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PESTICIDE APPLICATOR CERTIFICATION TRAINING

Category 2 Manual

Forest Pest Control

EXTENSION DIVISION

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

FOREST PEST CONTROL

A Training Program for the Certification

of Pesticide Applicators

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INTRODUCTION

This training manual is intended to provide information that you may need to comply with EPA's Standards for Certification. It will help you prepare for the Certification examination prepared and administered by the Virginia Department of Agriculture and Consumer Services.

The emphasis of these standards and this training is on the principles of applying pesticides safely for man and the environment. It is not intended to provide you with all the knowledge needed. Additional information in the form of publications, short courses, field days, and professional meetings can be obtained from the local Cooperative Extension Service Office in your area.

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VIRGINIA"S FOREST SITUATION (An Overview)

Sixty-four percent (16.4 million acres) of Virginia's total land base is in forest lands. Of this total, 15.8 million acres are commercial forest lands capable of producing wood products and other goods and services derived from forest land. The remaining 600,000 acres of non-commercial land are areas of low site quality where productivity is too low, or are recreational lands on which wood production is not an objective of management.

The forest-based industries of Virginia are of great economic importance to the state. Seventeen percent of the work force have jobs directly related to the wood products industry growing, harvesting, and transporting forest products and working in sawmills, pulpmills, furniture plants, and other wood-using industries. The total value of these activities is over $1 billion annually. In addition, hunting, fishing, camping, and other outdoor recreation-oriented businesses contribute several hundred million dollars each year to the state's economy.

Geographically, Virginia extends over three major physiographic provinces 1. the coastal plain of the East, 2. the rolling hills of the Piedmont in the central part of the state, and 3. the mountains and valleys of western Virginia. Specific climatic conditions, timber types, sites, and management problems are associated with each province.

Coastal Plain

This physiographic province can be characterized as a wide, relatively flat plain of deep sand and sandy loam topsoils underlain by sandy clay to clay subsoils. In the extreme southeast, large areas of organic topsoils are underlain by clay. The climate is mediterranean, as influenced by the ocean, and can be characterized by hot summers and relatively mild winters. Growth of both forest stands and agronomic crops is among the best in the southeast, and large areas are devoted to both forestry and agriculture. Several of the most extensive commercial forest ownerships are located in the coastal plain, and, in addition, several thousand individual owners maintain forest stands for wood production and other goods and services.

Both conifers and hardwoods abound in coastal plain woodlands. Loblolly pine (*Pinus taeda*) is the most abundant conifer and is found in pure stands as well as in association with other pines and with hardwoods in mixed pine-hardwood stands. Loblolly is a pioneer species where agricultural lands have been abandoned. Close associates include the gums, oaks, and other indigenous hardwoods. Loblolly is regenerated artificially on many ownerships and managed as pure stands for pulpwood, veneer, and sawtimber production. In the past, large blocks of several hundred to a thousand acres or more were often clear-cut, site prepared, and replanted. More recently, environmental considerations have somewhat reduced the maximum size of operational units to be clear-cut at one time. One objective of clear-cutting and site preparation has been to eliminate hardwood competition, but, following stand establishment, subsequent hardwood control of trees by physical or chemical techniques is sometimes necessary.

Other conifers commonly found in the coastal plain include Pond Pine (Pinus serotina), Shortleaf Pine (Pinus echinata), Eastern Red Cedar (Juniperus virginiana), Cypress (Taxodium distichum), and Atlantic White Cedar (Chamaecyparis thyoides). In addition, isolated individuals and small stands of slash pine (Pinus carribaea) and longleaf pine (Pinus palustris) are sometimes found. The latter species were introduced several years ago for commercial production, but their relatively poor performance compared to indigenous species forced the abandonment of these introductions.

Coastal hardwoods of major significance include both white and red oaks, yellow poplar, sweetgum, maples, and, on the wetter sites, swamp black gum and water tupelo. Inter-species associations between hardwoods and pines are varied and dependent upon soils, moisture relationships, and type of forest management to which they have been subjected.

