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FOREST STAND *Improvement*

Implementation for Wildlife in Hardwood Stands of the Eastern US

Craig A. Harper

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Forest Stand Improvement

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WHAT IS FOREST STAND IMPROVEMENT?

Forest stand improvement (FSI) composes practices that guide or influence a forest stand to meet a particular objective, such as improving habitat for various wildlife species, changing plant species composition, or influencing the structure and visibility within a stand to meet aesthetic objectives. FSI does not necessarily involve timber considerations as does timber stand improvement (TSI), including tree value, volume or merchantability, though it may. FSI does not involve regeneration methods (such as clearcut, shelterwood or group selection) that establish a new stand, but instead represents any non-regeneration practice to make an existing stand better for a particular objective. As such, FSI may involve various types of thinnings, cuts, prescribed fire and herbicide applications.

This publication is intended to highlight various applications of FSI when wildlife is the primary objective. In particular, many landowners are interested in improving their woods for wildlife, but either 1) they are not interested in a regeneration harvest (do not want to see a majority of the trees harvested), 2) the stand is not ready to regenerate (either not old enough or there is a lack of advanced regeneration of desirable trees, such as oaks), or 3) the trees do not have enough value to attract a logger. Indeed, many forest landowners have relatively little interest in timber value. The interests of many landowners concentrate on the abundance, visibility and huntability of certain wildlife species. FSI is a term that encompasses practices and techniques landowners can use to improve their woods for wildlife or to achieve other objectives, including aesthetics. The information, recommendations and ideas that follow were generated by research conducted by several of my graduate students as well as the extensive work we have conducted on demonstration areas over the past 20-plus years.

Fig 1. FSI involves practices that improve species composition and vegetation structure in a particular stand to meet your objectives. Here, undesirable tree species have been cut or killed and prescribed fire has been used to influence the composition and structure of the understory to increase food and cover for white-tailed deer and wild turkey.

WHEN SHOULD FSI BE PUT INTO PRACTICE?

You may implement FSI anytime conditions in a particular stand do not meet your objectives. For example, a mature oak-hickory stand may be ready to regenerate, but instead, FSI through an improvement cut and prescribed fire may be most appropriate to meet your objectives of improving forage availability and fawning cover for white-tailed deer. FSI through girdle-and-spray or an understory broadcast herbicide application may be used to control nonnative, invasive plant species, including trees, shrubs, woody vines or herbaceous species. FSI through a thinning operation, whether harvesting, felling or hack-and-squirt, may be used to encourage additional growth of desired tree species (consistent with TSI) or increase the amount of sunlight entering the stand to stimulate understory development for various wildlife species. There are many examples and levels of implementation of FSI that may be used to meet specific objectives. Various FSI techniques, such as a foliar spot-spray treatment, may be most appropriate during specific seasons of the year, but there are FSI practices that can be implemented any time of year depending on your objectives and current stand conditions.

WHAT'S THE DIFFERENCE BETWEEN THINNINGS AND CUTS?

Thinnings are conducted in immature stands with the primary intention of improving growth and volume of remaining (retention) trees or increasing the amount of sunlight entering the stand. Cuts are made to more mature stands to improve species

composition, allow additional space for crowns of remaining trees, and to add sunlight to the forest floor in order to stimulate the understory or influence the structure of the stand.

Fig 2. This 8-year-old regenerating mixed-hardwood stand could go in a number of directions at this point. Depending on your objectives, various management practices could be implemented. For example, a precommercial thinning could be implemented to release desirable species, such as oaks, for future timber or mast production. Undesirable trees could be killed by hack-and-squirt, basal bark treatment or felling, upon which stumps may or may not be treated to prevent sprouting. The stand could be burned with moderately intense fire to top-kill all stems if the objective was to maintain dense stem structure for deer, grouse or shrubland songbirds. A low-intensity fire could be used to top-kill some trees and encourage understory development. A combination of thinning and fire could be used to ensure the trees that live are desirable and begin the process of creating an oak woodland. There is no one treatment that is best for all objectives. The correct treatment is dependent upon your objectives!

CAN TREES IN A THINNING OR CUT BE HARVESTED FOR WOOD PRODUCTS?

Sure, depending on the species, size and quality of the trees removed. In pine stands, thinnings commonly involve harvest that generate income for the landowner. However, in hardwood stands, trees removed often are low-quality species or relatively small stems that loggers will not harvest because those trees will not pay their way out of the woods. Thus, you may have to allow loggers to harvest some high-value trees in order for them to fell (cut down) or harvest the low-value trees you would like removed.

However, tree value is relative. If you are wanting to improve your woods for deer and turkeys, for example, you likely would retain high-value food trees, such as oaks, persimmon, mulberry and various other mast producers. And there may be high-value timber trees, such as yellow-poplar, walnut, hickory, sugar maple and others (depending on current market), that you would want a logger to remove because the value of those species relative to your objective of improving habitat for deer and turkeys is low. If eastern gray squirrel and black bear are focal species, then you may retain a majority of the hickories. If various songbirds are of interest, then promoting trees that provide fruit, such as hackberry, black cherry, flowering dogwood, American holly, sassafras, blackgum and serviceberry, will benefit many species, including gray catbird, Baltimore oriole, American robin and other thrushes, brown thrasher, cedar waxwing, Northern mockingbird, Northern flicker, and summer tanager. Again, value is relative to your objectives, and there is nothing wrong with managing your forest to meet your objectives, even if your objectives are not timber-value related! Another consideration is the impact of logging, including ruts made from logging equipment and damage to residual trees.

Fig 3. Depending upon species, size, form and available market, undesirable trees can be harvested through an improvement cut. However, often the undesirable trees you would like removed, such as red maple, sourwood, sassafras, elm, and even yellow-poplar and hickory, may have low value, and it is difficult to entice a logger to harvest them without harvesting higher-value trees.

For example, it is not uncommon for loggers to drag harvested trees against the stem of retained trees, damaging the base of retained trees and allowing insects or fungi to enter the tree and reduce quality or even lead to tree mortality. If that is a concern, you can include a requirement in your timber sale contract that felled trees must be cut to length before skidding to minimize damage to residual trees, but some damage will be inevitable. Therefore, according to your objectives and financial considerations, it may be best to kill or fell undesirable trees yourself rather than having them harvested by a logger.

IF TREES ARE NOT HARVESTED, HOW ARE THEY KILLED OR REMOVED?

Trees may be felled using a chainsaw or they may be killed and left standing via girdle-and-spray or hack-and-squirt. I prefer to girdle-and-spray using a small chainsaw, as opposed to using a hatchet for hack-and-squirt, because it allows the option of felling trees. Girdling involves making a shallow cut severing the inner bark layer (cambium) all the way around the tree. An herbicide then is sprayed into the wound to ensure the tree dies. Hack-and-squirt involves using a machete or a hatchet, severing the inner bark layer with angled cuts (about 45-degree angle) around the tree approximately 3 inches apart. An herbicide then is sprayed into the wounds. A light squeeze with a squirt bottle held closely to the girdle or hack is all that's needed to moisten the wound all the way around the tree or in each hack. Applying more herbicide than is necessary to moisten the wound, such that it drips or runs down the trunk from the girdle or hack is excessive and wasted. The herbicide should be applied while the wound is still fresh and prior to surface hardening (usually within an hour) to help ensure the herbicide is able to soak into the wound. Trees also can be injected with herbicide using an injection gun.

Fig 4a, b and c. Girdling a tree and spraying the wound with an appropriate herbicide is an efficient method to kill the tree without felling. A shallow girdle is all that is needed to sever the cambium layer (a). Herbicide applied should wet the cambium. A blue dye can be added to the herbicide mixture to help make it more noticeable if you missed any trees. Trees with double trunks, such as this sweetgum, can be girdled below the split to prevent having to girdle both stems (b). Hack–and–squirt also is effective (c), but you have the option of felling smaller trees if you girdle–and–spray with a small chainsaw vs. using a hatchet or machete to hack–and–squirt.

Arsenal contains imazapyr, which is soil active, so is there concern about killing nontarget trees?

No, not with the mixture, rate and method described above. The rare exception is when killing a tree that may be a sprout arising from a shared root system of an adjacent tree of the same species, such as sweetgum or aspen, and even then it is rare to see a nontarget tree killed with the mixture and method described above.

Fig 5. There is no danger in killing nontarget trees that are not growing from the same root system with the 50 percent Garlon 3A/40 percent water/10 percent Arsenal AC herbicide mixture when used as described in the text. Here are two red maples that were treated and killed with the mixture growing adjacent to two northern red oaks, which were not harmed and now their crowns are released and free to grow larger, thus enabling them to produce more acorns.

