VIRGINIA DEPARTMENT OF FORESTRY

Forest Health Review

September 2005

In this issue...

Greetings

This is the first issue of the Forest Health Review since the retirement of Tim Tigner, my illustrious predecessor. I will do my best to continue this publication twice a year and carry on with reporting the most up to date forest health information for the Commonwealth. While my style may differ slightly from Tim's, the basic format will be much the same.

For those of you I have not yet had the pleasure of meeting, I look forward to working with you in the future. I'm sure it won't be long before some pest problem brings me your way. I have been working hard to maintain the standard of excellence Tim has set, although his 30 years of experience will obviously be difficult to replace in the short term. I am also new to Virginia, so please bear with me as I learn my way around and familiarize myself with the forest health issues that are most relevant to all of you. As always, I hope you find the Review to be useful and informative.

Chris Asaro, forest health specialist

Oak Decline versus Oak Wilt

In the wake of years of drought followed by two years of above-normal precipitation and flooding in some areas, many hardwood trees have been undergoing a considerable amount of stress, the signs of which are now showing up all over Virginia in the form of branch dieback and other symptoms. In some cases, these conditions can predispose the tree to other secondary pests and, ultimately, the trees die. In the case of oak trees, this condition of multiple stressors acting in concert to slowly kill the tree is often labeled "oak decline." Oak decline is usually a gradual process involving dieback from the branch tips, leading to a "stagheaded" crown. Other symptoms can include chlorotic, dwarfed, or sparse leaves, premature leaf drop during autumn, and sprouting on the main stem and branches.

Some common secondary pests associated with oak decline include the two-lined chestnut borer, *Armillaria* root disease and *Hypoxylon* canker; the presence of any

"Experience is the name everyone gives to their mistakes."

Oscar Wilde

Oak Decline versus Oak Wilt, continued

of these agents usually means tree death is soon to follow due to girdling or root killing. The chestnut borer (*Agrilus bilineatus*) often works from the upper crown down towards the base of the tree, creating meandering galleries in the inner bark and outer sapwood as it feeds. Signs of *Armillaria* or "shoe-string rot" include black rhizomorphs along the base and roots of the tree, white mycelial fans or fungus mats underneath the bark, and honey-colored mushrooms around the base of the tree in Autumn. *Hypoxylon* canker, when advanced, produces flat, black, fruiting bodies along the bole of the tree that usually break through the outer bark.

Decline and death can occur over a period of years or within one season, although leaves that turn brown will remain attached during the whole season. The more rapid declines tend to occur on stressful sites such as drought-prone areas, ridges, or areas that experience regular flooding. Oak decline usually affects a large number of widely scattered trees over an extensive area. In summary, oak decline is a process initiated by stress that leads to a host of other secondary pest conditions, gradual decline and death of the tree.

By contrast, oak wilt is a condition caused by a single organism, *Ceratocystus fagacearum*, which can very rapidly kill trees with no history of abiotic stress. Often, affected trees are isolated or in small pockets. Unlike oak decline, oak wilt is much more lethal on species within the red oak group, while white oaks are fairly resistant to the disease and are rarely killed. In Virginia, oak wilt has never been found on trees east of the Blue Ridge Mountains. The main symptom of oak wilt is a sudden wilting of leaves throughout the tree, usually from the top down. Leaves with blackened petioles begin to fall off the tree before turning brown, and the whole tree may be defoliated in 3-6 weeks. Some 3-9 months after wilting there may be dark streaking of the outer sapwood and oval-shaped mycelial pads underneath the bark. These fungus pads are often exposed as the outer bark above them begins to peel off. They also produce a fruit-like odor that is attractive to bark beetles and fungus beetles, which can transmit the disease to other trees. The disease can also spread to other trees through root grafts, leading to "infection centers."

On white oaks, oak wilt is much more difficult to distinguish from oak decline. Often, only a single branch is affected and the leaves usually remain on the tree. Usually only the terminal portion of the leaves will turn brown. Because only individual branches are affected, white oaks can exhibit the same "stagheaded" appearance as is commonly seen with oak decline. Fungus pads under the bark are relatively rare. In the rare instance where a white oak species is killed, this can take from 1-4 years.