Piedmont

The Piedmont of Virginia, between the coastal plain and the mountains, is characterized by rolling hills interlaced by numerous small and large drainages flowing to the coastal plains. Topography is relatively flat to moderately steep. Soil types are numerous and varied. Soils vary in both depth and quality with productivity ranging from the very fertile to infertile. Loss of topsoil from past farming and forestry practices has reduced fertility and productiveness in many areas. Numerous small and large forestry ownerships are found in the Piedmont.

Vegetatively, hardwoods assume a more important role in forest stand make-up in the Piedmont than they do in the coastal plain, but the pines are a major species group in the Piedmont, particularly in stands managed for wood production. Loblolly continues to be a major species adapted to Piedmont conditions, with shortleaf and Virginia Pine (Pinus virginiana) assuming major importance. In commercial plantations, Loblolly is invariably the preferred species. Virginia Pine seeds in abundance where seed sources are available.

Although numerous pure pine stands are in evidence, and Virginia Pine is found mainly in only pure stands, the mixed pine-hardwood stand is a common association in the Piedmont. On the moist sites, pines can be found in association with the better oaks, yellow poplar, sweetgum, maples, and other species. Oaks and hickories predominate on the drier sites and ridge tops.

As in the coastal plain, regeneration of managed pine stands is normally by artificial means. After timber removal, unmerchantable standing material is felled by mechanical means, larger trees may be killed chemically, and the site prepared by some combination of clearing equipment and fire. Following this, new stands are established by planting.

Mountains

Forest stands, species, and management techniques in the mountains of the western part of the state are quite different from those in the coastal plain and Piedmont. For the most part, topography is steep. Soils are thin on most sites, except in coves and along streams which have not been mismanaged or subject to erosion.

Hardwoods are the dominant forest types in the mountains, and over 100 species have commercial value. Among the most valuable are the oaks, maples, yellow poplar, walnut, black cherry, white ash, and hickories. Most species are in demand for sawtimber and some, notably walnut, cherry, poplar, and ash, are used extensively in the furniture industry. Sugar maple is a valuable sawtimber species and a modest maple sugar industry has developed in Highland and surrounding counties. An attempt is being made to extend a maple products industry into southwestern Virginia.

White Pine is the major conifer of the mountains. Virginia

Pine is present, but not as extensively as in the Piedmont, with Pitch Pine being relatively unimportant as a commercial species. Table Mountain Pine is present as a remnant species on the higher, drier sites, and both balsam fir and spruce can be found on a few of the higher peaks. Eastern hemlock is often found on moist sites.

Historically, mountain logging has been by the selection method, with the better trees of all species removed from time to time. Poorer-formed and slower-growing trees were left to regenerate forest stands so that the value of many mountain hardwood stands has deteriorated greatly from that of virgin forests. An attempt to restock mountain stands with better species and individuals is part of the reason for clear-cutting in the mountains, a practice which has led to great controversy in other states.

Unlike the coastal plain and portions of the Piedmont, fire is not used as a silvicultural tool in the mountains. Whereas the thick bark of pines serve as an insulation against fire damage in control burns, the hardwoods are extremely susceptible to fire and will not tolerate even a light fire. Also, the extremely rough topography of the mountains makes use of fire very risky even if the species could tolerate it.

Regeneration of most species indigenous to the mountains is by natural means. Small openings created by selective cutting provide the full sunlight necessary for seed germination and growth of root sprouts for the succeeding stand which will occupy the site. Such a system of regeneration results in many small even-aged patches of trees in a stand, but is not necessarily the most efficient means of managing a forest when logging costs are considered.

In summary, forestry in Virginia is varied from east to west in the three physiographic provinces found in the state. Each province has its particular soils, weather conditions, and indigenous species. Each presents particular problems in logging, the types of forest industry it supports, and the steps necessary to perpetuate healthy forest stands. This brief survey of the types of forests found in each province sets the stage for discussions of activities in which pesticides are necessary in forest management.