There are several herbicides that can be used to kill various tree species via girdle-and-spray or hack-and-squirt and to treat the inner bark layer of stumps of felled trees to prevent them from sprouting. I prefer a mixture of triclopyr and imazapyr. I typically use Garlon 3A (50 percent), water (40 percent) and Arsenal AC (10 percent), mixed in that order by volume. I use this mixture because various herbicides are weak on various tree species. For example, Garlon 3A, which contains triclopyr, is weak on hickory, sourwood and black cherry. Arsenal AC, which contains imazapyr, is weak on leguminous species, such as honeylocust, black locust, mimosa and redbud, as well as elms, wax myrtle, pines and eastern redcedar. A mixture of triclopyr and imazapyr kills a broad spectrum of tree species, which is advantageous when treating stands of mixed species. However, a mixture of herbicides is not necessary if all the trees in the stand you are treating can be killed with a single herbicide. Refer to herbicide labels regarding use and susceptible tree species.

Trees treated by girdling and spraying typically die over a 3- to 4-month period. Trees can be treated at any time of year, and treatment is equally effective at all times, except early spring when some species, such as maples, may have actively flowing sap. In those instances, when the tree is girdled, the sap can flow so heavily from the wound that the herbicide is washed out. In general, most trees treated in fall and early winter will not leaf-out the following spring. If implemented in late winter, all will leaf-out in spring, but they slowly die over the next couple months. If implemented in spring, trees slowly die through summer. If implemented in summer, they slowly die and drop their leaves in fall, but do not leaf-out the following spring. Fall and winter are excellent times to work in the woods because of the cooler temperatures, but spring and summer also are good times because trees are more easily identified with the leaves present. I keep a small chainsaw and squirt bottle with herbicide mixture in the truck or ATV anytime I'm working on a property and treat undesirable species as I see them.

Treatment cost for girdle-and-spray varies depending on the number and size of trees treated. At the rate mentioned above, a 24-oz spray bottle of the herbicide mixture costs about $8. On average, you can treat 1-2 acres of most typical mixed hardwood stands to allow 20-30 percent sunlight into the stand using one 24-oz spray bottle of herbicide.

HOW MUCH TIME DOES IT TAKE TO IMPLEMENT FSI?

As you might imagine, time required to implement FSI is highly dependent on what you are doing. Felling trees greater than 12 inches dbh generally takes more time than girdle-and-spray or hack-and-squirt. Young stands typically take more time to reduce canopy cover to allow a certain amount of sunlight into the stand than an older stand with fewer trees. Hinge-cutting (described below) requires more time than girdling-and-spraying, but the effect is different. Treating a stand with a chainsaw typically requires more time than burning, but burning can require more time than chainsawing if you consider time to establish firebreaks and especially if the fire gets into unintended areas! However, to provide some general time frame, I have found that when treating an "average" mature, closed-canopy, mixed hardwood stand via girdle-and-spray to allow approximately 30 percent sunlight into the forest floor, you can treat about 8 acres in a short winter day with two people (one operating the chainsaw and one squirting the girdled trees and stumps). Indeed, just one person with a chainsaw or hatchet and a squirt bottle can implement some level of positive change over 10 acres in a day with no problem. More intensive work incorporating girdle-and-spray, felling and hinge-cutting to create a "bedding block" for deer in a relatively dense stand will take more time, but two people working together still can create a super-attractive 10- to 15-acre area to hold deer on a property in only a couple of days.

What about basal-bark applications?

Basal-bark applications can be used in young stands to control species composition and allow selected stems more room to grow. Basal-bark applications typically employ a triclopyr-based herbicide with an oil carrier or diesel fuel. It is sprayed on the lower 18-24 inches of a tree trunk. The oil or diesel fuel enables absorption of the herbicide through the bark. Basal-bark applications are made to young trees because the bark of young trees is relatively thin and absorption through the bark is much easier and more effective than if applied to relatively thick bark. Basal-bark applications are very effective and efficient to control undesirable trees up to about 4 inches in diameter and too tall to treat with a foliar application. Basal-bark applications are most often implemented in winter, but they can be applied any time of year.

Fig 6. Basal bark applications are most effective when applied to young trees with thin bark. However, relatively large trees with thin bark also are susceptible, such as this sycamore, which was killed to favor an adjacent oak not seen in the picture.

INFLUENCING UNDERSTORY COMPOSITION WITH HERBICIDE APPLICATIONS

Herbicide applications can be used to control nonnative invasive and other undesirable plant species or to reduce woody cover and promote more herbaceous plants in the understory. Spot-spraying is appropriate in the majority of situations, but there are times when a broadcast application is warranted. Broadcast applications using an ATV with a boomless nozzle are possible in some situations, but tree spacing, slope, and terrain make broadcast applications with an ATV difficult if not impossible in many cases. Most often, herbicide applications in the woods are made with a backpack sprayer. Although it may seem overwhelming if you have never done it, do not overlook use of a backpack sprayer to improve plant composition in the understory. You can cover a lot of ground in your woods by spot-spraying foliage of undesirable species with a 4-gallon backpack sprayer! Different nozzles and spray-gun attachments may be used depending on the problem plant species.

Various soil-active herbicides, including imazapyr, should **not** be used when implementing broadcast applications because of potential damage to desirable overstory trees. However, glyphosate and triclopyr are not soil active and work very well as a foliar application to control

most undesirable plants, including Oriental bittersweet, garlic mustard, English ivy, Chinese privet, bush honeysuckle, multiflora rose, autumn olive and shrub lespedeza. Foliar applications using a 4-5 percent solution of a glyphosate or triclopyr herbicide are recommended for most woody plants, but you should always read and follow label directions.

Fig 7. A backpack sprayer with a GreenGard spray gun is efficient and effective to treat problem plants, such as Chinese privet and bush honeysuckle, which may require a spray distance of 30 feet or more.

Fig 8a, b and c. Oriental bittersweet had overtaken the understory of this stand (a), essentially requiring a broadcast application of Garlon 3A, which was applied using a backpack sprayer with a simple spray wand with a flat-fan nozzle. One month later (b), the Oriental bittersweet was eradicated. One growing season later (c), native groundcover flourished. However, be aware: a single application is never all that is needed. How did the bittersweet get there? Birds. Will they deposit more seed back later? You bet. And you must sever and treat all the large, bittersweet vines that are growing up in the tree crowns producing fruit. You must be diligent treating nonnative invasive species in your woods. It is never a single event, but an ongoing process.

WHICH TREE SPECIES SHOULD BE RETAINED?

In general, species that provide an important food source for the focal wildlife species should be retained (see Appendix 1). You also might retain some evergreen species, depending on the species, site and objective. For example, sporadic shortleaf or loblolly pine mixed in with desirable hardwoods provide seed for several bird species, and white pine, hemlock, spruce or fir can provide seed as well as protective cover for various birds, including ruffed grouse. Oaks are the primary hard mast producers for most wildlife species in the eastern US. A variety of species within both the white and red oak groups should be retained. Hickories also are common, but unless you are managing for squirrels or black bear, retaining hickories will not benefit many wildlife species. I'm not suggesting you cut or kill all the hickories. Certainly, you can at least leave a few for the squirrels, but the point is, you definitely should favor oaks over hickories when selecting trees for retention. American beech is another common species, and beechnuts are eaten by many wildlife species, but American beech is a very sporadic producer (maybe one good mast year out of 3-5 years) and it casts about as much shade as a hemlock. I leave the occasional large, mature beech tree when managing for deer or turkeys, but will kill most beech trees to favor understory development and more desirable overstory species. Persimmon, red mulberry and serviceberry are soft-mast producers that should be favored. Mulberry is the only soft-mast producer in late May/early June, and it can be an important source of energy at that time for many species. Note: keep in mind that persimmon and red mulberry are dioecious, which means the male and female flowers are on separate trees. Thus, don't cut or kill persimmon or mulberry trees that do not produce fruit—they likely are males, which are needed to fertilize the females! I also retain the occasional yellow-poplar, blackgum and black cherry. Various birds may eat yellow-poplar seed, and deer relish the big yellow and orange flowers rich in energy when they drop in June. Deer also may eat blackgum drupes and wild cherries to a lesser extent, but the number of those trees retained is determined by species composition of the stand and your objectives.

Fig 9. Retaining a variety of oak species, such as this northern red oak, increases chances for acorn production within a particular stand.

WHICH TREES SHOULD BE FELLED AND NOT TREATED WITH HERBICIDE?

