INSECTS AND DISEASES

Important Problems of Florida's Forest

and Shade Tree Resources

FLORIDA

FOREST SERVICE

Agriculture & Consumer Services

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Important Problems of Florida's Forest

and Shade Tree Resources

by

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FOREWORD

The forest needs of Florida citizens are growing faster than the trees. The demand for wood as an industrial raw material is forecast to double in the next 20 years, while the ever-growing population also must look to declining forest acreages for expanded outdoor recreation, air and water quality protection and for those scenic attractions which only Nature can produce. In the cities, the need for healthy trees to alleviate the tensions of urban life will be greater than ever as larger numbers of persons will be affected.

This booklet is intended to help people meet the threat of insects and diseases to the trees growing now, and those of future. It is written equally for use by the commercial tree planter and the average homeowner. Its presentation of information concerning identification, life cycles and control of insects and diseases is intended to meet the needs of tree expert and lay person alike for clear, practical information concerning threats to trees.

We are confident that this publication will serve Florida citizens well in providing for the essential forest benefits of the future.

October, 1983

INTRODUCTION

Trees in Florida are of inestimable value as aesthetic, environmental, and economic resources. Each year untold numbers of trees throughout the state are damaged or killed by destructive insects and diseases. If values could be accurately placed on trees destroyed, annual statewide losses would easily reach into the tens of millions of dollars.

This book is designed to introduce the reader to the more common and important insects and diseases as well as certain other problems affecting the predominant species of trees native to northern and central Florida. While some of the material covered in this volume is applicable to trees in southern Florida, logistical and budgetary constraints have precluded an "all inclusive" edition. Many of the important insects pests affecting southern Florida's unique forest and arboricultural resources are treated in a companion volume entitled *Pests and Problems of South Florida Trees and Palms* by Charles W. Chellman.

It is our hope that this volume will provide a useful reference for homeowners, foresters, arboriculturalists, landscapers and others interested in trees. It is also our hope that the reader will apply the principles and concepts presented herein for preventing or controlling losses to insects and diseases affecting Florida's forest and shade tree resources.

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HOW TO USE THE BOOK

The following charts are to assist in determining the probable insect, animal, bird, disease, or vertebrate pests damaging trees. The key elements of the charts are the distinctive damage clues that are characteristic of a pest, group or species.

Don't be hesitant to refer to other similar descriptions if the identification appears suspicious. Damage does not always appear exactly as described. It may be worthwhile to try the chart again just to make sure you didn't make a wrong choice at some early point.

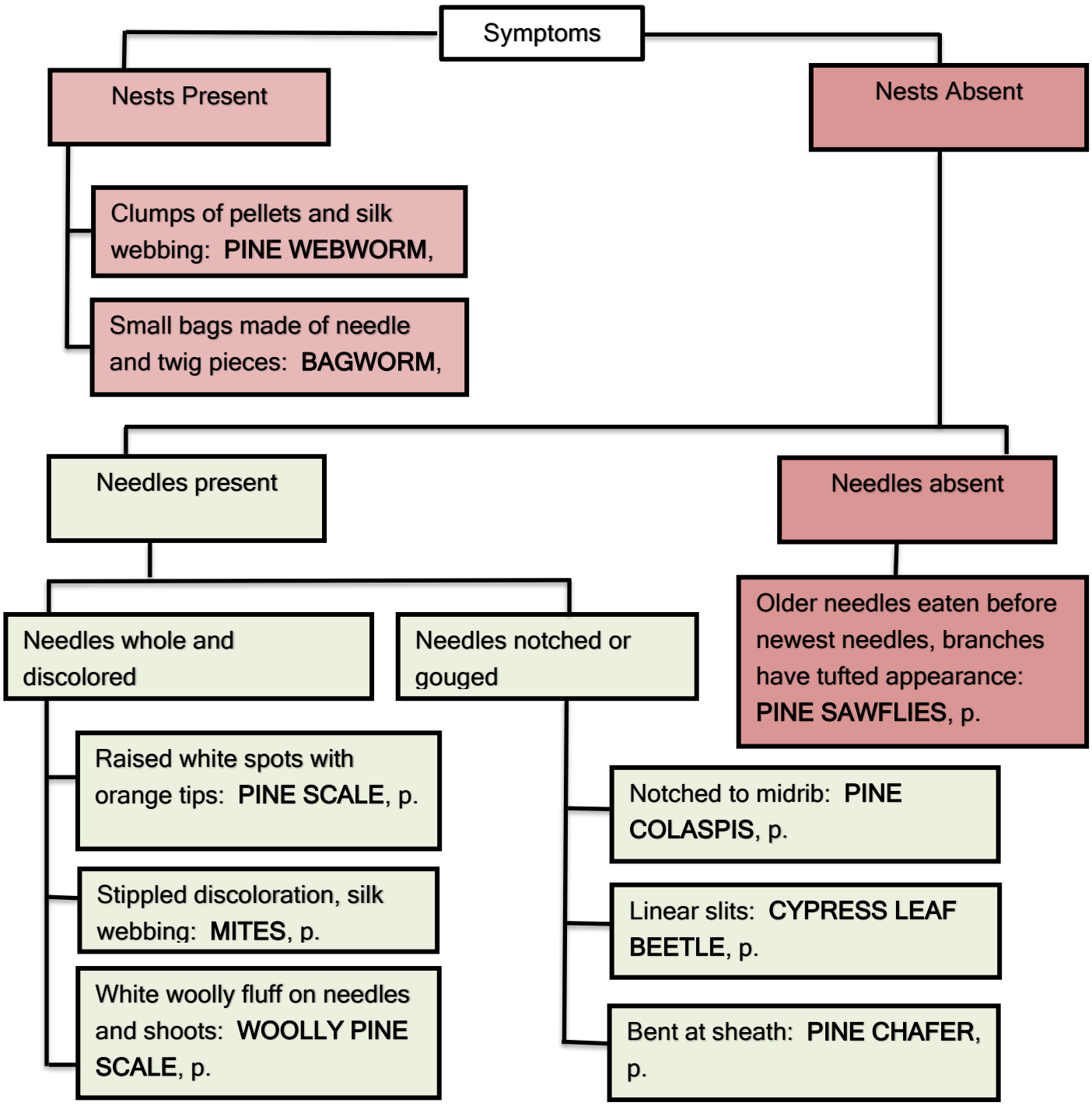
Remember that only some of the most common pests of the thousands that damage trees in Florida are described. You may well have one of the others. Further assistance can be obtained from your local county or urban forester to identify the pest and determine the best control methods.

How to Use the Keys

- Determine which set of keys – Insect or Disease – best characterizes the damage under consideration. Admittedly, certain damage types (wilting, galls, pitch or sap flow, etc.) are common to both insects and diseases. In such cases, consulting both insect and disease keys is recommended. In fact, a quick overview of the box descriptions may be a helpful decision aid. Generally, the presence of holes, tunnels, sawdust, small excrement pellets, nests, webbing, or evidence of chewing on bark or leaves suggests insect-caused damages.
- Determine which chart best identifies the tree (conifer or hardwood) and that part of the tree damaged by the insect or disease.
- Start at the topmost box, move down along connecting lines and decide which box best describes the observed damage. Continue moving downward, choosing from boxes connected by lines, until you reach a box with an insect/disease name and page number.
- Turn to that page to read a fuller description of the probable pest problem.

DAMAGE KEYS

Tree Insects - Key 1
Conifer Foliage

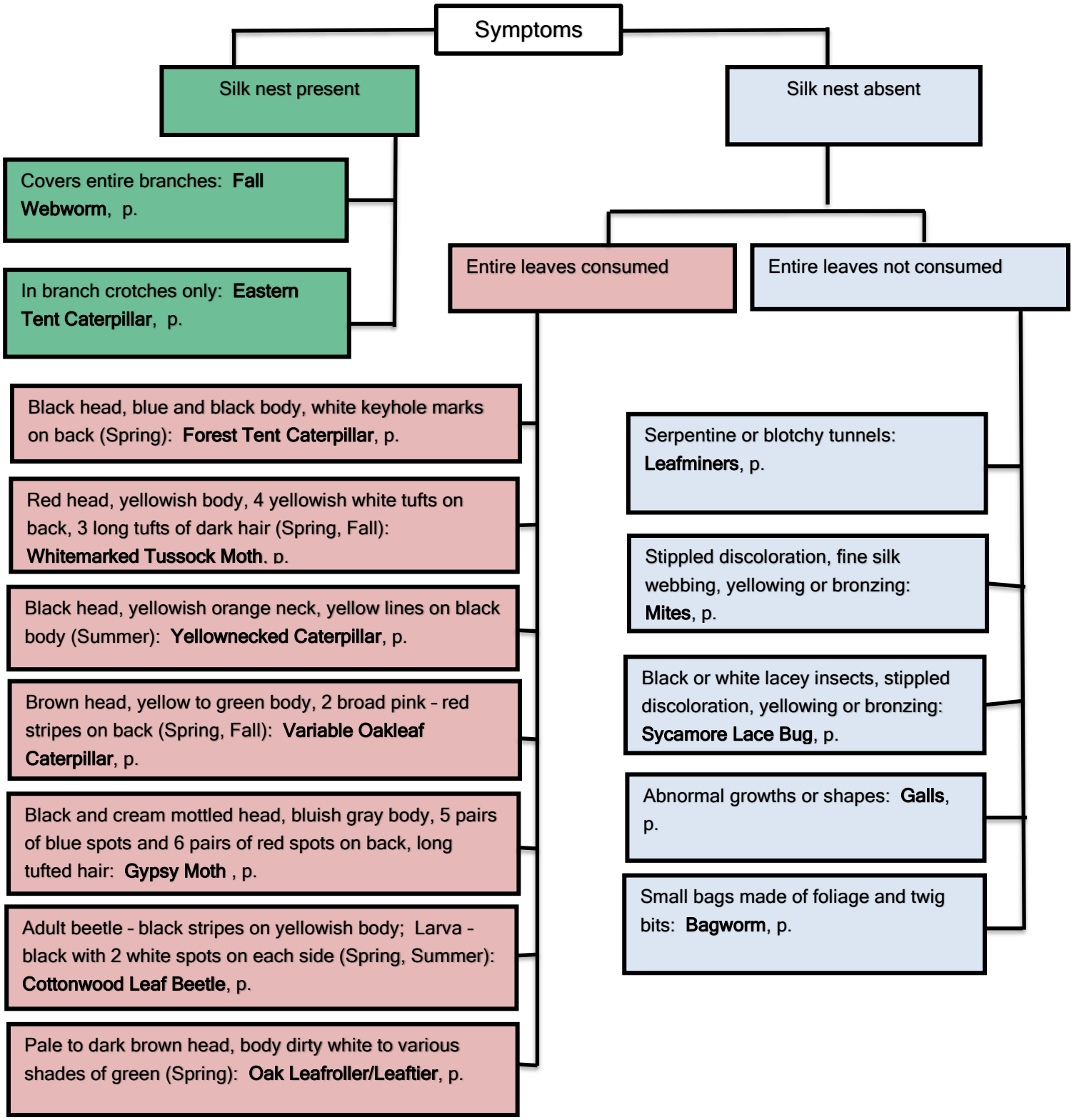


Tree Insects - Key 2
Conifer Branch and Stem

Symptoms

- **Pitch masses present**
  - 5-12 mm diameter, reddish white color, hole in center
    - Branch tips, smaller pitch lumps, 1-2 mm hole: **Twig Beetles**, p.
    - Branch and stem larger pitch lumps, 1-3 mm hole: **IPS Engraver Beetle**, p. **Southern Pine Beetle**, p.
  - More than 12 mm diameter, with or without hole in center
    - Lower stem, 3-4 mm hole, reddish purple to white color: **Black Turpentine Beetle**, p.
    - Branch or stem, no hole in center, white to pinkish, often near wounds: **Southern Pine Coneworm**, p.
- **Pitch masses absent**
  - Bark not missing
    - Abnormal growths or shapes: **Galls**, p.
    - Holes in bark
      - 3-10 mm diameter, round, long wood fibers may be present: **Round-Headed Borer**, p.
      - 3-13 mm diameter, flattened shape, no wood fibers: **Flat-Headed Borer**, p.
      - 1-3 mm diameter, reddish brown boring dust: **IPS Engraver Beetle**, p.
      - Small black punctures approximately 0.5 mm, in branches: **Deordar Weevil**, p.
    - No holes in bark or not readily seen
      - Fine white sawdust at base of tree: **Ambrosia Beetle**, p.
      - Branch tips dead, resin flakes and beads, fine silk webbing: **Pine Tip Moth**, p.
      - Hemispherical shells on shoots: **Pine Tortoise Scale**, p.
      - Extensive galleries throughout wood, pellets or soil particles present; soft white-legged insects: **Termites**, p.
      - Extensive galleries throughout wood, clean; reddish black, ant-like insects: **Carpenter Ant**, p.
  - Bark missing
    - Small irregular patches, branch flagging, seedlings: **Reproduction Weevil**, p.
    - Large patches, stem breakage or removal: **Vertebrates**
    - Seedling girdled at stem base: **Mice & Rats**, p.
    - Seedling clipped off 7-10 cm high, top nearby or eaten: **Rabbit**, p.
    - Bark removed from one side, up 1m, foliage and buds browsed: **Deer**, p.
    - Gouging of bark close to ground, branches broken, foliage browsed: **Cattle**, p.
    - Stem severed at ground, broad band of bark removed: **Beaver**, p.
    - Bark flakes piled at base, deep gouges on stem or holes: **Woodpecker**, p.
    - Extremely large area of bark removed on stem or branches: **Squirrel**, p.
    - All roots except collar removed; dirt mounds present: **Pocket Gopher**, p.
    - Inner bark removed from root collar, lateral roots girdled: **Pig**, p.

Tree Insects – Key 3
Hardwood Foliage



Tree Insects - Key 4
Hardwood Branch and Stem

Symptoms

Holes and/or sap-staining of bark present

- 1 mm holes, fine boring dust, wilted foliage: **Black Twig Borer**, p.
- 3-13 mm round or flattened holes, wood granules or fibers may be present at hole or near base of tree: **Roundheaded Borer**, p. **Flatheaded Borer**, p.
- 15-25 mm rough elongate holes, open or loosely filled, wood chips and pellets at base of tree: **Carpenterworm**, p. .
- 9-12 mm round holes, fine or granular frass: **Clearwing Moth**, p.
- 0.5-3 mm round holes, fine sawdust piled at base of tree: **Ambrosia Beetle**, p.
- Rough slits in bark, extensive galleries with no frass or sawdust: **Carpenter Ant**, p.

Wilted, discolored foliage and/or insects present

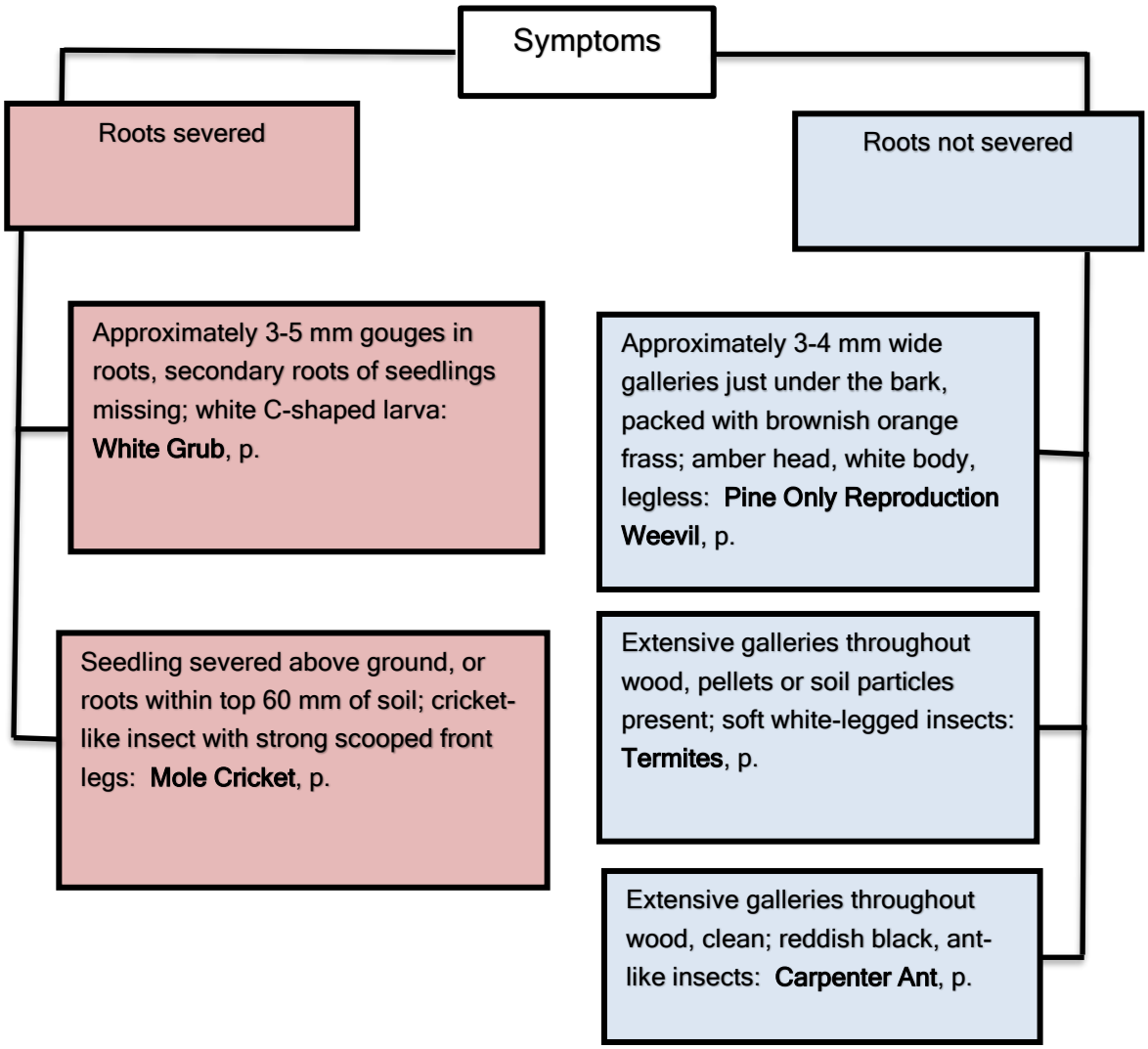
- Grayish, black insect, long slender legs, bluish-white bloom: **Giant Bark Aphid**, p.
- Brownish-black insect, wings dark with white markings, held roof-like over body, silk webbing may be present: **Psocids, Bark Lice**, p.
- Triangular-shaped insect, tan color with darker stripes or spots, forward pointing horn: **Oak Treehopper**, p.
- Stout, greenish brown insect, loud piercing trilling sound, slits in bark of branches and wood fibers sticking out: **Cicada**, p.
- Gall-like globes, yellow to black color, solid or mottled patterns: **Kermes Scale**, p.
- Waxy, white lump on leaves or shoots: **Florida Wax Scale**, p.
- Flat, yellowish circles, ring-like pits or swellings in bark: **Holly Pit Scale**, p.
- Flat, grayish to brown circles, near match to bark colors: **Obscure Scale**, p.
- Raised, hemispherical shell, reddish brown: **Oak Lecanium Scale**, p.

Abnormal growths or shapes: **Galls**, p.