PESTS AND PESTICIDES IN FORESTRY

Insects and diseases are ever-present in the forest environment. From the seedling stage through maturity, insects and diseases are present; some playing a beneficial role in the forest ecosystem, others being deleterious to individual trees and stands.

Some pathogens play positive roles in forest development. The mycorrhizal fungi form a symbiotic relationship with the roots of plants, increasing the water absorbing capacity of roots and significantly increasing the ability of the roots to maintain the internal water balance necessary for plant growth and vigor. The wood rotting fungi are important in returning the nutrients of dead trees and tree parts to the soil in the form of humus. Without these beneficial fungi, dead material would pile-up on the ground, reduce soil fertility, and drastically limit the ability of forests to renew themselves.

Beneficial insects include the honeybees, necessary for pollination in species such as yellow poplar; the termites which aid in deterioration of dead material; and, the many harmless insect species which prey on destructive insects.

However, trees are subjected to destructive insects and diseases throughout their life cycle. These destructive pathogens and insects are ever-present in the forest environment, normally at low population levels in healthy forest stands. Adverse weather conditions, imbalanced moisture regimes, loss of topsoil, and other environmental changes which periodically occur, serve to decrease the vigor of trees and stands and allow the destructive insects and diseases to build-up their numbers to epidemic levels which are injurious to forest stands. There are many examples from the geologic past where entire species and genera have been eliminated. The most recent near-eradication of a species is the demise of the chestnut from Eastern American forests after the invasion of the chestnut blight, Endothica parasitica pathogen.

In nature, healthy trees have a natural ability to resist attack from pests and the least expensive method of combating insects and disease problems is to maintain healthy stands through proper forest management practices.

Such stands resist attack and reduce the risks of pest population build-ups. Over-mature trees and stands lose their ability to resist pests, however, and become centers of attack. In any over-mature timber stand, the incidence of both insects and diseases increases. This fact alone is sufficient justification for removal of timber for man's use before it becomes decadent.

In Virginia, many examples of serious pest problems can be found in both conifers and hardwoods. Among these are:

Insect Pests:

Southern pine beetle	- yellow pine
IPS beetle	- yellow pine
Turpentine beetle	- yellow pine

tip moth	- pine
White Pine weevil	- white pine
Pales weevil	- pine
seed and cone insects	- all species
Gypsy moth (potential)	- oak
canker worms	- hardwoods
Locust Leaf miner	- locust

Destructive Pathogens:

<u>Crunartium fusiformae</u>	- yellow pines
<u>Fomes annosus</u>	- yellow pines
oak wilt	- oak
oak decline	- oak
Dutch Elm disease	- elm

As in agronomic crops, pesticides are used in forestry for a variety of reasons to aid in establishing and maintaining healthy stands of tree species. For example, herbicides are used for site conversion, release of crop trees from competition, removal of weed species and trees of poor form, and weed control in highly specialized stands such as forest tree nurseries, seed orchards, and Christmas tree plantations.

Insecticides are used in these same specialized orchards and nurseries, and may be used on an extensive scale to combat epidemic outbreaks of certain devastating insects. Fungicides normally are limited to use in such high-cost specialized areas as forest tree nurseries, and only occasionally would be used elsewhere.

PESTICIDE APPLICATION

Pesticides may be applied in any one of several different ways, dependent upon the pest to be controlled, the chemical formulations used, and the equipment available to do the job.

Sprays, mists, and fogs are often applied with air-moving equipment either from the ground or from the air by helicopter or fixed-wing aircraft.

Foliar Applications - Aerial

Aerial application of herbicides is a fast, efficient, economical method of controlling the growth of undesirable woody vegetation. It is imperative that the proper equipment and techniques be utilized. Most of the advancement in chemicals and applicator systems has involved the use of a helicopter as the aerial applicating vehicle.

Because of its slow flying characteristics and maneuverability, the helicopter readily lends itself to this job. It is capable of flying at treetop level, limiting the distance the chemical must fall, thereby reducing the possibility of wind drift. The pilot is afforded excellent vision from the helicopter, which further assists in controlling the application.

