol will evaluate habitat conditions for deer and other wildlife more precisely in order to meet stated DMAP habitat thresholds and goals measured by the collected data. This data collection protocol involves collecting herbaceous data (indicators of balanced deer populations) and regeneration data and will be based on a

district-level stratified sample based on community type. This protocol will incorporate the data collected during the continuous forest inventory to increase precision. Therefore, the data for DMAP decisions will be evaluated on a three to five year cycle. We hope to have this new protocol implemented in all of the forest districts by 2014.

Goal 3: To provide access and opportunities for viewing and hunting on state forest land

Strategies:

I. Hunter Access

Increased access into remote areas is an option to help increase deer harvest. The Bureau annually opens administrative roads to hunters in areas where additional deer harvest is needed. This activity is predicated on the condition of the road and the potential for environmental damage through erosion and sedimentation. Public safety is another consideration in determining which roads can and cannot be opened for hunting access. Analysis of all the roads open to public travel during the deer season reveals that hunters have access to nearly 3,000 miles of roadway in the state's 20 forest districts. Further Geographic Information System (GIS) analysis shows that, statewide, 75 % of state forest land is within ½ mile of an open road.

II. Hunters Sharing the Harvest

Wild game, especially venison, clearly provides superior, more nutritious meat than that commercially available as documented in studies by Novakowski and Solman (1975) and others. Woven deeply within the fabric of Pennsylvania's hunting heritage are the concepts of venison as an annual food source and an unwillingness of hunters to harvest more deer than their family and friends can consume. The capacity to use the venison within the hunter's household will likely be exceeded as we need to harvest more deer with fewer hunters. Efforts must be undertaken to provide incentives for the hunter to harvest the deer, ensuring an outlet for the excess venison.

Currently the Bureau of Forestry has agreed to reimburse the Hunters Sharing the Harvest program for up to \$50 for any deer brought to a participating HSH venison processor that was harvested from a DCNR DMAP area using a DMAP permit. Therefore, hunters who harvest deer using a DMAP permit on state forest land may have those deer processed by participating deer processors for up to \$50 off. This is a joint program administered through the Pennsylvania Department of Agriculture and Pennsylvanians for the Responsible Use of Animals where hunters bring harvested deer to an approved processor for processing and distribution to the needy, with a recommended monetary donation. It is hoped that this option is a meaningful incentive for hunters to continue to harvest the

needed deer, while providing an important source of venison to the needy in our communities. The Bureau is providing information on this program as DMAP coupons are distributed to hunters and through media outlets

III. DMAP

See DMAP section under goal 1 above

Goal 4: To improve communications and education to the public regarding deer on state forest land.

Strategies:

I. Communications/Outreach on State Forest Lands

The DCNR recognizes that balancing deer impacts is a divisive issue in Pennsylvania; therefore, making communication of these issues on state forest land important. The Bureau of Forestry seeks to communicate the importance of balancing deer populations with available habitat on all forests across the state, but particularly on state forest lands where the mission includes sustainable forestry and conserving native, wild plants. Communications of these issues can be found in brochures, webpage's, habitat tours, and meetings.

Brochures

Healthy forest, healthy deer brochure

The Bureau of Forestry created a guide to forest visitors examining the balance between deer and habitat. The brochure features a field guide to help identify healthy forest features. Brochures can be found in district forest offices, on the DCNR website, or one can be sent to the public by calling the Bureau of Forestry Harrisburg office.

Web Pages

White-Tailed Deer Website

The DCNR website has a section dedicated to white-tailed deer and can be found by going to <http://www.dcnr.state.pa.us/forestry/deer/index.htm>. The website contains information regarding DCNR's role in deer management, DCNR's deer management plan, hunting information on State Forest lands, and the status of open roads during deer season. Other information available on the site include key research reports on deer and their relationship to our forest ecosystems, information about the status of forest habitat, upcoming habitat tours within a district forest, as well as, a link to the healthy forests-healthy deer brochure.

DMAP web page

DMAP is an important tool in balancing deer with the habitat on areas within State Forest land. It is a popular program and generates a lot of public interest. Within the white-tailed deer website there is a link to the DCNR DMAP program (<http://www.dcnr.state.pa.us/forestry/deer/dmap/index.htm>). The DMAP website contains

information on how to purchase a DMAP tag from the Pennsylvania Game Commission, an interactive map to find out where available DMAP units are on state forest lands, a link to find out how many permits remain in selected DMAP units. The number of permits available in selected DMAP units is updated weekly during the summer months, then every other week. Harvest data from each DMAP unit on State Forest and State Parks is also available on the website. Harvest information from the previous hunting season can usually be found in April of the following year. If a hunter would like some insider information about where to hunt, they can check out the “forester’s Picks” section and learn about their recommendations for deer hunting. Finally, this site provides answers to frequently asked questions and contact information with questions that still remain.

Habitat Tours

Several of the forest districts provide tours of the district to the public to showcase the projects the districts have completed, as well as, to demonstrate where habitat is improving and where it may not be recovering. The tour dates can be found on each district’s website.