"If we want things to stay as they are, things will have to change."

Giuseppe di Lampedusa

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Weather

The year 2005 started off on the warm side, averaging 2-4 degrees warmer than average in January and 4-6 degrees warmer in many areas of the southwest and western mountains. Precipitation was about normal for most except in extreme southeastern Virginia, which was 50-70% of normal, and the northern Shenandoah Valley, which was 25-50% of average in most locations. February temperatures were about normal to slightly above in the west and north. About half the state was between 25-50% of normal, the rest between 50-90% of average monthly precipitation. The notable exception for February was Augusta County, which experienced a localized storm or two and was between 200-300% of average precipitation for the month. March saw the beginnings of an unusually cool spring, with temperatures throughout most of the state averaging 2-8 degrees cooler. Some locations in the Farmville area averaged 6-8 degrees cooler than normal. Most locations were just slightly below or above average in precipitation. Periods of unusually cool weather continued into April, but periods of excessively warm weather were interspersed as well throughout the month, evening out the monthly average temperatures, which were uniformly normal for most of the Commonwealth. Precipitation in the southwest and north were 100-150% of normal, but the rest of the state was quite dry, running 25-75% of normal. The unseasonably cool weather continued into May, averaging 2-4 degrees below average in most places, and 4-8 degrees below in the north, Northern Neck and Eastern Shore. Late cold snaps left many mountaintops and ridges devoid of foliage by early May, when leaf out is normally complete. Precipitation during May was highly variable and followed a general trend from very dry (25-50% of normal) in the southwest, moderately dry (50-90%) in the central part of Virginia, to slightly wet (100-130%) in the east and northeast.

By June, temperatures shot up to their normal range and most of the state was about average for the month. Precipitation continued to be low in most areas, averaging 25-50% of normal in the north and 50-70% in most other areas. Only areas near Roanoke, the New River Valley and Farmville were about normal. By the end of June, most areas in the northern, central and eastern part of Virginia were 3-6 inches below normal cumulative precipitation for the year, but closer to normal in most of the west and southwest. Unusually hot weather hit during July-August, with most areas 2-5 degrees above normal during this time. A return to normal precipitation levels occurred for a majority of the Commonwealth, although scattered locations in the southwest, northern Blue Ridge and Shenandoah Valley, south central and southeastern Virginia received 50-75% of normal precipitation through the rest of the summer.

Delayed impacts from past years of drought followed by two years of above normal precipitation plus flooding and wind damage from Hurricane Isabel in 2002 and Tropical Storm Gaston in 2003 have taken their toll on the health of many trees, particularly in eastern Virginia.

Pine Bark Beetles

Last year there was very low activity among southern pine beetle, engraver beetles, and turpentine beetles, with only a few scattered pockets and no major eruptions. Trap catches

"The truth is rarely pure, and never simple."

Oscar Wilde

from this spring in Cumberland and Chesterfield counties suggest that this trend should more or less continue this year. As of August, I have not received any reports of significant bark beetle activity.

Interestingly, southern pine beetle (SPB) appears to be quite low throughout most of the Southeastern U.S. In east Texas, which historically seems to experience some of the most severe and widespread SPB outbreaks, they have not trapped a single beetle in seven years. Where SPB disappears to during these down years between outbreaks is a mystery, since presumably it has to kill trees in order to survive and reproduce. One thing we can be sure of is that they will be back.

We continue to receive substantial Federal funds for our SPB cost-share program. Applications for pre-commercial thinning have more than doubled since last year. Thanks to all our DOF foresters for your hard work in getting the word out and getting folks signed up. In addition, we have added cost-sharing for longleaf restoration projects using these funds since longleaf pine is resistant to SPB. We hope to eventually restore thousands of acres of longleaf pine on state and private land throughout its native range in southeastern Virginia.