1. Aerial Applicating Systems

   There are several applicating systems available for spraying. Some are designed to handle a thickened material to reduce possible wind drift and resultant damage. More recent equipment is designed to control drift by delivering uniform large droplets.

a. <u>Amchem Micro-Foil Boom</u>

This equipment provides a method of applying non-thickened material and still maintaining control of the chemical. The system consists of a boom with many small nozzles. Low pressure carries the material to the nozzles. The nozzles are trimmed into the airflow and the chemical is laid into the air stream and falls like a sheet of rain.

b. <u>Amchem 060</u>

This is a recent adaptation of the Micro-Foil Boom. Its name is derived from the orifice size of 0.060 inches. The large, uniform droplets formed with this nozzle penetrate the leaves of foliage and kill small brush at ground level. Another advantage of the 060 boom is that more precise control is maintained on the swath, enabling the pilot to adequately cover brush. The design of the 060 boom practically eliminates fine droplets in the spray pattern, when the boom is used correctly.

c. <u>Dow R-511</u>

This equipment utilizes hydraulic or electric pumps to move the mixture of chemical and Norbak (a particulating agent used to thicken the chemical) into a series of large nozzles. The combination of large orifices, low pressure, and thickening agent allows proper control of the material.

d. Conventional Boom

This equipment utilizes pressure to force the chemical through a number of nozzles. The chemical falls as a mist of various-sized droplets. The lack of drift control greatly limits the use of a conventional boom.

e. Amchem Spray Disk

This unit is used for the application of Amchem's Envert Emulsion. Properly mixed, the envert material reaches a consistency approximately that of heavily whipped cream. The material is pumped into the tank of the helicopter and gravity fed to a rotating disk fitted with nozzles. The material is dispensed in large, heavy droplets allowing control and placement of the material.

2. Aerial Application Techniques

Flying techniques will vary according to the pilot, his experience, and his capabilities. However, there are several methods or techniques that, if followed, will eliminate damage and reduce the number of complaints and damage claims. The following items are considered essential for safe and effective aerial spraying.

a. <u>Reconnaissance</u>

A proper aerial reconnaissance before spraying will give the pilot advance knowledge of the presence of homes, gardens, valuable crops, trees, or other areas that should not be sprayed. Known restrictions should be marked on maps.

b. <u>Observations of wind direction, wind speed, and other climatological factors</u>

Since wind drift of chemical is the major cause of damage, it is very important that the wind speed and direction be known at all times. Wind limits should be set for the chemical being used, application equipment, height of drop, proximity and species of crops or plants next to spray areas.

Normally, the wind is of lower velocity early in the morning (dawn) and early in the evening; therefore, most spraying is accomplished during these periods.

c. <u>Continuous observation</u>

The pilot should constantly observe the spray pattern to see that it does not exceed the limits of the situation. He should search for any signs of the presence of valuable property or crops that may have escaped his vision on the advanced reconnaissance and be ready to halt spraying at any point.

d. <u>Sensitive crops and other areas</u>

Spray should not be applied closer than 100 feet, even under ideal conditions, adjacent to certain crops such as tobacco, grapes, and vegetables. Never spray toward sensitive crops. These areas should be noted during reconnaissance and marked on a map prior to the actual spraying.

Homes, parks, recreation areas, and the like should be avoided by several hundred feet, unless specific instructions to the contrary are given. Avoid lakes, streams, ponds, and other water sites when applying most brush control chemicals. Drainage areas that go into irrigation water should be avoided by at least 500 feet.

e. <u>Precautions in Aerial Spraying</u>

Regardless of the amount of judgment and caution applied in aerial application, occasional damage claims or complaints may result, legitimate or otherwise. There is no substitute for quick, personal response to these complaints. A rapid investigation of damage complaints can save many dollars in unwarranted claims, and can create good public relations for the rapid settlement of those that are justifiable.