I commonly fell trees less than 12 inches diameter at breast height (DBH) and girdle-and-spray larger undesirable trees, especially if there are many of them, because if you fell them, you can create a tremendous amount of large debris all at once, which can hinder movement and use by some species, including deer and turkeys. I prefer to kill large undesirable trees and allow them to fall apart slowly and provide snags that woodpeckers and many other species use for nesting, denning and foraging for years to come. The benefit of snags, as well as large downed logs, with regard to wildlife diversity cannot be overstated. If you want to manage your woods for a variety of wildlife species, and if you enjoy seeing all types

Fig 10a and b. Stumps of species commonly eaten by deer, such as this red maple (a) and blackgum (b), may be allowed to sprout to provide browse. Leaves of stump sprouts have a higher mineral content than leaves of saplings, likely because of the increased root:shoot ratio.

of wildlife, then you want snags and downed logs. From raptors to chickadees, black bears to shrews, and box turtles to fence lizards, snags and large downed logs provide something for a multitude of species. The exception to creating snags and allowing them to stand is when a snag is near the edge of a stand managed with fire. If fire gets into a snag, it can burn or smolder for days, which is problematic if the snag is adjacent to an unburned stand as wind can blow embers into areas not intended to burn.

I decide whether to spray the stump of felled trees based on the desired structure as well as browse preference. If I want to encourage dense woody sprouts for decreased visibility, or nesting structure for songbirds that require dense woody stems in the understory, I do not spray any stumps except nonnative invasive species. If I want a more open stand with increased visibility, I spray most if not all of the stumps to prevent them from sprouting. If deer is an objective, then I spray the stump of those species that deer do not typically eat, and allow more preferable species to sprout (see Table 1). Species that I regularly allow to sprout include the elms, blackgum, red maple, hackberry, redbud, green ash, white oak, laurel oak, shingle oak, black birch, striped maple and aspen (popple). I also may allow a few yellow-poplar, sourwood, sugar maple and black locust to sprout in a mixed stand, according to overall species composition. I typically retain flowering dogwood unless it is dense, and then I will fell many of them and allow them to sprout. Relatively small trees more limited in their distribution that I commonly allow to stump-sprout include common sweetleaf (horse-sugar) and swamp titi (American cyrilla), which are often browsed by deer.

HOW MANY TREES SHOULD BE CUT OR KILLED?

Your objectives and current stand conditions determine how many trees should be cut or killed and how much sunlight you allow into the stand. Closed-canopy stands typically allow only 2-5 percent sunlight in to the forest floor. A minimum of 20 percent sunlight is necessary on most sites to stimulate considerable understory development. Correspondingly, if a lush understory is desirable, you would want to kill or fell enough overstory trees to allow 20-30 percent sunlight into the stand. Additionally, you will need to kill or remove a majority of the midstory trees. If only midstory trees are removed in a closed-canopy stand, you typically will increase the amount of sunlight into the stand to about 10-15 percent. Cutting or killing a certain number of overstory trees is necessary to see considerable increases in light entering the stand, and you may need to cut or kill more than you initially think necessary to get the amount of light desired because of overlapping and subdominant tree crowns in the canopy.

Fig 11. This stand shows the structure and understory response typical after allowing approximately 20 percent sunlight into the stand.

You can expect increased understory development, and faster development, with increased amounts of sunlight allowed into the stand. In particular, woody sprout growth increases considerably with 50 percent or more sunlight entering the stand, which may be good, depending on your objectives. Such structure provides escape cover for white-tailed deer and black bear, foraging sites for ruffed grouse and woodcock, and nesting cover for wild turkey and shrubland songbirds. Many woody sprouts will grow 3-6 feet in a single growing season with sufficient rainfall and at least 50 percent sunlight. Growth of woody sprouts is not as fast with only 20-30 percent sunlight. Woody sprout development and density directly influence the structure of the understory.

If your objective is an open stand with little visual obstruction, then you might cut or kill only midstory stems or enough overstory trees to allow about 10 percent sunlight into the stand. Such stands may provide forage for deer (depending on understory plant composition), loafing areas for wild turkeys, and foraging sites for woodland songbirds. Open stands also are aesthetically pleasing to many people. If stands are managed as such for deer and turkeys, they should not be more than about 10 acres and positioned close to other stands or vegetation types that provide more understory cover with less visibility. If the stand is larger (with greater distance to cover), the central portion may not receive as much use by deer and turkeys.

If your objective is to increase mast production, then the number of trees to cut or kill is determined by tree species composition and overall tree density. Cutting or killing undesirable trees adjacent to the crown of desirable trees will

Fig 12. Woody stems typically are dense and grow relatively fast when greater than 50 percent sunlight is allowed into a stand, which is good for various objectives. This stand was thinned 8 years prior to allow sufficient sunlight to stimulate dense woody stems. If you retain good mast producers, such as this white oak, and allow dense stems to regenerate within the stand, food (acorns) within dense cover is provided for species such as white-tailed deer, black bear and ruffed grouse. However, disturbance through fire or cutting every several years (usually within 6–8 years) is necessary to retain dense cover.

allow the crown of desirable trees to spread, often increasing in size by 25 percent in one growing season. You will find that as you kill or remove undesirable trees, the crowns of retention trees fill the available canopy gaps rather quickly. Thus, it may be necessary to kill or remove additional trees after a few years to maintain a certain amount of sunlight entering the stand. This type of crop-tree release obviously influences tree species composition in the stand. With just a little work, the percentage of trees in the stand is strongly increased in favor of desirable species.

Regardless of the number of trees cut or killed and the amount of sunlight entering the stand, some type of disturbance is required periodically to maintain the desired plant species composition and structure. Without disturbance, woody stems in the understory grow into a midstory, and those trees shade-out desirable plants in the understory, leaving the forest floor relatively open and with only shade-tolerant plants, such as a few tree seedlings or sprouts, ferns, greenbrier, japangrass and Pennsylvania sedge. Prescribed fire (discussed in the following pages), chainsaw work and herbicide applications are options to maintain desirable understory cover and structure.

The value of dead wood

Standing dead trees, called snags, as well as downed logs provide shelter and food for a plethora of wildlife species. The presence of dead wood, particularly relatively large stems greater than 10 inches or so in diameter, likely leads to greater increases in wildlife diversity than any other single in-stand characteristic. Woodpeckers are the most obvious species that are attracted to standing dead trees. Pileated woodpeckers and northern flickers, in particular, are primary cavity excavators that may be regarded as keystone species, meaning their presence leads to presence of many other species as the woodpeckers provide subsequent nesting cavities and dens for other animals after the woodpeckers leave a cavity. Red-bellied woodpeckers also are common in hardwood forests, and red-headed woodpeckers are a woodland obligate commonly found in both pine and hardwood woodlands in portions of the eastern US. These species also excavate cavities. Other woodpecker species, such as hairy and downy woodpeckers and red-bellied sapsucker, and some nuthatches excavate cavities in soft woods with advanced decay or use cavities made prior by other woodpecker species. Other birds that nest or roost in cavities of snags in upland hardwood forests and woodlands, but are unable to excavate cavities, include barred, screech and great horned owls; American kestrel; wood duck; Carolina chickadee; tufted titmouse; great crested flycatcher; Carolina wren; and Eastern bluebird. Other birds may not nest in snags, but use them for perching, including hawks, bald eagle, kingbird, and various herons and egrets when snags are adjacent to beaver ponds and rivers. Mammals also make use of snags. Eastern gray

Fig 13a and b. Snags created through FSI operations provide critical nesting, roosting and denning sites for many animals. A Carolina chickadee is nesting in this 8-inch diameter hickory (a) killed by girdle-and-spray. Sassafras (b) is a soft wood commonly used by woodpeckers and other species for cavities.

squirrel, raccoon and even black bear often den in snags of hardwoods in the eastern US. Several species of bats, including evening bats, roost in snags. Some snakes and lizards hide under the sloughing bark of snags

Downed logs are created when a live tree, tree limb or snag falls or is cut; they offer critical cover and foraging sites for many species, especially reptiles, amphibians and small mammals. Several species of snakes and salamanders are found under relatively large-diameter (4 inches or larger) wood, whether for the moist microclimate or to find food by way of the many ants, worms, beetles, spiders, centipedes, millipedes and other invertebrates commonly associated with decaying wood. Fence lizards are closely tied to downed wood in woodlands and savannas where there is a drier climate influenced by relatively frequent fire. Shrews also forage for invertebrates, and chipmunks cache nuts and den under logs. Eastern box turtles burrow under logs during periods of drought and during fire events, and male ruffed grouse use large logs for drumming to attract females. All this to say that large logs and decaying wood should not be viewed negatively, but as a vital component of healthy functioning forests, woodlands and savannas.

Fig 14. Downed logs provide critical sources of cover and food for many wildlife species. And even when using frequent fire to maintain oak woodlands, downed logs will remain for many years.