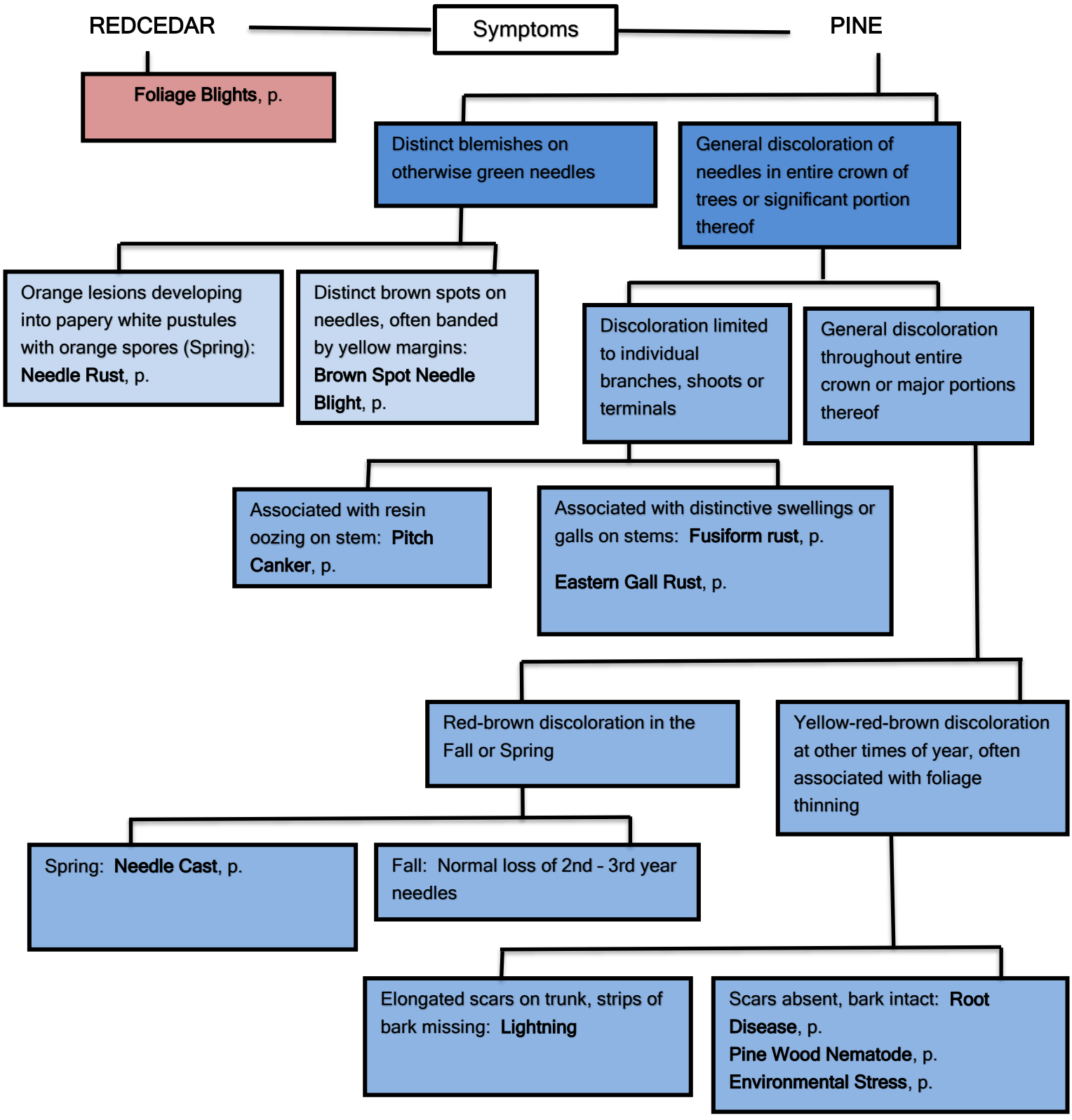
Scattered or circular arrangement of branches on ground around tree: **Twig Girdler**, p.

Large patches of bark removed, stem breakage or removal: See **Conifer Branch and Stem**, Key, p.

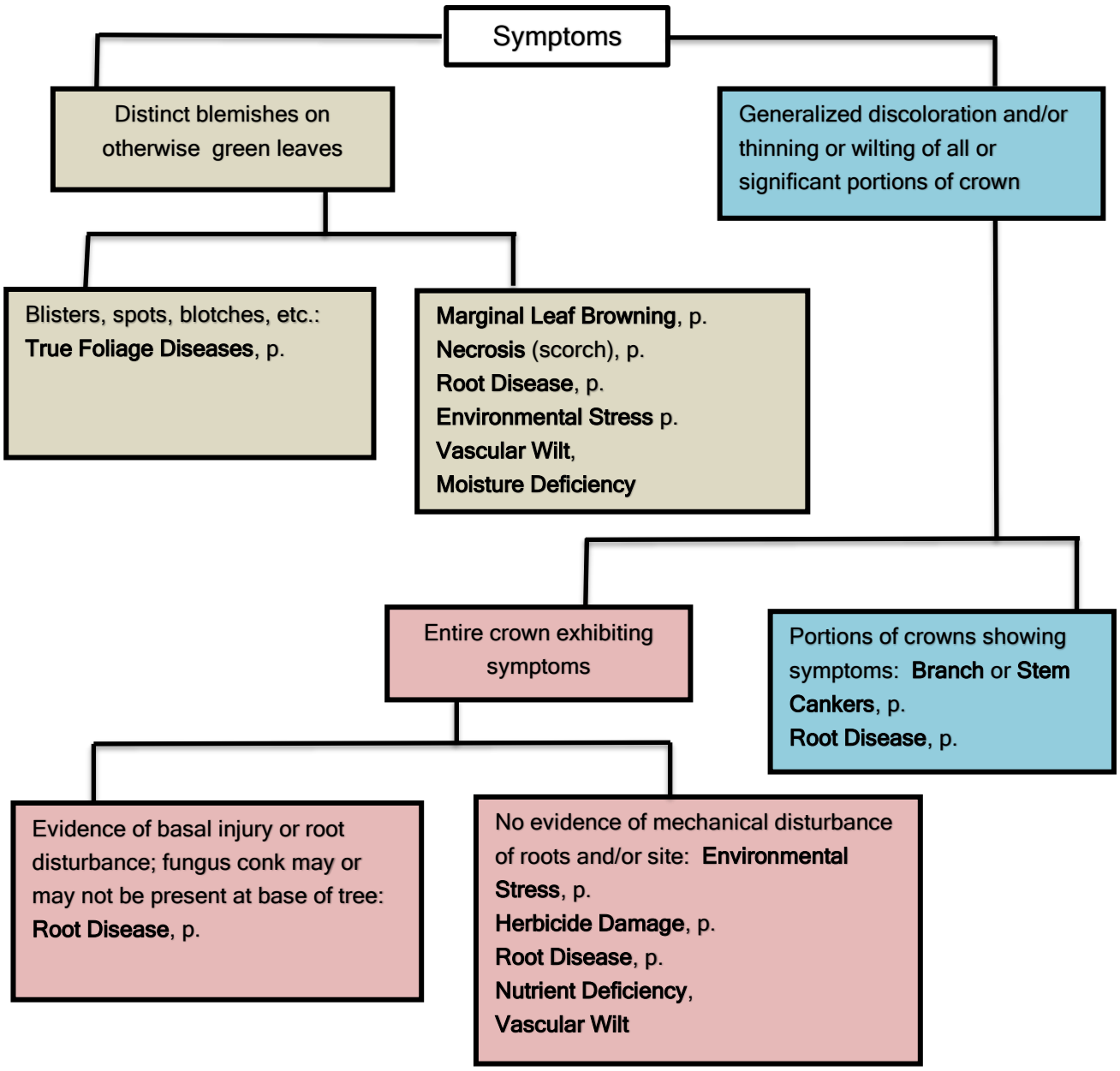
Tree Insects - Key 5
Roots



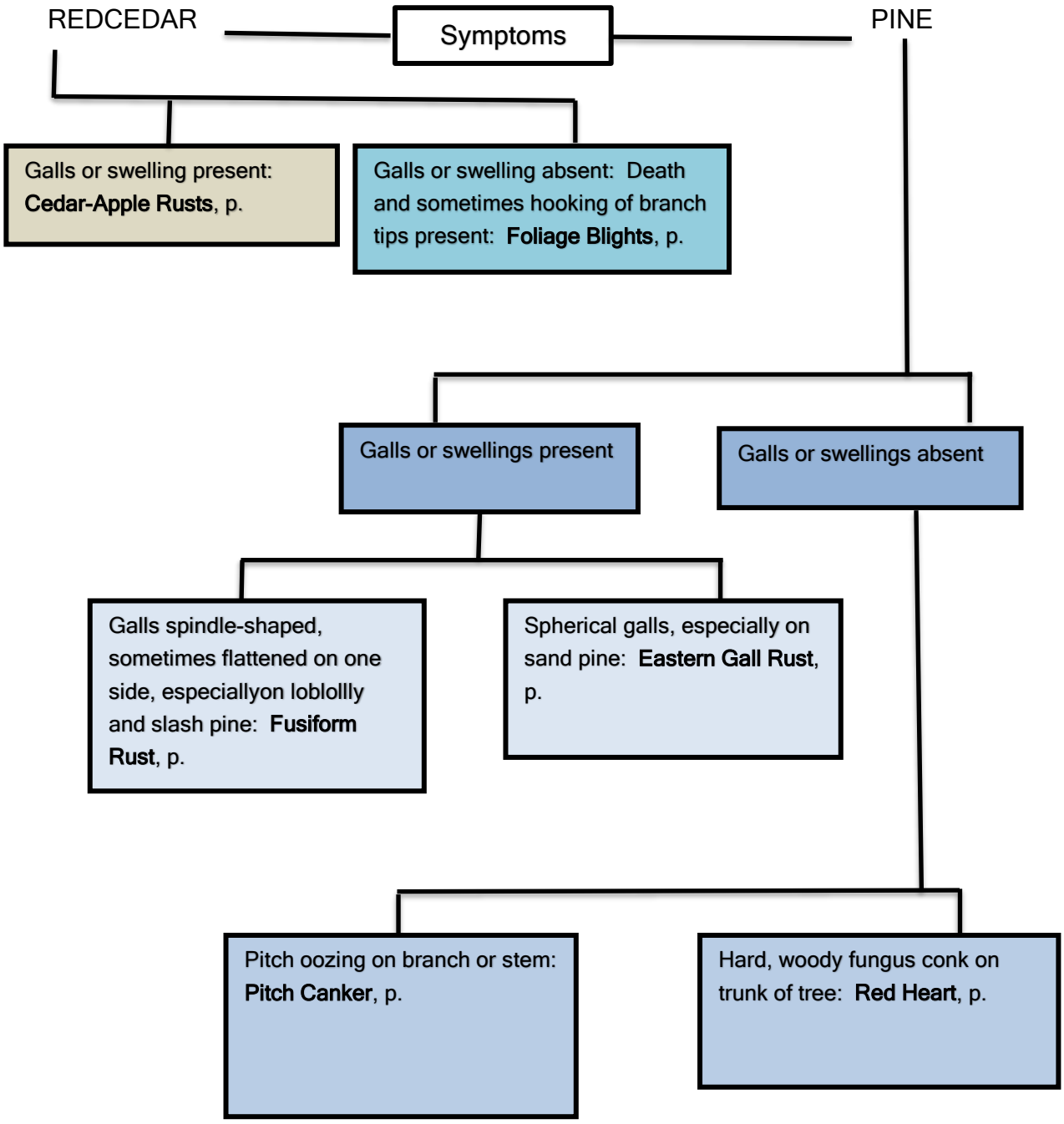
Diseases of Trees - Key 1
Conifer Foliage



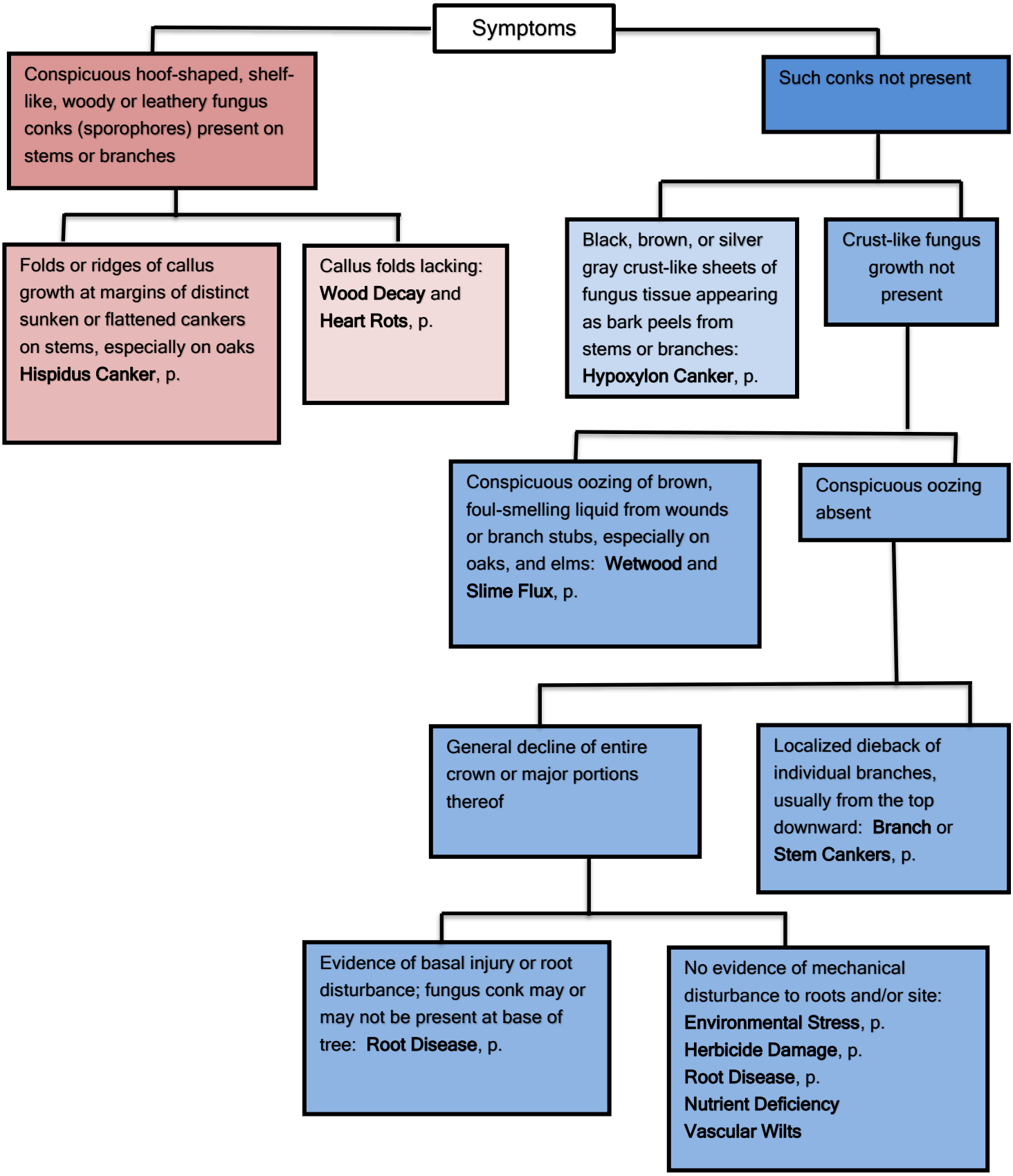
Diseases of Trees - Key 2
Hardwood Foliage



Diseases of Trees - Key 3
Conifer Branch and Stem



Diseases of Trees - Key 4
Hardwood Branch and Stem



INJURY AND STRESS

Trees are like people. When people are tired and run down, they are often more susceptible to various diseases. Likewise, trees subjected to environmental stresses or injuries are usually more vulnerable to damage caused by insects and diseases. The concept of STRESS, as it relates to insects and diseases affecting trees, is vitally important. Natural and man-made stresses are major contributors to insect and disease problems in Florida. Knowledge of how susceptibility is affected by stress or, on the other hand, how pests interact with a tree under stress, is a key element in the reduction of losses to stress-related pests.

Stress in trees is induced by a variety of factors and may be chronic (recurrent or long lasting) or acute (sudden and intense). Mineral nutrient imbalances and extended droughts are examples of factors including chronic stress. Untimely and severe freezes, lightning damage, floods, and construction damage are examples of acute stress. Most causes of stress are capable of inducing either chronic or acute stress; the distinctions being those of degree and duration. Table I provides a summary of some common causes of injury and stress in trees. Examination of the table will reveal that both insects, and organisms that cause disease (pathogens) are included as causes. While we're currently emphasizing that many insects and diseases become problems as a *result* of stress or injury, it is equally true that insects and diseases are also *causes* of stress and/or injury.

TABLE I. Some Common Causes of Injury or Stress in Trees

Environmental	*Human-Controlled*	*Animal*	*Plant*
Mineral Nutrient Deficiencies	Industrial Wastes	Nematodes	Viruses
Frost or Freeze	Air Pollution	Insects	Mycoplasmas
Sun Scorch	Soil Compaction	Mites	Bacteria
Drought	Mechanical Injuries	Millipedes	Fungi
Lightning	Construction Damage	Slugs	Mistletoe
Wind	Changes in Soil Levels	Snails	Algae
Hail	Changes in Soil Water Status	Birds	Moss
Fire	Improper Planting	Rabbits	Weeds
Flood	Improper Pruning	Mice	Strangling Vines
Salt Water Spray or Intrusion	Excessive Fertilization	Rats	
	Misuse of Herbicides	Dogs	
	Excessive Irrigation	Livestock	
		Squirrels	
		Deer	
		Humans	

Stress on Trees

Stress on trees can often be a subtle thing. Tree trunks and branches damaged (stressed) by construction activities are usually obvious (breakage and debarking). Much more difficult to recognize and define are, for example, stresses resulting from soil compaction, changes in soil water drainage patterns, or air pollution. Nonetheless, these factors are just as real, and in many cases result in more damage than their visible counterparts.

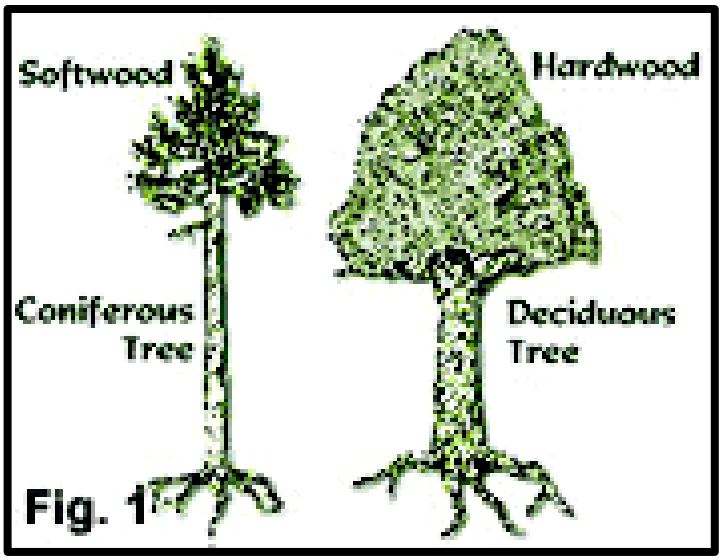


Fig 1. An example of softwood and hardwood trees. Softwood, or coniferous, trees have needle-like, linear, or scale-like leaves and are usually evergreen, though some do shed their needles annually. Hardwood, or deciduous, trees have broad leaves that are usually dropped every year. Some hardwoods are evergreen, however, and their leaves persist for two or more years.

