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Understanding White-tailed Deer and Their Impact on Indiana Woodlands

Harmon Weeks Jr., Jarred Brooke, Lenny Farlee, Elizabeth Jackson, Michael Jenkins, and Richard Sample

PURDUE UNIVERSITY
Extension - Forestry and Natural Resources

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HOW TO USE THIS PUBLICATION

It would be advantageous to the user to read through the complete publication; early background material helps understand and frame the subsequent evaluation materials (pages 25-29). There are so many variables that go into such an evaluation that arriving at a concise conclusion is not possible. Still, the more complete your understanding of deer, plant communities, and their relationships, the more valid your general evaluations will be. The numbers inserted behind various statements refer to numbered papers in the *Further Reading* section of this publication; you may want to delve deeper into some topics. Scientific names for most plant species can be found in Tables 1, 2, and 3. For species not included in those tables, scientific names are given in the text when species are first mentioned. This publication is also part of a series of publications called *Deer Impact Toolbox*, which is aimed at helping woodland owners understand, monitor, and address deer impacts.

Introduction

White-tailed deer!! What a – graceful, challenging, magnificent, beautiful, successful, pestilent, destructive, dangerous – animal! Choose your adjective. Everyone has an opinion, often quite different. Depending on the context, that opinion may change within the individual – whether the deer is a quarry for your hunt (Figure 1) or has just destroyed a landscape shrub for which you paid $200 (Figure 2). The diverse values placed on deer by Hoosier citizens make deer management more controversial than that of any other species.

Modern management of deer in Indiana has a relatively brief history, yet the changes in the abundance of deer in Indiana have indeed been remarkable. From their extirpation in about 1900 until reintroductions began in 1934, there were no deer in Indiana. Thus, many Hoosiers spent their childhood having never seen a wild white-tail or even tracks of one, only to spend most of their adult life hunting the creatures and perhaps ultimately hand-feeding Twinkies to herds of the little devils with the grandkids in Brown County State Park in the late 1980s (Figure 3). How is this possible?! Even though deer are roughly the same size as humans, their productivity is impressive. In the 1930s, the George Reserve Deer Herd in southern Michigan grew from 6 individuals to 222 deer in 7 years. That's almost a doubling of the population each year!

Figure 1. *White-tailed deer, a beautiful animal of complex relationships.*

Figure 2. *Overabundant deer can do costly damage in suburban environments.*

Deer are an essential part of our ecosystems, but the phenomenon of too many deer should be of concern to forest landowners and the public in general. Many studies have confirmed that overabundant deer populations can severely impact the occurrence and diversity of native woodland shrubs and herbaceous plants, tree seedlings' condition and species composition, and the diverse wildlife species that depend on

Figure 3. *Panhandling deer in Brown County State Park prior to 1990's reductions.*

forests for cover and food. Many of such studies in the eastern U.S. have been in the Northeast (especially Pennsylvania) and the Upper Lake States (especially Wisconsin). But, some studies have been conducted in Indiana and surrounding lower midwestern states, and they confirm the general applicability of deer-habitat relationships (10, 20, 40, 42).

The most dramatic illustration of the negative influence of deer on native woodlands for the Hoosier state is our state parks, especially Brown County State Park (see page 6), the vegetation of which was decimated by overabundant deer (Figure 4) before control activities that began in the 1990s (40) led to the recovery of vegetation communities (13,14).

Figure 4. *Dense deer populations produce forest understories largely devoid of vegetation.*

Damage as devastating as that seen in several state parks is unlikely on private woodlands in landscapes in which deer are hunted. However, relatively smaller populations can still seriously impact biodiversity and forest regeneration in our private woodlands. Landowners need constant vigilance and frequent evaluation of the impact deer might be having on the quality of their woodlands. This publication will help landowners better understand the impacts of deer on Indiana's woodlands.

Indiana Deer—History and Current Status

Deer in Indiana have a long and interesting history, which has relevance because it impacts the current management strategies and their effectiveness. In pre-European settlement times, Indiana was primarily covered with forests, except for some intrusion of tallgrass prairie along the western margins and where Native Americans maintained openings. Although this does not describe ideal deer habitat, deer populations, in general, were likely about 5-15 deer/square mile (22). Nevertheless, after settlement unrestricted year-round killing led to notable decreases in the 1870-1880 period and to the ultimate elimination of deer by about 1900 (26). This means that there was no hunting of deer in Indiana for well over half a century and thus no hunting tradition.

Deer restocking (moving deer from other states to Indiana) efforts began in Indiana in the 1930s. By 1944, an estimate of 1,200 deer was made for the population that occupied 35 counties; by 1951 the population quadrupled. The first hunt of the century was held in November of that year. By 1966 deer resided in every county, and by 1991, the statewide deer population was estimated at 300,000, and the annual harvest approached 100,000. In 2021, Indiana hunters harvested around 112,000 deer (12).

Harvesting of female deer (does) had begun in various contexts by 1980. Indiana hunters accepted without much hesitation the judgments of biologists regarding the need to harvest females to curtail population growth. This is a critical consideration in managing a population capable of rapid growth. Legal harvest of does – especially in the absence of other large predators – is the primary factor in regulating deer populations at levels acceptable to various human endeavors, the regeneration of woody plants, and the maintenance of forest biodiversity.

DEER IMPACT AND HUNTING IN INDIANA STATE PARKS

After successful deer restocking efforts in Indiana, a deer hunting season was initiated in 1951. This first hunting season included Brown County State Park. But, subsequent hunting seasons from the 1950s through the early 1990s did not include any state parks. The lack of predators and restrictions on hunting in state parks led to burgeoning deer populations within the parks. In the 1970s, estimated deer populations at Brown County State Park were 4 to 8 times larger than nearby forests (25). This expanding deer population was harming the state park's ecosystems. So much so, that deer browse lines (where deer have consumed everything within their reach) were evident throughout the park (Figure 5). This overabundance of deer was causing the plant community and structure to look very different from forests outside of the state park, where hunting was occurring.

After several committees of experts convened and public meetings were held, the first deer hunt at Brown County State Park occurred in 1993, with hunts starting in other parks in subsequent years. Deer harvested during the first years of the state park hunts were smaller, in poorer condition, and had lower reproductive rates than deer harvested from other properties previously hunted (40). The overall poorer condition of deer resulted from deer overabundance and very little food being available within state parks.

These hunts were started to reduce deer populations and restore native forest ecosystems within the park. But have they worked? Recent research has reported the hunts helped restore degraded plant communities in state parks. Browse-sensitive plants (e.g., trilliums), herbaceous plant diversity, and tree seedling abundance and diversity increased in state parks following the hunts, whereas invasive species decreased (13,14). Deer hunts still occur periodically on several state parks, and the need for a hunt is evaluated annually by natural resources professionals at each state park.

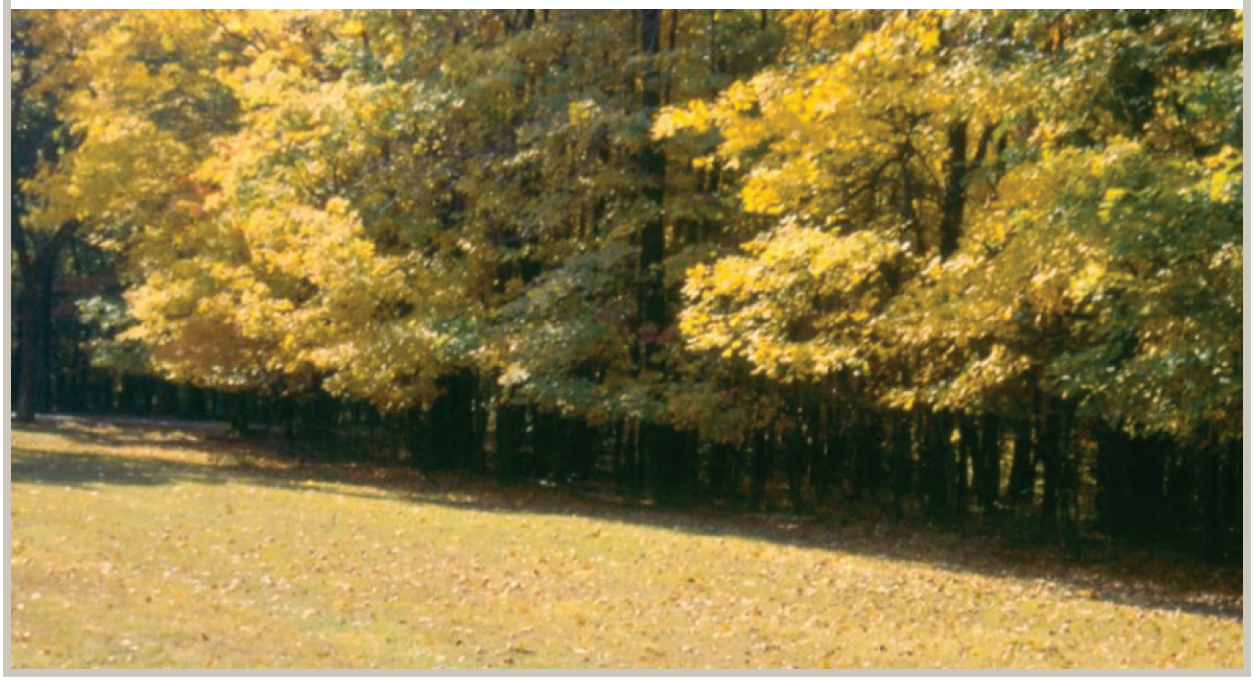


Figure 5. *A browse line at the edge of a woods in Brown County State Park, 1993*

This same scenario of cooperative hunters helping to regulate populations through doe harvest was not as evident in states with residual white-tail populations and a continuous history of harvesting almost exclusively bucks. Hunters often resisted killing does to control deer populations. This is an attitude that continues to some degree presently.