The individual who suffers actual damage deserves fair treatment for his loss. The individual who believes he has been damaged deserves the consideration of a quick response to his complaint and an explanation of the facts. Even though chemicals and application systems have been continuously improved to make aerial spraying practical and controlled and even with the reduced possibility of damage due to wind drifts, the equipment is only as good as the pilot that uses it. The pilot is the key to successful application. He must maintain a proper attitude toward aerial application. He must be constantly aware of the serious problems that could result from any improper techniques he employs. He must be constantly alert for any changes in weather or equipment that could affect the safe application of the chemical. Most of all, he must have a sincere desire to do the best possible job.

Due to inaccessible terrain and other factors, aerial application may often be the most practical method of controlling vegetation. However, aerial treatment has no place in urban and suburban areas.

Some pesticides, particularly herbicides, may be applied by broadcasting granules on the ground surface. Such application may be desirable but can be hazardous if not well-controlled. Without proper precautions, pesticides may kill vegetation other than the target individuals and may enter the ground water. The following section on weed control in forestry explains these hazards in detail.

A very effective means of killing larger trees is the insertion of herbicide in frills girdling the target individuals. By employing this method, using axes and/or special injection tools, the applicator can deposit the herbicide under the bark where it enters the conductive tissue and is transported throughout the tree. This method is effective, with certain chemicals deterring regrowth by sprouts, but is both labor-intensive and expensive.

WEED CONTROL IN FORESTRY

It has long been known that better timber results from stand management. This may involve removing certain species and allowing others to grow, or removing poor trees of a desirable species. Before the advent of herbicides, this was accomplished by mechanical means. Undesirable trees were cut or girdled, providing more light, moisture, and nutrients for the remaining desirable trees.

The use of herbicides in forestry became significant only after the discovery of 2,4-D and 2,4,5-T in the 1940's. The use of 2,4,5-T now has been suspended by the U. S. Government. This suspension may be temporary or permanent, pending future judicial results.

There are now many different areas of forest management where herbicides are being used.

Timber stand improvement - Mechanical kill of poor trees is very time consuming, and, therefore, very expensive and impractical on large acreages. Using an injector, herbicides can be placed beneath the bark of the undesirable tree. This method requires far less labor and gives quicker kill than girdling the tree bark.

Site preparation - Regeneration of timber stands on cutover areas requires killing the undesirable trees and brush on the cutover area. Using broadcast application of herbicides after the cutover area resumes growth will kill the undesirable growth and allow establishment of desirable species in the absence of undue competition. This can be followed, in some case, with prescribed burning.

Pine release - When a cutover area is replanted to pines, the hardwoods will rapidly regenerate from stump sprouts and compete severely with the pines. Using low-volume aerial application of herbicides, it is possible to selectively kill the hardwoods and release the pines from competition. The present suspension of 2,4,5-T use for this purpose will greatly restrict pine release procedures.

Seedling establishment - The selective pre-emergent herbicides discovered during the last 15 years have found uses in the forest industry. In many instances where the proposed planting site has annual or perennial weeds or grasses, it is possible to selectively eliminate these from around the newly planted seedlings and allow them to become established in the absence of competition. Simazine has been used extensively for seedling establishment in timber and Christmas tree plantings and seed orchards.

CLASSIFICATION OF HERBICIDES BY METHOD OF APPLICATION

Foliar Sprays

Foliar sprays are applied to large acreages each year. The phenoxy herbicides (2,4-D; 2,4,5-T) have been the major herbicides used for this purpose. The February 28, 1979 emergency suspension order against 2,4,5-T and silvex prevents further use of 2,4,5-T until a final decision is made. Dicamba (Banvel-D) and picloram (Tordon) are used in some instances where difficult-to-control species exist. These materials are absorbed through the foliage of the tree and then move throughout the tree with the plant's food supply. Complete coverage of the tree is not required because of the mobility of the material within the plant.

Fuel oil is often added to the foliar spray mixture to give more rapid kill. In many cases, this has a reverse effect. Rapid kill of the plant foliage may reduce movement of the herbicide from the foliage to the roots and growing points. The end result is less translocation or movement of the herbicide and less complete kill.