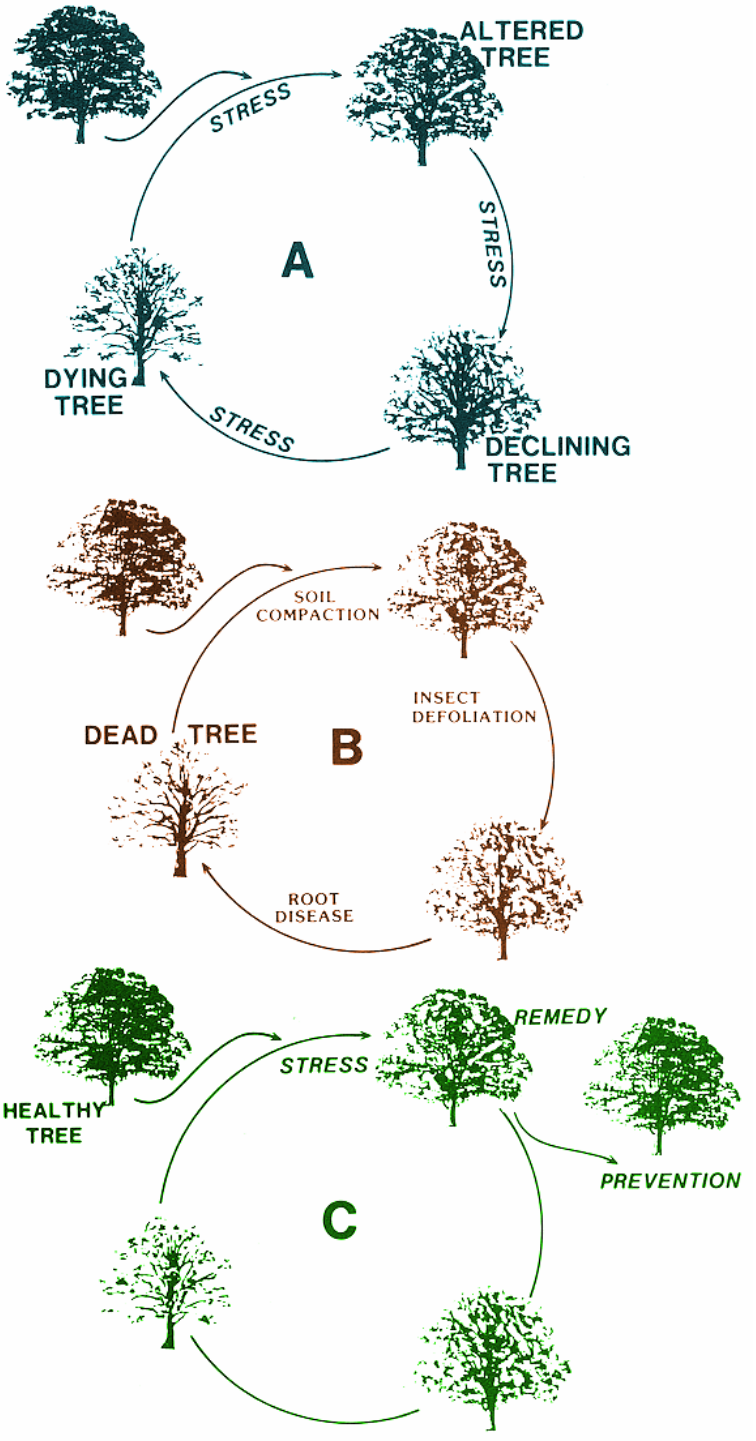
A tree under stress often does not exhibit any immediately recognizable external symptoms. Internally, however, a variety of physiological changes are usually taking place. For example, photosynthesis, the process by which the tree manufacturers its food (carbohydrates, etc.) may be upset. The tree begins to starve, rapidly depleting necessary food reserves. Adequate water and nutrients are usually not supplied by root systems of stressed trees and thus fall to dangerously low levels. Growth regulating chemicals (hormones) within the tree become unbalanced. Although stressed trees may go completely unnoticed, the net result of these internal physiological changes is a tree with growth and metabolism operating at less than peak efficiency - a preferred target for many insect and disease pests.

If stress is severe (acute) or prolonged (chronic), the tree eventually exhibits various external symptoms. For example, the tree's growth rate is reduced and stunting may occur. New leaves may be smaller, fewer, and more yellow (chlorotic) in color than normal. Older leaves as well may become discolored, and fall from the tree prematurely. Branch dieback begins, giving the crown of the tree a ragged or staghead (much like deer antlers) appearance. These symptoms are outward expressions of internal, physiological imbalances. The tree has entered a vicious cycle, the Stress Cycle (Fig. 2A), and begins a progressive decline, usually terminating in death.

Many insects and disease will not seriously affect a tree until it has reached some point in the stress cycle. Unfortunately, insect pests, as well as

Figure 2. The Stress Cycle

A healthy tree that comes under stress may die. Usually the appearance of a tree changes as it goes through the stress cycle (A). Once under duress a tree may be affected by very different types of stress, such as soil compaction, insect defoliation, and root disease (B). Unless the cycle is broken, the tree may die. If stress is recognized in time and the cycle is broken - by preventing continued exposure of the tree to stress, or by providing appropriate cultural measures to bolster the tree's health - the tree may be saved (C).



certain tree pathogens (especially fungi), are actually better at recognizing trees under stress than most tree enthusiasts. As a result, stressed trees may go completely unnoticed until they are "suddenly" damaged or killed by insects or diseases. Some insects are actually attracted to stressed trees by chemical signals (odors) released into the air by trees in response to stress. Most trees are usually exposed constantly to one degree or another to many ordinarily non-aggressive tree pathogens (especially fungi). It is only when trees are seriously injured or stressed that they lose their natural ability to ward off infections by these organisms and fall victim to the attack. Once established in a stressed tree, insect and disease pests often give the stress cycle another turn full circle. See Stress Cycle (Fig. 2B).

A tree under continued stress can only become more stressed. Finally, it dies - in a period of days or several years, depending upon a variety of circumstances - unless the stress cycle is broken. See Stress Cycle (Fig. 2C). Whatever the homeowner or forest manager can do to avoid or minimize the causes of stress in trees will aid in the reduction of losses to insects and disease. Prevention of Stress by avoiding unnecessary injuries to trees during construction, road-building, or timber harvesting operations is probably the single most effective method of controlling stress-

related pests. Sometimes, of course, stress cannot be prevented as in the case of untimely hailstorms, freezes or floods.

One thing can be said for sure. In Florida, as well as across the nation, what can be done is all too often not being done! Lawnmowers are still banging into trees, as are trucks at construction sites; bulldozers are tearing root systems apart and burying others to the point of suffocation; road and parking lots are still being built over tree roots; roots of trees are still being severed to make way for sewers, television cables, and building foundations; and on and on and on . . . urbanization is taking its toll!

When trees are unknowingly or wantonly treated in such a manner, the end result is inevitable - death and destruction caused by insects and diseases.

In most cases, damage sustained by trees during construction or similar activities is irreparable. It's anybody's guess whether or not damaged trees will succumb or survive. One thing is certain, prevention of stress is impossible after the damage is done.

PRINCIPLES OF CONTROL FOR INSECTS AND DISEASES

SPRAY! Unfortunately, this is the most common response of laymen desiring control of an insect or disease damaging their trees. It is true that pesticide applications may be an acceptable and effective control in certain situations. Yet, it is important to realize that pesticide application is only one of an array of control methods available for preventing or suppressing insect and disease activity in trees.

In many cases involving insects or diseases in trees, the use of a pesticide (fungicide, insecticide, miticide) can't be justified economically, legally or biologically. In fact, for many tree pest problems pesticides just don't work. Thus, the desired result is often better achieved through the application of one or more alternative control methods.

Today, pest management specialists, such as entomologists and pathologists, expound the virtues of Integrated Pest Management (IPM). This term is actually a rephrasing of what was previously considered to be a common-sense approach to the control of insect and disease pests. IPM does not promote any one control method above another, or to the exclusion of all other methods. Instead, IPM advocates the employment of those control methods which are most effective, efficient, and economical, as well as biologically, ecologically, and sociologically sound. One pest management problem may require one control method. Another may require a totally different approach. Others may be best handled by a combination of methods.

Here is an introduction to some general principles and methods of pest control:

Behavioral Method

Behavioral control generally employs synthetic chemicals, which are similar to natural chemicals utilized by insects in their interactions with trees (insect pheromones and host tree odors), to disrupt behavior on which insects normally depend to successfully mate or locate food or habitat. Repellants, confusion or inhibition chemicals prevent or minimize infestation of susceptible trees. Attractants are often used to lure insects to glue or poison traps. Pheromone-baited traps are currently employed as useful survey and detection tools for insects such as the gypsy moth and the Nantucket pine tip moth. Research may soon provide a method for using natural chemicals, inhibitory to pine bark beetles, to protect southern pines.

Biological Method

Biological control is the use of beneficial or harmless organisms to control or suppress a pest organism. Biological control has two aspects: natural and classical. Natural biological control is deceptively important in the day-to-day suppression of insects and diseases that would otherwise cause serious damage to trees. Most pests native to North America have an abundance of natural enemies that serve a vital role in keeping pest populations at innocuous levels. Biological control agents or natural enemies include mammals, birds, insects, mites, spiders, amphibians, reptiles, fungi, bacteria, nematodes and viruses. These agents function as predators, parasites, pathogens, antagonists, and/or competitors of pest organisms. In contrast, classical biological control involves the introduction of natural enemies into specific areas to control a pest which has previously been introduced inadvertently, and is a problem because it is not controlled by native biological or environmental factors. Typically, imported natural enemies are from the area of origin of the target pest.

An important development in the biological control of insects entails the mass production and application of parasitic microorganisms (bacteria, viruses, nematodes) which attack only one or a few related insect species. These microorganisms are often very effective control agents and their apparent toxicity to man is minimal or none. *Bacillus thuringiensis*, a bacterium, is widely used around yards and in commercial settings in control a number of caterpillars that feed on trees and other crops. The use of a competitive fungus to suppress annosum root rot activity in thinned pine plantations is an excellent example of biological control of a tree disease.

Genetic Method

The most familiar use of genetics for control of insects and diseases is the breeding and utilization of varieties (genotypes) of host tree species which are genetically less susceptible or more resistant to problem insects or diseases. For example, commercial forest industries currently cooperate with federal and state government agencies in the South to select, breed, and utilize pines which are resistant to fusiform rust. Another approach to genetic control of harmful pests is the introduction of genetically weak (avirulent) pest strains or varieties into pest populations which are normally damaging or aggressive (virulent). The assumption is that the results of interbreeding will eventually be a pest population that is less damaging than the original. This approach is showing promise in research efforts aimed at controlling the infamous chestnut blight fungus.

Regulatory Method

The fundamental objectives of regulatory pest control include preventing entry and establishment of foreign plant and animal pests, and the

eradication, containment, or suppression of pests established in limited areas. These objectives are accomplished by a variety of means including (1) Certification that plant materials being moved from state to state or country to country are pest free, (2) Inspection of nurseries and plant materials being transported to detect, identify, and control harmful pests before they are spread, (3) Surveys to detect and delineate infestations or infections of harmful pests which may have inadvertently been introduced into an area, and (4) the establishment and enforcement of Quarantines where necessary to prevent movement of dangerous pests. In Florida, the legal authority for the implementation of regulatory plant pest control calls within the jurisdiction of the Department of Agriculture and Consumer Services, Division of Plant Industry, headquartered in Gainesville.

Cultural Method

Cultural methods of pest control are many and diverse but are particularly applicable and effective in many situations. Generally, cultural control methods are practices which are good for trees and bad for harmful pests. Common practices include:

(1) Sanitation and host eradication which involve removal and/or destruction of host material (leaves, branches, trees) infested with insects or exhibiting symptoms of diseases. This practice reduces the threat of spread and/or intensification of the problem.

(2) Fertilization, or keeping trees well fed, often enables them to ward off a variety of pest problems.

(3) Irrigation, natural or mechanical, is important. Moisture deficiencies can render trees susceptible to a variety of insects and diseases. Note: overwatering can be just as serious as underwatering.

(4) Alternative host eradication means removal and/or destruction of alternate host plants not desired by the landowner, but necessary for the successful development of certain insects and diseases (especially applicable to various rust diseases caused by certain fungi).

(5) Avoidance means prevention of insect and disease problems through practices such as planting nonsusceptible species and preventing injuries to existing trees.

(6) Proper site selection means planting trees in locations to which they are well adapted to avoid unnecessary stress, or planting trees on sites that are not conducive to pest activity.

(7) Timber stand improvement involves aspects of other practices, but includes thinning forest stands to promote tree vigor and removing undesirable, pest infested or diseased trees.

(8) Proper timing of forest and shade tree practices means planting,

thinning, pruning and harvesting of trees at times when associated pest problems are less likely to cause serious damage.

(9) Use of clean planting stock, seeds and seedlings free of harmful pests, is a key element in preventing insect and disease problems from developing.

Physical and Mechanical Methods

Physical and mechanical controls are the oldest of all control methods. They differ from cultural methods in that they are employed directly against pests and are not a part of regular or preventive cultural practices per se. Physical and mechanical methods are particularly applicable to insect pests, and are employed to destroy pests outright, disrupt normal biological habits, or modify the environment to discourage pest activity. Some tools employed as physical or mechanical control include adhesives, sound, screens, or other barriers, traps, light, heat and refrigeration. Handpicking, brushing, crushing, or washing insect pests from infested trees are also physical or mechanical controls.

Pesticidal Method

Pesticides are chemicals specifically designed to kill or harm pests. Today, several hundred pesticides are available and are designed to address a wide variety of pest problems. However, each pesticide is applicable, either biologically or legally, to a limited number of pest organisms and sites. No one pesticide is applicable for all situations. Pesticides are poisons, and by their very nature require judicious and skillful use. In the hands of knowledgeable users, pesticides can be an important control method. All pesticide containers must have labels. READ THE LABEL!

PESTICIDES

Specific pesticide recommendations are not included in this book for a variety of reasons including the following:

(1) Most pesticides (insecticides, fungicides, miticides) are toxic or poisonous to people and other organisms – pets, livestock, fish, birds, beneficial insects, wildlife – as well as the pests they're designed to kill. To protect the environment, pesticides and their uses are monitored by federal and state agencies. Regular and timely reviews are conducted to examine a pesticide's effectiveness and the potential or actual risks associated with its use. Sufficient negative evidence may result in a pesticide's cancellation or suspension; often at short notice. In other cases, the legal uses (rate, sites, target pests) may be altered.

(2) Pesticide manufacturers generally attempt to increase the market of a pesticide by expanding the label uses. Often a new pesticide has a limited applicability. As research continues, new and effective uses are documented, and presented to the appropriate regulatory agencies. If these are approved, the label is expanded to include the new pests, sites of application, method of application, or some combination.

To address the specifics of pesticide use, we recommend the following publications.

- "Florida Disease Control Guide"
- "Florida Insect Control Guide"
- "Florida Weed Control Guide"
- "Fungicides for Use on Ornamentals" –
- Circular No. 484

All four are compiled and distributed by the Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville. Copies can be obtained, at a cost for certain volumes, through your local county extension agent.

These publications are the best means of obtaining currently recommended and legal (Florida only) pesticides for specifically identified pest problems. If the control guides are acquired, revisions or updates are automatically forwarded to the control guide owner (a current address is necessary). There is a cost for this system, but it is minimal and worthwhile.

Other sources of information:

- Local Florida Forest Service Office – county and/or urban forester

- Local Cooperative Extension Office – county extension agent
- Pest Control Operators – private firms that will provide a service to directly control a problem as well as provide technical advice
- Leaflets – both the Florida Forest Service and the Cooperative Extension Service provide concise publications that address a single pest or group of pests, and pesticide recommendations are usually listed and discussed where applicable.

Conclusion

All of these methods of pest control involve the concept of prevention. If all other words, concepts, and definitions are forgotten, remember prevention. Many insects and disease problems affecting trees can easily be prevented. Unfortunately, they are not. Clearly, some pest problems are unavoidable. Trees that are properly cared for, however, are far less likely to fall victim to harmful pests than those which are neglected or abused.

CONCEPTS OF ENTOMOLOGY

Insects feed on all parts of a tree (see Fig. 3 for some common insects that damage trees). Sounds ominous. Yet trees survive and perpetuate themselves. A daily contest occurs between trees and insects – usually the score is even. Insects have developed habits, capabilities, and body parts that allow them to attack a tree, but trees have developed a number of defense mechanisms. Let's take a closer look at insects.

Entomology is the study of insects. The root word entomos is Greek and was used to identify a variety of crawling and flying creatures. The word bug is widely used but is entomologically incorrect. To stay out of trouble we'll use insect.

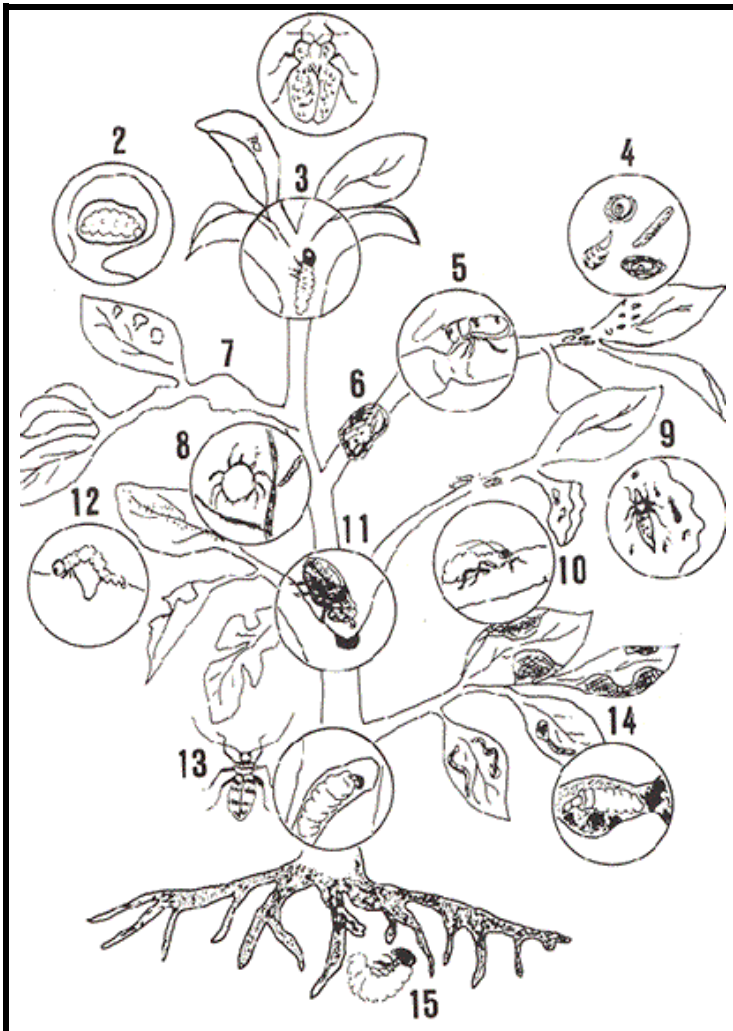


Figure 3. Some Common Insects that damage trees:

1. Lace bug sucking sap from a leaf.
2. Gall wasp feeding in a leaf gall.
3. Tip moth boring in the tip of a branch.
4. Scale insects feeding on sap from leaves and shoots.
5. Twig girdler biting through a branch.
6. Egg case of a tent caterpillar on a branch
7. Twig swollen by a gall insect.
8. Red spider mite feeding on a leaf.
9. Leaf folded and deformed by thrips feeding.
10. Aphid feeding on a plant sap.
11. Bark beetle boring into a stem.
12. Caterpillar chewing on a leaf.
13. Long-horned beetle and roundheaded borer boring in stem.
14. Leafminer feeding between leaves.
15. White grub feeding on roots.