Invasive Ambrosia Beetles

Invasive bark beetle species continue to be a threat to our forests. Ambrosia beetle damage has been widespread this year in the Coastal Plain, particularly in the greater Richmond-Petersburg area, as evidenced by extensive accumulations of boring dust at the base and in bark crevices of dying trees. Ambrosia beetles are secondary insects that attack highly stressed and dying trees. A complex of native and introduced ambrosia beetle species have been exploiting many trees, particularly red and white oaks, that are in late stages of decline and decay due to years of drought followed by heavy flooding during the past two years. Area trees hard hit by Hurricane Isabel and Tropical Storm Gaston seem particularly vulnerable to these and other secondary insects and diseases. Because many species of ambrosia beetle are introduced, there is much we do not know about them. Although they are very likely secondary, it remains to be seen whether some of these introduced species play a more significant role in tree decline.

Gypsy Moth

After bottoming out last year, gypsy moth has reappeared in a few scattered locations at seemingly moderate to high densities. Isolated reports have surfaced from Frederick, Giles, Pulaski, and Roanoke counties. During the past couple of years, very wet spring weather has made feeding larvae highly susceptible to diseases, which has helped keep populations at bay. Although we had a cool, humid spring this year, it dried out by June when peak larval activity was occurring, so it remains to be seen what kind of survival we will see through the summer. Egg mass surveys this fall will reveal whether sufficient survival occurred and whether we will see a significant resurgence next year. In the meantime, the Slow the Spread Program continues to release

"Ask yourself whether you are happy, and you cease to be so."

John Stuart Mill

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pheromone flakes along the leading edge of the gypsy moth range, which is now along the southern edge of the Commonwealth from Bland County to Virginia Beach.

Other Defoliators

Eastern tent caterpillar seemed to be locally heavy throughout many areas. Many cherry trees were completely stripped of leaves and some had as many as 30 individual nests. Fall Cankerworm was reported along a stretch of ridge on Massanutten Mountain in Shenandoah County and in lower densities around Big Devils Stairs in Shenandoah National Park. June beetles and Japanese beetles have been quite heavy this year throughout the Commonwealth, the latter causing significant defoliation in many areas, particularly around homes and gardens. The locust leaf miner has presented itself in usual fashion throughout Virginia, although damage seems a little heavier than normal in many places.

Sudden Oak Death (SOD)

We continue with our annual SOD survey along forested nursery perimeters. Survey sites are primarily located in the vicinity of Virginia Beach, Richmond, Washington D.C., and Roanoke. So far, our samples continue to test negative for Phytophthora ramorum, the agent that causes SOD, and there is no evidence to suggest that it has been introduced into forests as of yet. At this point, no one is really sure how serious of a problem it will be if it is introduced into our eastern forests. However, given the susceptibility of western oak species as well as some laboratory evidence that our eastern red oaks are susceptible, we don't want to have to find out. For now, it is something to be aware of, but, equally important, not to panic about. Unfortunately, because the fungus is carried by numerous other plant species common to nurseries, including azalea and camellia plants, we must maintain vigilance as Virginia nurseries continue to import material from large exporters in California and Oregon. Hopefully our continued survey work will prevent it from establishing here.

Emerald Ash Borer (EAB)

We continue to monitor ash trees for EAB infestation throughout the Commonwealth. Following the seemingly successful eradication of EAB in Fairfax County two years ago, there have been no further detections of this pest in Virginia. EAB was first detected in Michigan in 2002. Unfortunately for them, it had already been widely established by then; so they were unable to eradicate it, and they have lost millions of ash trees to date.

In addition to visual surveys conducted throughout the state and adjacent to nurseries that import ash, we have set up some trap trees in the Conway Robinson Sate Forest in Prince William County to further monitor for this pest. Since a bait for EAB is not yet available, trap trees are currently our only means of attracting this pest for monitoring purposes. Trap trees are ashes that have been girdled in two locations about a foot apart, with the bark stripped off between the two girdles, exposing the sapwood and releasing ash tree volatiles into the air. These volatiles are attractive to EAB and other borers because they signal that the tree is under stress and is vulnerable. A piece of laminated paper is attached to the tree between the two girdles and Tanglefoot is applied to the paper to trap any borers attracted to the dying tree. The Fairfax County government is employing this method on a much larger scale using hundreds of tree saplings laid out in a grid

"Some are weather-wise, some are otherwise."