This little history lesson is not without a moral for the individual woodland landowner. If you have too many deer that are damaging the quality of your woodlands, you have the tools to lower that population density to acceptable levels—you, your family and friends, and the local hunting community can be very effective in this process. You must, however, be willing to kill excess deer; some folks are opposed to this for various reasons. If unwilling, you will likely be left with few options to protect your woodlands (i.e., fencing deer out of certain areas).

Around the Year with Indiana's White-tailed Deer

Although deer in various regions of the state behave somewhat differently through the year, a synopsis of "usual" behavior, food habits (Figure 6), and general occurrences through a typical year are instructive. This will give you, the woodland owner, some baseline data to evaluate your observations.

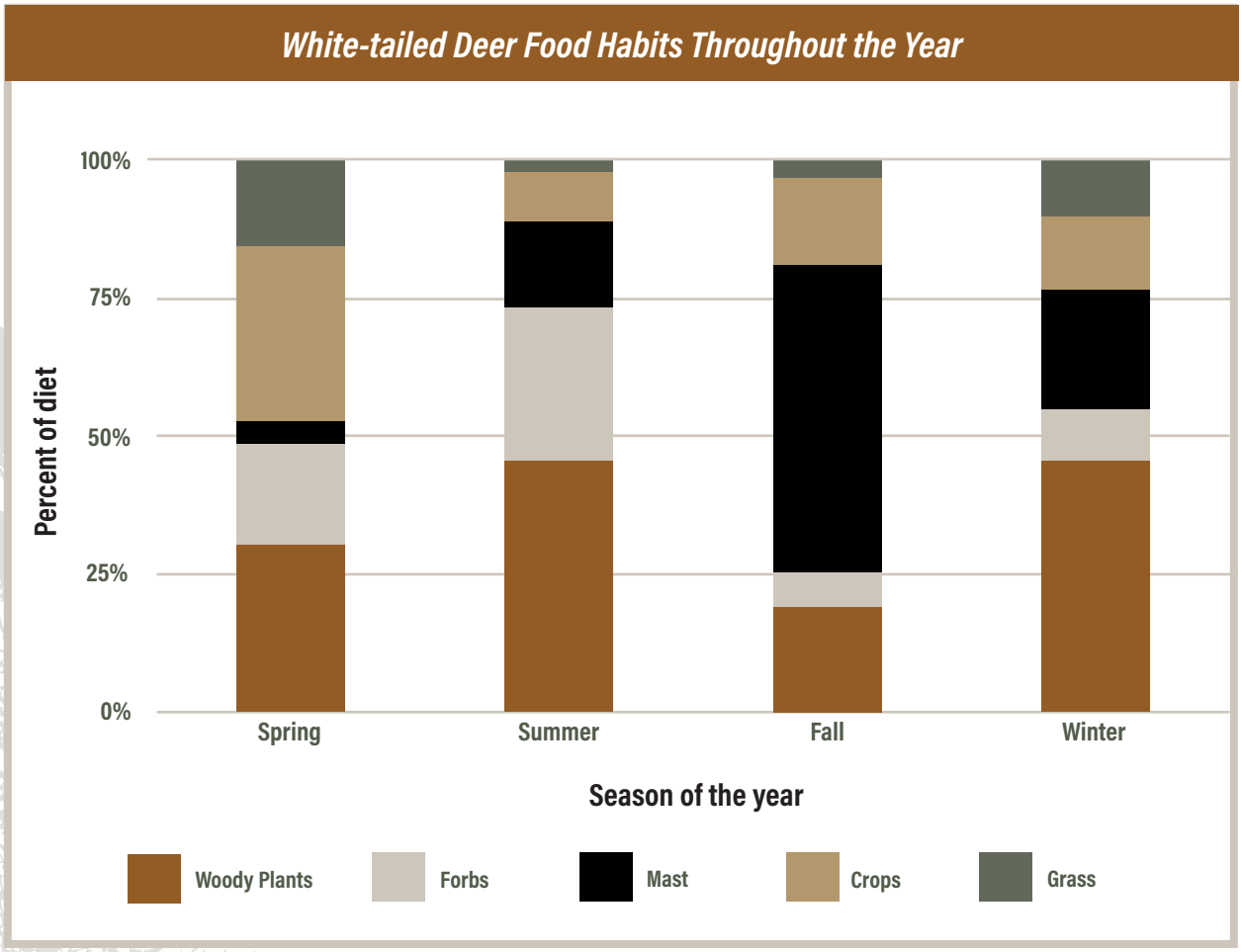


Figure 6. White-tailed deer food habits through the year from midwestern deer research projects. Forbs are non-woody broadleaf plants (also referred to as wildflowers), such as goldenrod. Mast includes both hard mast (e.g., acorns) and soft mast (e.g., persimmon fruit). Data for this figure were gathered from the book, Biology and Management of White-tailed Deer (9).

Fall

The early fall is an excellent time to start, since so many important events occur then. At this time of the year, deer are moving toward "rut," or breeding season, the period when male antler growth concludes with rising testosterone levels. This occurs principally in October and November, although in late September, bucks may begin to "polish" antlers by rubbing on vegetation—this can lead to substantial damage to isolated shrubs/trees. By late October/early November, does enter estrus, and bucks begin to follow them until they are receptive, and mating occurs.

The peak of the rut occurs throughout the state between November 2nd and November 16th, depending on location. This is when the majority of does are bred. A percentage of fawns (6+ months old) may breed and usually do so later, sometimes as late as January. During December, testosterone levels begin to drop, especially in older bucks, leading to antler drop, occasionally as early as mid-December and lasting into March or April (15).

Food habits during this fall period are dynamic, depending on the availability of mast (acorn) crops and the variability of foods in the landscape forming a deer's home range. In early fall, deer turn to soft fruits as they become available, principally in young forests and on forest edges—especially favored are persimmons and wild crabapples. These are used as long as available; by then acorns are generally beginning to fall. Acorns are by far the favorite foods of deer and dominate their diets as long as available (38). Species of oaks are not critical (they eat them all!), but in a woodland, it is good to have a good mix of oak species, as deer will often eat white oak acorns earlier in the fall and turn to red oak acorns later. A mix of oak species is also beneficial because the fruiting

Figure 7. *Acorns are a major and important fall/winter food for midwestern deer.*

strategies of the two groups differ, with white oaks requiring one growing season to move from flower to mature acorn. In contrast, the red/ black oak group requires two growing seasons (Figure 7). Thus, a bad weather event in one spring, which kills flowers (usually a late frost), will perhaps cause a total failure to produce acorns in the white oaks that fall; however, since the red/black oaks produced flowers for this year's acorns in the previous spring, they still have the potential to produce a good crop.

Once acorns are gone, deer fall into their typical winter food habits (see below). In areas where deer occur in agricultural landscapes (most of Indiana), waste corn and soybeans become very important post-harvest in the fall. They are used heavily in fall and through winter.

Winter

Winter is typically the most trying time for deer. Food is limited because of a lack of foliage on deciduous woody plants and a lack of availability of forbs (a term typically used to describe all non-grass/sedge, non-woody plants), either because they've died back or because they're covered with snow. Deer are also limited by available cover, especially in heavily agricultural areas. The harvest of corn and soybean fields concentrates deer in the remaining cover, principally forested areas or grasslands.

In Indiana, winter rarely presents significant challenges to survival, but can impact deer condition. Snow rarely is of substantial depth

or lasts for long. Thus, remaining acorns, crop residues, woody browse (a term used for the leaves, twigs, and buds of woody plants eaten by deer), and evergreen forbs are available almost all winter. Nearly half (45%) of a deer's winter diet is woody browse (9). To this, they add miscellaneous green material, waste grain, or available mast. Deer may also use perennial forage crops like alfalfa and cool-season cover crops (e.g., wheat, cereal rye, brassicas, clovers) during the winter and early spring months.

In rare instances of winters with heavy snowfall, such as the winter of 1977-78 statewide or various other winters in far-northern Indiana, snow depth is substantial enough and remains long enough to limit the availability of these typical winter foods, and deer begin to gather under conifer cover (pine plantations or cedar thickets).

Most females are pregnant during the late winter and tend to form all-female groups of varying sizes, usually composed of relatives; males are without antlers, docile, and travel in all-male groups. Typically, all groups can be found where food and protective cover are adjacent.

Spring

As spring begins to slowly replace winter, diets of deer start to broaden as more digestible and protein-rich forage becomes available. The first new growth in spring is typically grasses, and diets beginning in March and lasting into April may include grasses. This also includes cereal grains like wheat and cereal rye. Deer are browsers and not grazers, so the presence of grass during this season, while predictable and consistent, does not last. As soon as other plants – herbaceous forbs first and then leaves of woody plants – become available during April, the use of grass falls to essentially zero. During spring, use of agricultural crops in most regions of the state begins to expand as well; the gleaning of last year's waste grain slowly gives way to feeding on hay and pasture legumes (especially alfalfa) and young soybean plants (2, 28). Deer also feed heavily on many spring ephemeral wildflowers, including trilliums, at this time.

Spring, especially late spring, is a time of significant behavioral changes. In males, antler growth initiates in April and continues until hardening off in early fall. During this time, bucks tend to be very secretive, but gregarious, forming "bachelor groups." Does begin to isolate themselves from their groups and select areas suited for giving birth and fawn seclusion. Typical fawning sites in Indiana are areas with thick herbaceous cover, like bottomland forests, early successional areas like those created through the Conservation Reserve Program, or disturbed sites like old fields with dense woody and/or herbaceous growth (Figure 8). Most fawns are born in mid-May after a gestation period of 7 months.