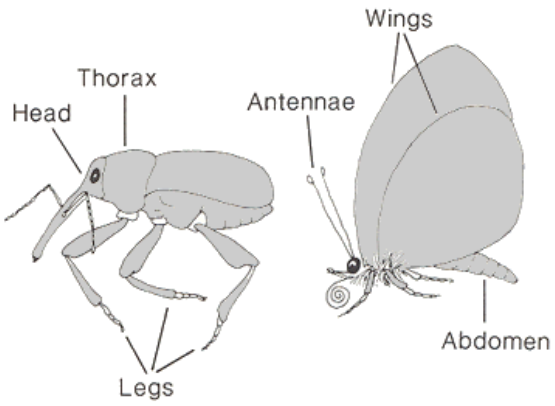


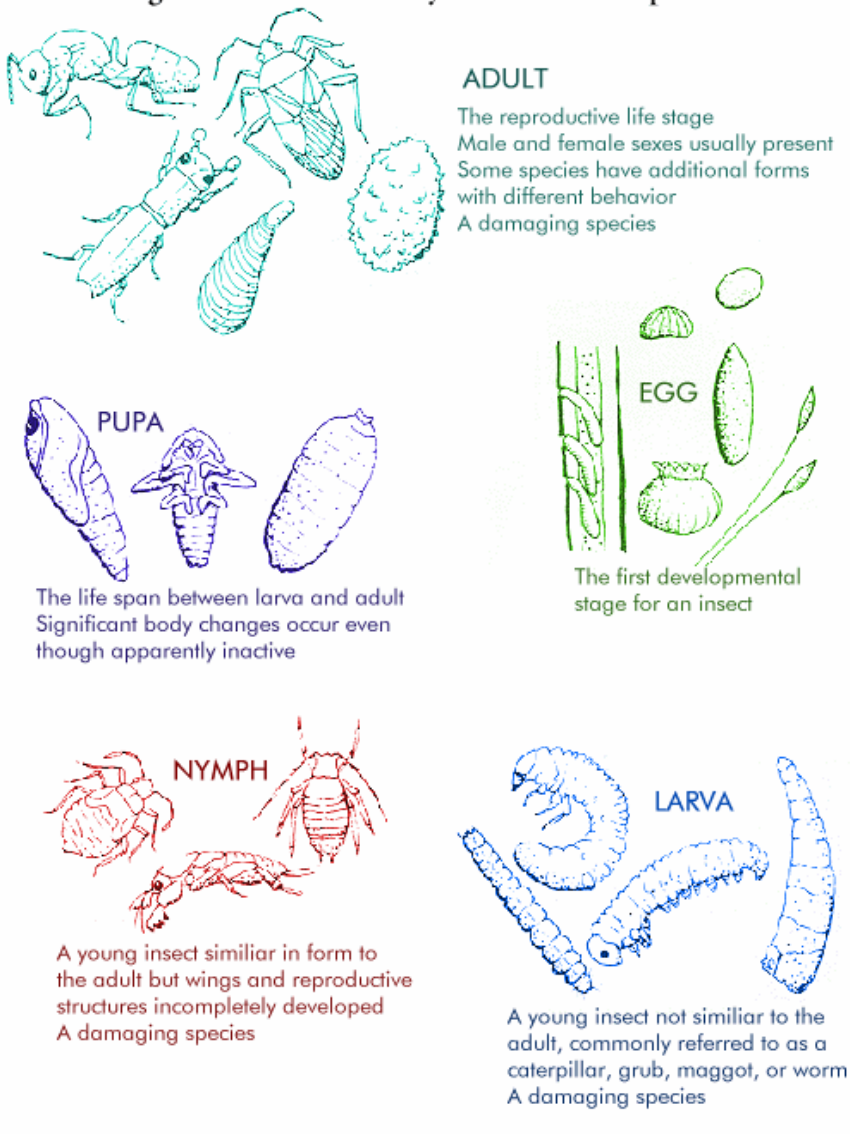
Fig. 4. The characteristic body parts of adult insects. An adult beetle and moth are depicted in the illustration.

(pupal) state. After a period of time an adult insect emerges from the now empty shell of the pupa.

Insects come in a variety of shapes and sizes. The great divergence in appearance of the adults, pupae larvae, nymphs, and eggs (Fig. 5) can be confusing. To apply the best control or preventive measures, an accurate identification is needed. This book can assist in identifying the more common insect pests of trees in Florida.

Insects are distinguished from other types of animals by having certain structural features (see Fig. 4 for characteristic body parts of adult insects). The possession of antennae, head, thorax, abdomen, 3 pairs of legs and usually 1 or 2 pairs of wings separates adult insects from similar animals like mites, spiders, and lobsters. Also, insects develop through a progression of growth stages (see Fig. 5 for a generalized life cycle for tree insect pests). In the usual sequence the adult female insect lays from a few to several hundred eggs. A larva or nymph emerges from each egg. Nymphs grow and molt several times before becoming adults. Larvae grow and molt to an intermediate

Fig. 5. Generalized life cycle for tree insect pests.



Key Words

As few words as possible of entomological jargon are used in the book. Some words creep in because nobody else has come up with better ones. Besides the names given for life stages in Figure 5, the following terms are absolutely necessary.

- Frass - solid insect excrement
- Honeydew - a sweetish liquid excrement produced by certain insects, especially aphids and scale insects
- Pitch tubes - hardened resin with a tube-like or balled form on the outside bark of pine trees infested by pine bark beetles
- Cocoon - a covering, composed partly or wholly of silk, spun by a larva to protect the enclosed pupa.

Checklist of Insect Damage

Usually, evidence of damage caused by insects can be found on or in most trees, especially older trees. Table II is a checklist of some of the more common clues that indicate such damage has taken place.

If such damage is seen on or in a tree a landowner is faced with a decision – what to do? To complicate matters, insects may or may not be present.

To assist the reader in making the decision of what to do, a control section is included for all pests discussed in this book. In most cases an insecticide or fungicide will be only one of several options available to the landowner. A chemical solution to the problem is not always the best or first to use. Cultural or physical control options may be the best choice.

Contact your local Florida Forest Service office if you have questions or need assistance with a pest problem or tree care and maintenance.

Table II. Checklist of Insect Damage to Trees

Fruit	Leaves	Twigs/Buds	Stem	Roots
Mines Premature drop Damaged seed Chewed Galls Holes Abnormal shape	Discolored Curled Spotted Galls Notched Holes Mines Skeletonization Defoliation Disfiguration with excrement	Girdled Galls Mines Pruned Wilted twigs Discolored Holes Enlarged buds	Mines in bark or cambium Borer channel into wood Chewed bark Galls Pitch masses Fine sawdust Sapstaining Holes	Girdled Galls Mines Chewed Borer tunnels into wood Mines in bark or cambium

INSECTS OF CONFER FOLIAGE

Common Name: CYPRESS LEAF BEETLE

Other: Leaf beetle

Species: *Systena marginalis*

Common Hosts:

Baldcypress *Taxodium distichum*
Pondcypress *Taxodium distichum var. nutans*
Sand pine *Pinus clausa*

Leaves damaged by adult Cypress Leaf Beetle

Description:

- Adult - approximately 4 mm long; pale yellow to gold head and body, black wing edges and dark stripe down center of back

Importance: Cypress leaf beetle outbreaks commonly occur over large areas. The damage typically becomes noticeable within a short period of time due to the mass congregations of beetles in one area. Infested trees shed damaged needles and within a few months it is difficult to identify the affected trees because of the new foliage growth.

Biology and Habits: Adult beetles are common in the tree crowns by midsummer. They congregate in great numbers on a single tree or a small group of trees and just as abruptly leave for another area of host trees. The larvae are thought to feed on the roots of grasses and weeds.

Number of Generations: 1 generation per year

Signs of Infestation: Foliage discoloration: bright to dark red appearance. Small linear gouges (3 mm long) in the needles. Swarm of small yellowish beetles highly active around the crowns of trees.

Similar Damage: Drought or other stress factors can bring on a similar needle color change, but none will make the small slits.

Control: The generally favorable response of refoliation by the defoliated trees suggest that control is not warranted in most instances. When additional stress factors are present, however, an approved insecticide may be useful. Promote tree vigor and health to aid in the recovery from defoliation.

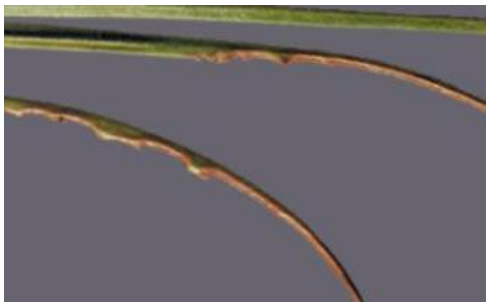
Common Name: PINE COLASPIS

Other: Leaf beetle

Species: *Colaspis pini*

Common Hosts:

Loblolly pine *Pinus taeda*
Longleaf pine *Pinus palustris*
Sand pine *Pinus clausa*
Shortleaf pine *Pinus echinata*
Slash pine *Pinus elliottii*
Spruce pine *Pinus glabra*



Pine needles showing feeding damage by adult PINE COLASPIS

Description:

- Adult - approximately 6 mm long; rusty yellow to brown head and body; robust body with reflective green highlights

Importance: Pine colaspis damage occasionally becomes severe in a young pine stand, however, growth loss is little or none in most cases.

Biology and Habits: Adult beetles become active on trees by early summer. The females beetles lay their eggs on the herbaceous undergrowth in the pine stand. The larvae feed on roots of the grasses and weeds in the stand. Overwinter as larvae in the soil and then pupate in the spring.

Number of Generations: 1 generation per year

Signs of Infestation:

- Scattered patches of reddish-brown or scorched crowns in a young pine plantation.
- Needles with a ragged or serrated edge; needles turn brown opposite the chewed tissues.
- New needles alone affected if the beetle population is low; otherwise all needles are injured by the feeding adult beetles.

Similar Insects and Damages:

- PINE CHAFER: Approximately 8 mm long; entirely light tan or head and neck a greenish bronze, body a dark tan; damage is a notching of a needle bundle just above the sheath; the needles become brown or appear scorched.

- REPRODUCTION WEEVILS: Small patches of bark removed from branches and stems; long snout on beetles

NOTE: All three types of insects feed on pine trees at night. It is difficult to detect the insects because of this habit.

Control: Promote tree vigor and health to aid in the recovery from defoliation. Generally, only severe defoliation of high-value trees warrant the consideration of control with an insecticide. Use an approved insecticide.

Common Name: PINE WEBWORM

Other: Webworm

Species: *Tetralopha robustella*

Common Hosts:
Japanese black pine *Pinus thunbergiana*
Loblolly pine *Pinus taeda*
Longleaf pine *Pinus palustris*
Sand pine *Pinus clausa*
Shortleaf pine *Pinus echinata*
Slash pine *Pinus elliottii*
Virginia pine *Pinus virginiana*

Frass nest of the PINE WEBWORM

Description:
- Adult- brownish-gray head and body; front wings dark at base and tips, hind wings light brown; wingspan approximately 25 mm
- Pupa- size of adult; reddish-brown
- Larva- size variable, approximately 20 mm long when mature; dark and light brown head, light brown body with 4 darker strips

Importance: Young (1-2 year) pine seedlings are most susceptible to webworm infestation; older trees infrequently infested. Growth loss may occur, but death is uncommon. Generally, few infested seedlings are present the year following a high webworm infestation rate.

Biology and Habits: Adults moths emerge from the soil early-late spring, mate, and the female lay eggs on the pine needles. The young larvae mine the needles; older larvae construct silken webs which become covered by coarse pellets of frass (insect wastes). The larvae feed within the nest, clipping off pine needles and pulling them into the nest.

Several (1-14) larvae may occupy a single nest. Pupation occurs in the soil; overwinters as an adult.

Number of Generations: 3 or 4 generations per year

Signs of Infestation: Loss of foliage Balls or lumps of coarse frass (dark pellets) on stem or branches

Control: Natural enemies, especially insect parasites, usually keep webworm population at low levels. Promote tree vigor and health to aid in the recovery from webworm defoliation. Handpick and destroy the nests and larvae. Use an approved insecticide; however, most times an insecticidal treatment is not necessary.

Common Name: PINE SAWFLIES

Slash pine sapling defoliated by larvae of the slash PINE SAWFLY.

Other:

- Conifer sawfly
- Webspinning sawfly

Species:

- Neodiprion spp.
- Acatholyda sp.

See Table 3. Common Species of pine-feeding sawflies

Common Hosts:

- **Loblolly pine** *Pinus taeda*
- **Longleaf pine** *Pinus palustris*
- **Pond pine** *Pinus serotina*
- **Sand pine** *Pinus clausa*
- **Shortleaf pine** *Pinus echinata*
- **Slash pine** *Pinus elliottii*
- **Spruce pine** *Pinus virginiana*

Description:

- **Adult** -female approximately 8-10 mm long; head with narrow antennae, body light to dark brown, robust and wasp-like, but waist is thick; wings light brown with prominent veins
- **Pupa** -similar to adult; yellowish-white; conifer sawfly encased in a brown papery cocoon, webspinning sawfly naked

- Larva -size variable, approximately 18-25 mm long when mature; see Table III for distinguishing characteristics to determine species.

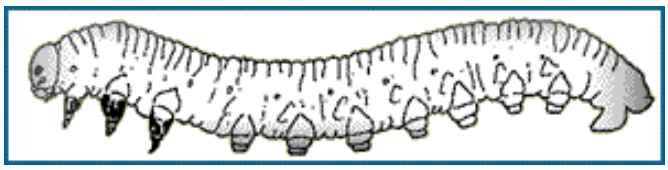


Fig. 6. General appearance of a sawfly larva. The characteristics commonly used to distinguish species are head coloration, background color of the body, and pattern of stripes and/or spots on the body. Identification of host tree species is also useful.

Importance: Sawfly outbreaks are cyclical (approximately 8-10 year intervals) and can occur over a widespread area. Severe defoliation during late fall can result in reduced tree growth, lowered resistance to other pests (bark beetles) and death.

Biology and Habits: Adult sawflies emerge from cocoons in the spring, mate, and the females lay eggs in slits sawed into pine needles. Young larvae feed on the outermost parts of the needles; older larvae consume entire needles. Pupate inside brown papery cocoons located under bark flaps, in crevices, or in soil litter and mineral soil.

Signs of Infestation: Loss of foliage; older foliage consumed before current foliage; branches appear tufted-like. Needles with straw-like appearance or small light-yellow patches (egg pockets) along the length of needles. Colonies of sawfly larvae on branches; larvae may number in the hundreds per colony. Thick layer of green to brown pellet-like frass (insect wastes) in leaf litter. Webbing attached to needles and shoots (webspinning sawfly only).

Control: Natural enemies and unfavorable weather usually keep webworm populations at low levels. Virus diseases and insect parasites are particularly useful in sawfly control. Promote tree vigor and health to aid in the recovery from defoliation. Use an approved insecticide.

Table III. Common Species of Pine-feeding Sawflies

Common Name	Species	Description	Host
Slash pine sawfly	*Neodiprion merkeli*	Two-tone head (red above, black below); yellow-green body with 4 faint black stripes and a large black spot on hind end on each side	*Slash pine*
Redheaded pine sawfly	*Neodiprion lecontei*	Red head; whitish or yellowish- green body with 6 rows of irregular black spots, large black spot on hind end	Longleaf pine
Blackheaded pine sawfly	*Neodiprion excitans*	Shiny black head; olive-green body with two black stripes and row of black spots, large black spot on hind end	Slash pine

Sand pine sawfly	*Neodiprion pratti*	Black head; pale green body with 2 black stripes and a row of black spots	Loblolly pine Pond pine Sand pine Spruce pine
A pine sawfly (no common name)	*Neodiprion virginianus*	Black head; row of distinct, nearly square black spots on each side of the body	Loblolly pine Choctawhatchee sand pine Ocala sand pine
Spruce pine sawfly	*Neodiprion warreni*	Black head; two dark stripes on each Spruce pine side of the body	Loblolly pine Longleaf pine Shortleaf pine
Abbot's sawfly	*Neodiprion abbotii*	Brown-black head with a white spot on the front; yellow to pale green body with 4 dark green stripes	Slash pine
Sand pine webspinning sawfly	*Acantholyda circumcincta*	Red head; yellowish-orange body with broad reddish-brown stripe; webbing on foliage	Sand pine

Common Name: WOOLLY PINE SCALE

Other: Leaf beetle

Species: *Pseudophilippia quaintancii*

Common Hosts:

Loblolly pine *Pinus taeda*
Longleaf pine *Pinus palustris*
Shortleaf pine *Pinus echinata*
Slash pine *Pinus elliottii*

Loblolly pine branch infested with the Woolly Pine Scale

Description:

- Adult - female approximately 2 mm long; hemispherical and greenish-brown body; covered with a thick layer of fleecy white wax

Importance: Woolly pine scale populations occasionally become noticeable on single or small groups of trees. Severe feeding damage can cause branch dieback. Death is rare unless accompanied by other stress factors.

Biology and Habits: Adult beetles are common in the tree crowns by midsummer. They congregate in great numbers on a single tree or a small group of trees and just

as abruptly leave for another area of host trees. The larvae are thought to feed on the roots of grasses and weeds.

Number of Generations: 1 or 2 generations per year

Signs of Infestation: Masses of woolly wax at base of needles and on shoots. Sooty mold fungi may blacken needles and shoots.

Control: Natural control factors usually keep scale populations at low levels. Promote tree vigor and health to aid recovery. Use an approved insecticide for high value trees or especially damaging scale populations.

Common Name: PINE SCALE

Other: Pine Scale

Species: *Chionaspis heterophyllae*

Pine needles infested with the PINE SCALE

Common Hosts:

Japanese black pine *Pinus thunbergiana*
Loblolly pine *Pinus taeda*
Longleaf pine *Pinus palustris*
Sand pine *Pinus clausa*
Shortleaf pine *Pinus echinata*
Slash pine *Pinus elliottii*
Spruce pine *Pinus glabra*

Description:

- Adult - female approximately 3 mm long; elongated white body with one yellowish-orange tip.

Importance: Pine scale populations often become noticeable, especially on ornamental trees. High population levels and feeding damage may lead to dead foliage and branches.

Number of Generations: 1 or 2 generation per year

Signs of Infestation: Discoloration of foliage: reddish-yellow to gray. Pine needles may appear white due to high density of scales on the foliage.

Control: Predators, parasites, and unfavorable weather usually keep scale populations at low levels. Population flare-ups do occur, but generally subside due to natural control factors. Use an approved insecticide for high-value trees or especially damaging scale population

INSECTS OF CONIFER BRANCH AND STEM

PINE BARK BEETLES

Pine Bark Beetles account for more damage to southern timber than any other types of insect. The following important information concerns all pine bark beetles. The individual insects will be discussed in detail following this section.

The Black Turpentine Beetle (BTB) the IPS Engraver Beetles (IEB), and the Southern Pine Beetle (SPB), although the names differ, have many similarities. Specific information on each species follows, but an accurate name for all three is simply Pine Bark Beetles. This reflects their habit of tunneling and feeding within the soft inner bark of pine trees. In Florida, the most important pine bark beetles are the IEB, followed by the BTB; significant losses to the SPB occur infrequently in Florida. A substantial portion of the 3 billion cubic feet lost in the South is due to pine bark beetles.