RECOMMENDATIONS FOR PERCENT SUNLIGHT VS. TARGET BASAL AREA

The scenarios explained above discuss and recommend providing a certain amount of sunlight into the stand as opposed to recommending a certain residual basal area (BA), which is the amount of space represented by tree trunks, usually expressed in square feet per acre measured at 4 ½ feet aboveground. The reason I recommend a certain amount of sunlight instead of a target BA is because BA is so variable with regard to site quality, tree species and age (size) of the trees that a BA recommendation is almost meaningless. For example, on a poor-quality site with mature mixed-hardwood species, a closed-canopy stand may have a BA of only 85 sq ft/ac, whereas a younger developing stand on that same site may have a BA of 125. A mature stand on a high-quality site may have a BA of 120-150, and on a really good site, it is possible for a stand to have greater than 200 sq ft of BA. However, on all those sites, the amount of sunlight entering the stand can only range from 0-100 percent, and it is the amount of sunlight entering the stand that determines plant response, influencing both composition and structure.

It can be a little tricky estimating percent sunlight coming into a stand. Without a ceptometer (an electronic device that precisely measures light infiltration) or a densiometer (a hand-held device with a convex mirror that provides a crude estimate of light infiltration), you are essentially guessing how much sunlight is entering the forest canopy. That's OK. You don't have to be exact. Crude estimates (such as 10 percent, 25 percent, 50 percent) work fine. And you will discover that managing light levels coming into the stand is an ongoing process. As the understory plants and the overstory trees respond to changes in light levels, continued management is necessary to maintain the structure and light levels that you desire.

Fig 15. A ceptometer provides precise measurements of light infiltration when conducting research related to vegetation response and available sunlight. Fortunately, this level of precision is not necessary when implementing FSI.

TREE SPACING

Another consideration is tree spacing. Consistent spacing at a certain BA is used when managing pine plantations because crown size of individual trees of a given age are very similar and an even spacing promotes tree growth and volume for timber production. However, crown sizes of different hardwood species vary considerably, and an uneven spacing promotes heterogeneity in species composition and structure of the understory, which is highly desirable for many wildlife species. Therefore, in general, I recommend ***variable retention*** when managing mixed hardwood stands. That is, you don't need an even spacing of trees, and you likely will benefit with uneven spacing. There will be areas in a mixed stand where most of the trees are desirable, and there will be other areas where few if any trees are desirable, and of course other areas where there is a relatively even mix. If you "treat it as you see it," then you will kill or cut fewer trees where most of them are desirable, you will kill or cut several where there is an even mixture, and you will kill or cut a lot where most are undesirable. That type of treatment provides a mosaic of conditions that can provide multiple benefits, including food and cover, for more wildlife species, and it better meets the requirements of species that require multiple types of cover and food. For example, the areas of a stand with fewer trees and more sunlight may provide optimal nesting cover for wild turkey, whereas areas of the stand with more trees and less sunlight typically have lower cover and more open structure at ground level, which may be optimal brooding cover for wild turkey. Where there is more sunlight, woody sprouts will grow taller and provide nesting cover for shrubland songbirds,

Fig 16. Even tree spacing should not be an objective when managing a hardwood stand for most wildlife species. Fewer trees may be killed or cut in sections of stands where a majority of the tree species are beneficial, whereas more trees may be killed or felled in sections where a majority of the trees are undesirable or when increased understory development is desirable. This variable retention provides a mosaic of structure, food and cover for a wider suite of wildlife species.

such as hooded and worm-eating warbler. Where there is less sunlight, understory cover may be shorter and sparser, attracting more woodland songbirds, such as red-headed woodpecker and great crested flycatcher, that nest in overstory tree canopies, but forage in open stands with less midstory development.

WHAT IF ALL THE TREES ARE DESIRABLE SPECIES?

Although relatively uncommon, there are some stands, or relatively large areas within a stand, where nearly all of the trees are desirable species. In those situations, trees of desirable species must be cut or killed to stimulate the understory or enhance the structure of cover (height and density of understory and midstory vegetation) in the stand. Determining which trees to retain continues to be based on species, crown class and mast production potential. In general, it is a good idea to retain multiple mast-producing species, including those within a single genus, such as oaks, as well as others that produce mast at a different time of year, including hard and soft mast producers. For example, chestnut oak produces acorns relatively early in September, whereas white oak produces later in October and early November. Oaks from the white oak group and the red oak group commonly have good acorn production in different years because red oak acorns require two years to develop, whereas white oak acorns develop in the fall after flowering in spring. Therefore, if you have to cut/kill some oak trees, be sure to retain some from both groups and of different species. If you need to cut/kill individuals within a species, it is best if you can identify which ones are the best mast producers. The only way you can do that is by observing which trees are good producers in a good mast-production year. For example, in a year when the white oak acorn crop is good, walk through your woods and mark those white oak trees that do not have any (or very few) acorns under them. Those are the inherently poor

producers. Interestingly, some individuals of a given species are good producers and some hardly ever produce anything (see sidebar). Not all trees of a given species produce mast equally, and there is no way to predict which trees are the good ones. Age also can be a factor, especially among red oak species. Trees of advanced age in the red oak group often decline in acorn production, and a decision to select longer-lived white oak species may be appropriate. Nonetheless, surveying your trees during good acorn years of particular species will highlight which trees are productive and those that are not.

Fig 17a and b. Sometimes it is necessary to kill/cut desirable species to increase sunlight into the stand. It is best if you can identify which individual trees are good producers, then remove those that are poor producers. Suppressed individuals and those with poor form can be removed to add small amounts of light. Look up, not down! These decisions are made by evaluating the shape, size, and position of the tree crowns. Here, a double-stemmed white oak, positioned between two desirable trees, was killed because it had such poor form and virtually no crown.

Does fertilization increase acorn production?

No. However, you commonly see recommendations in hunting magazines and other non-scientific sources to fertilize oak trees to produce more (and even sweeter) acorns. To evaluate these claims, my graduate students and I began a field experiment in 2006 whereby we marked 120 dominant or co-dominant white oak trees and collected acorns in mast baskets under each tree for 5 years. Following 5 years of pretreatment data collection, we were able to place trees into four production classes: excellent, good, moderate and poor. In 2011, we implemented three treatments proportionately to each of the production classes. Our treatments included 1) crown release (CR), 2) fertilization (F), and 3) crown release and fertilization (CRF). We also maintained a group of control (C) trees (no treatment) for comparison. Crown release involved killing or removing competitors all the way around the tree to provide CR and CRF trees with open growing space. Fertilization included application of 150 lbs/ac actual N as well as applications of phosphate and potash according to soil test to raise soil P and K to high levels around each F and CRF tree. We applied fertilizers in this manner, according to soil test conducted each year, for 5 years. We collected acorns under C trees and F trees, hulled the acorns, and submitted the acorns to a lab for nutritional analysis.

From the pretreatment data collection period, we discovered approximately half of the trees were poor producers and accounted for only 10 percent of the acorns produced. Approximately one-third of the trees produced 75 percent of the acorns. Following 5 years of treatment, CR trees increased acorn production by 65 percent. Canopy-released and fertilized trees (CFR) increased acorn production by 47 percent. Fertilized-only (F) trees did not increase in acorn production. After 5 years of treatment, 35 percent of the CR trees increased in production class, and 28 percent of the CRF trees increased in production class, whereas F and C trees remained similar in production class. Lab analysis indicated nutrient content in acorns from fertilized and

non-fertilized trees were similar, with no increase in sugar content to make fertilized trees "sweeter."

Our research demonstrated that releasing white oak trees from competition can lead to increased mast production, and that fertilization coupled with release did not increase acorn production beyond release only. Clearly, fertilizing oak trees in the woods is a waste of time and money. For trees grown in open spaces, such as those planted in fields, fertilization may lead to increased growth of the tree, but not mast production beyond the effect of growing a larger crown in open space. And healthy trees grown in the open, even without fertilization, commonly produce mast/fruit at earlier ages than those growing with competition in the woods.

Fig 18a. We measured acorn production for 10 years to determine acorn production class and whether crown release and fertilization influenced acorn production.

Fig 18b. Five years of continuous fertilization did not increase acorn production among white oaks.

Fig 18c. Some oak trees produce acorns, some do not, and there is no known characteristic to determine which are the good producers. You simply have to identify the good producers during years of good acorn production.

Fig 18d. Releasing tree crowns from surrounding competition did lead to increased acorn production.

WHAT ABOUT FIRE?

Fire is a natural disturbance in hardwood forests of the eastern US. Prescribed fire is used to consume leaf litter, stimulate fresh understory growth, and top-kill small-diameter woody sprouts to maintain a desired structure of vegetation in the understory and midstory, according to objectives. Fire is most ecologically suited to exposed south- and west-facing slopes, which are relatively dry and easier to burn, but fire also may be used on more mesic (relatively moist) sites when conditions allow.