Figure 8. *Areas with thick cover like this old field are important reproductive areas. A fawn was spotted laying in this field just prior to taking this picture.*

Summer

The summer is a period of plenty, with abundant food and of high quality unless areas have been severely damaged by deer overpopulation and agricultural fallbacks are unavailable. Diets diversify and include a wide variety of both woody and herbaceous species. Hay and pasture legumes and field crops continue to be very important and are heavily used. This is also a period when deer impact can easily be assessed, especially on woodland herbaceous plants, by examining the degree of browse on woodland forbs. Although vegetation biomass is abundant, impacts on sensitive, highly preferred species by overabundant deer populations can be substantial.

In Indiana, non-agricultural diets throughout the summer focus to a surprising degree on the leaves of woody vines—poison ivy, Virginia creeper, wild grape, and greenbrier (Figure 9). From May through August, browse from vines made up nearly 50% of the diet in a study on Crane Naval Base, an area without any agricultural crops (38). Forbs, which are highly nutritious and common during summer, also play an important role in the diets of deer during this time.

Summer behavior is unique principally in the behavior of does with fawns—their movements are greatly restricted from normal, but groups of related does re-form with their fawns, once they begin accompanying their mothers in June. Males continue to be secretive and non-aggressive as

Figure 9. *Foliage of vines is the predominant natural food in spring and summer in Indiana.*

Too Many Deer—What a Novel Idea

For much of the brief history of deer management in Indiana, deer were in the "recovery" phase. Managers and landowners alike were interested in increasing deer populations across the state. It wasn't until deer populations began to burgeon and damage became evident that the thought of too many deer arose in Indiana. Of course, as early as the 1930s, wildlife professionals in other areas (including a pioneer of wildlife management, Aldo Leopold) had already begun to warn about the consequences of too many deer for a given area.

Deer always have an impact on their environment. This is the nature of the deer-habitat relationship and why they are considered a *keystone species* (i.e., a species that affects the composition and structure of plant and animal communities). Deer browse some plants more commonly than others and don't browse some at all. This makes deer *concentrate selectors*; they selectively eat certain plant species and the most nutritious parts of those plants (young tender growth). How deer select and browse plants (see food preferences later) can shape woodland plant communities.

When deer numbers are below a level the landscape can support, referred to as *carrying capacity* (see sidebar on page 11), the impact from deer is considered negligible or low. And in many cases, the impact can be positive. Through their browsing, deer can reduce or slow the growth of quick-growing pioneer plants like blackberry and woody seedlings. When this browsing occurs at low to moderate levels, it can enhance the plant diversity in a woodland (27, 36).

The dilemma of deer impact occurs when deer populations become overabundant or begin to approach or exceed what a woodland can support. This is when damage to the ecosystem occurs. The closer deer are to reaching carrying capacity, the more significant their impact on the ecosystem. Deer start to shape the plant communities negatively with species deer prefer to browse being reduced or eliminated and those avoided increasing.

The point at which deer become "overabundant" will vary based on your objectives and what impact you are willing to tolerate in your woodland. For a woodland owner interested in maintaining a high diversity of spring wildflowers, deer may be overabundant when they begin to negatively impact species such as trilliums, which could occur at a relatively small population size and well below biological carrying capacity. Whereas a landowner interested in regenerating certain tree species, such as white oak, may not consider deer overabundant until they begin to impact oak regeneration, which would occur at a higher population (closer to carrying capacity) than impact to trilliums.

CARRYING CAPACITY

What is the impact, then, of too many deer? Before that can be explored in a little detail, let's cover the concept of carrying capacity (CC). The original concept was that "there is a maximum number of individuals of a species that a given unit of land can support through the most limiting time of the year." That number is the *biological carrying capacity* of an area. For example, if a brushy field of 20 acres had 50 rabbits in the fall and that number fell (through losses to disease, predators, starvation) to 20 at the end of the winter (the most limiting period in Indiana), then the carrying capacity for that field for cottontails is 20 or 1 rabbit/acre. Remember that carrying capacity can change over time; in this example, if the field became a woodland (less desirable for cottontails), then CC for cottontails for that same piece of ground might drop to almost zero/acre. In contrast, if you managed that same old field by providing more cover or food (whatever might be limiting), you might be able to raise the CC to 1.5 or 2.0 rabbits/acre.

Carrying capacity for deer will vary from woodlot to woodlot based on how much food, cover, and other resources are available in that woodlot and the surrounding landscape. A woodlot in one part of the state where food and cover are abundant would have a higher carrying capacity than a woodlot in another part of the state where food and cover are limited. Thus, the same number of deer may exert a different level of impact on each woodlot. Carrying capacity for deer can also be increased through management practices (timber harvest, forest stand improvement, old field management) that increase the amount of food and cover for deer.

Deer impacts to woodland vegetation vary as deer approach carrying capacity. Just because deer are below biological carrying capacity – the maximum number of deer an area can support over time – doesn't mean they are not impacting the ecosystem. Even relatively small populations of deer can impact some browse-sensitive plants like trillium. As deer approach carrying capacity, their impact on various parts of the forest ecosystem (composition, structure, regeneration, etc.) will increase. They will also begin limiting their food availability and potentially reducing their body size, health, reproduction, and population growth.

Figure 10. *Browse lines form when deer push food resources to the maximum.*

Impacts of overabundant deer populations

The impacts of overabundant deer populations can come in many forms. Some of which are apparent to even the most casual of observers. But others are less obvious and require a more intimate study of the environment to become evident. These impacts are often quantified from low to high (severe), with the most severe impacts being the most obvious.

STRUCTURAL DAMAGE

The obvious – at least to the naked eye – result of too many deer is structural damage to woodlands by severe overbrowsing, almost regardless of species of vegetation and food preferences of deer. This was the situation in some of Indiana's state parks before the deer reduction programs began in the 1990s. In these situations of high densities of deer for extended periods, almost all vegetation within reach of deer is consumed; understory vegetation essentially disappears, and a "browse line" develops (Figure 10). A browse line forms when all foliage of lower limbs of larger saplings and trees within reach of deer (general 5-6 feet) is eaten, producing a distinctive layered appearance.

Occasionally in these situations, a ground cover that is totally composed of unpalatable species (usually grasses, sedges, and ferns or invasive plant species) develops, dominates, and may impede the redevelopment of native understories if deer numbers are eventually reduced (Figure 11). These occurrences are relatively rare in Indiana but have been recorded with some regularity in Pennsylvania and other northeastern states where deer numbers were historically high because of resistance to the harvesting of does (33,37,39,45). When forests are damaged to this degree, understory plant cover is significantly reduced (Figure 12), and animal communities dependent on that vegetation structure for feeding and breeding are also diminished. Studies have shown significant changes in bird, small rodent, shrew, and even insect populations in woodlands damaged by deer over-browsing.

Figure 11. *A white-tailed buck lays in a bed of Japanese stiltgrass, an invasive species disdained by deer.*

Figure 12. *Heavily browsed forest displays a total lack of understory vegetation.*

FOREST REGENERATION AND STAND COMPOSITION CHANGE

Most woodland owners would recognize the development of severe structural damage (if for no other reason than it resembles the damage inflicted by cattle when grazing woods) and hopefully curtail it by reducing deer density through hunting. However, damage to forest regeneration (i.e., tree seedlings and saplings) may not be so readily evident, and early detection requires vigilance.

Numerous studies have indicated that selective browsing can significantly hinder the development of an adequate sapling understory needed to replace overstory trees as gaps appear in the forest canopy. Furthermore, such selective feeding can change the trajectory of the forest by removing more preferred species and leaving less preferred to dominate the replacement stand. Examples of such conversion is the replacement of hemlock and yellow birch (*Betula alleghaniensis*) in Northern Lake States by sugar maple and American beech (6) or the replacement of black cherry and sugar maple by American beech, black birch (*Betula lenta*), and striped maple (*Acer pensylvanicum*) in Pennsylvania (29). In Indiana, oak seedlings are preferentially browsed by deer, and substantial browsing pressure can hinder oak regeneration, favoring less preferred species like American beech (Figure 13). However, overabundant deer is just one contributing factor to the lack of oak regeneration in many Indiana forests.

Figure 13. *Oak seedlings are favorite browse and repeated damage can lead to death.*

In newly forested or reforested areas like tree plantings, deer selectively browse species like red oak and can eliminate them almost entirely from the planting. Deer can also reduce the survival and growth of species like white oak, red oak, and black cherry in tree plantings in both retired agricultural fields and canopy openings (31). These negative impacts often result in the need to fence tree plantings until the trees grow out of a deer's reach.

THREATS TO BIODIVERSITY

Numerous surveys of woodland owners in Indiana (and other states) reveal one of the primary motivations for owning woodlands is to provide a home for a diversity of plants and animals. Overabundant deer can negatively affect biodiversity by reducing or eliminating certain plants and causing others to increase. Plants in the forest understory are not limited to trees but also include a wide variety of shrubs, vines, and herbaceous plants, which are of value to many wildlife species and likely more vulnerable to deer damage than trees because they spend more of their lives within reach of deer. Plants that are preferred browse may be significantly reduced or eliminated by overabundant deer.

Woody plants

Unlike grass which can withstand frequent and heavy grazing, woody plants cannot tolerate repeated heavy removal of foliage and woody tissue. Over time, woody plants decline in vigor and ultimately die from such heavy browsing. Even when woody plants continue to live under such pressure, their functional role in the ecosystem disappears—that is, they're there, still alive, but don't supply the cover, flowers, and seeds/fruits that may be important to wildlife in that environment.