Biology and Habits: Generally, adult bark beetles are first attracted to weakened or stressed trees, however, during outbreaks seemingly healthy trees are susceptible to beetle infestation.

Death of a pine tree results from the pine bark beetles boring through the outer bark and into the inner bark and outermost sapwood. It is not uncommon for two or more pine bark beetle types or species to infest a tree simultaneously.

The female beetles construct long egg galleries, depositing eggs along the sides of the tunnels. After emerging from the eggs, the larvae tunnel in the same tissues as the adult beetles. The tunneling of the larvae and adults severs the tree's nutrient transport systems. Equally damaging to the tree is the plugging of the water transport system by bluestain fungi, which are introduced into the tree by the adult bark beetles. When they have finished feeding the larvae pupate within the bark in small cells or chambers. Following pupation, the new adult bark beetles emerge from the tree to begin the cycle again in another susceptible tree.

Number of Generations: There can be up to 10 generations per year for the smaller IEB species, but only 2 ½ -3 generations per year of the much larger BTB. Variation will occur from year to year due to changes in temperature, moisture, and nutrition.

Management of Pine Bark Beetles: In many instances pine bark beetles are designated as secondary pests, much

like a cleanup crew for weak and suppressed trees. Typical materials utilized by pine bark beetles are fresh logs, logging debris, windthrown trees, and trees damaged or killed by natural or man-caused means. Living pine trees in a weakened condition are especially susceptible to pine bark beetle infestation. This condition may have arisen from a temporary or permanent weakening caused by drought, age, competition disease, annosom root rot, fire, hail, lightning, logging injury, or other insects.

IEB and BTB attacks on standing trees are usually of short duration due to a limited supply of acceptable host material (stressed trees) occurring in one area. Rarely are healthy trees killed in large numbers.

Vigorously growing trees with a high oleoresin exudation pressure and a copious resin supply are more resistant to bark beetle attack. A mechanical resistance results from the high resin pressure because attacking beetles are simply pitched out or forced out from the inner bark. Chemical resistance is imparted by the toxic vapors of fresh resin. An important component of the pitch-out mechanism is a ready access to water. Adequate soil moisture is important in maintaining high resin pressure in pine trees.

Forest management practices or homeowner yard-care which emphasize the reduction or minimization of tree stress while encouraging vigorous growth reduce the susceptibility of the stand or individual tree to bark beetle infestation. NOTE: There is the danger of pine trees growing too well. (See pitch canker).

Two important and related factors in the resistance of pine to bark beetle attack are (1) a healthy root system with sufficient moisture and air supplies, and (2) sufficient resin pressure in the stem and branches to resist the first beetles.

Pine bark beetle attacks in urban areas are associated most frequently with root injury, especially through the alteration of soil and water levels. Mechanical root injury is evident at all building sites and results from construction of curbs, driveways, sidewalks, patios, foundations, drainages, and utility trenches. The following are some suggestions for maintaining a tree's resin pressure when such damages occur:

- Maintain soil moisture with irrigation
- Prune back or thin tree crowns to restore root to shoot balance. Prune preferably during the coldest months of the year to lessen beetle activity.
- Conduct early removal of high-risk trees where more than half of a root system is or will be destroyed by construction.

Soil fill is often found to be fatal to pines, causing a lack of oxygen for respiring roots. As little as 5-10 cm of heavy clays, 10-15 cm of clay loams, or 15-20 cm of sandy loams spread over root systems is generally associated with

pine bark beetle infestations. The use of gravel, bricks, tiles, or commercially available aeration systems should be considered if soil fill is planned for landscaping.

Common Name: BLACK TURPENTINE BEETLE

Large pitch tubes at base of a tree infested by the Black Turpentine Beetle.

Other: Pine bark beetle

Species: *Dendroctonus terebrans*

Common Hosts:

- **Loblolly pine** *Pinus taeda*
- **Longleaf pine** *Pinus palustris*
- **Pond pine** *Pinus serotina*
- **Sand pine** *Pinus clausa*
- **Shortleaf pine** *Pinus echinata*
- **Slash pine** *Pinus elliottii*
- **Spruce pine** *Pinus glabra*

Description:

- Adult - approximately 9 mm long; reddish-brown to black; round rear end
- Pupa - size of adult; creamy white
- Larva - variable size, approximately 12 mm long when mature; orange-brown head, white body; legless

Number of Generations: 2 ½ to 3 generations per year

Signs of Infestation: Foliage discoloration: needle color sequence, green to yellow to red to brown. Large lumps of pitch (approximately 25 mm wide) on stem of tree; prevalent from butt and up 2m. Pitch tubes pinkish-white to reddish-brown, fade to purplish gray after 1 or 2 months. Coarse dark brown particles caught in bark crevices or at base of tree. Wide D-shaped galleries under bark. Roots infested. Rarely infests trees under 15 cm in diameter.

Similar Damage: Southern Pine Beetle: Adult beetles have rounded rear ends; galleries S-shaped; adult beetles smaller, approximately 3 mm long. IPS Engraver Beetles: Adult beetles have scooped, spined rear ends; galleries Y-shaped or H-shaped; adult beetles smaller, approximately 3-5 mm long.

Control: Maintain tree health and vigor. Avoid mechanical injuries to trees. Compare total number of pitch tubes to diameter of tree in inches at a point approximately 4 ½ feet above ground. If the number of pitch tubes is less than the tree diameter, see 1; if the number of pitch tubes is greater than the stem diameter, see 2:

1. Spray the infested tree and nearby uninfested trees with an approved insecticide. Apply spray three feet above highest pitch tube and work down to ground level. This method may save the infested tree.
2. Cut and remove beetle-infested tree if bark beetles are still present.

Common Name: IPS ENGRAVER BEETLE

Other:

1. Small southern pine engraver
2. Eastern 5-spined engraver
3. Eastern 6-spined engraver

Species:

1. Ips avulsus
2. Ips grandicollis
3. Ips calligraphus

Pitch tube and trapped IPS Engraver Beetle.

Common Hosts:

- **Loblolly pine** *Pinus taeda*
- **Longleaf pine** *Pinus palustris*
- **Pond pine** *Pinus serotina*
- **Sand pine** *Pinus clausa*
- **Shortleaf pine** *Pinus echinata*
- **Slash pine** *Pinus elliottii*
- **Spruce pine** *Pinus glabra*

Description:

- Adult - size according to species --
  - Ips avulus approximately 3 mm long;
  - Ips grandicollis approximately 4 mm long,
  - Ips calligraphus approximately 5 mm long;
  - body reddish-brown to black; scooped out and spined rear end.
- Pupa - size of adult; creamy white .
- Larva - variable size, approximately 6 mm long when mature; orange-brown head, white body; legless.

Number of Generations: 8 to 10 generations per year, dependent on beetle species

Signs of Infestation: Foliage discoloration: needle color sequence, green to yellow to red to brown Small lumps of reddish-orange pitch (approximately 12 mm wide) on tree stem or branches. Reddish-orange boring dust caught in bark crevices or leaves of undergrowth plants. Narrow Y-shaped or H-shaped galleries in inner bark.

Similar Damage: Southern Pine Beetle: adult beetles have rounded rear ends; galleries S-shaped. **Alert local Division of Forestry forester.** Black Turpentine Beetle: adult beetle larger, approximately 9 mm long; pitch tubes larger and at base of tree; galleries D-shaped.

Control: Maintain tree vigor and health. Avoid mechanical injuries to trees. Cut and remove Ips engraver beetle-infested tree or peel bark and destroy. Spray nearby uninfested or high-risk trees with an approved insecticide during period of Ips engraver beetle activity. NOTE: Natural enemies emerge after Ips engraver beetles. Delay tree removal for up to three months if beetles have recently left the tree to allow emergence of beneficial insects.

Common Name: SOUTHERN PINE BEETLE

Other: Pine bark beetle

Species: *Dendroctonus frontalis*

Common Hosts:

- **Loblolly pine** *Pinus taeda*
- **Shortleaf pine** *Pinus echinata*

S-shaped, or serpentine, galleries made by adult Southern Pine Beetles.

Description:

- Adult- approximately 3 mm long; reddish-brown to black; round rear end.
- Pupa - size of adult; creamy white
- Larva - size variable, approximately 4 mm long when mature; orange-brown head, white body; legless.

Number of Generations: 6 to 8 generations per year

Signs of Infestation: Foliage discoloration: needles color sequence, green to yellow to red to brown. Small lumps of whitish pitch (approximately 12 mm wide) on stem of tree, extending up to a height of 18 m on the stem. Reddish-brown boring dust caught in bark crevices or on leaves of undergrowth. Narrow S-shaped galleries under bark.

Similar Damage: IPS Engraver Beetles: Adult beetles have scooped, spined rear ends; galleries Y-shaped or H-shaped. Black Turpentine Beetle: Adult beetles larger, approximately 9 mm long; pitch tubes larger, at base of tree; galleries D-shaped.

Control: Maintain tree vigor and health. Avoid mechanical injuries to trees. Cut and remove infested tree or peel bark and destroy beetle infested bark. Spray the nearby uninfested or high-risk trees with an approved insecticide during periods of beetle activity. Note: Contact your local forester if you believe that the pine bark beetle is infesting your trees is the Southern Pine.

Common Name: DEODAR WEEVIL

Other: Snout beetle

Species: *Pissodes nemorensis*

Common Hosts:

- **Deodar cedar** *Cedrus deodora*
- **Loblolly pine** *Pinus taeda*
- **Longleaf pine** *Pinus palustris*
- **Sand pine** *Pinus clausa*
- **Shortleaf pine** *Pinus echinata*
- **Slash pine** *Pinus elliottii*
- **Spruce pine** *Pinus glabra*

Chip cocoons made by mature larvae of the deodar weevil underneath the bark of an infested tree.

Description:

- Adult - approximately 7mm long; long snout on small head; rusty red to grayish-brown head and body; 2 white spots on rear end
- Pupa - similar to adult; creamy white
- Larva - size variable, approximately 12 mm long when mature; amber to dark orange head, white body; legless

Importance: Trees of all ages are susceptible to weevil damage. Trees severely stressed by fire, drought, extreme cold, fusiform rust, wind damage, and other problems are prone to weevil infestation.

Biology and Habits: Adult weevils become active in fall, feed and mate, and females lay eggs in the holes made while feeding in the bark. Larvae emerge from the eggs and feed in the inner bark. The pupae occupy chambers (chip cocoons) made by the larvae. New adults emerge in spring and are inactive during the summer.

Number of Generations: 1 generation per year

Signs of Infestation: Foliage discoloration: needles with scorched appearance, particularly topmost branches. Small holes (approximately 0.4 mm wide) in shoots, often the most dominant branch. Shallow depressions or chambers in the sapwood with a layer of long yellowish-white wood fibers on top.

Similar Damage: Reproduction Weevils: Adult weevils larger, approximately 10 mm long; several small yellowish-white patches on body; large patches of bark removed from branches.

Control: Maintain tree health and vigor. Avoid mechanical injuries to the trees. Cut and remove severely infested trees. Use an approved insecticide for high-risk trees or weevil-infested trees. NOTE: The deodar weevil is a vector of pitch canker fungus which can reduce the growth rate or kill southern pines. Any control methods should consider the disease aspect.

Common Name: PINE TIP MOTHS

Other:
1. Nantucket Pine Tip Moth
2. Subtropical Pine Tip Moth

Species:
1. *Rhyacionia frustrana*
2. *Rhyacionia subtropica*

Common Hosts:
- **Japanese black pine** *Pinus thunbergiana*
- **Loblolly pine** *Pinus taeda*
- **Pond pine** *Pinus serotina*
- **Sand pine** *Pinus clausa*
- **Shortleaf pine** *Pinus echinata*
- **Slash pine** *Pinus elliottii*
- **Spruce pine** *Pinus glabra*
- **Virginia pine** *Pinus virginiana*

Branch tip damaged by the Nantucket Pine Tip Moth.

Description:
- Adult - gray head and body; front pair of wings with irregular patches of red, copper, and gray bands; wingspan approximately 13 mm
- Pupa - size of adult; light to dark brown
- Larva - size variable, approximately 9 mm long mature; head and body light brown to dark orange

Importance: Severe damage can occur in young natural and planted stands, especially those growing offsite. Growth loss and stem deformity can be considerable, however, infestation rates usually decline as trees reach 3 m in height or crowns grow together.

Biology and Habits: Adult moths emerge from infested branches in the early spring, mate, and females lay eggs on the foliage or buds. The larvae first gouge needles when feeding, then bore into branch tips. Pupation occurs inside the damaged area; overwinter as pupae.

Number of Generations: 4 to 5 generations per year

Signs of Infestation: Foliage discoloration. Dead or dying branch tips. Resin beads or flakes and fine silk webbing on branch tips.

Similar Damage: Reproduction Weevils: small patches of bark removed from the branches.

Control: Natural enemies, especially insect parasites, and crown closure will lower infestation rates as the stand matures. Plant the best pine species for the site to reduce stress on the trees. Consider planting longleaf pine if the site is appropriate. Longleaf pine is not attacked by the pine tip moths. Prune out infested tips if handwork is feasible. Use an approved insecticide for severe damage in high-value stands or shade trees. An attractant-baited (pheromone) trap is available to determine when moths are present. A chart, based on the number of moths caught, will aid in determining the best time for insecticide application.

Common Name: REPRODUCTION WEEVILS

Other:

1. Pales weevil
2. Pitch-eating weevil

Species:

1. *Hylobius pales*
2. *Pachylobius picivorus*

Common Hosts:

- **Loblolly pine** *Pinus taeda*
- **Longleaf pine** *Pinus palustris*
- **Pond pine** *Pinus serotina*
- **Sand pine** *Pinus clausa*

Feeding damage of seedling bark by adult Reproductive Weevil.

- Shortleaf pine *Pinus echinata*
- Slash pine *Pinus elliottii*
- Spruce pine *Pinus glabra*

Description:

- Adult - approximately 8-12 mm long; long snout on small head; light to dark brown head and body; many scattered yellowish-white patches on wings; long-legged
- Pupa - size of adult, creamy white
- Larva - variable size, approximately 8-15 mm long when mature; amber to orange head, white body; legless

Importance: Adult weevils can cause severe damage or death to newly planted pine seedlings, especially those on or near recently clearcut logging sites. Young pine plantations are susceptible if fresh slash (debris) or windrows (piled slash) are nearby.

Biology and Habits: Adult weevils emerge from soil or leaf litter in the early spring, feed on pine seedlings, and mate. The females lay eggs in roots of recently cut stumps or severely damaged trees (fire, hail, logging). Larvae emerge from the eggs and feed in the inner bark. Cells are constructed in the sapwood for pupation. Overwinter as adults. Two activity peaks for adults: spring and late summer-early fall.

Number of Generations: 1 or 2 generations per year

Signs of Infestation: Foliage discoloration. Bark of seedlings removed in small, shallow patches from branches and stem. Girdling of root collar below the ground line. Buds and needles may also be damaged. Roots of stumps or dying older trees with long galleries packed with a bright reddish-orange frass (insect wastes). Insects' presence: adults feed primarily at night, inactive in leaf litter during the day light hours.

Similar Damage: DEODAR WEEVILS: adult weevil smaller, approximately 7 mm long; 2 large white patches on rear end; small holes (less than 1 mm wide) in bark.

Control: Postpone reforestation 9 months to 1 year if logging occurred after July. This allows aging of the stumps and slash which then become less attractive to the weevils for breeding. Minimize amount of residual slash; maximize slash breakup; remove stumps. Use an approved insecticide to dip roots, spray foliage, or place granular material at the base of seedlings; or spray stumps. Do not dip roots and use granular insecticide in the same year.

Common Name: SOUTHERN PINE CONEWORM

Other: Pitch Moth

Species: *Dioryctria amatella*

Common Hosts:

- **Baldcypress** *Taxodium distichum*
- **Loblolly pine** *Pinus taeda*
- **Longleaf pine** *Pinus palustris*
- **Pondcypress** *Taxodium distichum var. nutans*
- **Sand pine** *Pinus clausa*
- **Shortleaf pine** *Pinus echinata*
- **Slash pine** *Pinus elliottii*
- **Spruce pine** *Pinus glabra*

Pitch mass caused by Southern Pine Coneworm feeding in the inner bark of a sand pine.

Description:

- Adult - blackish-gray head and body; front wings dark grayish-brown with white zig-zag crossbands and patches, hind wings light grayish-brown; wingspan approximately 30 mm
- Pupa - size of adult; dark brown
- Larva - size variable, approximately 20 mm long when mature; dark head, upper surface of body red-purple brown, undersurface greenish

Importance: Severe losses can occur in seed orchards with the destruction of flowers, conelets, and cones. Susceptible shade trees include those with stressed or mechanically-injured stems or branches, especially material with fusiform galls. Death is uncommon, but saplings with a high attack rate may die from the girdling caused by larvae feeding in the inner bark.

Biology and Habits: Adult moths become active in early spring, mate, and females lay eggs on or near cones, shoots, or wounds. The larvae feed within the cones or inner bark of shoots, branches, and stems. Pupation occurs in the damaged area. Overwinter as pupae.

Number of Generations: 1 to 4 generations per year

Signs of Infestation: Large pitch masses on branch or stem; often the diameter of the pitch mass exceeds 30 mm. Usually a milky white color with little redness or pinkness. Tan pupal case protruding from a pitch mass. Commonly adjacent to a recent bark injury or fusiform rust gall.

Similar Damage: Black Turpentine Beetle: adult a beetle, not a moth; pitch mass reddish color with small bark particles; hole in center of mass; at base of tree.

Similar Disease and Symptoms: Pitch Canker: usually topmost branches; often not a small pitch mass but a sheet or large area of dripping pitch. No galleries present in the inner bark. Staining is common.

Control: Maintain tree health and vigor. Avoid injury of the tree's bark. Prune out branches that have pitch masses or fusiform galls. Use an approved insecticide for high-value trees.

Common Name: TORTOISE SCALES

Other: Pine Tortoise Scale
Striped Pine Scale
Virginia Pine Scale

Species: *Toumeyella parvicornis*
Toumeyella pini
Toumeyella virginiana

Striped pines scales on a pine shoot.

Common Hosts:

- **Canary pine** *Pinus canariensis*
- **Italian stone pine** *Pinus pinea*
- **Japanese black pine** *Pinus thunbergiana*
- **Loblolly pine** *Pinus taeda*
- **Longleaf pine** *Pinus palustris*
- **Pond pine** *Pinus serotina*
- **Sand pine** *Pinus clausa*
- **Shortleaf pine** *Pinus echinata*
- **Slash pine** *Pinus elliottii*
- **Spruce pine** *Pinus glabra*

Description:

- Adult – female approximately 6 mm diameter; round and raised body; light to dark brown body with white streaks or patches
- Nymph or crawler – approximately 1-2 mm long; pinkish-orange to red head and body; legs evident

Importance: Tortoise scale populations occasionally become large on individual trees or small groups of trees. Severe feeding damage can reduce tree growth, cause branch

dieback, and possibly cause death. Sooty mold buildup can be substantial. Excessive sooty mold reduces the ability of a tree to manufacture its food (photosynthesis). Also, the honeydew (liquid excrement) produced by scales may attract ants, wasps, and bees who feed on the sugary honeydew.