Meetings

Hunter Roundtable Meeting

In an effort to communicate DCNR’s efforts and gain feedback, a Hunter’s Roundtable meeting is held every year. This meeting includes representatives from hunting and conservation organizations such as Ruffed Grouse Society, Quality Deer Management Association, Isaac Walton League, Woodcock Limited, Trout Unlimited, and many others including several local sportsmen’s associations. These meetings include tours of habitat projects on state forest or park lands and discussion of important habitat related topics.

Goal 5: Utilize State Forests as a model for scientific forest and deer management across the Commonwealth of Pennsylvania

I. Research on State Forest Lands

The Bureau of Forestry has always supported other agencies and universities to conduct research on state forest lands, including projects related to forest regeneration, deer impacts, deer ecology, and forest ecology. A number of research studies have been performed (partially or fully) on state forest land to address management and scientific needs including, but not limited to:

Studies Investigating:

- 1994: Regeneration within enclosures for 19 years in northern hardwood and mixed oak habitat types**
- 1995-2008: Long-term impacts of liming on growth and vigor of northern hardwoods**
- 1998: Interactions between the white-tailed deer and the forests in Pennsylvania**

- 2000-2001:** Fawn survival to estimate survival rates of neonatal white-tailed deer fawns in good and poor habitats of Pennsylvania
- 2004:** Indicators of regeneration capacity for eastern hardwood forests
- 2005:** Vegetation survey protocols (rapid assessment) on state forests enrolled in the PGC's DMAP to assess advanced regeneration of tree species and presence of competitive species of tree seedlings and sapling
- 2005-2006:** Female survival and mortality causes of white-tail deer
- 2006:** Monitoring songbird densities on both sides of deer exclosure areas (browsed vs. un-browsed)
- 2007-2008:** Survival, mortality causes, and antlered harvest rates of white-tailed deer in Pennsylvania
- 2008-now:** Biological and social implications of a 7-day concurrent firearms season

REVIEW AND FUTURE DEER MANAGEMENT EFFORTS

The Bureau of Forestry constantly works to improve the effectiveness of balancing multiple resource values on its state forest lands. This has led the Bureau into partnerships with internal staff, external consultants, and other agencies to advance the efficiency of monitoring and targeted deer management efforts.

An example of such partnering occurred in 2006 when the Bureau of Forestry commissioned three research studies of deer effects on the Commonwealth's forests. These three research efforts were landmark studies, the first to address the connection between deer population reduction and forest ecosystem recovery since the 2000's, when the Pennsylvania Game Commission began offering landowners additional tools, including DMAP, to reduce deer numbers of their properties if they desire to do so. Synopses of the three studies are below

Browsing and regeneration monitoring report for Pennsylvania's state forests (Benner 2007). The objective of Benner's study, conducted internally by DCNR staff, was to assess the current levels of deer browsing and tree regeneration across the entire state forest system in order to allocate and prioritize the use of DMAP and other deer management options.

Deer density and impact on the Kinzua Quality Deer Cooperative Area (deCalesta 2008). This study's objective was to compare yearly deer population estimates and surveys of browsing intensity indicators on a large forested area enrolled in DMAP, seeking trends and correlations that might link changes in density with changes in impact. The study area was the 115-square-mile Kinzua Quality Deer Cooperative Area in western McKean County.

Developing and testing a rapid habitat assessment protocol for monitoring vegetation changes on state forest lands (Diefenbach and Fritsky 2007). This study's objectives were to develop a forest vegetation survey protocol that could be completed quickly across large areas and to test it in state forest areas that are enrolled in DMAP. The protocol was designed to measure vegetation characteristics likely to respond to changes in deer browsing intensity whose measurement is cost-effective.

The aim of these studies was to help develop and test effective monitoring protocols for tracking key indicators of management success and of the need for additional management action. In order to further identify the most efficient protocols, the Bureau of Forestry undertook a formal evaluation of its commissioned studies in 2008, using outside experts as reviewers. By subjecting its research to the examination of qualified biologists, including experienced forest and wildlife management professionals from outside, a report was generated with comments and recommendations.

In the next five years the Bureau of Forestry will work towards our commitment to ecosystem management. This will be accomplished by continuing to work towards each of our goals,

including putting into action a new forest monitoring protocol for DMAP by 2014, continuing to improve communications with hunters and outdoor enthusiasts by improving our hunting website, increasing habitat tours on State Forest land, and working with partners such as PSU, USFS, USGS and PGC to determine best methods to measure habitat improvements.

To ensure steady progress toward the management goal for deer on State Forest land, the Bureau of Forestry will review habitat objectives every 3-5 years. The white-tailed deer plan will be reviewed in 5 years to determine if any necessary revisions of the plan may be warranted.

INFORMATIONAL RESOURCES

Pennsylvania Game Commission's Deer Program website

<http://www.pgc.state.pa.us/pgc/cwp/browse.asp?a=465&bc=0&c=70124>

Department of Conservation and Natural Resources Bureau of Forestry White-Tailed Deer website

<http://www.dcnr.state.pa.us/forestry/deer/index.htm>

Department of Conservation and Natural Resources Bureau of State Parks hunting website

<http://www.dcnr.state.pa.us/stateparks/recreation/hunting/index.htm>

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