Herbaceous plants

Of great importance and interest in healthy woodlands are herbaceous plants that occur on the forest floor—these add significantly to biodiversity, because there are hundreds of species. Many of these species are perennials which die back to permanent rootstocks in the winter and emerge again each spring. For some species, emergence is very early, before leaves appear on the woody plants. These "spring wildflowers" or "spring ephemerals" not only bring beauty to the spring forests (Figure 14), but also have important functional roles. Deer favor many of these wildflowers, and their disappearance from over-browsing galvanized state park naturalists to sound the alarm in the late 1980s and early 1990s. Once populations of these plants are severely reduced or eliminated by over-browsing, their recovery is prolonged, since seeds of many of these species are dispersed by dropping from the plant or being moved by ants. Thus, reestablishment from distant seed sources may take centuries.

Studies have shown a high preference for many herbaceous species by deer (see page 22). These are, of course, those most at risk of disappearing from the forests with too many deer. In Indiana, as well as other areas of the Midwest, plants belonging to the lily (Liliaceae), bunchflower (Melanthiaceae), and orchid (Orchidaceae) families seem especially preferred by deer (7, 24). These plants are also especially vulnerable because they grow on a single stem and browsing typically takes all foliage; additionally, research has shown that deer prefer the largest plants and those in flower (Figure 15). In most cases, these larger plants that are browsed are mature seed-producing plants. The impact on heavily browsed populations is creating smaller and smaller plants that produce fewer seeds and eventually eliminate the plants (16, 17, 18).

With plants like trillium, we tend to think of each year's growth as a new plant, but the rootstock grows each year and, in many species, produce leaves for 5 to 6 years before they are capable of flowering—their success is thus more fragile than one might think. Accordingly, this means what we

Figure 14. *Spring wildflowers in a woodland minimally impacted by deer.*

Figure 15. *Trilliums are beautiful and are favorites of deer.*

see this year in the herbaceous layer, just like in the woody plant community, may be a product of the past history of the woodland, reflecting not only deer impacts (and other disturbances) for this year and the previous year, but also the previous decade(s). Recovery can be slow, excruciatingly so at times, so it is best to prevent or shortstop deer damage in the first place by effectively controlling deer density.

Wildlife

The changes in the plant community from overabundant deer can also lead to changes in the wildlife community. Several studies have reported changes to songbird, small mammal, and invertebrate diversity as a result of deer over-browsing (4, 23, 32). These changes result from deer influencing the plant community and structure within a forest, thus changing habitat conditions by reducing plants that provide food and cover for wildlife.

Invasive plants

A relatively new area of concern for woodland owners is invasive plant species that threaten the health of our woodlands by outcompeting native plants, thereby reducing diversity and impacting forest regeneration. The list seems formidable (and growing), and programs are in place to assist landowners in controlling problem invasive populations.

Recent research has demonstrated that high deer densities, which reduce native plant abundances and even disturb the litter layer through trampling, enhance the establishment of invasive plants (3, 19). Unfortunately, the most problematic invasives in Indiana, such as garlic mustard and Japanese stiltgrass, are avoided by deer (Figure 16); thus, once established and ignored by deer, these species not only replace natives, but their presence also leads to even greater browsing pressure on the declining natives. Deer may browse some invasives like bush honeysuckle, but primarily at times of the year or in areas where little other food is available, and never to an extent large enough to slow their spread (21).

Figure 16. *Most invasive exotics, like this garlic mustard, are disdained by deer.*

TOO MANY DEER OR NOT ENOUGH FOOD: MANAGING THE FOODSCAPE

If deer are causing negative impacts to a woodland, there are two lenses through which to view the underlying problem; 1) there are too many deer for the amount of food on the landscape, and 2) there is not enough food for the amount of deer on the landscape. Your perception of the problem often reflects your thoughts about deer. In reality, it's likely both a deer *and* food problem. And by addressing both an overabundant deer population and a lack of food, we can work to create healthy woodlands.

Royo et al. 2017 introduced the idea of managing the amount of food available for deer as managing the "foodscape" (35). By increasing the amount of food-rich vegetation types (e.g., young forests, diverse old fields, etc.) on the landscape, you could reduce the amount of damage to a woodland.

Previous studies in Minnesota and Indiana have supported this concept. These studies found deer damage to forests was lower in areas with a higher abundance of alternative foods like alfalfa fields or early successional vegetation like old fields and young forests (2, 10).

It is important to note that if you work to increase the amount of food available to deer, you also need to work to manage the deer herd through hunting. This is because having more food available will likely cause deer to increase in population (without some control) as the carrying capacity increases (Figure 17). For more information about improving habitat for deer, you can visit the *Managing Your Woods for White-Tailed Deer* publication from Purdue Extension.

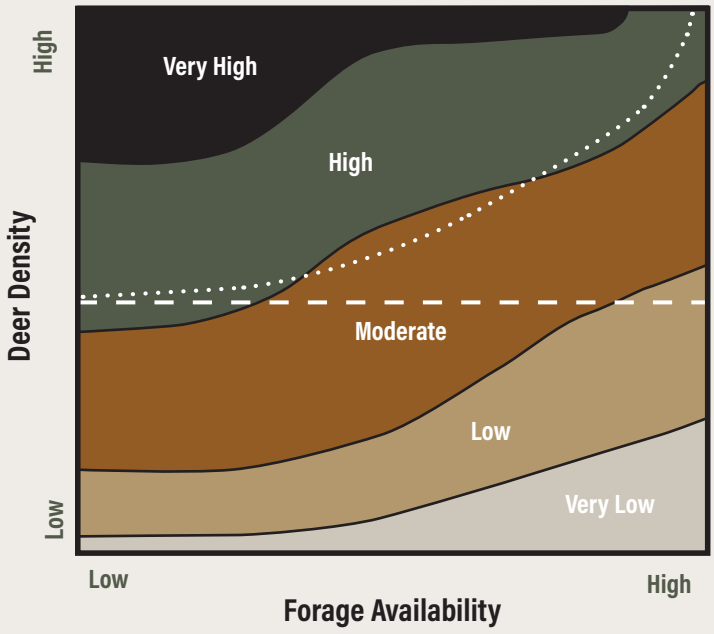


Figure 17. *This graph shows the concept of how browse impact (colored areas) varies with forage availability and deer density. For example, when deer density is high and forage availability is low, deer impact is very high. The dashed line shows a constant deer density, but changing forage availability. The dotted line shows an increasing deer density as forage availability (or carrying capacity) increases. Figure adapted from Royo et al. 2017 with permission (35).*

Monitoring Deer and Forest Vegetation

Deer densities

It is helpful if a woodland owner has some perception of the white-tailed deer population size on their property. This is best achieved by devoting time to the process—reading background material and spending time in the woods, observing deer and signs of their presence. Occasionally, you will be able to see deer, especially if there is a vista, where you may view deer from a distance without disturbing their activities— along a wood's edge, within powerline rights-of-way, or in nearby agricultural fields or pastures. Deer use such areas regularly in multiple seasons, and observations may give an indication of abundance. In your woodland, you may see deer infrequently, but be observant of deer sign, such as trails, pellet groups, and browsed vegetation (Figure 18).

Figure 18. *Fecal pellet groups indicate deer presence in your woodland.*

Visits to woodlands should be frequent and, in all seasons. Deer sign and deer abundance and use vary greatly through the year (Figure 19). Winter in Indiana is an especially instructive period; a visit soon after a snowfall can highlight deer abundance and habitat use by allowing you to follow new tracks (preferably backward to not spook deer) and assess the use of habitat and vegetation. Once trails are found, the use of trail

Figure 19. *Browsing by deer can be found in all seasons. This red oak seedling was browsed in May during the growing season.*

cameras can be exciting and indicate the relative number of deer using a woodland.

These observations will not give you an exact estimate of deer density but will help you understand deer populations on your property over time. This information is useful when completing the *Deer Impact Assessment* on page 25.

Before we move on, a comment on deer densities, what they mean, and how they are generally expressed in publications to which you might refer. Deer abundances are typically expressed as a density (the number of anything per unit area—plant stems/square foot, aphids/square inch, etc.); the unit traditionally used by wildlife biologists is deer/square mile. Deer density can range from as low as 2-3 deer/square mile to 100 deer/square mile or more. According to a 2009 deer report from the National Deer Association, deer density in Indiana ranged from less than 15 deer/square mile to 45 deer/square

mile, depending on the county (1). Once you get a feel of "per square mile" densities, you may need to convert metric measurements (deer/square kilometer) that you see in more scientific publications into this familiar standard. For example, 15 deer/square mile equals 5.79 deer/square kilometer.

Understanding deer density can be helpful but knowing the exact density of deer in your woods is of minor importance, and it is an extremely difficult value to establish. It is of little significance because the relationship between the number of deer and their impact on a woodland depends on many factors (e.g., landscape composition, food availability, carrying capacity, etc.). For example, deer at 10 deer/square mile in one area where food is limited may be causing more damage than 20 deer/square mile in another area where food is not limited. **Instead of concerning yourself with the exact number of deer (a difficult and fruitless endeavor), you should consider the level of impact exerted by deer.** This can be determined by monitoring deer impact on vegetation rather than monitoring deer themselves.

Monitoring deer impact

To properly assess the impact a deer population has on a woodland, an evaluation of vegetation and what proportion of it has been browsed is necessary. This relationship is not simple and can vary with location, landscape, and land-use history. First, however, because of differences among plants in their palatability (how well they like to eat it) to deer, it is critical that you be able to identify plant species—it can be a challenge and requires study. Still, mastery of identification can be extremely rewarding and give you a feeling of connection with your woodland. A group of good reference books will make the identification process easier and learning more satisfying. Some specific books for Indiana are found at the end of this publication in the Additional Resources section.