Biology and Habits: Female scales resume activity by early spring laying eggs within their own scales. The nymphs emerge from the eggs, disperse, and begin feeding on pine shoots. Shortly thereafter, they become relatively immobile and begin forming a shell. The females will have the characteristic shell shape. Adult male scales develop wings and search for female mates. Over winter as immature female.

Signs of Infestation: Blackened needles or shoots due to the presence of sooty mold fungi. The fungi grow on the honeydew produced by the scale insects. Honeydew is rich in sugars and proteins and attractive to bees, wasps, and ants. Branch dieback and foliage discoloration. All life stages present by late summer; old shells of females will adhere to shoots.

Control: Predators, parasites, disease, and unfavorable weather usually keep scale populations at low levels. Outbreaks do occur, but generally subside within a few years by natural control factors. In many instances, control of the ant population which tends the scales may prove the key point for reducing the scale population. The ants feed on the honeydew and protect the scales from insect predators and parasites. Promote tree vigor and health to aid in the recovery from scale damage. Use an approved insecticide for high-value trees or for especially damaging scale populations.

INSECTS OF HARDWOOD FOLIAGE

Common Name: BAGWORM

Species: *Thyridopteryx ephemeraeformis*

Bag constructed of small twigs and silk by Bagworm.

Common Hosts:

- **Arborvitae** *Thuja occidentalis*
- **Juniper** *Juniperus spp.*
- **Live oak** *Quercus virginiana*
- **Southern red cedar** *Juniperus silicicola*
- **Willow** *Salix spp.*

Description:

- Adult -- male moth sooty black, densely hairy; wingspan approximately 25 mm. Female wingless, no legs, maggot-like; yellowish color; in bag.
- Larva -- size variable, approximately 25 mm long when mature; head and neck yellow spotted with black, body brownish.

Importance: Not abundant in Florida; most common in Panhandle. Severe defoliation may stress trees especially coniferous or softwood host trees.

Signs of Infestation: Loss of foliage. Small bags constructed of small bits and pieces of leaves and twigs; adhering to branches.

Control: Handpick and destroy bags.

Common Name: COTTONWOOD LEAF BEETLE

Other: Leaf beetle

Species: *Chrysomela scripta*

Adult and immature Cottonwood Leaf Beetles.

Common Hosts:

- **Cottonwood** *Populus deltoides*
- **Poplars** *Populus spp.*
- **Willows** *Salix spp.*

Description:

- Adult -- approximately 6 mm long; head and neck black with yellow or red margins; wings yellow to gold with interrupted black stripes
- Pupa -- size of adult; formed within skin of last larval form
- Larva -- size variable, approximately 12 mm long when mature; black head and body with 2 whitish spots on each side

Importance: Large numbers of beetles may occur on an individual tree or a small group of trees. Usually a pest of shade trees and not the forest. Infested trees rarely die from cottonwood leaf beetle defoliation.

Biology and Habits: Adult beetles become active in the spring, feed on the tender foliage and bark. After mating, the females lay their eggs in mat on the underside of leaves. Young larvae feed together and skeletonize the leaves. Older larvae feed separately and consume all but the major leaf veins. Pupation occurs on leaves, bark, or down in the undergrowth. The adults overwinter in protected sites.

Number of Generations: 3 or 4 generations per year

Signs of Infestation: Loss of foliage. Skeletonized, ragged leaves. By late summer, larvae, pupae and adults can be found on one tree.

Similar Damage: Drought or other stress factors can bring on a similar needle color change, but none will make the small slits.

Control: Natural control factors (predators, parasites, disease, weather) usually keep leaf beetle populations at low levels. Small population flare-ups do occur occasionally. Handpick beetles off trees if possible. Promote tree vigor and health to aid in the recovery from defoliation. Use an approved insecticide for high-value trees or for high populations of beetles. CAUTION: The leaf beetle larvae emit a foul-smelling fluid from swellings on neck when handled or disturbed.

Common Name: EASTERN TENT CATERPILLAR

Other: American tent-caterpillar

Species: *Malacosoma americanum*

Silk tent of the Eastern Tent Caterpillar.

Common Hosts:

- **Apple** *Malus pumila*
- **Black cherry** *Prunus serotina*
- **Hawthorn** *Crataegus spp.*
- **Oaks** *Quercus spp.*
- **Pecan** *Carya illinoensis*
- **Plums** *Prunus spp.*

Description

- Adult -- light to dark brown head and body; front pair of wings same color plus 4 angled yellowish-white stripes; wingspan approximately 45 mm
- Pupa -- size of adult; reddish-brown; enclosed in a silk cocoon of yellow powder and white silk
- Larva -- size variable, approximately 60 mm long when mature; black head, white line on back bordered by reddish-brown and black wavy lines; long fine tan hairs
- Egg -- Shiny black mass cemented around twigs (may contain 100-300 eggs)

Importance: Trees that experience widely spaced years of defoliation rarely die. Several consecutive years of severe defoliation will cause stress. In combination with other stress factors, death may follow.

Biology and Habits: Adult moths emerge from cocoons in late spring, mate, and females lay eggs on branches. The larvae hatch from the eggs the following late winter-early spring. A common silk nest is made by a group of caterpillars. Pupation occurs in the tents.

Number of Generations: 1 generation per year

Signs of Infestation: Silk tents enclosing branch crotches. Loss of foliage. Black cylindrical masses wrapped around branches (egg masses). Branch dieback and/or crown thinning.

Similar Damage: FALL WEBWORM: silk nest or tent around entire branches or tree.

Control: Predators, parasites, disease, and unfavorable weather usually keep caterpillar populations at low levels. Outbreaks do occur, but usually subside in 1 or 2 years. Prune

small branches that have egg masses. Remove and destroy tents that have small caterpillars. Promote tree vigor and health to aid in the recovery from defoliation. Use an approved insecticide for high-value trees.

Common Name: FALL WEBWORM

Other: Tiger moth

Species: *Hypantria cunea*

Common Hosts:

- **Baldcypress** *Taxodium distichum*
- **Black walnut** *Juglans nigra*
- **Hickories** *Carya spp.*
- **Pecan** *Carya illinoenis*
- **Persimmon** *Diospyros virginiana*
- **Sweet gum** *Liquidambar styraciflua* **Other hardwoods**

Beginning nest of silk webbing made by Fall Webworm Caterpillars.

Description:

- Adult -- white head and body; front wings white and with or without black spots; wingspan approximately 30 mm
- Pupa -- size of adult; brown; enclosed in a thin, transparent cocoon
- Larva -- size variable, approximately 35 mm long when mature; black or deep orange head, yellow to green body with a black stripe on back and a yellow on each side; long white or brown hairs

Importance: The fall webworm is commonly seen along road sides and in pecan groves. Rarely of importance except aesthetically, however, severe repeated defoliation will cause extreme stress. In combination with other stress factors, death may follow.

Biology and Habits: Adult moths emerge from the soil, mate and females lay eggs in white cottony mats on the undersurface of leaves. The larvae feed together within the silk nests spun around entire branches. Pupate in the soil or leaf litter. Overwinter as pupae.

Number of Generations: 3 or 4 generations per year

Signs of Infestation: Nest of silk webbing enclosing branches or an entire tree. Skeletonized leaves. Masses of long-haired caterpillars in the silk nests.

Similar Damage: EASTERN TENT CATERPILLAR: silk nests in branch crotches.

Control: Natural enemies (wasps, flys, beetles, birds) and unfavorable weather usually keep populations at low levels. Outbreaks do occur, but usually subside in 1 or 2 years. Prune nests from small branches and destroy caterpillars. Promotes tree vigor and health to aid in the recovery from defoliation. Use of approved insecticide for high-value trees.

Common Name: FOREST TENT CATERPILLAR

Other: Tent caterpillar

Species: *Malacosoma disstria*

Common Hosts:

- **Black tupelo** *Nyssa sylvatica*
- **Oaks** *Quercus spp.*
- **Sweetgum** *Liquidambar styraciflua*
- **Water tupelo** *Nyssa aquatica*
- **Plums** *Prunus spp.*
- **Other hardwoods**

Mature larva of the Forest Tent Caterpillar.

Description:

- Adult -- light brown head and body; front pair of wings same color plus 4 angled dark brown stripes; wingspan approximately 32 mm
- Pupa -- size of adult; reddish-brown; enclosed in a pale yellow cocoon
- Larva -- size variable, approximately 60 mm long when mature; light blue head mottled with black, brown body with yellowish-white keyhole spots on back bordered by pale blue lines, body brown; sparse white hairs
- Egg -- shiny black mass cemented around twigs (may contain 100-400 eggs)

Importance: Oak and gums are the most preferred and severely defoliated trees. Several consecutive years of severe defoliation will stress trees. In combination with other stress factors, death may result.

Biology and Habits: Adult moths emerge from cocoons in late spring, close to time of oak leaf expansion or unfolding. The larvae feed together initially, but then disperse to other trees. Pupation occurs between leaves or in the soil or soil litter.

Number of Generations: 1 generation per year

Signs of Infestation: Loss of foliage. Falling frass (dark pellets of caterpillar excrement). Caterpillars clustered on lower trunks and branches of trees. Branch dieback and/or crown thinning.

Control: Predators, parasites, disease, and unfavorable weather usually keep caterpillar populations at low levels. Outbreaks do occur, but usually subside in 1 or 2 years. Prune small branches that have egg masses and destroy. Promote tree vigor and health to aid in the recovery from defoliation. Use an approved insecticide for high-value trees.

Common Name: GYPSY MOTH

Other: Tussock moth

Species: *Lymantria dispar*

Mature larva of the Gypsy Moth.

Known hosts in other states:

- **Apple** *Malus pumila*
- **Black tupelo** *Nyssa sylvatica*
- **Hawthorns** *Crataegus spp*.
- **Maples** *Acer spp.*
- **Oaks** *Quercus spp.*
- **Willows** *Salix spp.*

Potential hosts in Florida:

- **Laurel oak** *Quercus laurifolia*
- **Live oak** *Quercus virginiana*
- **Loblolly pine** *Pinus taeda*
- **Longleaf pine** *Pinus palustris*
- **Sand pine** *Pinus clausa*
- **Slash pine** *Pinus elliottii*
- **Southern red cedar** *Juniperus silicicola*
- **Water oak** *Quercus nigra*
- **Other hardwoods and softwoods**

Description:

- Adult -- male has dark brown head and body; feathery antennae; front pair of wings with blackish bands; wingspan approximately 35 mm. Female almost entirely white; stout abdomen with yellowish hairs; wingspan approximately 50 mm.
- Pupa -- size of adult; mahogany color; scattered reddish hair.
- Larva -- variable size, approximately 50 mm long when mature; black and yellow mottled head; double row of 5 blue spots followed by 6 red spots on back; body brownish-gray; tufts of light and dark brown hairs.

- Egg -- thick buff-colored mat composed of hairs and 75-1000 eggs.

Importance: Few documented infestations have appeared in Florida, however, the continued southward spread from northern states suggests the likelihood of established populations in the future. Its impact as a public nuisance and on the shade tree and forest resource can be significant.

Biology and Habits: Adult moths emerge from pupal cases by early to midsummer, mate, and females lay eggs on tree trunks or under protective items. The larvae emerge the following spring and readily disperse on silk strands. Older larvae eat entire leaves, feed at night. Pupate by early to midsummer in sheltered areas.

Number of Generations: 1 generation per year

Signs of Infestation: Loss of foliage. Falling frass (dark pellet-like) of caterpillar excrement). Caterpillars clustered on lower tree trunks and under leaf litter, rocks, and other objects. Egg masses in sheltered areas. Crown thinning and/or branch dieback.

Control: Gypsy moth outbreaks are not as predictable in duration as native pest insects. Generally, several years may pass before the population crashes. Use an approved insecticide for high-value trees or for extremely damaging caterpillar population.

Important: Notify your local forester if you suspect the pest insect is the gypsy moth. Check the description for the forest tent caterpillar.

Common Name: LEAFMINERS

Species: Moths, Beetles, Flies

Common Hosts:
- Hardwoods
- Softwoods

Magnolia leaf damaged by a weevil or snout beetle Leafminer.

Importance: Leafminers are common on shade trees. Sudden population increases do occur on individual trees or small groups of trees. Several consecutive years of severe infestation may unduly stress a tree. Death is uncommon unless other stress factors become apparent.

Signs of Infestation: Leaves with blotches, mines, or deformity of shape. Small, usually flattened, larvae of various shapes, sizes and color between the upper and bottom leaf

layers. Hold a suspected leaf up to the light to see small (3-10 mm long) larvae through semi-transparent damaged areas.

Control: Promote tree health and vigor. Rake fallen leaves and burn to destroy insects that may be present. Use an approved insecticide for high-value trees or especially damaging leafminer populations.

Common Name: MITES

Species:

- *Eotetranychus* spp.
- *Oligonychus* spp.
- *Tetranychus* spp.

Foliage damage caused by feeding of Mites.

Common Hosts:

- Hardwoods
- Softwoods
- Nursery stock in beds especially prone to mite infestations.

Description:

- Adult -- approximately 0.5 mm long; oval-shaped, wingless body; red, green, or white in color, 4 pairs of legs (not an insect).
- Nymph -- similar to adult, 3 pairs of legs.

Importance: Hot, dry weather favors the buildup of mite populations. Excessive use of insecticides for other problems is conducive to a mite problem. Severe infestations may place an undue stress on infested trees.

Signs of Infestation: Foliage discoloration: chlorotic stippling followed by yellowing or bronzing. Silk webbing and very small grayish-white skins on infested foliage. Hold sheet of white paper beneath suspected leaves and strike leaves sharply. Mites will appear to be small dark, moving spots.

Control: Minimize insecticide use whenever possible, especially in the nursery setting. Use an approved miticide when necessary. Inspect trees regularly during late summer, droughty weather.

Common Name: OAK LEAFROLLER / LEAFTIER

Other: Leaf roller moths

OAK LEAFROLLER larvae.

Species:

- *Archips* spp.
- *Croesia* spp. (and others)

Common Hosts:

- **Laurel oak** *Quercus laurifolia*
- **Live oak** *Quercus virginiana*
- **Water oak** *Quercus nigra*
- **Other hardwoods**

Description:

- Adult -- all yellow to light tan head and body; front pair of wings with dark brown markings or cross-bands; wings form a bell-shape when folded; wingspan 12-25 mm.
- Pupa -- similar to adult; dark brown in a flimsy silk cocoon.
- Larva -- size variable, approximately 12-30 mm long when mature; head pale to dark brown, body dirty white to various shades of green.

Importance: Widespread and severe defoliation occur infrequently. Larvae create a public nuisance due to their habit of dropping down from trees on a silk thread. The combination of consecutive years of severe defoliation plus other stress factors may result in tree mortality.

Biology and Habits: Eggs hatch in early spring, closely timed to oak leaf expansion. The larvae tie or roll leaves together with silk; remain inside when not out feeding. Pupation occurs in flimsy silk cocoons between leaves or in leaf litter on the ground. The adult moths emerge by midsummer, mate, and the females lay their eggs in bark crevices. Overwinter as eggs.

Number of Generations: 1 generation per year

Signs of Infestation: Loss of foliage. Greenish caterpillars hanging from silk strands at eyeball level. Common in areas with a dense oak canopy, for example, ferneries. Abundant small yellowish moths fluttering around underbrush. Foliage tied or rolled with silk webbing; caterpillars inside when not out feeding. Crown thinning or branch dieback.

Control: Natural control factors (predators, parasites, and diseases) usually keep leafroller populations at low levels. Outbreaks do occur, but generally decline within 2-3 years. Promote tree vigor and health to aid in the recovery from defoliation. Use an approved insecticide for high-value trees or where caterpillar populations are especially damaging.

Common Name: SYCAMORE LACE BUG

Other: Lace Bug

Species: *Corythuca ciliata*

Leaf damage caused by feeding of the Sycamore Lace Bug.

Common Hosts:

- **Ash** *Fraxinus* spp.
- **Hickories** *Carya* spp.
- **Sycamore** *Platanus occidentalis*

Description:

- Adult -- approximately 3 mm long; yellowish-green to brown head and body; milky white wings flattened to a lace-like effect, brown spot on each front edge of wings.
- Nymph -- body color and shape similar to adult, usually darker; wings absent.

Importance: Common on sycamore leaves in the late summer-early fall. Severe lace bud feeding damage may result in premature leaf drop. Several consecutive years of severe damage may unduly stress a tree. In combination with other stress factors, death may occur.

Biology and Habits: Adult lace bugs become active in the spring, mate, and the female lay their eggs on the ribs of leaves, usually the undersides. The nymphs emerge and feed on the leaf undersides as well. Adult and nymph lace bugs have piercing/sucking mouthparts to receive and suck out the contents of plant cells. Overwinter as adults under bark scales and other protective sites.

Number of Generations: 3 or 4 generations per year

Signs of Infestation: Discoloration of foliage - often a yellowing or bronzing. Premature leaf drop, much in advance of the usual fall occurrence. Whitish blotching or stippling on upper leaf surfaces. Dark brown spots and stains (lace bug excrement) on the leaves; insects and cast skins on the undersides of leaves.

Similar Damage: Lace bugs typically exhibit a very strong association with specific tree species. For instance, the sycamore lace bug primarily feeds on sycamore, the Hawthorn Lace Bug on hawthorns, and the Oak Lace Bug on oaks.

Control: Natural control factors (predators, parasites, diseases) usually keep lace bug populations at low levels. Local population flare-ups do occur occasionally. Promote tree

vigor and health to aid in the recovery from defoliation. Use an approved insecticide for high-value trees or for especially damaging lace bug populations.

Common Name: VARIABLE OAKLEAF CATERPILLAR

Caption for picture (not available): Mature larva of the VARIABLE OAKLEAF CATERPILLAR.

Other: Prominent moth

Mature larva of the Variable Oakleaf Caterpillar.

Species: *Heterocampa manteo*

Common Hosts:

- **American elm** *Ulmus americana*
- **Apple** *Malus* spp.
- **Black oak** *Quercus velutina*
- **Black walnut** *Juglans nigra*
- **Hawthorn** *Crataegus* spp.
- **Laurel oak** *Quercus laurifolia*
- **Live oak** *Quercus virginiana*
- **Persimmon** *Diospyrus virginiana*
- **Water oak** *Quercus nigra*
- **Willow oak** *Quercus phellos*

Description:

- Adult -- light to dark ashy-gray head and body; front pair of wings same color plus 6 dark wavy lines; hindwings light brown; wingspan approximately 40 mm.
- Pupa -- size of adult; reddish-brown and with 2 small spines on rear tip.
- Larva -- size variable, approximately 40 mm long when mature; amber head with 2 dark and 2 light side-bands; light pink to dark red broad stripes on back; body color green to yellow.

Importance: Trees that experience widely spaced years of defoliation rarely die. However, several consecutive years of severe defoliation will result in stressed trees. In combination with other stress factors, death may follow.

Biology and Habits: Adult moths of the first generation emerge from cocoons in the soil by early spring. The adults mate and the females lay eggs on the undersides of leaves. The larvae feed together in groups on the foliage. Mature larvae enter the soil to pupate. Second generation larvae are usually present during the fall months. Overwinter as prepupae (stage before true pupal stage) in the soil.

Number of Generations: 2 generations per year

Signs of Infestation: Loss of foliage. Falling frass (pellet-like caterpillar excrement) and caterpillars. Leaves skeletonized by young larvae; older larvae leave only the major leaf veins intact. Crown thinning and branch dieback

Control: Predators, parasites, disease, and unfavorable weather usually keep caterpillar populations at low levels. Outbreaks do occur, but subside in 2 or 3 years. Promote tree vigor and health to aid in the recovery from defoliation. Use an approved insecticide.