Dicamba and picloram also have the capability of movement through the soil and being picked up through the tree roots. This feature gives these materials added killing power, but increases the risk of damage to non-target plants. Several cases of injury are known where the material moved down-slope from the target area and injured susceptible plants.

The main concern with using herbicides as a foliar application is drift. The finer the spray droplets, the greater the drift. However, methods have been devised to reduce drift. More recently, specialized pieces of equipment such as the Micro-Foil Boom have been developed that will apply small droplets of uniform size. This allows better coverage and keeps drift at a minimum.

Basal Sprays

Water solutions of herbicides do not readily penetrate the bark of a tree, but it is possible to get herbicides to penetrate the bark of many woody plants using oil as a carrier. This technique usually works quite well until the brush reaches about three inches in diameter.

Larger brush and trees often have sufficiently thick bark to prevent entry of the herbicide. Once the herbicide gets through the bark, it is carried both upward and downward and results in both top and root kill. Basal application of herbicides can be accomplished any time of the year.

Basal application is usually by hand sprayer, or hand gun and hose attached to a larger sprayer. As spraying is by hand on an individual basis, it is possible to be selective. This technique has been widely used for removing sprouts of undesirable trees growing among desirable species.

Effective results have also been obtained using mist blowers. The risk of spray drift limits the usefulness of the mist blower to areas well away from desirable plants.

Soil Application

There are many temporary soil sterilants on the market that are capable of killing trees and brush. These materials are applied broadcast or selectively at the base of an undesirable tree. They move down readily in the soil with rainfall. When they reach the root area of the tree they are picked up by the tree roots and carried with the water up into the tree. Thus, the first foliar symptoms appear at the tops of the tree and the root system is the last to be affected. Root kill will result later when the above-ground portion dies and no longer feeds the roots.

Their high degree of mobility in the soil limits the usefulness of these materials. They have been in general use around industrial areas for years. Problems result when soil water carries the material away from the treated area. This movement can be a considerable distance in the case of surface runoff, or several feet down a slope through internal movement of water. Problems may also result when the roots of a desirable tree extend into a treated area that is several feet beyond the tree dripline. To be safe, these materials should not be used within 100 feet of desirable trees, and should not be applied on sloping areas above desirable vegetation.

Frill and Injector Treatment

It was mentioned earlier that herbicides do not readily penetrate the thick bark of an older tree (three inches or more in diameter). Entry of chemicals into large trees can be provided by cutting through the bark of the tree with an axe or hatchet. Appropriate addition of small amounts of herbicide concentrate to these frills will result in tree death. Specialized pieces of equipment have been developed to inject herbicides beneath the bark of trees. These instruments make a hole and add a metered amount of herbicide to the wound.

Stump Treatment

Many tree species will quickly regenerate from stump sprouts after the tree is cut. Regrowth from stump sprouts can be prevented by spraying the freshly cut stump with brush killer. Again, oil is used as a carrier to facilitate entry of the herbicide.

FOREST INSECT PESTS

Forest trees are susceptible to insect attack at all stages of growth and development, from newly established seedlings to mature individuals. Maintenance of healthy and vigorous stands and individuals is recognized as being an effective means of lowering the incidence of attack and the degree of risk to insect attack. However, uncontrollable soil, site, and weather conditions preclude the elimination of both disease and insects as a threat to forest trees.

Insects important in forestry may be classified in several ways, dependent upon their methods of entry and the seriousness of their attack to the health and vigor of the tree. A common method of classification relates to the point of attack in the tree and the type of injury sustained from the attack. By this method, major insect pests are classified as bark beetles, defoliators, bud and twig insects, sapsucking insects, seed and cone insects, and root insects. Many tree species may be more subject to attack by certain of these insect types at particular stages in their life cycles than at other times, but most are subject to attack by several of them throughout their lives.

Bark Beetles

The bark beetles are perhaps the best known of the major insect pests in the state because of incidence of attack, loss in economic value, and presence of dead trees and stands when bark beetles are present in epidemic numbers. Included among the bark beetles, are IPS beetles, black turpentine beetles, and the southern pine beetle.