Figure 20. *Damage to conifers, like this red-cedar, suggest deer overabundance.*

In addition to identifying plants, it is equally important to understand *what* species deer prefer to eat. Because deer are selective browsers, they consume the plants they like before consuming less preferred species. Identifying what deer are browsing can be as informative as *how much* deer are browsing. When deer are eating less preferred species, it can indicate that they have little else available. You will find detailed information about deer food preferences in the next section of this publication.

Making some general observations about your woodland can also give you insight into the situation. Regularly seeing groups of deer in adjoining fields (in crops or fallow) and pastures might suggest a substantial population; local success rates by deer hunters might provide

Figure 21. *Viewed from an opening, development of browse line is easy to recognize.*

further evidence. Are yard plantings of nearby homes regularly damaged by deer, and do ornamental shrubs show browsing? Do conifers, especially red-cedar in the southern part of the state or white-cedar in the north, that grow in old fields or woods edges show substantial browsing on lower limbs (Figure 20)? Is there a browse line, or a hint of one, as you view the edge of your woods from an open field (Figure 21)? These observations may give you an idea of what level of impact you might expect to find in your woodland.

For an initial evaluation of the deer impact in your woodland, see the Deer Initial Impact Assessment on page 25 of this publication. This assessment serves as a starting point for monitoring deer impacts. You can find more detailed information on monitoring deer impact in your woodland by reading the publication *Monitoring Deer and Their Impact on Indiana Woodlands* from Purdue Extension.

Food Preferences

Thus far, there have been several references to "preferred species" or "food preferences." This designation has proven very useful to wildlife biologists in describing the food habits of various wildlife; it has been in common use for almost a century, and most folks generally understand its inferences. It is, however, important to remember that it is a relative term, as is implied by its general definition—it is "qualities that make an item chosen when a choice between items is given." Preferences of deer can vary depending on 1) plant species available, 2) plant parts available (ex., fruits versus leaves), 3) nutritional or physical quality of foods within or among species, 4) physiological and nutritional condition of individual deer, and 5) taste variation of the individual. Thus, preference is dynamic and may change depending on what is available from which to choose.

Preference also seems to vary from one part of the country to another, or even within the state, although it is likely that these differences reflect one of the above factors. For example, a plant may be consumed regularly in Indiana but seldomly consumed in Tennessee. Or a species may be preferred in the northern part of Indiana but avoided in the southern part of the state. Also,

as Aldo Leopold pointed out almost a century ago, under heavy deer pressure, the most preferred plants are quickly eliminated, and deer switch to species that would have initially been classified as "less preferred." Investigations would then conclude these are "highly preferred" because of changes in availability. **This is why understanding *what* a deer is eating on your property is so important.**

Preference rankings for plants are generally broken down into three categories: preferred species (Table 1), avoided or less preferred (Table 2), or neutral (eaten, but not preferred or avoided; Table 3). In the tables in the appendix, you will find naturally occurring species common in Indiana woodlands (although we include a few escaped exotics, several of which are problematic).

The preference rankings for each table reflect a combination of data collected through research projects in Indiana and other states, ratings from several publications, and personal experiences from the authors (5,11,38,43,44).

Preferred species

TREES

Trees that have commercial value are frequently planted, generally in plantations. This adds a complexity to interpreting "preferences." Planted trees, obtained from private or state nurseries, will be browsed much more frequently and intensely than the same species growing in the wild. This is surely because nursery trees are fertilized heavily, resulting in higher nutrient levels than in their wild counterparts; deer select not only for species, but also for high nutrient levels. This higher preference for plantation trees seems to continue for several years post-planting and indefinitely if they are fertilized. Even if individuals are not planted or fertilized, leaves from seedlings to 2-3 feet tall or sprouts from stumps seem to be preferred to leaves from more mature trees of the same species.

Sugar maple is widely distributed, and seedlings/saplings are frequently abundant at the browsing level of deer. It seems preferred throughout the Midwest but can withstand considerable browsing and thereby persists in the understory. Red maple is not nearly as common as sugar maple in Indiana but is even more highly preferred where it occurs. Seedlings from ash species, such as white and green, are also abundant, widely distributed, and frequently browsed by deer.

Oak seedlings and saplings are often hard-hit by deer; northern red oak seems especially attractive, but all oaks are preferred (Figure 19). This is somewhat surprising since mature oak leaves seem tough, and oaks generally have defensive compounds (ex., tannin) to repulse browsers; most browsing damage is done in the spring and early summer when these factors are likely less of an issue.

Flowering dogwood is a common understory tree that is relished by deer. It is browsed throughout the summer, and, somewhat surprisingly, dead leaves are regularly eaten from the forest floor in late fall and winter. Its fruits are favored as well. Blackgum and hackberry, which also produce soft mast, are commonly browsed by deer.

The aspens, especially quaking, are staple browse species in the Northern Lake States, where they are prevalent. While quaking and bigtooth aspen both occur in Indiana and are browsed when available, their distribution is so scattered that using them in browse-pressure evaluation is not worthwhile. Similarly, the only conifer we have included in this "preferred" ranking is eastern hemlock, and its distribution in Indiana is even more limited than aspens.

SHRUBS AND WOODY VINES

Several shrubs and woody vines are preferred by deer and can be especially vulnerable because many spend their lives within reach of deer. Many species of shrub-like brambles (blackberries, raspberries, and their kin) and wild roses (except multiflora rose) are preferred by deer. They are regularly found along forest edges and within canopy openings. Deer commonly eat the leaves of brambles and relish the fresh, tender growth of new canes but largely avoid the older canes, which make up a large proportion of a bramble thicket. The thorns found on these older canes are generally considered "anti-browsing" adaptations.

A universal feature of spring/summer diets of Indiana deer is the heavy use of foliage of woody vines. In many places, where deer are not overly abundant, the summer forest floor may be covered with foliage of poison ivy and Virginia creeper, two species heavily used in this season. Their being browsed by deer may not be as easy to discern as browsing on individual shrubs (or tree seedlings/saplings) because of their abundance and resilience to browsing. Greenbrier is another vine that is relished by deer and one you will see browsed (often heavily) across most woodlots in Indiana. Wild grape is also browsed commonly by deer.

Two other shrub genera that are regularly browsed are *Euonymus* and *Hydrangea*. Strawberry bush and running wahoo are essentially eliminated when deer are overabundant. The same might be said for wild hydrangea, which was the first species that biologists observed being browsed heavily by deer in the 1950s! Hydrangea still occurs principally on steep rock outcrops (evidently its preferred microhabitat anyway) that are relatively inaccessible to deer (Figure 22). Yew (*Taxus canadensis*) is another shrub that is so highly preferred that it only occurs in such locations.

Figure 22. *Protected areas out of easy access to deer can serve as comparisons for deer browse in accessible areas.*

Deer are known to frequently browse sumacs (again, these are mainly in woods-edge situations), but this is somewhat species-specific, with foliage and fruits of dwarf and staghorn sumac regularly taken and that of smooth sumac rarely so. Dwarf sumac is one of the only woody plants in which woody twigs are regularly browsed in the winter; they are evidently highly preferred.

HERBACEOUS PLANTS

There are over 1500 possible non-grass species (forbs) from which deer might select, so any listing will cover a woefully small number of preferred and non-preferred species. This is not to say that deer cannot impact the health or abundance of a given species, because it has been shown in both Indiana and the rest of the Midwest that such has occurred (18, 24, 39).

The trilliums are highly preferred, and deer impacts are substantial—we'll use them as a "poster-child" group for herbaceous species (Figure 15). There are seven trillium species in Indiana, but the most common are likely prairie trillium, drooping trillium, and large-flowered trillium. This latter one has been the most studied trillium species relative to deer impacts; it occurs principally in the northern part of Indiana but becomes extremely common as one moves northward into the Upper Lake States. All three are perennials and readily taken by deer; their biology and responses to browsing are similar. Deer also prefer many other spring wildflowers. These include Canada mayflower, sweet-cicely, smooth Solomon's seal, false Solomon's seal, trout lilies, and bellwort.