Benjamin Franklin

throughout the County. Although this method is more effective at detecting beetles than visual surveys, it is also more labor intensive and can, therefore, be practical only over a limited area. Hopefully, through continued vigilance, we can avoid the Michigan experience.

Sirex Alert

It seems there is no end to the potential threats to our forests by invasive species. On February 19, 2005, a single woodwasp, *Sirex noctilio*, was identified in a beetle trap sample collected in upstate New York on September 7, 2004. Since then, it has been found in other areas of New York in substantial numbers. The Sirex woodwasp is considered a secondary pest of trees in its native range in Europe, Asia and North Africa. However, it is a major pest in exotic pine plantations in Australia, New Zealand, South America and South Africa. Females carry a fungus that they deposit in trees when laying their eggs and the developing larvae feed on the fungus. This fungus and a mucus injected by the wasp rapidly weaken and kill host trees. This pest is attracted to stressed trees that are often used to make solid wood packing material. Since the life cycle can take a year or more, the insect is transported easily in pallets or other wood packing material and not readily detected at ports. Among its hosts are many species of pine trees, but it seems particularly lethal to Monterey pine and loblolly pine. We definitely want to keep this one out of Virginia and out of the Southeast. Stay tuned.

Voles, Voles, Voles

This past winter has seen more than its share of vole problems. Numerous areas throughout Virginia have reported significant pine seedling mortality from meadow voles. One landowner in Cumberland County lost more than 100 acres of 1-year-old pines, and there was significant feeding on older pines and hardwoods as well. Voles moved across this tract in a very short period of time during January-February. As an emergency measure and to prevent further spread into an adjacent 40-acre tract, DOF hand-applied a rodenticide to the burrows at the base of the trees along a buffer zone between damaged and undamaged trees. Further spread was limited after that, but since this was done just before green-up in mid-March, it is not clear whether it was the rodenticide or the availability of other food sources that prevented further damage to the pines. It did appear that most of the bait was eaten shortly after we placed it out there, suggesting that the voles consumed a good portion of it.

What was unusual about this and other instances was that these were cutover sites that had received standard weed control treatments. Traditionally, voles cause problems in heavy grass areas. Mowing and sod control have been the traditional methods of keeping vole populations down. Unfortunately, those recommendations do not apply in some cases. There has been a great deal of frustration this past year by DOF personnel due to a lack of viable strategies for dealing with this problem. Jim Parkhurst of Virginia Tech has plans to implement some research this fall and winter, which will – hopefully – provide some much-needed answers. However, as with most problems, there will not likely be any silver-bullet solutions.

"If A is a success in life, then A = x + y + z. Work is x; play is y; and z is keeping your mouth shut."

Albert Einstein

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Hemlock Woolly Adelgid

The status of this problem remains more or less the same. Many hemlock trees continue to slowly decline and die after a number of years of infestation. On June 13th, the U.S. Forest Service shut down trails leading to the popular Cascades waterfall due to the risk to hikers from falling dead hemlock trees. There were about 600 trees near the park's upper and lower trails that needed to be removed. Currently, only a handful of counties in extreme southwestern Virginia remain uninfested. These include Lee, Wise, Dickenson, Buchanan, Scott, and Tazewell Counties.

Interestingly, hemlock mortality in some areas is spotty, and some hemlocks in areas that have had the adelgid for many years remain in relatively good shape. Is this related to tree genetics, site differences, or random chance? There is also at least one and perhaps more areas that seemed to have escaped the adelgid. A stand of about 400 hemlocks along the bluffs of the James River in James River State Park are apparently healthy with no adelgid to be found. Are these trees genetically resistant? More likely, since this location is somewhat isolated from the general range of eastern hemlock, they have been able to avoid the insect for the time being.