Bark beetles bore through the bark of southern pines, tunnel between the bark and wood, and lay their eggs. A pitch tube normally develops at the entry points of the borers. When the eggs hatch, the grubs feed on the cambium and, in effect, girdle the tree and disrupt the conductive system by which water and nutrients are borne to the crown and sugars transported to the roots, causing the death of the tree if it is unable to "throw-off" the attack.

As with all insects, bark beetles are always present in the forest environment. Periodically, however, dependent upon available soil moisture, weather, and other factors, populations can reach epidemic numbers with devastating effects on stands of the southern pines.

Defoliators

The defoliating insects are the leaf and needle chewers which manifest their presence by eating the chlorophyll tissue essential in photosynthesis. The extent of injury which a tree can sustain without excessive damage varies by species, incidence of attack, and the periodicity with which such attacks occur. Evergreen species usually suffer more extensively than hardwoods. Conifers such as Scotch pine, present in many Christmas tree plantations in Virginia, may be killed if completely defoliated for a single year. Some hardwood species can sustain attack from defoliators for 2 or more years without lethal injury.

The most noted defoliator in recent years is the tussock moth which caused widespread damage to Douglas fir in the West. This outbreak was brought under control only after regulations were relaxed to allow the use of DDT by aerial application. Among the defoliators common in Virginia are the tent caterpillars and webworms, which attack many species, and the locust leaf miner which periodically attacks locust trees over a wide area of the state.

Bud and twig insects

Several insect orders fall within this classification. Bud and twig insects attack trees throughout their life cycle. Reproduction weevils such as the pales weevil and the Nantucket tip moth are very common; the former being capable of killing entire stands of newly germinated and year-old seedlings; the latter being prevalent in young stands of southern pine where it often restricts growth and causes deformations in young trees by repeatedly killing the terminal buds. Many species of borer attack buds and twigs of hardwoods at all stages in their life cycle. Although such attacks are seldom lethal, they do cause growth losses and alter patterns of growth and tree shape.

Sapsucking insects

As with the bud and twig insects, sapsucking insects are a threat to trees of all ages, although evidence of their injuries may not be dramatic to the casual observer. The gall and scale insects, spider mites, lace bugs, aphids, spittle bugs, and leafhoppers are included in this group. Although their combined effects are seldom lethal in older trees and stands, they do restrict growth and cause tree deformities. They are, however, capable of killing seedlings.

Aphids and other sapsucking insects are particularly important in pine seed orchards, where they can cause failure in newly-made grafts and kill young seed orchard trees if not controlled.

<u>Seed and cone insects</u>

This group of pests, although not dramatic in appearance, cause extensive damage to seed crops in both conifers and hardwoods. Where artificial regeneration is prevalent, such as in Piedmont and Coastal Virginia, loss of seed potential to seed and cone insects can be devastating. In fact, at the present time, shortages of loblolly seed in Virginia and through the southeast are threatening to seriously curtail an assured seed supply until a good seed year materializes. Bumper seed crops may occur every 5-10 years, and during such years large collections must be made to cover the intervening years.

It was hoped that seed orchards would at least partially smooth-out the feast-or-famine availability of seed on a yearly basis in addition to their other attributes, but serious seed and cone insect problems also are suffered in these specialized areas where control mechanisms are far more feasible than in commercial forest stands.

<u>Root-feeding insects</u>

The most serious damage by insects attacking the roots of trees occurs in forest tree nurseries and in very young plantations. Such pests as grubs, borers, root collar weevils, and the like can be tolerated when they attack only isolated portions of the root systems of large trees; but, when attacks are upon the roots of small seedlings, the entire root systems of very small plants can be lost with subsequent death of the plants.