Caution: Variable oakleaf caterpillars produce formic acid when disturbed. Excessive handling may result in skin irritations for susceptible people.

Common Name: WHITEMARKED TUSSOCK MOTH

Other: Tussock moth

Species: *Orgyia leucostigma*

Mature larva of the WHITEMARKED TUSSOCK MOTH.

Common Hosts:

- **Apple** *Malus pumila*
- **Elm** *Ulmus* spp.
- **Laurel oak** *Quercus laurifolia*
- **Live oak** *Quercus virginiana*
- **Mimosa** *Albizzia julibrissin*
- **Pyracantha** *Pyracantha cocinnea*
- **Redbud** *Cercis canadensis*
- **Water oak** *Quercus nigra*
- **Other hardwoods**

Description:

- Adult -- male has brownish-gray head and body; front pair of wings same color plus darker wavy bands and 2 prominent white spots; wingspan approximately 30 mm. Female is gray and wingless.
- Pupa -- size of adult; brown; enclosed in a tan to gray silk cocoon.
- Larva -- size variable, approximately 35 mm long when mature; coral red head, yellow to cream color body with black stripes on back, 2 long tufts of dark hair over head, 1 tuft on in the rear, and 4 short tufts of yellow to white hairs on back.
- Egg -- gray to white hard, frothy mat of eggs on female's old cocoon.

Importance: A common spring pest, especially around oak-populated areas. Severe defoliation for 2 or more consecutive years will stress trees. Death may result if other stress factors also weaken the trees. Its habit of falling or spinning out of trees is unnerving to most people.

Biology and Habits: Larvae emerge from eggs during leaf expansion in spring. They disperse readily on silk strands while still young. Older larvae are active crawlers. Pupation occurs in any shaded and protective site. Generally, the 2nd or 3rd generations are not as noticeable as the 1st or spring generation. Overwinter as eggs laid on the females' cocoons.

Number of Generations: 2 or 3 generations per year

Signs of Infestation: Loss of foliage. Falling frass (dark pellets of caterpillar excrement). Cocoons in bark crevices, under overhangs of buildings, and other shaded, protective sites. Crown thinning and/or branch dieback.

Control: Predators, parasites, diseases, and unfavorable weather usually keep caterpillar populations at low levels. Outbreaks do occur, but generally subside after 2 or 3 years. Promote tree vigor and health to aid in the recovery from defoliation. Use an approved insecticide for high-value trees or for extremely damaging larval populations. Caution: rash-like symptoms have been reported by some individuals exposed to repeated contact with caterpillar hairs.

Common Name: YELLOWNECKED CATERPILLAR

Other: Prominent moth

Species: *Datana ministra*

Mature larva of the Yellownecked Caterpillar.

Common Hosts:

- **Apple** *Malus pumila*
- **Elm** *Ulmus* spp.
- **Hickories** *Carya* spp.
- **Maples** *Acer* spp.
- **Oaks** *Quercus* spp.
- **Pecan** *Carya illinoensis*
- **Walnut** *Juglans nigra*
- **Other hardwoods**

Description:

- Adult -- reddish-brow head and body; front pair of wings tan to cinnamon with several dark lines; hind wings yellowish-brown; wingspan approximately 45 mm.
- Pupa -- size of adult; shiny dark brown.

- Larva -- size variable, approximately 50 mm long when mature; black head, bright orange to yellow neck, black body with 8 thin yellow to white stripes; sparse, long white or gray hairs .

Importance: Oaks and hickories are commonly defoliated trees. Several consecutive years of severe defoliation will stress trees so that death may result, especially in combination with other stress factors. Shade trees more often defoliated than forest trees.

Biology and Habits: Adult moths emerge from the soil by late spring, mate, and the females lay eggs on the undersides of leaves. The larvae feed together in colonies during summer and fall. Pupation occurs in the soil during the winter.

Number of Generations: 1 generation per year

Signs of Infestation: Loss of foliage. Falling frass (dark pellets of caterpillar excrement). Leaves skeletonized by young larvae; older larvae consume all but leave petioles. Caterpillars rear into U-shape when disturbed. Crown thinning and/or branch dieback.

Similar Damage: WALNUT CATERPILLAR: no yellow neck; long white denser hairs; yellowish-white stripes on back. Biology and Habits and Signs of Infestation are similar. See Control recommendations.

Control: Predators, parasites, disease, and unfavorable weather usually keep caterpillar populations at low levels. Outbreaks are rare. Promote tree vigor and health to aid in the recovery from defoliation. Use an approved insecticide for high-value trees or extremely damaging moth populations.

INSECTS OF HARDWOOD BRANCH AND STEM

Common Name: BLACK TWIG BORER

Other: Ambrosia Beetle

Species: *Xylosandrus compactus*

Wilted branch infested by Black Twig Borer.

Common Hosts:

- **Apple** *Malus pumila*
- **Boxelder** *Acer negundo*
- **Camphor** *Cinnamomum camphora*
- **Dogwood** *Cornus florida*
- **Elms** *Ulmus* spp.
- **Goldenrain tree** *Koelreuteria formosana*
- **Pecan** *Carya illinoensis*
- **Redbud** *Cercis canadensis*
- **Red maple** *Acer* spp.
- **Southern magnolia** *Magnolia grandiflora*
- **Many other hardwoods**

Description:

- Adult-- female approximately 1.6 mm long, light to dark reddish-brown; stout cylindrical body. Male rarely seen.
- Pupa-- size of adult; creamy white.
- Larva-- size variable, approximately 2 mm long when mature; dark brown head, yellowish-white body, legless.

Importance: First detected in Florida in 1941, the black twig borer is now distributed nearly statewide. Its aggressiveness in infesting healthy trees distinguishes it from most other AMBROSIA BEETLES. Severe infestations can significantly reduce the growth rate and alter the form of ornamental and shade trees. The stress of infestation plus other stress factors may induce death.

Biology and Habits: Adult beetles emerge from small branches and twigs by late winter-early spring, mate, and the females bore into shoots to lay eggs. The larvae feed on fungi growing on the tunnel walls. They pupate inside the damaged material; overwinter as adults.

Number of Generations: Several generations per year

Signs of Infestation: Foliage discoloration and/or wilting. Branch dieback. Small holes on underside of twigs and branches. Canker formation around holes.

Control: Prune off and destroy beetle-infested twigs and branches. Use an approved insecticide on high-value trees or those exhibiting notable levels of beetle damage.

Common Name: CARPENTERWORM

Species: *Prionoxystus robiniae*

Entrance hole to a carpenterworm's gallery in an oak tree.

Common Hosts:

- **Cottonwood** *Populus* spp.
- **Oaks** *Quercus* spp.
- **Willows** *Salix* spp.
- **Other hardwoods**

Description:

- Adult-- female moth light grayish-black body and front pair of wings, wingspan approximately 75 mm; male moth smaller and darker.
- Larva-- size variable, approximately 65 mm long when mature; brown head, reddish-pink to greenish-white body.

Importance: Severe infestations can decrease the rate of growth of a tree. The large holes provide an ideal entrance for decay pathogens. Trees may be mechanically weakened and suffer wind breakage.

Signs of Infestation: Sapstaining on bark. Wood chips and pellets at base of tree. Rough elongate holes in bark on trunk. Brown pupal skin protruding from holes.

Control: Identify and remove highly susceptible trees. Minimize injuries to trees; promote health. Use an approved insecticide to minimize possibility of infestation.

Common Name: CICADAS

An adult Cicada.

Species:

- *Diceroprocta* spp.
- *Tibicen* spp.

Common Hosts:

- **Hardwoods**
- **Softwoods**

Description:

- Adult-- approximately 15-35 mm long; prominent eyes; brownish-green head and body; stout body; transparent wings with conspicuous veins. Loud trilling noisemakers.

Importance: Severe damage by egg-laying habit of the adult females may result in branch dieback or altered growth form. Nymphs feed by inserting sucking mouth parts into roots in the soil.

Signs of Infestation: Foliage discoloration and/or wilt. Branch wounds consisting of a slit surrounded by torn wood fibers through the bark; caused by females laying eggs in the branch. After hatching, nymphs drop to the ground. Nymphal skins (light brown, split insect cases with prominent legs) attached to tree trunks or lower branches. Adults emerge from the skins. Male adults call from tree crowns to attract females.

Control: Protect recently transplanted trees with netting. Use an approved insecticide timed to emergence of adults from soil.

Common Name: CLEARWING MOTHS

Entrance to gallery of a Clearwing Moth in a willow tree.

Species:

- *Paranthrene* spp.
- *Synanthedon* spp.

Common Hosts:

- **Cottonwood** *Populus* spp.
- **Elm** *Ulmus* spp.
- **Oaks** *Quercus* spp.

- **Willows** *Salix* spp.
- **Others**

Description:
- Adult-- varied sizes, shapes, and colors; wasp-like in appearance; yellow, black, dark blue common colors; wingspan approximately 25-40 mm.
- Larva-- size variable, approximately 20-30 mm long when mature; coloration variable: white to purplish gray.

Importance: Severe infestations can decrease the rate of growth and alter the form of ornamental and shade trees. Entrance holes in stem provide entry to decay pathogens.

Signs of Infestation: Foliage discoloration and/or wilt. Branch dieback. Sapstaining of bark and fine frass caught on branches, trunk, and at base of tree. Frass may also have a granular appearance. Round entrance holes (approximately 4-15 mm wide) in bark.

Control: Identify and remove highly susceptible trees. Minimize injuries to trees. Use a stiff wire to probe and stab larvae in galleries underneath the bark. Use an approved insecticide for high-value trees or those exhibiting severe damage levels. Gallery fumigation is enhanced by typically short, frass-clear galleries.

Common Name: FLORIDA WAX SCALE

Species: *Ceroplastes floridensis*

Common Hosts:
- **Crape myrtle** *Lagerstroemia indica*
- **Deodar cedar** *Cedrus deodora*
- **Elm** *Ulmus* spp.
- **Hollies** *Ilex* spp.
- **Loblolly pine** *Pinus taeda*
- **Oaks** *Quercus* spp.
- **Other hardwoods and softwoods**

A Florida Wax Scale feeding on a leaf.

Description:
- Adult-- female approximately 3 mm wide; circular, raised, dirty white to pinkish wax cover.

Importance: Severe infestations may result in shoot or branch dieback.

Signs of Infestation: Foliage discoloration and shoot dieback. Soft waxy domes adhering to leaves and shoots.

Control: Promote tree vigor and health. Use an approved insecticide for high-value trees.

Common Name: GIANT BARK APHID

Species: *Longistigma caryae*

Common Hosts:

- **Basswood** *Tilia* spp.
- **Hickories** *Carya* spp.
- **Oaks** *Quercus* spp.
- **Pecan** *Carya illinoensis*
- **Sycamore** *Platanus* spp.
- **Walnut** *Juglans* spp.

Description:

- Adult-- approximately 6 mm long; light to dark brown body; long hind legs; bluish-white bloom on body.
- Nymph-- similar to adult.

Several Giant Bark Aphids feeding on the underside of an oak branch.

Importance: Severe infestations may result in shoot or branch dieback. Honeydew will damage cars parked under infested trees. Sooty mold prevalent.

Signs of Infestation: Foliage discoloration and branch dieback. Underside of branches populated by clusters of many dark large aphids.

Control: Promote tree vigor and health. Use an approved insecticide for high-value trees or especially damaging aphid populations.

Common Name: HOLLY PIT SCALE

Species: *Asterolecanium putneanum*

Holly Pit Scales on the bark of an American hollytree.

Common Hosts:

- **American holly** *Ilex opaca*
- **Burford holly** *Ilex cornuta*
- **Dahoon holly** *Ilex cassine*
- **Japanese holly** *Ilex crenapa*
- **Yaupon** *Ilex vomitoria*

Description:

- Adult-- female approximately 1-2 mm wide; circular, slightly raised, yellowish-green, waxy body covering.

Importance: Severe infestations may result in branch dieback; death of tree uncommon.

Signs of Infestation: Foliage discoloration and branch dieback. Twigs and branches with ring-like swellings or pits in bark. A result of reduced growth at the scale feeding site, but continued growth of surrounding tissue.

Control: Promote tree vigor and health. Use an approved insecticide for high-value trees or high scale populations. Prune branches that have significant scale levels.

Common Name: KERMES SCALE

Species: *Kermes* spp.

A Kermes Scale on petiole of oak leaf.

Common Hosts:

- **Laurel oak** *Quercus laurifolia*
- **Live oak** *Quercus virginiana*
- **Water oak** *Quercus nigra*
- **Other oaks** *Quercus* spp.

Description:

- Adult -- female approximately 3-7 mm wide; gall-like or globular; light brown with darker irregular lines.

Importance: Severe infestations may result in branch dieback; death of tree rare.

Signs of Infestation: Foliage discoloration. Gall-like or globular growths - kermes scales.

Control: Promote tree vigor and health. Use an approved insecticide for high-value trees or especially damaging scale populations.

Common Name: OAK LECANIUM SCALE

Species: *Parthenolecanium quercifex*

Common Hosts:

- **Laurel oak** *Quercus laurifolia*
- **Live oak** *Quercus virginiana*
- **Other oaks** *Quercus* spp.

Description:

- Adult-- female approximately 5 mm wide; circular, strongly raised, reddish to dark brown body; tortoise-like, but double hump.

Oak Lecanium Scale on an oak twig.

Importance: Severe infestations may result in branch dieback; death uncommon.

Signs of Infestation: Foliage discoloration and branch dieback. Clumped swellings- the scales - on branches or twigs.

Control: Promote tree vigor and health. Use an approved insecticide for high-value trees or high scale populations.

Common Name: OAK TREEHOPPER

Other: OAK TREEHOPPER

Species: *Platycotis vittata*

Common Hosts:

- **Laurel oak** *Quercus laurifolia*
- **Live oak** *Quercus virginiana*
- **Water oak** *Quercus nigra*
- **Other oaks** *Quercus* spp.

An adult Oak Treehopper.

Description:

- Adult-- approximately 12 mm long; forward pointing horn on head area; triangle body with brownish background and red or brown stripes/spots.
- Nymph -- similar to adult.

Importance: Severe infestation may lead to branch dieback.

Signs of Infestation: Foliage discoloration or branch dieback. Clusters of treehoppers on branches. Double crescent shaped slits in bark; females cut bark and lay eggs underneath the bark.

Control: Promote tree vigor and health. Use an approved insecticide for high-value trees.

Common Name: OBSCURE SCALE

Species: *Melanaspis obscura*

Common Hosts:

- **Laurel oak** Quercus laurifolia
- **Live oak** Quercus virginiana
- **Pecan** Carya illinoensis
- **Turkey oak** Quercus laevis
- **Water oak** Quercus nigra
- **Other oaks** Quercus spp.

Obscure Scales on twigs. Note the close resemblance in color of scales and twig.

Description: Adult-- female approximately 3 mm wide; circular, slightly raised, grayish to black body; closely matches bark color.

Importance: Severe infestations may result in branch dieback; death of tree uncommon.

Signs of Infestation: Foliage discoloration and branch dieback. Roughened appearance of bark due to layering of scales one on another.

Control: Promote tree vigor and health. Use an approved insecticide for high-value trees or high scale populations.

Common Name: PSOCIDS OR BARK LICE

Species: Several

Common Hosts:

- **Rough-barked hardwoods**
- **Palms**

Description

- Adult -- approximately 6 mm long; brownish-black body with white edges and stripes on wings; wings held roof-like over body.
- Nymph -- similar to adult; wingless.

Protective silk webbing spun by Psocids over the bark of an oak tree.

Importance: Large populations may produce a great amount of silk webbing on a tree, but no damage is done. Insects feed on fungi, spores, pollen, lichen, and other debris on a tree's bark.

Signs of Infestation: Small portions or entire tree trunk covered with a fine silk webbing. Dark area on trunk or branch comprised of several hundred psocids or bark lice.

Control: Use a garden hose and water to wash insects and silk webbing off infested trees. May need to repeat through the year.

Common Name: TWIG GIRDLER

Species: *Oncideres cingulata*

Common Hosts:

- **Australian pine** *Casuarina cunninghamiana*
- **Hickories** *Carya* spp.
- **Oaks** *Quercus* spp.
- **Pecan** *Carya illinoensis*
- **Pear** *Pyrus communis*
- **Persimmon** *Diospyrus virginiana*

Fallen branches clipped from tree by adult Twig Girdlers; immature beetles in branches.

Description:

- Adult-- approximately 15 mm long; grayish-brown body with scattered yellowish spots; antennae longer than body.
- Larvae-- size variable, approximately 18 mm long when mature; dark brown head, yellowish-white body.

Importance: Severe infestations may weaken and distort the shape of ornamental and shade trees.

Signs of Infestation: Foliage discoloration and hanging branches in tree crown. Severed branches on the ground; may be in circles around base of tree.

Control: Collect and destroy branches on the ground - these contain the immature twig girdlers. Use an approved insecticide for high-value trees or those experiencing severe levels of damage by the twig girdler.

INSECTS OF CONIFER AND HARDWOOD BRANCH AND STEM

Common Name: AMBROSIA BEETLES

Other:
- Pinhole borers
- Shothole borers

Species:
- *Gnathrotrichus* sp.
- *Platypus* spp.
- *Xyleborus* spp.
- *Xylosandrus* spp.

Common Hosts:
- Hardwoods
- Softwoods

Sawdust pile indicative of a AMBROSIA BEETLE infestation.

Description:
- Adult -- *Gnathrotrichus, Xyleborus*, and *Xylosandrus* approximately 1.5-3.3 mm long; head and body reddish-brown to black; stout robust shape; *Platypus* approximately 5.0 mm long; head and body light to dark brown; elongate cylindrical body .
- Pupa -- similar to adult; creamy white.
- Larva -- size variable, approximately 2-6 mm long when mature; head light brown to amber orange; body creamy white; legless.

Importance: Ambrosia beetles generally utilize dead, dying, or severely stressed or weakened trees as well as seasoning logs or lumber. Timber values decrease not only because of the pinholes made by beetles but also the staining by ambrosia fungi brought into the galleries by the beetles.

Biology and Habits: Adult beetles emerge from infested material year-round, mate, and females deposit eggs in galleries constructed in sapwood and heartwood. The larvae feed on the special fungi - the ambrosia - first brought in by the parent adult beetles. The fungi actually feed on wood fiber, not the ambrosia beetles. Pupation occurs in the galleries. Mating occurs in galleries and only females fly to new hosts, or both sexes fly to a new host and then they mate.

Number of Generations: Several generations per year

Signs of Infestation: One or more piles of white fluffy boring dust at base of an infested tree. Small holes (0.5-3 mm wide) through the bark and into sapwood and heartwood, referred to as pinholes or shotholes. Split wood with small diameter galleries running with and against the wood grain. Galleries free of frass or sawdust. Staining of wood in association with galleries, referred to as pinholes, shotholes, or grease spots.

Control: Prompt removal and disposal of infested material. A severe stem infestation is usually indicative of a dying tree; salvage cut as soon as possible. Use an approved insecticide for infested and nearby susceptible trees. Promote tree vigor and health to minimize possibility of ambrosia beetle infestation.