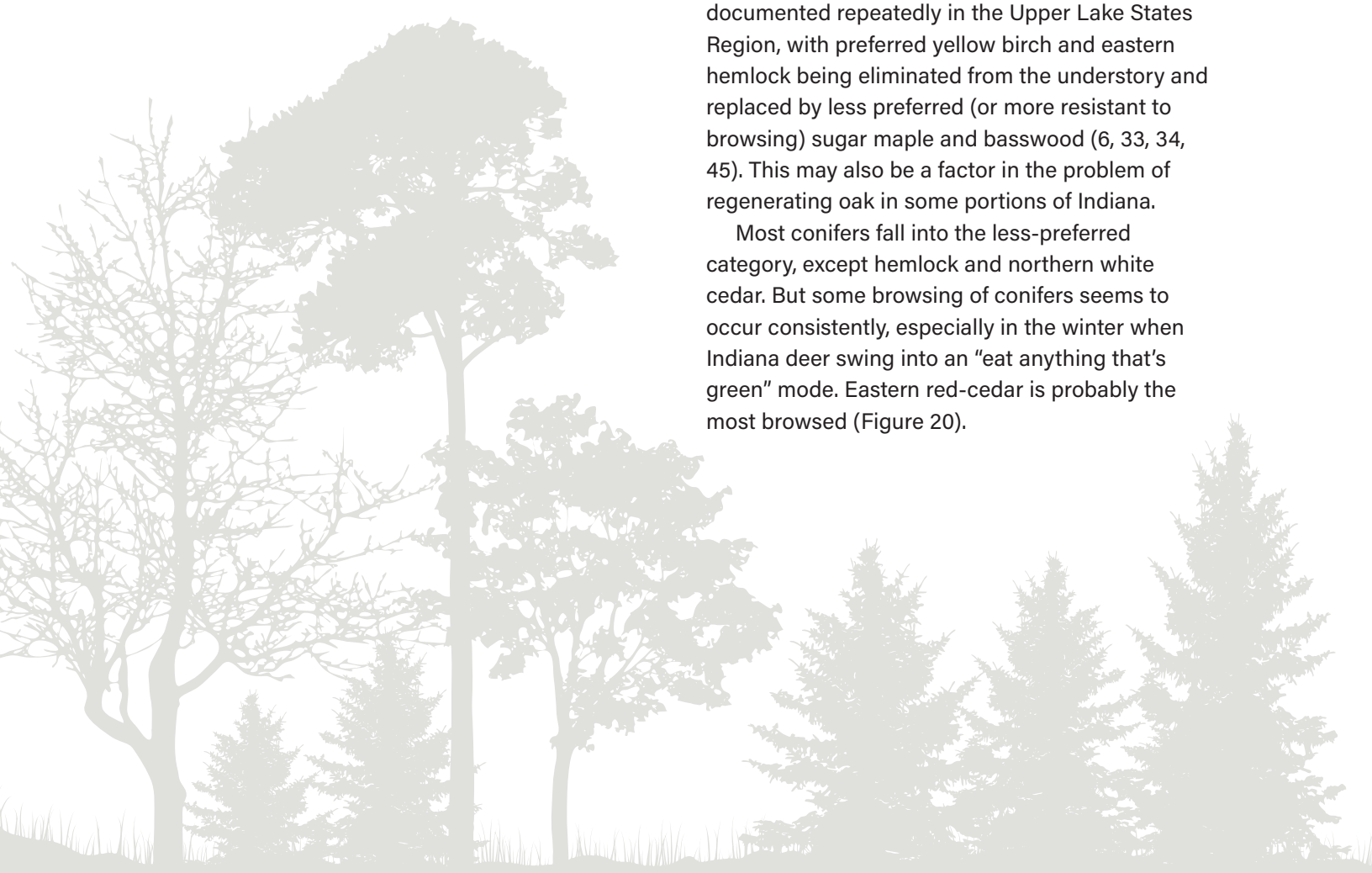
Deer prefer several other common woodland forbs. Especially favored in Indiana is jewelweed, tall white lettuce, wild lettuce, hog-peanut, woodland sunflower, and several asters (*Symphitricum*), goldenrods (*Solidago*), and tick-trefoils (*Desmodium*). Some species that we might consider "weeds" are relished by deer, including pokeweed and common and giant ragweed.

Low-preference species

TREES

Heavy browsing of preferred species by overabundant deer tends, over time, to favor less preferred species, which ultimately will become canopy trees. This phenomenon has been documented repeatedly in the Upper Lake States Region, with preferred yellow birch and eastern hemlock being eliminated from the understory and replaced by less preferred (or more resistant to browsing) sugar maple and basswood (6, 33, 34, 45). This may also be a factor in the problem of regenerating oak in some portions of Indiana.

Most conifers fall into the less-preferred category, except hemlock and northern white cedar. But some browsing of conifers seems to occur consistently, especially in the winter when Indiana deer swing into an "eat anything that's green" mode. Eastern red-cedar is probably the most browsed (Figure 20).



Black walnut and hickories (other than bitternut) are little-used in natural stands. In bottomland forests, where walnut does best, it is often in competition with other less preferred species, such as silver maple, river birch, and American sycamore. Two other species commonly growing in these forests, pawpaw and sweetgum (in southern Indiana), are among the least preferred of all tree species, essentially being used not at all (Figure 23). In forest edges and young second-growth forests in Indiana, black locust and honeylocust are frequently found but are used very little by deer.

For several avoided or low-preference tree species above, deer seem to avoid feeding on vegetation from seedlings, saplings, and mature trees, but readily consume vegetation from stump sprouts (Figure 24). This is likely because sprouts from the stumps are highly nutritious and more palatable.

American beech is a great indicator plant of deer impact on Indiana forests. It is generally not preferred and often sends up root sprouts around the parent tree. Stump sprouts are also frequent in cut or damaged trees. When deer populations are high, they browse these sprouts—if these sprouts are browsed to the degree that they fail to escape the reach of deer, your deer population is almost certainly too high. Even if some sprouts grow beyond the reach of deer, deer populations may still be too high and directing your woodland toward a beech-maple and away from an oak-hickory composition.

SHRUBS AND WOODY VINES

Several native woodland shrubs and woody vines are browsed occasionally but not preferred, such as smooth sumac, spicebush, and black huckleberry. We have included the willows in this less preferred grouping, as deer do not seem to regularly browse any of the 14 species of shrub willows found in Indiana. This is somewhat surprising since willows are important browse species for large ungulates in the western U.S. and northward through Canada and Alaska.

Figure 23. *Pawpaw is a species that is usually untouched, regardless of deer density.*

Figure 24. *Stump sprouts are favorites, even for less preferred species like this black locust.*

Deer almost totally avoid several invasive exotic shrubs. In many woodlands, the shrub layer is increasingly occupied by these exotics, which seem able to outcompete native shrubs and tree seedlings/saplings. This competitive advantage is exacerbated by deer taking preferred and less preferred (with heavy deer densities) natives, giving further advantage to the avoided exotics. Most notable in this category are European buckthorn, glossy buckthorn, and Tatarian honeysuckle (*Lonicera tatarica*) in far northern Indiana and autumn olive and Amur honeysuckle in most of Indiana. While most of these species are entirely avoided, in woods where few native shrubs and woody vines are available, deer will eat bush honeysuckle, especially in the spring when it is one of the first plants to produce leaves.

HERBACEOUS SPECIES

There are many woodland herbaceous plants which deer do not prefer, with several, such as wild ginger, white snakeroot, and false hellebore, evidently containing somewhat toxic compounds that deter browsing (Figure 25).

Deer do not take sedges and many ferns, and the ground layer of the most severely over-browsed woodlands may be dominated by these species (Figure 13). This was an occasional situation in Brown County State Park before the deer reductions. This dominant layer can perpetuate itself by preventing the reestablishment of other native flora once deer numbers are reduced.

Most grasses are of limited value to deer and are rarely consumed, with two exceptions. First, in the spring when grasses are one of the few green and growing sources of vegetation, a portion of a deer's diet will be comprised of grasses. And secondly, deer will readily consume cereal grains such as wheat, oats, and cereal rye.

Many native plants likely fit into this "not preferred but taken (and negatively impacted) when deer are overabundant" category. Unfortunately, many of the herbaceous invasive species with which landowners (and public land managers) struggle to remove from natural communities are not used by deer – at all! As such, species like garlic mustard and Japanese stiltgrass can become dominant in areas with heavy deer browse. But, when the impact of deer browsing is reduced (as studied in deer exclosures in the Smoky Mountains National Park), species like Japanese stiltgrass are dramatically reduced because other plants – more preferred by deer – escape deer browsing and shade out these species. (8)

Figure 25. *Leaves of white snakeroot, common in Indiana, are usually avoided; toxins caused "milk fever" in pioneers who drank milk from woods-grazing cows.*

Putting it All Together: Initial Deer Impact Assessment

The information from this publication serves as helpful background information about deer, their diet, and their overall impact on Indiana's woodlands. Now comes the time to take the information you have learned and put it to use on your property. You can refer to previous sections to help you complete this assessment.

By following this assessment and making the observations described previously, you will likely have a reasonable idea of the degree to which deer are impacting your woodland. Consider the questionnaire below a starting point. It will give you a general idea of deer impacts but may not show the true impact of deer on your woodlands. A more thorough evaluation of deer impacts or a discussion with a biologist or forester may be warranted. The publication *Monitoring White-tailed Deer and their Impacts on Indiana Woodlands* will provide you with information about how to conduct a more thorough evaluation of deer impacts.

Deer Impact Assessment	
Questions	Circle One Value for Each Question
1. Observations of deer in openings adjacent to your woodland can reflect abundances and, thus, potential browsing damage.	
a. I see few or no deer	1
b. I occasionally see small groups	2
c. I regularly see deer and occasionally see large groups	3
2. Viewed from outside the woods, is a browse line evident or suggested?	
a. No browse line evident along whole extent	1
b. Slight hint of browse line in spots	2
c. Definite browse line along the entire perimeter	3
3. Deer frequently use openings (agricultural fields, fallow areas, utility rights-of-way, rural homesites) for feeding. Is damage evident in these areas near your woodland?	
a. Little or no damage	1
b. Occasional browsing noted or reported	2
c. Substantial damage—tree saplings appear "bushy," low preference conifers with lower limbs browsed, etc.	3
4. Deer overpopulation can have substantial impacts on understory structure; the worst damage results in a "clear vista" so that one can see a long way through even summer woods. Standing in your woods in summer, can you see a companion in most locations at:	
a. Only 25 yards or less	1
b. 50 or so yards, but not at 50—100 yards	2
c. 100 or more yards	3
5. Trilliums are highly preferred by deer, which tend to select the largest plants; these are the older plants typically in flower. Rate the following in late April and May.	
a. Trilliums are in flower, with several visible from a single location in several places in the woods	1
b. Some trilliums flowering, but very few; small plants evident	2
c. No trillium flowering, although small plants evident	3
d. Not applicable; no trilliums in woods (note: may be habitat-related or because of severe, long-term deer damage)	N/A