Prescribed fire can be used safely in hardwood stands without damaging or killing overstory trees as long as low-intensity fire is used and large woody debris is not accumulated at the base of retention trees. Some hardwood trees are more resistant to fire than others. Relatively thin-barked trees, such as American beech, black birch and flowering dogwood, are more susceptible to heat than species with thicker bark. In general, backing fire and flanking fire should be used with flame lengths no more than 6-10 inches if damaging retained overstory trees is a concern. However, strip-heading fire often is necessary to get the fire to move through the stand, especially when using growing-season fire after full leaf-out when the forest floor is shaded and fuel moisture is relatively high.

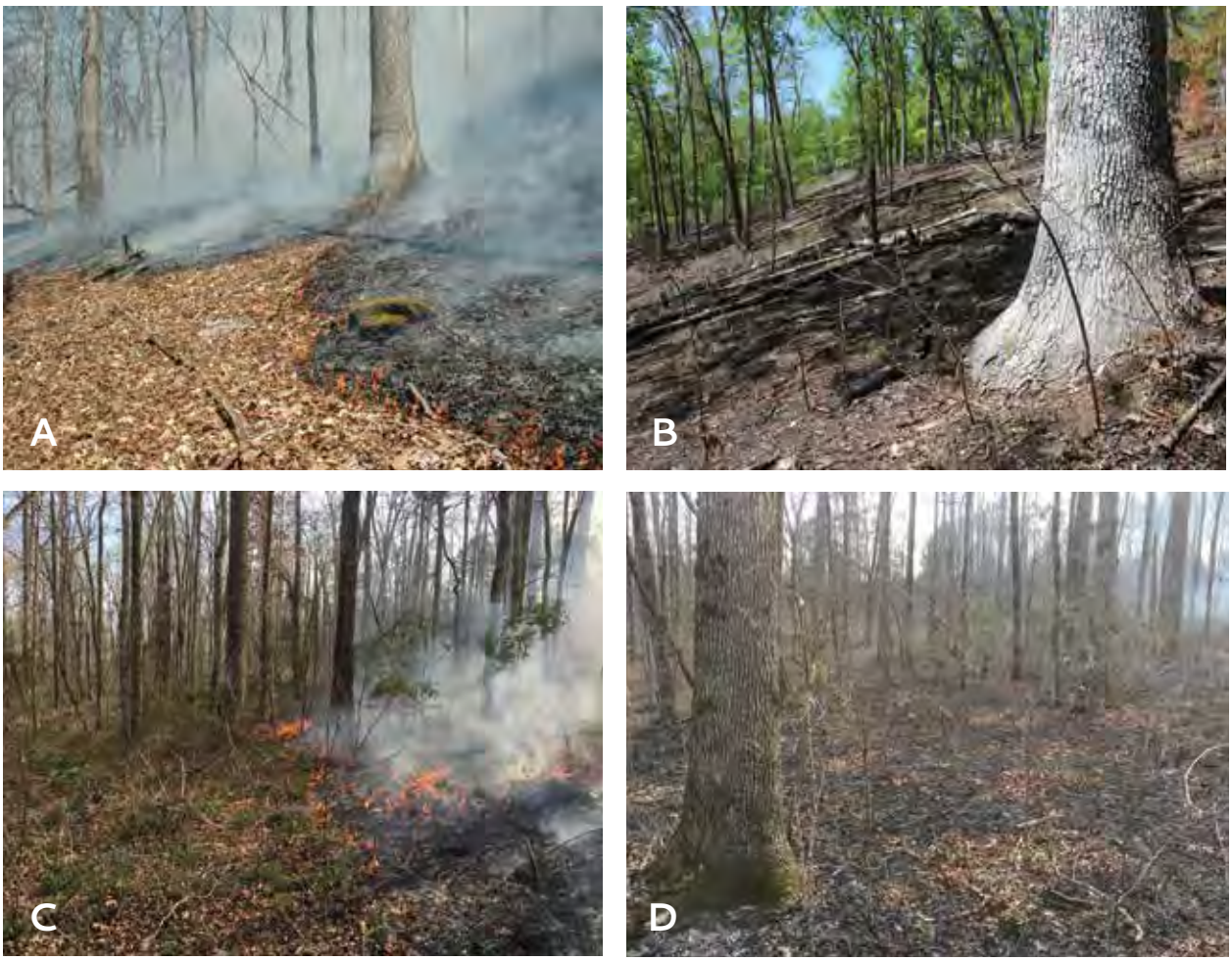

Fig 19a, b, c and d. Low–intensity fire with flame lengths less than 6 inches should not damage overstory trees, whether burning upland hardwoods in the Ridge and Valley (a and b) or in the Coastal Plain (c and d).

Fig 20. Moderate-intensity fire, as seen here with this heading fire with flame lengths greater than 10 inches, are more likely to damage overstory trees and will kill most midstory trees.

Prescribed fire is by far the most efficient practice used to manage and maintain understory composition and structure. For example, think of how much easier it is to allow a slow-moving, low-intensity backing fire to top-kill all those woody stems in the understory as opposed to cutting them with a chainsaw or spot-spraying using a backpack or ATV sprayer! Fire effects on vegetation are influenced by fire intensity, frequency and season of burning, and you really cannot consider one without considering them all because they are so interrelated, and each impacts the other. Site quality (soil nutrient availability and moisture) and available sunlight also influence fire effects on vegetation. General fire effects on vegetation are described below, but keep in mind, there may be considerable variation from site to site.

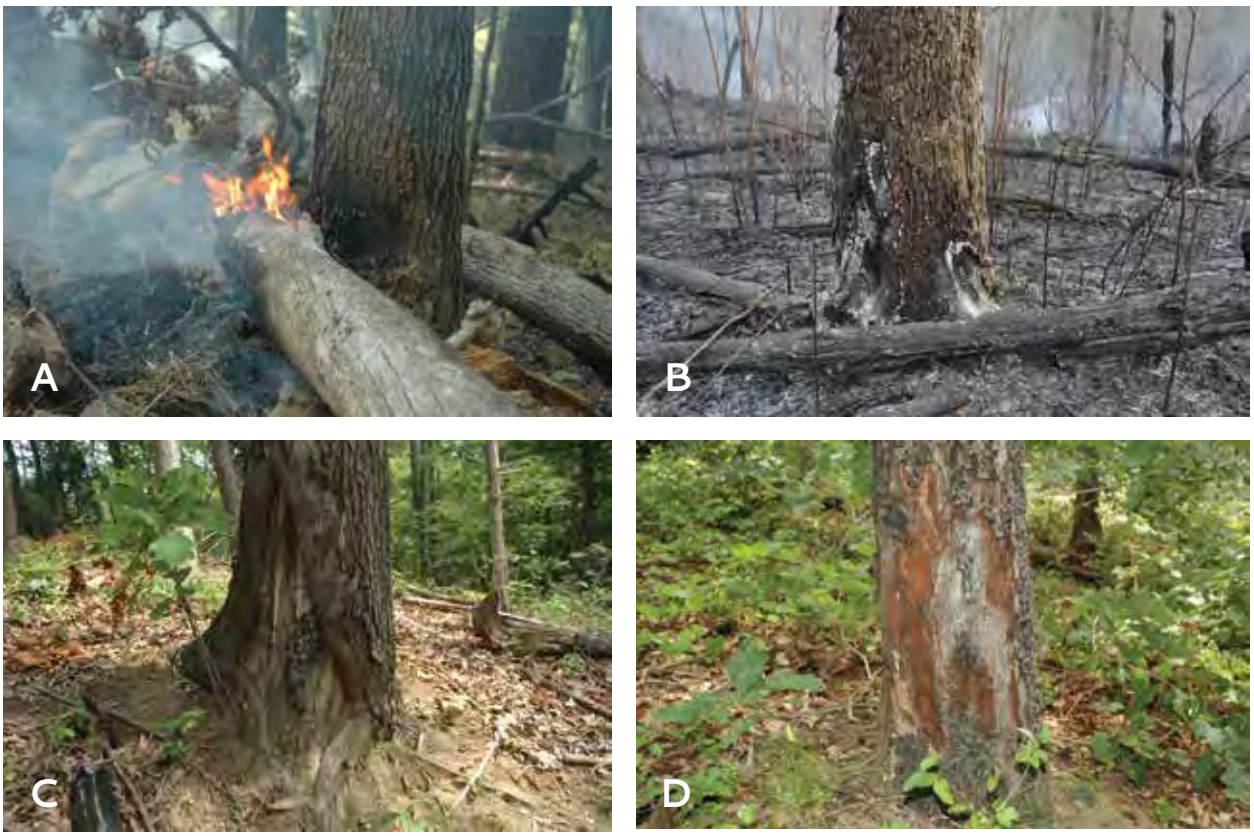

Fig 21a, b, c and d. Relatively large debris at the base of overstory trees may burn over a relatively long period of time and allow heat to penetrate the bark and damage the cambium layer (a and b). Such damage may lead to tree mortality, or in many cases, the scar heals over (c, d and e).