Biological control efforts continue, with releases of predatory lady beetles occurring in many areas of state. Thus far, these efforts have not proven to be a silver bullet, as biological control rarely is. Even if these predators become well-established, they do not seem to be able to match the reproductive capacity and prevent the spread of the adelgid. It may be our only viable strategy for controlling adelgid populations in the long term, but in the short term many hemlocks will continue to die. While not likely to become completely extinct, hemlock appears destined to become ecologically extinct in many areas.

Fusiform Rust

As Tim mentioned in last summer's issue, fusiform rust had appeared at unprecedented levels in loblolly seedlings planted last year. There has never been a record of this disease occurring at such high levels before in Virginia, and it has been attributed to the extremely wet weather during 2003-2004. Interestingly, the range of fusiform rust seems limited by cold temperatures. Could the warming trend we have seen during the last 10-20 years be responsible for a northward shift in the range of fusiform rust, as is being observed with many other species of plants and animals?

Dean Cumbia, director of forest management, has compiled detailed data on fusiform rust infection rates for Regions 1-5: Region 1 – 11%, Region 2 – 3%, Region 3 – 6%, Region 4 – 9% and Region 5 – 15%. An estimated total of more than 2 million seedlings were affected. Despite these unusually high infection rates, most individual plantations remained adequately stocked and reforestation was not necessary. Very few stands met the threshold for reforestation, which is being done at

"The rich man gets his ice in the summer and the poor man gets his in the winter."

Anonymous

DOF's expense. In the future and as a matter of routine, pine seedlings will be sprayed with a fungicide in the nursery prior to planting to avoid problems with rust infection.

White Pine 'Decline'

This describes a number of conditions acting alone or in concert that contribute to a seemingly rapid browning and death of white pine. This condition appears to be widespread among scattered landscape trees in the Richmond area this year, as well as in Christmas tree plantations in southwest Virginia and probably other locations. Generally, we attribute this phenomenon to one of two root diseases, *Leptographium procerum* or just 'Procerum' for short, and/or *Phytophthora cinamommi*, the same pathogen that causes littleleaf disease in southern yellow pines. These root diseases thrive in wet clay soils, so the recommendation is to generally avoid this kind of site when planting white pine. Another possible agent causing these symptoms is the pine wilt nematode. It is usually impossible to tell which of these agents is responsible for tree mortality without sending diseased tissue to a laboratory for pathogen identification by a specialist. Even then, it is often difficult to say for certain what actually killed the tree, particularly if multiple pathogens and abiotic stressors are present, which they often are.

Pine Needlecast

This disease was widespread this spring among 2-3 needle pine species throughout many areas of the state. Loblolly pine in the Coastal Plain and lower Piedmont seemed particularly hard hit. Fortunately, this pathogen affects only the older needles and is usually pretty harmless, although the sudden browning of trees in April can be alarming and lead many a landowner to believe their trees are dying from southern pine beetle or some other agent of destruction. As the summer progresses, the brown outer half of the old needles are "cast" off, while the new growth comes out healthy and the trees green up again. The wet weather of the past two years followed by the unusually cool weather we experienced this spring may have been the reason needlecast was so widespread this year. There seems to be a strong genetic component to needlecast resistance among pines, which is why some trees that appear completely brown are adjacent to others that remain green or are only lightly affected. This phenomenon was readily apparent among the loblolly pine seed orchard trees at the New Kent Forestry Center, which was particularly hard hit.

"Mankind have been created for the sake of one another. Either instruct them, therefore, or endure them."