Deer Impact Assessment Cont'd	
Questions	Circle One Value for Each Question
6. Repeated browsing of trilliums by deer results in small plants incapable of flowering. Rate the following in late April-May.	
a. Many trillium heights (stem from ground to leaf attachment; flowering and non-flowering) 8 inches or greater	1
b. Most stems < 8 inches in height, although a few may approach this height (esp. in Trillium recurvatum)	2
c. No stems at or approaching 8 inches	3
d. Not applicable; no trilliums in woods (see note in # 5)	N/A
7. Several other spring wildflowers are highly preferred by deer and are often heavily browsed. Evaluate your woods in May for these common species: sweet cicely, Canada mayflower, smooth Solomon's seal, false Solomon's seal, large-flowered bellwort, and trout lily.	
a. Species present and many in flower	1
b. Some species are rare and flowering spotty	2
c. Plants average < 8 inches tall; few flowering	3
8. Jack-in-the-pulpit is a common woodland plant that is not considered preferred by deer. However, research in Indiana and elsewhere has shown that overabundant deer can reduce the average heights of these plants at flowering (as with trilliums). Measure height from ground to leaf-whorl.	
a. Plants in flower average about 15 inches; many flowering	1
b. Plants average 8-15 inches tall	2
c. Plants average < 8 inches tall; few flowering	3
9. Evaluate "spring browsing" of woody plants in May and early June. For preferred woody species (Table 1), estimate the percentage of available twigs (within 4.5 feet of the ground) browsed.	
a. Less than 10% browsed	1
b. 10% - 40% browsed	2
c. > 40% browsed	3

Deer Impact Assessment Questions

	Circle One Value for Each Question
10. If browsing of preferred species is > 40%, estimate the browsing of woody species from the low-preference list.	
a. Less than 10% browsed	1
b. 10% - 40% browsed	2
c. > 40% browsed	3
d. Not Applicable; browse on preferred species is < 40%	N/A
11. Deer find twigs and foliage of stump-sprouts irresistible. If you can find cut (by humans or beavers) stumps or damaged trees with stump sprouts, evaluate the following.	
a. Sprouts are unbrowsed or lightly so; many stems can grow above the reach of deer (4.5 feet)	1
b. Sprouts are heavily browsed, but at least a few stems can grow above the reach of deer	2
c. All sprouts browsed; none escape	3
d. Not applicable; no sprouting stumps present	N/A

SUM OF ALL THE CIRCLED NUMBERS	
DIVIDE THIS VALUE BY 11 (MINUS THE NUMBER OF NA DESIGNATIONS) **(Sum of circled numbers)/(Number of questions answered)**	
FINAL IMPACT EVALUATION VALUE	

Example:

The sum of our circled numbers was 18 and we did not have trilliums in our woods, so we marked NA for questions 5 and 6. Therefore, we answered 9 of the 11 questions.

18 total points ÷ 9 questions answered = 2

What does this Final Evaluation Value mean?

If the value is:	Deer impact assessment is:
1.0 — 1.75	Deer are having minimal impact on your woodland quality. To maintain this quality, some annual harvest of deer is suggested.
1.76 — 2.50	Deer are having a substantial effect on your woodland quality. A more formal evaluation of deer impact is warranted. A heavy harvest of deer (especially does) must occur annually.
2.51 — 3	Your woodland is seriously threatened. Heavy annual harvest of does for multiple years is recommended, or fencing may be required. A more formal evaluation of deer impact is warranted. You should also consult a local forester or wildlife biologist to help address your problem.

What's Next?

The assessment questionnaire in the previous section serves as a great starting point to understand deer impacts on your woodland. But to truly understand the level of impact in your woodland, you should conduct a more formal evaluation. This is done by evaluating *what* and *how much* vegetation is being browsed in your woods. Luckily, several methods have been developed to help understand deer impacts in woodlands. Each technique may require a different level of time, effort, or knowledge of plant identification, but most methods are easy enough to be conducted by woodland owners. The right evaluation method for your woods will depend on your woodland, time, and plant identification skills.

For more information about evaluating deer impact in your woods, see the publication *Monitoring White-tailed Deer and their Impacts on Indiana Woodlands*.

Correcting the Problem

Whatever adjective you ascribe to deer – positive, negative, or both – deer can shape Indiana woodlands' composition and structure. To ensure our forests' future health and prosperity, we may need to correct the problem of overabundant deer, which means reducing deer on the landscape or reducing their ability to browse vegetation in our woodlands.

Reducing deer

Reducing deer is relatively straightforward and accomplished most effectively through recreational hunting. By harvesting deer – especially does - we can reduce the population and limit deer impacts. It is important to note that hunting will likely occur yearly to ensure it has the desired effect. By monitoring the vegetation each year or every couple of years, you will better understand if your hunting has been successful. If you are not a hunter yourself or do not have family members or friends that hunt, leasing your property to prospective hunters is an option.

Reducing deer browse

Beyond directly removing deer through harvest, the other option to limit deer impacts is to reduce their ability to browse desired vegetation. This is done primarily through fencing. Fencing can be placed around a tree planting (in the woods or a field), around existing vegetation in the woods, or around a forest opening to protect regenerating vegetation from deer browse. Tree tubes or exclusion cages can also be placed on individual trees to protect them. Fencing and tree tubes will solve a local problem (planted trees or fenced areas will be protected), but this will not address the root of the problem (overabundant deer), and unfenced vegetation will still be impacted.

Another option to reduce deer impact is to overwhelm them with more food they can eat – the idea of managing the foodscape (see previous sidebar on page 16). This is most commonly done by creating forest openings within your woodland through timber harvest or managing the plant communities in nearby old fields or grasslands. The flush of growth following a timber harvest can provide more food than deer can consume, allowing some woody seedlings to escape browsing. But for this method to work, it needs to be coupled with hunting to maintain deer within the carrying capacity of the landscape.

For a more in-depth discussion on potential options to reduce the impacts of deer on your woodland, visit the *Managing White-tailed Deer Impacts on Indiana Woodlands* publication.

Conclusion

Deer are an important part of Indiana's forests. A welcome sight to many landowners but a cause of frustration to others. Deer are a "keystone" species, meaning their browsing can impact forest and wildlife communities. It is clear that when deer become overabundant, their impact on the environment can be problematic. But by understanding the impacts deer have on our woodlands, their food preferences, and how to assess and evaluate impacts in your woodlands, we can begin to address the problems caused by overabundant deer.

Deer Impact Toolbox

This publication is part of a larger group of resources for landowners who are interested in learning more about how deer impact Indiana forests. The *Deer Impact Toolbox* can be found by visiting the Purdue FNR Extension Website. It provides landowners with more information to help understand, identify, monitor, and manage deer impacts in their woodlands. The publications within the Deer Impact Toolbox are listed below.

Acknowledgments

We want to thank various Indiana Department of Natural Resources employees who have been generous with their comments regarding their experiences with deer/habitat interactions. We have also used a plethora of published materials that have helped focus our thought process. Special credit to Tom Rawinski (30); we found his paper very helpful and adapted the format of his preference ranking tables for Tables 1, 2, and 3. Most photos are by Sally and Harmon Weeks. Figure 20 was taken by Tim Cordell; Figure 11 (credit; National Park Service) and Figure 21 was taken by Michael Jenkins. Figure 3 was from Jim Eagleman. As a naturalist at Brown County State Park, Jim suffered through the worst period of affliction deer have ever exerted on a natural woodland of Indiana; the experiences he has shared with us are appreciated. Thank you to Allen Pursell (Indiana Chapter of The Nature Conservancy) and Scott Haulton (Indiana Department of Natural Resources, Division of Forestry) for reviewing this publication.

Additional Resources

Books for plant identification in Indiana

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Tables

Table 1. **Forest species that are preferred by white-tailed deer in Indiana. Some are "marginally preferred" but regularly selected. Common names given after scientific names are those most often used in Indiana.**

Scientific name	*Common name*	*Indiana distribution*[1]
TREES		
Acer rubrum	red maple	1
Acer saccharum	sugar maple	1
Carya cordiformis	bitternut hickory	1
Celtis occidentalis	hackberry	1
Cornus florida	flowering dogwood	1
Fraxinus americana	white ash	1
Fraxinus pennsylvanica	green ash	1
Malus coronaria	wild crabapple	7
Nyssa sylvatica	blackgum	1
Populus grandidentata	bigtooth aspen	6
Populus tremuloides	quaking aspen	2
Prunus avium	sweet cherry	2
Quercus alba	white oak	1
Quercus montana	chestnut oak	5
Quercus muehlenbergii	chinkapin oak	1
Quercus pallustris	pin oak	1
Quercus rubra	northern red oak	1
Quercus velutina	black oak	1
Sassafras albidum	sassafras	1
Taxus canadensis	Canada yew	9
Tsuga canadensis	eastern hemlock	9
Ulmus rubra	slippery elm	1

Continued on next page

[1] 1= found throughout the state,
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may be connected along western edge of state,
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9= highly restricted distribution in wild

Table 1. *Continued*

Scientific name	*Common name*	*Indiana distribution*[1]
SHRUBS AND WOODY VINES		
Campsis radicans	trumpet creeper	1
Cornus spp.	shrub dogwoods	1
Corylus americana	American hazelnu	1
Euonymus americanus	wild strawberry bush	5
Euonymus atropurpureus	wahoo	1
Euonymus obovatus	running strawberry bush	1
Hamamelis virginiana	witchhazel	1
Hydrangea arborescens	wild hydrangea	8
Ilex verticillata	winterberry	1
Lonicera japonica	Japanese honeysuckle	1
Mitchella repens	partridgeberry	6
Parthenocissus quinquefolia	Virginia creeper	1
Prunus americana	American plum	1
Prunus virginiana	chokecherry	2
Rhus copallinum	dwarf sumac	6
Rhus hirta	staghorn sumac	4
Ribes spp.	gooseberry spp.	1
Rosa spp.	wild roses	1
Sambucus canadensis	elderberry	1
Smilax spp.	greenbrier species	1
Staphylea trifolia	bladdernut	1
Toxicodendron radicans	poison-ivy	1
Vaccinium spp.	blueberrys	4
Viburnum spp.	viburnums	1
Vitis spp.	wild grapes	1