Fire intensity and frequency strongly influence vegetation composition and structure. Of course, a very intense fire can kill all of the trees and enable full sunlight to enter a stand. Without additional fire, a new forest then establishes quickly from root sprouts and seed. Alternatively, a very low-intensity fire may not even consume all of the dead leaf litter and be so spotty that many of the seedlings and none of the small-diameter (less than 1 inch) saplings are top-killed, creating little or no vegetation change in the stand. If intensity is hot enough to top-kill seedlings and saplings, then an open understory structure is created in the stand, but these small trees typically sprout back and grow relatively quickly. Fire frequency (fire-return interval) then is important to maintain a particular structure (density and height) of vegetation in the understory and midstory, which strongly influences which wildlife species use the area.

Frequent low-intensity fire (every 1-2 years) maintains an open stand with limited to no midstory development, as long as fire intensity is hot enough to top-kill the woody sprouts. In areas receiving full sunlight, woody sprouts may grow 6-plus feet tall in one growing season, but in shaded areas, sprout growth usually is considerably slower. After several fires, a 1- to 2- year fire-return interval will lead to an understory dominated by herbaceous species. Less-frequent burning (every 3-5 years) maintains a mixture of herbaceous and woody species in the understory and allows many stems to develop into the midstory (which technically includes woody stems taller than 4.5 feet and those less than 4.5 inches in diameter measured 4.5 feet aboveground). Sporadic burning (every 5-8 years) maintains an understory dominated by sprouting woody stems, and with at least 30 percent sunlight entering the stand, maintains a relatively dense midstory with reduced visibility in the stand. If you wait more than 6-8 years to burn the understory, the woody stems will be so large in diameter (greater than 3-4 inches at ground level) that a more intensive fire is needed to top-kill them. With more intensive fire, there is greater chance of damaging residual overstory trees. However, an intensive fire that kills overstory trees can be good if most of the trees are low-value (for wildlife or timber) or if wildlife that require dense woody stems that regenerate

Fig 22a, b and c. Low-intensity fire every 1-2 years maintains an understory dominated by herbaceous species (a, shown in late May after burning in early April). An open structure is typical when no more than 30 percent sunlight enters the stand. Low-intensity fire every 3 years or so maintains a mixture of herbaceous and woody species with variable structure in the understory (b, shown in July after burning in February). Low-intensity fire every 5 years or so maintains relatively dense woody structure to provide bedding areas for deer and nesting/foraging cover for brown thrasher, eastern towhee and gray catbird (c, shown in September after burning in early April).

following fire are focal species. However, in almost all situations, it is most desirable and sensible to reduce canopy closure and allow more sunlight into the stand by killing or felling the specific trees that you do not want to retain. Intensive fire is not very selective!

Effects of season of burning on vegetation are not as strong as fire intensity or frequency. Most prescribed fire in hardwood stands is conducted during the dormant season when leaves are off the trees (see Figs 19a and c). Burning during this time of year can be relatively intensive as full sunlight reaches the forest floor and dries the leaf litter relatively rapidly and more thoroughly than during the growing season when the forest floor is partially to fully shaded (see Figs 20 and 24 vs. Fig 27a and b). Burning during the dormant season is relatively easy on a clear day with low humidity, but care must be taken to use backing and flanking fire, which are less intensive than heading fire, and to burn when the duff layer under the leaf litter is relatively moist to help prevent damaging overstory trees. Burning during the dormant season consumes leaf litter, stimulates fresh understory growth, and top-kills small-diameter woody stems. However, the woody stems sprout back, and continued burning during this time over many years tends to promote warm-season grasses as well as persistent woody sprouting. It may take 20-plus annual burns during the dormant season before most of the woody stems stop resprouting. Such frequent fire is unnecessary for the majority of objectives, but the point is that resprouting woody stems are incredibly persistent.

Burning during the early portion of the growing season (up to several weeks after bud break and leaf emergence) generally produces the same vegetation effects as burning during the dormant season. This time period also coincides with nesting and emergence of some species (such as box turtles) from hibernacula, which could have negative implications at a local scale if burn areas are extensive and if burning is conducted regularly during that time of year. However, if burn units are relatively small and separated in time and space, negative effects on local populations are unlikely. That being said, if the vegetation effects of burning during spring are no different than burning earlier in the dormant season, then there is little reason to burn during the reproductive season of so many wildlife species unless you need the additional burn days to achieve your burn-acreage goals.

Fig 23. Small-diameter woody sprouts, such as this red maple, typically resprout when top-killed by fire. Burning during the latter portion of the growing season may reduce woody sprouting better than burning during the dormant or early portion of the growing season, but expect most to resprout regardless of season of burn.

Fig 24. Fire intensity during the dormant season is more intensive than during the growing season after full leaf-out with similar environmental conditions. Backing and flanking fire usually are necessary to keep fire intensity low.

Fig 25a and b. Frequent low-intensity fire (every 1–2 years) during the early growing season over many years (at least five or six fires) often promotes an understory dominated by warm-season grasses, but composition varies by site, such as this silver plumegrass (top) and broomsedge bluestem (bottom). Altering your timing of fire helps promote a more diverse plant community.

Burning later in the growing season from midsummer though the end of the growing season may elicit change in plant composition. In particular, burning from midsummer until leaf-fall often promotes increased coverage of forbs and decreased coverage of warm-season grasses. Burning at this time also may reduce woody composition in the understory better than dormant- or early growing-season fire if the fire is intense enough to top-kill the woody stems. However, effects may vary by tree species, and most top-killed saplings will resprout regardless of season of burning unless burning is frequent and implemented over many years.

Fig 26. Frequent moderate-intensity fire is used to promote and maintain oak-pine savannas, such as this site at the Bridgestone-Firestone Prescribed Fire Demonstration Area near Crossville, Tennessee, which has been burned 5 times on a two-year fire-return interval.

Fig 27a and b. Low-intensity fire during the mid- to latter portion of the growing season can be used to increase forb coverage and decrease woody composition (a). When burning hardwoods in mid- to late summer, a heading fire often is necessary to get the understory to burn (b).

In general, burning in hardwoods during the growing season is much more difficult than burning during the dormant season because of fuel moisture and shade. Hardwood leaf litter retains moisture a long time, and green leaves are 70-90 percent water; thus, it requires a lot of energy for the fire to evaporate the water before the leaf material can be consumed. Often, it is impossible to burn in hardwoods during the growing season unless it is relatively dry and there is a minimum of 30 percent sunlight entering the stand, and even then, most often, a 3-5 mph wind will be necessary to move the fire. In general, fire intensity and fuel consumption are less when burning during the growing season after full leaf-out than during the dormant season, meaning there often will be unburned patches in the stand. Depending upon objectives, unburned patches may be desirable as they lead to increased diversity in plant composition and structure.

If high-quality forage for deer is the primary consideration, fire should be applied frequently (every 1-3 years) with some burns conducted in mid- to late summer. This burning regime will maintain an open stand condition, which also benefits various woodland birds, including red-headed woodpeckers, great crested flycatchers and summer tanagers, and provides outstanding brooding cover for wild turkey. With 30-50 percent sunlight entering the stand, these areas can provide nearly as much forage as a high-quality food plot, and the broken canopy facilitates foraging by bats.

If more dense cover is desired to maintain consistent bedding areas for deer, then less frequent fire is required. Burning should be implemented primarily during the dormant season, every 5-8 years, when young trees approach 3-4 inches diameter at ground level. These "bedding blocks" are optimal when about 10 – 15 acres in size, and they provide nesting cover for wild turkey, Kentucky warbler, eastern towhee, brown thrasher, white-eyed vireo, and worm-eating warbler, to name a few (see Figs 22c and 29). Ruffed grouse and black bear also are attracted to the dense cover.

Fig 28a and b. FSI using felling, girdle-and-spray, and low-intensity prescribed fire has been implemented in this stand since 2004. As of 2020 when picture was taken, it has been burned eight times during the dormant, early growing, and late growing seasons. Variable retention has been used to allow an average of 47 percent sunlight into the stand (a). There is 80 percent groundcover with 60 percent coverage of forbs, including beggar's-lice, asters, partridge pea, ragweed, sticktights, as well as scattered brambles and vines (b; inset). Available deer forage approaches 1,500 lbs per acre (leaves only, not total biomass, which rivals that of many warm-season food plots), every tree standing is a desirable mast producer, fawning cover is present throughout, nesting and brooding cover for wild turkey is excellent, and various shrubland, woodland and forest songbirds occupy in the stand.

Fig 29. Infrequent low-intensity fire can be used to top-kill small woody stems and stimulate herbaceous groundcover. Here, we have just completed a low-intensity fire in late September to set-back woody growth and maintain forb cover in the understory.