Pest control recommendations for all the above classifications of insects are available. In general, it can be concluded that the forest trees and stands least likely to suffer serious insect damage are those kept thriving under normal management practices. However, in areas where injurious insect populations have built up to epidemic proportions, and in such specialized areas as forest tree nurseries and seed orchards, it is often necessary to resort to chemical controls. Specific control recommendations are not made in this manual because they are constantly changing as better techniques and new insecticides become available. For the latest recommendations on control of specific insects, it is suggested that nurserymen's guides, the Virginia Division of Forestry, local VPI&SU Extension Agents, and specialists at VPI&SU Extension Division, be consulted.

FOREST TREE DISEASES

As with insects, forest trees at all stages in their life cycles are subject to a variety of diseases. While some forest tree diseases are nearly universal in their ability to attack many tree species, others are quite specific to a particular species, either in absolute specificity or in the manifestation of the seriousness of the disease. In the latter instance, a pathogen may be very serious in upsetting normal life processes of one species and be relatively harmless to another.

In general, forest tree diseases can be classified as branch and stem diseases, foliage disease, wood rotters, and root diseases. In addition to those having detrimental effects on growth and development, there are also pathogens which are not only beneficial but necessary to growth. The symbiotic relationships existing between mycorrhizal fungi and the root systems of many species are so necessary that adequate growth is not made in the absence of mycorrhiza. Wood rotters, those which attack and decompose dead and fallen timber, also serve a very beneficial role in returning nutrients to the soil and disposing of litter on the forest floor.

There are, however, many destructive pathogens which attack and kill, deform, or restrict growth of individual trees and stands.

Of the diseases of conifers, the two of most importance in Virginia are cronartium rust (Cronartium fusiformae) and Fomes annosus root rot.

Cronartium is a serious gall-forming disease of several southern pines, including loblolly. In addition to infecting southern pines, fusiform rust also attacks the oaks which are necessary as alternate hosts during certain portions of the life cycle of the disease. The disease is transported by aerial spores. On oaks, fusiform rust is unimportant and does little more than cause lesions on the leaf. On pine, however, stem and branch galls develop which result in wood deformation and weak points in the wood. On secondary branches, such galls are not significant; when on the boles, however, galls subject trees to breakage in high winds, or, in extreme cases, girdle the trees. Galls on primary limbs will grow into the trunk, and this causes death or deformation. Fusiform rust is economically the most important disease of southern pines. In some areas, literally hundreds of acres of trees, which would otherwise escape damage, can be blown down or break up in ice storms as a result of fusiform weakening. There appears to be a high degree of genetic inheritance to susceptibility to fusiform rust. All selections used in southern pine seed orchards are tested for disease resistance in an effort to reduce the incidence of this disease. Nursery seedlings are particularly susceptible to fusiform. Spray schedules of fungicides are used to reduce incidence on nursery-produced seedlings and infected material is removed at the grading table prior to shipment of materials for planting.

Fomes annosus root rot is a white, stringy root rot disease which attacks and destroys roots of southern pine, killing individuals by disrupting both the water-absorbing and support functions of the root system. The disease is transported by aerial spores and can travel short distances, measured in millimeters, in the soil. Although not nearly so important economically at this time as Cronartium rust, Fomes can be destructive in pine stands on certain soil types, particularly following cuts on these soil types in the winter.

Although not of great significance in Virginia, the greatest threat to white pine was the white pine blister rust which, like Cronartium rust, has an alternate host necessary to complete the life cycle of the pathogen. In this instance, the alternate host is Ribes, (currents and gooseberries).

The most dramatic disease of hardwoods, causing near extinction of the species, was the chestnut blight which hit eastern North America in the early 1900's and completely eliminated chestnut from our deciduous forests. Other diseases which remain a threat include Dutch elm disease, oak wilt, and a combination of insects, diseases, and water stress commonly called dieback.

Air pollution effects -- the destructive influence of sulphur dioxide, nitrous oxide, ozone, and particulate matter on plant life -- are often mistakenly thought to be disease-caused. In many instances, and over a broad range of species, results of continued exposure to air pollutants resembles invasion by a disease, when, in fact, no pathogen is involved. Although air pollution damage is most common near sources of combustion of fossil fuels -- near large plants, power generators, and highways -- air pollution injury may also occur in areas remote from the source of air contaminates.

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