Marcus Aurelius

Woodpeckers of Virginia

Woodpeckers are highly specialized birds whose main source of food are insects, primarily beetles, roaches and ants. With a thick protective skull, shock-absorbing membrane between the brain and skull, strong pointed beak, and a long, barbed tongue with sticky saliva, they are well equipped to search for their prey within trees by excavating a hole or stripping away bark. They also possess tails composed of strong, stiff feathers with pointed tips that enable them to brace themselves upright on the trunk of a tree. The toes are often arranged such that two face forward and two back in an "X" arrangement, which provides stability and, combined with sharp claws, allows them to hold onto the bark while maintaining an upright or upside down position with ease. In addition to helping them search for insects, the beak is also used to excavate tree cavities for nesting and for drumming to attract a mate and demarcate its territory. Often a woodpecker will have a preferred drumming tree which it returns to frequently, although some prefer drumming on other structures such as telephone poles or the siding on a house. Females usually lay between 2-8 eggs per nest and both sexes incubate and care for their young. Although not songbirds, some woodpeckers will produce a song-like call, which can often be loud and shrill. There are eight species of woodpecker that live and breed in Virginia:

The downy woodpecker (*Picoides pubescens*) is the smallest (about 6-7 inches long) and most common woodpecker in the eastern U.S., often seen in residential areas, backyards and orchards. These black and white birds are distinguished by a vertical white stripe or elongated patch along their back. Only the males have a patch of red on the back of the head. Their call: *Pik*, given evenly, or a descending whinny.

The hairy woodpecker (*Picoides villosus*) is almost identical to the downy in appearance, but is somewhat larger at about 9 inches long. Although fairly numerous, they are more shy and less abundant in backyards than the downy. Their call is somewhat louder than the downy: *Peek*!, given sharply, sometimes in a series.

The pileated woodpecker (*Dryocopus pileateus*) is the largest species in the east, around 18 inches long. They are mostly black with some white along the neck and a large red crest. Their beaks are very powerful and can tear apart stumps and dead trees as they search for insects. They particularly favor carpenter ants, but also feed on other insects, acorns, and fruit. With logging of mature forest in the East during the 19th and 20th centuries, their numbers declined sharply, but they have become fairly numerous and widespread with the increase and maturity of second growth forest during the last 75 years. Their call: *Wuk-wuk-wuk-wuk*, loud, ringing, rising and falling in pitch.

The red bellied woodpecker (*Melanerpes carolinus*) is about 9 inches long with a red nape that extends over the top of the head in males and white horizontal stripes along the back. Despite its name, the belly has only a slightly reddish tinge to it and is primarily tan or buff colored. This bird is numerous, noisy, and conspicuous, found in forests, parks, and suburbs. It feeds in the trees and on the ground and often flycatches. Their call: *Churr*, soft, rolling.

The red-headed woodpecker (*Melanerpes erythrocephala*) is about 9 inches long with a head that is completely red, a white body and conspicuous white

"I know nothing except the fact of my ignorance."

Socrates

patch on the wings. Once numerous, it is now much less common throughout its range due to competition with the European starling for nest holes. It prefers open stands of deciduous trees and is found in parks and suburbs. It feeds in the trees and on the ground and often flycatches. Their call: *Kweeer*, given loudly.

The yellow-bellied sapsucker (*Sphyrapicus varius*) is about 8-9 inches long and has a red forehead, black and white face and yellowish belly. The males have a red throat while female throats are white framed in black. Though common, this bird has a shy and quiet disposition and is therefore seldom seen. It is migratory and generally seen only during certain times of the year: in the Appalachians in summer, the piedmont during fall and spring, and coastal plain during winter. This bird creates a characteristic pattern of parallel rows of holes along the tree bole and feeds on the sap and small insects attracted to the flowing sap. Over time, it gradually enlarges the size of these holes by repeatedly feeding and removing bark around the edges until they appear as large square or rectangular patches in rows, which are very conspicuous. Their call: *Cheer*, given nasally.

The northern flicker (*Colaptes auratus*) is about 12 inches long and has a brown back with black horizontal bars, white rump, spotted underparts, black breast crescent, grey crown and a red nape. Males have a black "mustache." The underside of the wings is yellow. It is numerous and widespread in open woods, feeds in the trees and preys heavily on ants on the ground. Their call: *Wik-wik-wik-wik*, ringing call, higher than in pileated woodpecker. Also a loud *Kleer*!