Firebreaks are necessary when burning to help prevent fire from spreading into areas unintended to burn. Firebreaks may be natural or established. Roads, creeks and other drainages represent natural firebreaks. Firebreaks are often established with heavy equipment, such as bulldozers and tractors with a disk harrow. However, heavy equipment is not necessary to create firebreaks. Furthermore, some landowners do not have access to heavy equipment, terrain may preclude use of heavy equipment, and some people do not want see relatively long-term scars caused by heavy equipment in their woods. An alternative is use of backpack blowers, which are relatively cheap and easy to use. If there is considerable groundcover, use of a backpack sprayer to kill the vegetation several weeks prior to burning may be necessary. A blown firebreak 5-10 feet wide is sufficient in most cases. Use of a backpack blower also allows you to manage relatively small areas in your woods with fire. When managing for deer and turkeys, 1- to 5-acre sized areas can be very attractive for foraging, bugging and strutting. You don't have to burn 25-50 acres to be effective!

Fig 30a, b and c. Backpack blowers can be used to create effective and efficient firebreaks in woods without heavy equipment. They can be sown to annual clovers in late summer/early fall, such as this one with crimson clover.

Fig 31. You don't have to treat 50 acres to make a positive impact. Have you ever planted a small food plot and deer and turkeys used it? Well, you can cut/kill a few trees in a small area of woods, establish a firebreak around it with a backpack blower, burn the area with low-intensity backing fire, and provide increased deer forage and nesting cover for turkeys with relatively little effort and expense! Of course, the impact is greater if you implement several of these across the property.

HOW DOES HINGE-CUTTING FIT IN?

Hinge-cutting involves making a partial cut through a tree stem such that the tree falls but remains attached to what would be the stump. The intention is for the tree to remain alive and increase horizontal structure and reduce visibility in the stand. The resulting cover is attractive to many wildlife species and differs from the cover provided by dense stems growing vertically following a stand thinning or cut. The ability of the tree to remain alive is greatly influenced by the amount of hinge-wood or "meat" that is left intact. Typically, it is necessary to cut about 2/3 of the diameter of the stem to get the tree to fall over. Poles with a large hook or a V-shaped attachment fabricated at the end can be used to pull or push a tree over while retaining as much hinge-wood as possible. Wedges also can be inserted into the cut to aid and help direct felling. Hinge-cuts typically are made 2-5 feet aboveground, depending on the height of the structure you desire. Most often, hinge-cutting is restricted to trees 4-10 inches in diameter. Hinge-cutting trees smaller than 4 inches does not offer much cover, and hinge-cutting larger trees is more dangerous. Various tree species hinge better than others (see Table 1). Some species, such as ash, walnut and yellow buckeye, do not hinge, but split up the trunk when cut about halfway through.

Fig 32a, b and c. Hinge-cutting can be used to create immediate horizontal cover, such as this hinge-cut American beech (a). Be sure to identify the species of tree before hinging. Some species, like this hackberry (b), hinge better than others, such as this yellow buckeye (c), which can be dangerous because they split up the trunk.

Hinge-cutting may be implemented throughout a stand if extensive, dense cover is desired, or it can be implemented to only one or a few trees in a particular spot where increased horizontal cover is desired, or to influence direction of movement by wildlife, especially deer. Hinge-cutting can be used in combination with felling and girdle-and-spray depending on tree species, size of tree, and amount of horizontal structure desired. For example, species that deer prefer for browse may be felled and allowed to sprout from the cut stump because leaves from stump sprouts are much more nutritious and digestible than the crown leaves of a hinge-cut tree (see Figs 10a and b). Species that hinge well and are not as selected by deer (such as hickories, beech, sweetgum, oaks) can be hinge-cut to create horizontal structure attractive for bedding cover. Winged elm, American elm, blackgum, hackberry and sugarberry are a few species that hinge very well, but the stump spouts also are highly selected by deer.

MANAGING YOUR "WOODS ROADS"

An often-overlooked component of FSI is management of woods roads, and access to various parts of your property is important for many reasons. Woods roads vary greatly from

Figs 33a, b, c, and d. Woods roads that do not receive much travel can be planted, such as this road maintained with ladino clover (a). If the road receives much traffic, it should be graveled, but the sides can be widened and planted to provide additional forage (b). Woods roads don't have to be planted. Naturally occurring plants can provide warm-season forage (c). A common problem along woods roads is japangrass (d), but it is easily controlled with an application of imazapic (such as Plateau) or clethodim (such as Clethodim 2EC).

Woods road planting mixtures

Perennial mixture

4 lbs ladino clover
5 lbs red clover
2 lbs chicory
40 lbs awnless winter wheat

Manage by mowing once per year in late summer. Broadleaf weeds can be controlled with imazethapyr (such as Pursuit) or imazapic (such as Plateau) after the wheat has died, or you can leave out the wheat.

Annual mixture

15 lbs crimson clover
8 lbs Frosty berseem clover
4 lbs balansa clover
40 lbs awnless winter wheat

Manage by spraying a glyphosate herbicide to control incoming weeds after the planted forages have died in summer, or allow the seedbank to respond if you do not wish to maintain the road in planted forages.

All seeding rates are for broadcast plantings in pounds of Pure Live Seed (PLS) per acre. Refer to *Wildlife Food Plots and Early Successional Plants* (nocsopublishing.com) for additional information on planting, herbicide applications and woods road management.

wide graveled roads that support vehicle traffic to narrow trails suitable only to ATVs. From a wildlife perspective, woods roads can be managed in various ways to provide increased foods, enhanced cover or corridors for movement. The most common management of woods roads is planting and "daylighting."

Roads that receive little or no vehicular traffic can planted to various forages for wildlife. Planting roads helps prevent erosion and can be much more impactful to wildlife across a property than planting logging decks or isolated forest openings. Roads traversing properties provide forage to more animals because they intersect more individual home ranges than isolated openings. Entire roads do not have to be planted. Naturally occurring plants from the seedbank can be promoted when present, but some planting often is necessary on newly created roads where heavy equipment removed the upper layer of soil containing the seedbank and where erosion is a concern. If hunting is a priority, sections of roads that facilitate hunting can be planted and other sections managed with naturally occurring plants that are less attractive to deer and turkeys during the hunting season. All this to say, there are lots of options, and planting roads enables you to provide increased nutrition to portions of a property where forage may be lacking during a particular time of year.

Most often, perennial cool-season forages are used to increase available nutrition and prevent soil erosion. Perennial clovers and chicory are well-suited for most applications. Annual forages, including annual clovers, winter wheat, oats and brassicas, also may be used to enhance winter forage availability. Perennial grasses, such as tall fescue, orchardgrass and bluegrass, should not be planted where wildlife is a consideration because they provide exceptionally poor forage and outcompete more desirable plants.

Plants require sunlight, water and nutrients. Sunlight often is limited along woods roads because of shade from adjacent trees. "Daylighting" woods roads involves cutting or killing trees along the road to provide additional sunlight. You do not need to kill or cut all of the trees along a planted road, but you should kill or cut enough of them to allow at least 4 hours of direct sunlight to the road to ensure survival, growth and productivity of

Fig 34. This ATV road was created through the woods by cutting a few trees near the ground, spraying the stumps with an appropriate herbicide, killing existing vegetation along the road with ATV sprayer, then top–sowing wheat and oats to provide additional forage for deer and turkeys.

the planting. Trees of desirable species and form may be retained. Allowing a logger to come in and remove trees within a certain distance of the road is another option, especially if the road needs maintenance with regard to grading or culvert installation. Allowing a logger to take large trees of species that do not fit your objectives, such as sweetgum, yellow-poplar, walnut and hickories, along a road can "sweeten the pot" if you are wanting the logger to help you with thinning a particular stand, but the trees you want removed in the stand are not worth enough for the logger to conduct the operation. Even if you do not plant the road, daylighting encourages growth of naturally occurring plants in the road and stimulates fresh browse along the side of the road. Depending on how many trees are removed, dense structure can be created along the road, which is highly desirable for many species, including shrubland songbirds, deer, ruffed grouse and nesting wild turkey.

Most people think of woods roads only as those capable of driving a truck or large tractor. Do not overlook the value of woods roads that are only accessible via ATV. You don't have to have a bulldozer to create woods roads for ATVs. These roads can wind through woods without the need of cutting large trees. By cutting small trees near to the ground that are in the way, spraying the stump with the herbicide mixture provided on page 5, then spraying the road with herbicide containing glyphosate or triclopyr via backpack or ATV sprayer, you can create an ATV road fairly easily and with little expense. According to the amount of sunlight allowed onto the road, ATV roads also can be planted. After killing the plants along the road, a backpack blower can be used to clear the road of leaves, and you can no-till top-sow the road to clovers, small grains or brassicas, similar to a blown firebreak (see Fig 30c).