Continued on next page

Table 1. *Continued*

Scientific name	*Common name*	*Indiana distribution*[1]
HERBACEOUS SPECIES		
Agrimonia spp.	agrimony species	1
Ambrosia artemisiifolia	common ragweed	1
Ambrosia trifida	giant ragweed	1
Amphicarpaea bracteata	American hogpeanut	1
Aralia nudicaulis	wild sarsaparilla	4
Circaea lutetiana	enchanter's nightshade	1
Cryptotaenia canadensis	honewort	1
Cypripedium acaule	pink ladyslipper	4
Cypripedium calceolus	yellow ladyslipper	1
Desmodium spp.	tick trefoil species	1
Dioscorea villosa	wild yam	1
Duchesnea indica	mock strawberry	1
Erythronium americanum	yellow trout lily	1
Eupatorium purpureum	spotted joe pye weed	1
Fragaria vesca	American wood strawberry	1
Galium spp.	bedstraw species	1
Geranium maculatum	wild geranium	1
Geum spp.	avens species	1
Helianthus divaricatus	woodland sunflower	1
Hybanthus concolor	eastern greenviolet	1
Impatiens spp.	jewelweed	1
Lactuca spp.	wild lettuce	1
Laportea canadensis	Canadian woodnettle	1
Lilium michiganense	Michigan lily	1
Maianthemum canadense	Canada mayflower	4
Maianthemum racemosum	false Solomon's seal	1
Medeola virginiana	Indian cucumber root	6
Osmorhiza claytonii	sweet cicely	1
Panax quinquefolius	ginseng	1
Parietaria pensylvanica	Pennsylvania pellitory	1

Continued on next page

Table 1. *Continued*

Scientific name	*Common name*	*Indiana distribution*[1]
HERBACEOUS SPECIES		
Phryma leptostachya	American lopseed	1
Phytolacca americana	pokeberry	1
Polygonatum biflorum	smooth Solomon's seal	1
Potentilla simplex	common cinquefoil	1
Prenanthes altissima	tall white lettuce	1
Rudbeckia laciniata	cutleaf coneflower	1
Sanguinaria canadensis	bloodroot	1
Smilax ecirrhata	upright carrionflower	9
Solidago spp.	goldenrod species	1
Symphyotrichum spp.	aster species	1
Trillium spp.	trillium species	1
Uvularia grandiflora	large flowered bellwort	1

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Table 2. **Forest species that are avoided or less preferred by deer in Indiana. However, almost all will be eaten to some degree, either seasonally, or when deer densities are very high and more preferred species have been greatly reduced or eliminated. Invasive species are marked with °.**

Scientific name	*Common name*	*Indiana distribution*[1]
TREES		
Ailanthus altissima°	tree of heaven	1
Asimina triloba	pawpaw	1
Betula nigra	river birch	5
Diospyros virginiana	persimmon	5
Fagus grandifolia	American beech	1
Gleditsia triacanthos	honeylocust	1
Juglans nigra	black walnut	1
Juniperus virginiana	eastern red-cedar	1
Larix laricina	eastern larch	6
Liquidambar styraciflua	sweetgum	5
Ostrya virginiana	ironwood	1
Pinus strobus	eastern white pine	9
Platanus occidentalis	American sycamore	1
Robinia pseudoacacia	black locust	1

Continued on next page

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[2] The young tender growth, leaves, and fruit of brambles (*Rubus* spp.) are commonly selected as food by deer. But the older growth, which makes up a majority of a bramble thicket, is often not selected.

Table 2. *Continued*

Scientific name	*Common name*	*Indiana distribution*[1]
SHRUBS AND WOODY VINES		
Aronia prunifolia	chokeberry	2
Berberis thunbergii°	Japanese barberry	1
Celastrus scandens	American bittersweet	1
Cephalanthus occidentalis	buttonbush	1
Elaeagnus umbellata°	autumn olive	1
Frangula alnus	glossy buckthorn	4
Gaultheria procumbens	wintergreen	4
Gaylussacia baccata	black huckleberry	6
Ligustrum obtusifolium°	regal privet	5
Lindera benzoin	spicebush	1
Loniceria spp.°	bush honeysuckle species	1
Physocarpus opulifolius	common ninebark	1
Ptelea trifoliata	common hoptree	1
Rhamnus cathartica°	European buckthorn	4
Rhus glabra	smooth sumac	1
Rosa multiflora°	multiflora rose	1
Rubus spp.[2]	bramble species	1
Salix spp.	shrub willow species	1
Spiraea alba	meadowsweet	2
Spiraea tomentosa	hardhack	6
Symphoricarpos orbiculatus	coralberry	3
Zanthoxylum americanum	prickly ash	1

Continued on next page

Table 2. *Continued*

Scientific name	*Common name*	*Indiana distribution*[1]
HERBACEOUS SPECIES		
Actaea pachypoda	white baneberry	1
Aesclepias exaltata	poke milkweed	1
Alliaria petiolata°	garlic mustard	1
Allium spp.	wild onion	1
Apocynum cannabinum	American Indian hemp	1
Arctium minus°	common burdock	1
Arisaema dracontium	green dragon	1
Arisaema triphyllum	jack-in-the pulpit	1
Aristolochia serpentaria	Virginia snakeroot	1
Asarum canadense	wild ginger	1
Campanulastrum americanum	tall bellflower	1
Carex spp.	woodland sedges	1
Cardamine bulbosa	spring cress	1
Caulophyllum thalictroides	blue cohosh	1
Cirsium altissimum	tall thistle	1
Claytonia virginica	spring beauty	1
Collinsonia canadensis	horse balm	1
Conium maculatum°	poison hemlock	1
Corydalis flavula	pale yellow corydalis	1
Delphinium tricorne	dwarf larkspur	8
Dicentra canadensis	squirrel corn	8
Dicentra cucullaria	dutchman's breeches	1
Erechtites hieraciifolius	pilewort	1
Eupatorium rugosum	white snakeroot	1
Ferns	most fern species	1
Glechoma hederacea	ground ivy	1
Hackelia virginiana	Virginia stickseed	1
Heliopsis helianthoides	oxeye	1
Hieracium longipilum	hairy hawkweed	4
Hydrophyllum appendiculatum	appendaged waterleaf	1

Continued on next page

Table 2. *Continued*

Scientific name	*Common name*	*Indiana distribution*[1]
HERBACEOUS SPECIES		
Hydrophyllum macrophyllum	largeleaf waterleaf	1
Lobelia cardinalis	cardinal flower	1
Lobelia siphilitica	great blue lobelia	1
Lysimachia quadrifolia	whorled loosestrife	1
Melanthium woodii	false hellebore	8
Microstegium vimineum°	Japanese stiltgrass	1
Mints	most mint species	1
Packera aurea	golden ragwort	1
Packera obovata	round groundsel	1
Pastinaca sativa°	wild parsnip	1
Phlox divaricata	blue phlox	1
Podophyllum peltatum	mayapple	1
Sanicula canadensis	Canada snakeroot	1
Sanicula marilandica	black snakeroot	1
Saururus cernuus	Lizard's tail	1
Senna obtusifolia	sicklepod	9
Silene antirrhina	sleepy catchfly	1
Stylophorum diphyllum	wood poppy	1
Urtica dioica	stinging nettle	1
Viola spp.	wild violets	1

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[2] The young tender growth, leaves, and fruit of brambles (Rubus spp.) are commonly selected as food by deer. But the older growth, which makes up a majority of a bramble thicket, is often not selected.

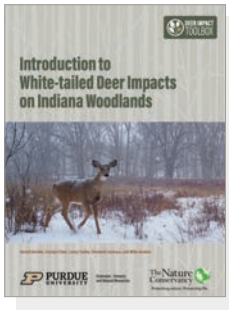
Table 3. **List of species considered neutral in their preference, meaning they are not preferred or avoided. Many are eaten by deer, but not to any great extent unless deer are overabundant.**

Scientific name	*Common name*	*Indiana distribution*[1]
TREES		
Acer negundo	boxelder	1
Aesculus glabra	Ohio buckeye	1
Amelanchier arborea	downy serviceberry	1
Carpinus caroliniana	musclewood	1
Carya glabra	pignut hickory	1
Carya ovata	shagbark hickory	1
Cercis canadensis	eastern redbud	1
Crataegus spp.	hawthorn spp.	1
Fraxinus quadrangulata	blue ash	1
Liriodendron tulipifera	tulip poplar	1
Prunus serotina	black cherry	1
Tilia americana	American basswood	1
Ulmus americana	American elm	1
HERBACEOUS SPECIES		
Acalypha virginica	Virginia three-seed mercury	1
Barbarea vulgaris	yellow rocket	1
Menispermum canadense	moonseed	1
Oxalis stricta	yellow wood sorrel	1
Pilea pumila	clearweed	1
Thalictrum thalictroides	rue anemone	1
Tradescantia subaspera	zig-zag spiderwort	1
Triosteum perfoliatum	late horse gentian	1
Verbena urticifolia	white vervain	1
Oxalis violacea	violet wood sorrel	1
Persicaria punctata	dotted smartweed	1
Persicaria virginiana	Virginia knotweed	1
Verbesina alternifolia	wingstem	1

[1] 1 = found throughout the state

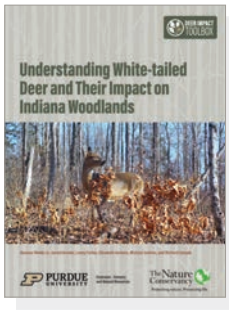
Find Out More

DEER IMPACT TOOLBOX



Introduction to White-tailed Deer Impacts on Indiana Woodlands

Monitoring White-tailed Deer and Their Impacts on Indiana Woodlands



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