The red cockaded woodpecker (*Picoides borealis*) is about 8-9 inches long, mostly black and white with a black head, white cheek and spotted sides. In males, a tiny red patch, or cockade, is on the top of the head, but is very difficult to see. This was once a common bird in mature pine forest throughout the southeastern U.S. and in southeast Virginia, but is now endangered due to habitat loss despite being protected by the Endangered Species Act since 1970. Its northernmost population is in Virginia, where fewer than 20 birds remain, nearly all of which are found on The Nature Conservancy's Piney Grove Preserve. One reason for its current predicament is its highly specialized and unusual way of life: it will nest only in open grown longleaf pines that are old enough to be infected with red heart rot fungus. This fungus decays the heartwood, allowing for excavation of nesting cavities. An ideal tree must have enough heartwood to contain a roosting chamber. These conditions are seldom present in commercial forests. Chambers excavated in sapwood would fill with resin and are therefore unsuitable. The birds chip away at the edges of the chamber entrance, producing a resin flow that soon coats the trunk with pitch and presumably provides protection from predators, such as snakes. This woodpecker seems to be unable to adapt to other ecological conditions. Their call: *Shripp*, raspy call.

"Half our life is spent trying to find something to do with the time we have rushed through life trying to save."

Will Rogers

Surfactant Chemistry

by Jerre Creighton, research manager

For landowners seeking to maximize the growth of conifer plantations, control of non-crop woody competition is a very important consideration. For example, in a long-term study in Alabama, plots containing just 20% of their basal area in hardwood species experienced a 50% loss in loblolly pine volume by age 24.

Surfactants are used to alter spray solution properties so that herbicides can be more effectively applied to and absorbed by the foliage of the target woody competition. By altering the surface tension of droplets, they shift the properties of liquid herbicide formulations to a more water- or oil-like state. This, in turn, optimizes the polarity, penetration, spreading, elasticity, drying, shearing, and cost of the spray solution.

In particular, glyphosate (Accord, Razor Pro, etc.) is a very water-like herbicide whose performance can be enhanced for site preparation by the addition of a surfactant that imparts more oil-like characteristics. The surfactant prescription for glyphosate progresses from more water-like to more oil-like as the predominant target species mix changes from annual, to herbaceous, to woody, to evergreen plants. This is because, in general, the ability of the plant to translocate a water-like herbicide across its leaf cuticle decreases along the spectrum from annual to waxy-type evergreen plants. Site prep recommendations usually include an oil-type surfactant to increase injury to and control of volunteer pines and other evergreen species.

However, for pine release treatments, there is increased likelihood of pine foliage and leader damage. Therefore, to widen the differential between conifer and broadleaf uptake, a more water-like surfactant is required. Historically, only Entry II (a cationic tallow amine surfactant) has been recommended for release treatments. In fact, the 1999 label for Accord Herbicide contained the following instructions specific to broadcast forestry conifer and hardwood release: "This product may require use with a surfactant. Unless otherwise recommended in this section of this label, use Entry II surfactant at 10 to 30 fluid ounces per acre." Entry II is no longer marketed, so replacements of similar chemistry are being tested.

In a 1991 study of several surfactants with Arsenal / Accord tank mixes for pine release, within two months of application, all treatments caused at least some pine leader damage, but Entry II caused significantly less than the other surfactants. For example, with 8 ounces of Arsenal and 1 quart of Accord, percent leader kill with Entry II, TimberSurf 90, and CideKick II averaged 9, 42, and 37%, respectively. Five years after application, all of the release treatments had controlled hardwoods and improved the free-to-grow rating of the stand compared to the untreated check. Entry II provided the lowest residual hardwood densities, and the best pine diameter and height growth of all the treatments. In spite of the early foliar burn and leader kill, there were no survival effects of treatment (all plots exceeded 93% survival after treatment), and, by age seven, all plots were growing as well as or better than the untreated checks.

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