CONCLUSIONS

Forest stands can be treated in many different ways to achieve desired objectives for wildlife. However, before you can decide what treatment or practice is best, you must identify and state your objectives explicitly. It is obviously important to distinguish wildlife objectives from timber objectives, but equally important and less intuitive is, which wildlife species are you trying to manage? What are the biological requirements for that (or those) species, and what are the current limiting factors on your property that need to be addressed? Bedding cover? Nesting or brooding cover? Snags or downed wood? Soft or hard mast production? High-quality forage? Structure to influence movements? These are just a few of the many considerations, and no one treatment or practice addresses or improves all of them. Furthermore, the level at which the various management practices are implemented strongly influences what type of cover, structure, or food is provided, as well as its distribution on the property. For example, as discussed, a thinning or cut that enables 20 percent sunlight to enter the stand will have a very different effect than one that reduces canopy cover by 75 percent. Finally, your perspective toward accomplishing your objectives is important. Managing your forested acreage, just like when managing old-fields and other early successional communities, is not an event, it is a process. You will never be "done." Trees continue to grow and the composition and structure of the understory will continue to change with changing light levels and management. Enjoy the process while you are able. There is much satisfaction in being a good steward of your forest resources as you guide the composition and structure of the forest in the direction you want it to go.

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Table 1. Trees common to eastern hardwood forests and their value to wildlife.

SPECIES[1]	MAST VALUE[2]	BROWSE VALUE[3]	HINGE SUITABILITY[4]	COMMENTS
Red maple *Acer rubrum*	Low/Med	Med	Fair	Browse from stump sprouts selected by deer; seed eaten by several bird species
Silver maple *A. saccharinum*	Low/Med	Low	Fair	Seed eaten by several bird species
Striped maple *A. pensylvanicum*	Low	Med	Fair	Browse from stump sprouts selected by deer; seed eaten by some bird species
Sugar maple *A. saccharum*	Low/Med	Low	Fair	Seed eaten by several bird species
Boxelder *A. negundo*	Low	Low	Poor	Seed eaten by some bird species
American holly *Ilex opaca*	Med	None	Fair	Drupes eaten by many bird species in winter
Yellow birch *Betula alleghaniensis*	Low	Low	Poor	Buds, twigs, and catkins eaten by squirrels and grouse
Black birch *B. lenta*	Low	Med	Poor	Buds, twigs, and catkins eaten by squirrels and grouse
River birch *B. nigra*	Low	Low	Poor	Buds, twigs, and catkins eaten by squirrels
American hornbeam *Carpinus caroliniana*	Low	Low	Very good	No timber value; no real wildlife value; good tree to hinge for horizontal cover if tree is large enough
Eastern hophornbeam *Ostrya virginiana*	Low	Low	Very good	No timber value; no real wildlife value; good tree to hinge for horizontal cover if tree is large enough
Dogwoods Cornus species	Med	Med	Very good	Drupes are eaten by many bird species
Blackgum *Nyssa sylvatica*	Med/High	High	Very good	Browse highly selected by deer; drupes eaten by many bird species, including wild turkeys, sporadically by deer
Eastern redcedar *Juniperus virginiana*	Low/Med	Low	Poor	Good cover value for lots of birds; cover for deer when trees are about 4 – 10 feet tall
Persimmon *Diospyros virginiana*	High	Med	Bad	Highly selected soft mast by many species; stump sprouts selected by deer
Sourwood *Oxydendrum arboreum*	Low	Low	Good	Browse of stump sprouts may be eaten sporadically by deer; flowers are important for bees
Eastern redbud *Cercis canadensis*	Low/Med	Med	Poor	Seed are eaten by a few bird species; young leaves in spring and stump sprouts selected by deer; flowers are important for bees

SPECIES[1]	MAST VALUE[2]	BROWSE VALUE[3]	HINGE SUITABILITY[4]	COMMENTS
Honeylocust *Gleditsia triacanthos*	Med	Med	Good	Deer and various mammals eat the fleshy portion of the seedpod and thus the seed; flowers are important for bees
Black locust *Robinia pseudoacacia*	Low	Med	Good	Flowers are important for bees; seed are eaten by a number of bird species; often contains cavities used by various wildlife species
American beech *Fagus grandifolia*	Med/High	Low	Very good	Sporadic producer, but lots of animals eat beechnuts
Oaks *Quercus* species	High	Low	Very good	Acorns most important hard mast in eastern US forests; browse of stump sprouts of some oak spp. selected by deer
Sweetgum *Liquidambar styraciflua*	Low	Low	Very good	Seed eaten by a few bird species
Yellow buckeye *Aesculus flava*	None	None	Bad	No real benefits for wildlife
Hickories *Carya* species	Med/High	Low	Very good	Squirrels and bear eat the nuts
Pecan *Carya illinoinensis*	Med/High	Low	Good	Squirrels and bear eat the nuts
Black walnut *Juglans nigra*	Med	Low	Poor	Squirrels and bear eat the nuts
Redbay *Persea borbonia*	Med	Low	Good	Drupes are eaten by many birds, including quail, wild turkey, deer, and bear
Sassafras *Sassafras albidum*	Low/Med	Low	Bad	Soft wood excellent for woodpeckers and other cavity excavators; several birds species, including quail and wild turkey, and deer eat the drupes to some extent
Yellow-poplar *Liriodendron tulipifera*	Low	Med	Poor	Flowers are eaten by deer in early summer when they fall to the forest floor; relatively soft wood often used by cavity excavators
Cucumbertree *Magnolia acuminata*	Low	Low	Fair	No real wildlife value
Red mulberry *Morus rubra*	High	Low	Poor	Highly selected soft mast by many species
Ash *Fraxinus* species	Low/Med	Med	Poor	Seed eaten by several bird species
Shortleaf pine Pinus echinata	Med	None	Poor	Seed eaten by many bird species and small mammals
Eastern white pine *Pinus strobus*	Low	Low	Poor	Good cover for deer and various songbirds when occurring in understory; buds of seedlings may be eaten by deer; seed eaten by many bird species and small mammals
Loblolly pine *Pinus taeda*	Med	None	Poor	Seed eaten by many bird species and small mammals

SPECIES[1]	MAST VALUE[2]	BROWSE VALUE[3]	HINGE SUITABILITY[4]	COMMENTS
Virginia pine *Pinus virginiana*	Med	None	Fair	Seed eaten by many bird species and small mammals; provides good cover for deer when low and dense
Eastern hemlock *Tsuga canadensis*	Low	Low	Poor	Good cover for several bird species and for deer when occurring in the understory
Sycamore *Platanus occidentalis*	None	None	Very good	Little specific wildlife value, but a gorgeous tree along riparian areas
Downy serviceberry *Amelanchier arborea*	High	Med	Fair	Fruit eaten by many bird species, including wild turkey
Black cherry *Prunus serotina*	High	Low–Med	Poor	Browse from stump sprouts may be selected by deer; fruit eaten by many birds and sparingly by deer
Eastern cottonwood *Populus deltoides*	None	Low	Fair	Little specific wildlife value, but a gorgeous tree along riparian areas
Bigtooth aspen *Populus grandidentata*	None	Med	Fair	Leaves, buds, and catkins eaten by ruffed grouse; softwood tree preferred by woodpeckers and other cavity excavators
Black willow *Salix nigra*	None	Med	Good	Flowers are used by bees
Carolina silverbell *Halesia carolina*	Low	Low	Fair	Flowers are used by bees
Basswood *Tilia americana*	Low	Low/Med	Poor	Relatively soft wood often used by woodpeckers and other cavity excavators; flowers used by bees
Sugarberry *Celtis laevigata*	Med/High	Med/High	Good	Berries eaten by many bird species; browse of stump sprouts selected by deer
Hackberry *Celtis occidentalis*	Med/High	Med–High	Very good	Berries eaten by many bird species; browse of stump sprouts selected by deer
Winged elm *Ulmus alata*	Low	High	Very good	Browse highly selected by deer; various birds eat the seed (a nutlet); squirrels eat the buds and seeds
American elm *U. americana*	Low	High	Very good	Browse highly selected by deer; various birds eat the seed (a nutlet); squirrels eat the buds and seeds
Slippery elm *U. rubra*	Low	Low	Very good	Various birds eat the seed (a nutlet); squirrels eat the buds and seeds

[1]Tree species arranged taxonomically as they appear in a tree identification guide.
[2]Mast value is a relative estimation considering how many wildlife species consume the seed or mast.
[3]Browse value is a relative estimation considering nutritional quality and selectivity by white-tailed deer. Stump sprout leaves have higher mineral content than leaves from trees that have not been cut. Younger leaves are more digestible and have higher mineral content than older leaves.
[4]Hinge suitability relates to the relative ability of the tree to hinge and remain intact without breaking or "barber-chairing," and to a lesser extent, the tree's relative ability to provide horizontal cover (blocking visibility) after hinge-cutting.

NOTES