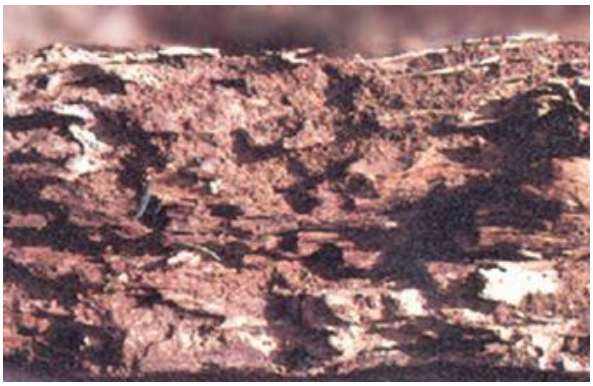
Common Name: DRYWOOD TERMITES

Other:

- Powerpost Termites
- Subterranean Termites
- Termites

Species:

- *Incisitermes* spp.
- *Kalotermes* sp.
- *Cryptotermes* spp.
- *Reticulitermes* spp.



Wood damaged by Termites.

Common Hosts:

- Hardwoods
- Softwoods
- Structural timber of buildings

Description:

- Adult (Reproductive) - approximately 8-16 mm long; light brown to black head and body, 2 pairs of clear opaque wings; thick waist, antennae many beaded.
- Soldier - approximately 6-10 mm long; light to dark brown enlarged head; prominent mouthparts; creamy to grayish white body; wingless.
- Nymph or Adult (Worker) - approximately 4-8 mm long; soft creamy to grayish-white head and body; wingless; usually most prevalent type in a nest.

Importance: Termites are vital to the decomposition and recycling of plant cellulose. However, they also infest buildings, telephone poles, fence posts, furniture, and living trees. Typically, a termite infestation is not detected until damages are extensive.

Biology and Habits: Reproductive adults swarm year-round. Each couple sheds their wings, mate, and begin a new nest. Within a few years, a termite colony contains hundreds to thousands of termites. The original couple may live several years. Termites have protozoa or bacteria (one-celled animals) in their guts which digest wood cellulose into a form usable by the termites.

Number of Generations: Several generations per year.

Signs of Infestation: Adult termites swarming at windows; shed wings near windows, especially January-May. Mud tubes (6-25 mm wide) from soil to infested wood: subterranean termites only. Small pellets (approximately 1 mm wide) of frass, yellowish to reddish-brown: dry-wood termites only. Fine sawdust at base of furniture: powder-post termites only. Surface blisters on wood: drywood termites only. Hollow, papery sound when infested wood is tapped. Tunnels in soft spring wood: subterranean termites. Tunnels in spring and summer wood: drywood and powderpost termites. ROOTS as well as above-ground parts of a tree are susceptible to termite infestation.

Similar Damage: FLORIDA CARPENTER ANT: clean galleries; coarse sawdust; ants have thin waists and elbowed antennae

Control: Preventive treatment is highly recommended: Proper building construction. Appropriate insecticide treatment. Treatment of wood with a preservative. Proper disposal of waste wood at site. Termite exclusion with putty, paint, and screens. Regular exterior and interior checks. Remedial treatment may include: Replacement of damaged wood. Appropriate insecticide treatment. Fumigation. Proper disposal of infested wood. Continuing checks for future infestations.

Common Name: GALLS

Other: Plant Galls

Species: Many species belonging to the following groups:

- Aphids
- Beetles
- Jumping plant lice
- Midges
- Mites
- Moths

One of the many types of Galls caused by insects and mites.

Common Hosts:

- Hardwoods
- Softwoods

Description: Most mites and insects are never seen unless deliberately reared or dissected from the gall. Their generally small size (less than 5 mm) and protective shelters serve to hide them well. Identification is usually based on the tree species attacked, the plant tissue utilized, and the form and color of the gall. These characteristics are oftentimes distinctive enough to identify the mite or insect species.

Some typical gall types:

- Erineum gall (velvety or hair-like)
- Leaf spot gall
- Flower gall
- Bud gall
- Twig gall
- Rosette gall
- Pouch gall
- Root gall
- Oak apple gall

Importance: Galls are abnormal vegetative growths or swellings resulting from insect or mite damage, as well as bacteria, fungi, or nematodes. Most galls are physiologically harmless to the tree or shrub. A few species of mites and midges are serious pests of fruit trees and ornamental shrubs. Some gall wasps infest trees to the point that one or more branches may die, but rarely the entire tree.

The gall is plant tissue. It may be the result of a chemical secretion of the adult applied while laying eggs or of immature gall-maker while feeding in the plant tissue. Galls also form because of mechanical damage to plant tissues. Regardless, a gall provides shelter and food for the insect or mite as it develops. Abandoned galls also serve as shelters for beneficial insects and spiders who, in turn, feed on the gall-makers.

Biology and Habits: The life cycles are as varied as the number of insects and mites species (over 3,000 species). Many are typical in sequence while others require alternate host tree species and may have several different adult forms. A life cycle may be completed in a matter of weeks or require several years.

Signs of Infestation: Abnormal swellings on any part of the tree. Dissection may reveal small immature insects; mites extremely difficult to see, even with a 10X lens.

Control: Control is very difficult to attain and is often unnecessary. If transplanting, select gall-free specimens. Prune infested material and destroy clippings by burning or removing from property. Rake leaf and twig litter from base of tree and dispose of

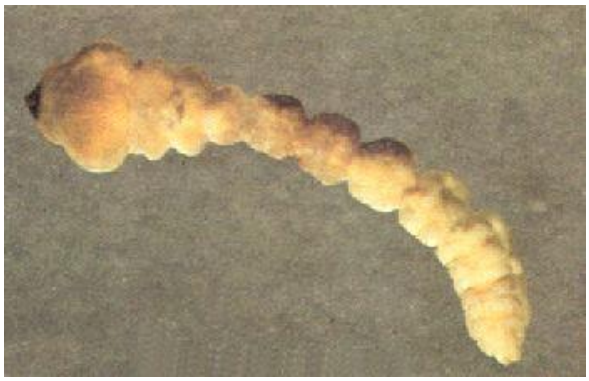
properly. Use an approved insecticide or miticide. It is very difficult to achieve proper and effective timing to kill emerging adult gall-makers.

Common Name: FLATHEADED BORERS

Other:
- Metallic beetles
- Wood borers

Species: Hardwoods:
- *Brachys* spp.
- *Chrysobothris* spp.

Softwood:
- *Acmaedera* sp.
- *Chalcophora* spp.
- *Chrysobothris* spp.



Typical larva of Flatheaded Borer.

Common Hosts:
- Hardwoods
- Softwoods

Description:
- Adult -- approximately 6-33 mm long; head and body with flattened appearance; coloration variable; often a metallic blue, green, copper, or red; sometimes distinctive banding.
- Pupa -- similar to adult; white.
- Larva -- size variable, approximately 8-50 mm long when mature; head and body yellowish to creamy white; mouthparts dark and prominent; neck region greatly expanded, flattened; legless.

Importance: The majority of flatheaded borers, like roundheaded borers, infest dead, dying, or high stressed or weakened trees. A few species do attack healthy trees. All tree parts are susceptible to flatheaded borer infestation. Seasoning timber is highly susceptible to borer infestation. A common occurrence in Florida is the emergence of adult beetles from newly constructed log houses; a result of improper log treatment prior to construction. Fortunately, the beetles will not reinfest the wood. The holes, however, should receive treatment to minimize decay.

Biology and Habits: Adult beetles emerge year-round from infested trees or material, mate, and the females lay eggs in protected sites; in bark crevices, under bark flaps, or in wounds. Larvae first feed on tree's inner bark, then bore into the sapwood and

heartwood. Pupation occurs in a chamber made by the mature larva. Overwinters as larva, pupa, or adult.

Number of Generations: Variable - several generations per year to 2-3 years for just one generation.

Signs of Infestation: Foliage discoloration and/or wilting. Some metallic beetles are leaf miners. Flattened holes (more than 4 mm wide) in bark and into sapwood. Sapstaining of bark around holes.

Control: Promote tree vigor and health to minimize the possibility of borer infestation. Avoid injury of trees. Promptly dispose of material infested by borers. Remove and destroy trees severely infested by borers. Use an approved insecticide to prevent infestation of susceptible trees or material. Use an approved insecticide to prevent complete emergence of adult beetles from infested material.

NOTE: Galley fumigation is difficult for this group of wood boring insects because the galleries are tightly packed with their frass, thus inhibiting fumigant penetration.

Common Name: FLORIDA CARPENTER ANT

Other: Wood Ants

Species: *Camponotus abdominalis floridanus*

Common Hosts:

- Hardwoods
- Softwoods
- Structural timber of buildings

Wood damaged by Carpenter Ants.

Description:

- Adult -- approximately 6-13 mm long; reddish-yellow head and thorax, black abdomen; elbowed antennae, constricted waist.
- Pupa -- size of adult; creamy white.
- Larva -- size variable, approximately 10 mm when mature; head and body white; legless.

Importance: Carpenter ants do not eat wood as do termites – wood is removed to construct galleries for their nests. Ants do feed on honeydew from sapsucking insects, dead and live insects, and food wastes in and around houses. Generally associated with logs, stumps, dead trees, but will infest structural wood of buildings. First start in the damp rotting wood areas and then extend galleries into sound wood.

Biology and Habits: Winged male and female ants leave a nest in the spring-summer, mate, and the females establish a nest in suitable wood. The initial progeny of the first female are fed by her; thereafter, succeeding generations care for others. The first female or queen then lays eggs exclusively. A typical nest will contain several thousand individuals, have all developmental stages present, and can exist for several years. Living trees are occasionally infested, but the galleries are usually restricted to the defective portions of the trees.

Number of Generations: Several generations per year

Signs of Infestation: Slits in wood and sawdust borings caught on bark or piled on floors. Galleries across wood grain and free of frass, very smooth walls. Swarm of large red-black ants upon disturbance of nest.

Control: Remove infested material as soon as possible. Replace structurally damaged timber. Clear all downed timber, rubbing branches, wood wastes from buildings to minimize the chance of wood an infestation. Use an approved insecticide to prevent infestation or control a current problem.

Common Name: ROUNDHEADED BORERS

Other:

- Long-horned beetles
- Wood borers

Species: Hardwoods:

- *Goes* spp.
- *Neoclytus* spp.
- *Prionus* spp.
- *Saperda* spp.
- *Xylotrechus* spp.

Softwood:

- *Acanthocinus* spp.
- *Prionus* sp.
- *Xylotrechus* spp.

Typical larva of Roundheaded Borer.

Common Hosts:

- Hardwoods
- Softwoods

Description

- Adult -- approximately 10-37 mm long; head with prominent antennae, often as long as body or more; elongate body; coloration variable: dark brown or shiny black to distinctive banding or spotting with red, yellow or white.
- Pupa -- similar to adult; white.
- Larva -- size variable, approximately 30-60 mm long when mature; head and body yellowish to creamy white; mouthparts prominent; legless.

Importance: The majority of roundheaded borers, like flatheaded borers, infest dead, dying or highly stressed or weakened trees. A few species infest healthy or slightly weakened trees. All tree parts are susceptible to borer infestation. Seasoning timber is susceptible to borer infestation. A common occurrence in Florida is the emergence of adult beetles from newly constructed log homes. The infestation occurred prior to construction and the beetles will not re-infest the house.

Biology and Habits: Adult beetles emerge year-round from infested trees or material, mate, and females lay eggs in cone-shaped holes or protected sites. The young larvae feed on the tree's inner bark, then bore into the sapwood or heartwood. The mature larva makes a chamber for pupation. Overwinters as larva, pupa, or adult.

Number of Generations: Variable - several generations per year to 2-3 years for just one generation

Signs of Infestation: Foliage discoloration and/or wilting. Round holes (more than 3 mm wide) in bark and into sapwood. Sapstaining of bark around holes. Wood granule or fibers, or sawdust caught in bark crevices or piled at base of tree. Cone-shaped holes in bark - adult females chew holes for placement of eggs.

Control: Prompt tree vigor and health to minimize the possibility of borer infestation. Avoid injury of trees. Promptly dispose of material infested by borers. Remove and destroy trees severely infested by borers. Use an approved insecticide to prevent infestation of susceptible trees or material. Use an approved insecticide to prevent complete emergence of adult beetles from infested material. Gallery fumigation may prove useful; particularly for large hardwoods slightly to moderately infested by borers. Galleries are usually free of frass and thus amenable to effective fumigation.

Common Name: TWIG BEETLES

Species:

- *Pityophthorus* spp.
- *Pseudopityophthorus* spp.
- And others

Holes made by adult Twig Beetles leaving infested twig.

Common Hosts:

- Hardwoods
- Softwoods

Description:

- Adult --approximately 1-3 mm long; light brown to shiny black head and body; body cylindrical.
- Larva -- size variable, 1-3 mm long when mature; brown head, white body.

Importance: Generally, twig beetles are limited to recently cut, damaged, stressed, or dying branches but not always. Most times they are beneficial branch pruners. Some species may transport pathogenic fungi, such as wilts.

Signs of Infestation: Foliage discoloration and/ or wilt. Small holes (approximately 1-2 mm wide) in twigs or branches. Pitch or sap present or absent. Fine boring dust caught in bark crevices. Small galleries under bark or in the pith of branches and twigs.

Control: Prune off and destroy beetle-infested twigs and branches. Promote tree vigor and health to minimize the possibility of beetle infestation and to aid in the recovery from attack. Use an approved insecticide for high-value trees.

INSECTS OF CONIFER AND HARDWOOD ROOTS

Common Name: MOLE CRICKETS

Species:

- Neocurtilla spp.
- Scapteriscus spp.

Common Hosts:

- Hardwoods
- Softwoods
- Especially seedlings in nurseries

Nursery grown cedar seedling killed by Mole Crickets.

Description:

- Adult -- approximately 30-40 mm long; light to dark brown body; front legs strongly scooped for digging.
- Nymph -- similar to adult, but wings not developed.

Importance: Mole crickets cause only occasional damage. Most cases will be in forest nurseries or recently planted seedlings in a shade tree site.

Signs of Infestation: Seedling severed just above the ground or within to 60 cm of soil. Major and minor roots removed or severed; pitted areas may be present. Extensive, meandering galleries in exposed soil, approximately 3 mm diameter. Fallen or wilting seedling.

Control: Baited insecticides

Common Name: WHITE GRUBS

Species: *Phyllophaga* spp.

Common Hosts:

- Hardwoods
- Softwoods
- Especially seedlings in new nurseries or recently prepared plantations from fallow fields.

White Grub.

Description:

- Adult -- approximately 12-20 mm long; robust, oval-shaped body; brown or black head and body; a beetle.
- Larva -- size variable, approximately 25 mm long when mature; head amber-orange, body C-shaped and creamy white; well-developed legs and jaws; hind end black or dark blue.

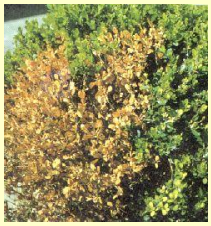
Importance: Seedling losses can be severe in areas of high white grub population.

Signs of Infestation: Foliage discoloration of seedlings. Uprooted seedlings with no lateral or tap roots. Roughly circular gouges in bark along length of larger roots.

Control: Nurseries and plantations recently developed from fallow fields may require a soil insecticide treatment. Delay reforestation of plantations in old fields for 1 year after site preparation.

VERTEBRATES: ANIMALS AND BIRDS

TABLE IV. VERTEBRATE PESTS OF SOUTHERN HARDWOOD AND SOFTWOOD TREES

Pest Animal	*Tree Age Class*	*Damage Characteristics*	*Control Options*
Beaver	Seedling Sapling	• New sprouts clipped • Stem severed close to ground • Broad band of bark and sapwood removed, less than 30 cm height • Conical stump, pronounced channels in wood (approximately 13 mm wide)  *Longleaf pine partially girdled by beaver.*	Place metal bands at base of trees Trap and remove beaver population (check Florida trapping laws)
Cattle	Seedling Sapling	• Foliage and buds browsed • Trampling of stems • Gouging of bark close to ground  *Broken branches*	Fencing Deer repellent Removal of cattle population
Dog	Seedling Sapling	• Outer foliage wilted, discolored or dead, up to 60 cm height • Branch dieback • Surrounding grass dead  *Foliage damage of hedge caused by scent-marking of male dogs.*	Fencing Dog repellent Avoidance training Contact owner
Rabbit	Seedling Sapling	• Stem clipped off less than 45 cm above ground, angled cut • Top eaten or lying beside stump • Bark removed in patches or stripped off larger stems 	Prescribe burn to remove cover vegetation

Deer	Seedling Sapling	• Foliage and buds browsed • Ends of branches bitten squarely • Bark rubbed off one side of stem, up to 1.5 m height  *Bark removed from slash pine sapling by buck deer rubbing velvet from antlers.*	Fencing Deer repellent Small block cuttings
Squirrel	Seeds Sapling Mature	• Buds browsed out of shoots • Nut shells and partially eaten nuts on ground; reduced nut crop, cone cutting • Small to large patches of bark and inner bark removed from trunk and upper branches  *Camphor tree bark removed by grey squirrels.*	Trap and remove squirrel population Use an approved rodenticide (check Florida hunting laws)
Mice **Rats**	Seeds Seedling Sapling	• Small holes in seeds • Lower stem and roots partially or completely girdled, teeth marks approximately 1.5 mm wide (mice) or 3-4 mm (rats) • Soil scratched away from lower stem or root collar	Prescribe burn to remove cover vegetation Use an approved rodenticide
Pig	Seedling Sapling Mature	• Ground disturbed, plants uprooted, inner bark removed from root collar, especially longleaf pine • Lateral roots dug out and girdled in older trees	Fencing Hunting (check Florida hunting laws)
Pocket gopher	Seedling Sapling	• Whole tree foliage discoloration • All roots except collar removed; only a stub may be present • Dirt mounds prevalent • Teeth marks about 2 mm wide	Trapping Poisoned bait

Woodpecker	Sapling Mature	Bark flakes piled at base of tree, deep gouges in outer bark	 *Bark flakes removed from live longleaf pine by pileated woodpecker feeding on ants.*	Avoidance training: noise, moving objects
Yellowbellied sapsucker	Sapling Mature	Lines of deep drill-holes in bark	 *Holes made in bark of a sweetgum tree by feeding yellowbellied sapsuckers.*	Eliminate insects living under bark with an insecticide
Yellowshafted Flicker	Sapling Mature	Deep hole with exuding sap or pitch	 *Longleaf pine with large holes in bark and exuding pitch caused by yellowshafted flickers.*	Trapping (check Florida trapping laws)

CONCEPTS OF TREE DISEASE

Disease, as it pertains to trees, may be defined as a sustained and progressive impairment of the structure or function of any part of a living tree. Diseases are caused by a variety of factors or agents which are divided into two general groups: non-living (abiotic) and living (biotic). Biotic agents are called Pathogens. Generally, it is essential to know the specific cause or causes of a tree disease to determine (a) what course of remedial action (treatment), if any, might be effective, and (b) the prognosis for survival and recovery of the diseased tree. Accurate identification of specific causes of tree diseases is important (if not essential) for preventing or avoiding repeat problems in the future.

Determining the cause of tree disease can be compared to the work of a detective. This process is commonly known as Diagnosis. One begins by examining the available evidence and considering all related circumstances.

Visible evidence used in the diagnosis of disease is typically classified as either a symptom or a sign.

Symptoms are the abnormal characteristics expressed by a diseased tree (e.g., dieback, foliage discoloration, decay, galls, wilting, etc.).

A Sign is the physical presence of a causal agent (e.g., fungus, parasitic plant, an empty herbicide container, etc.)

Related Circumstances are often extremely important in properly diagnosing a tree disease problem. For example, has the tree been exposed to severe or unusual weather conditions? Has there been a history of site disturbance such as building or road construction near the tree? What is the history of tree removal or thinning in the area (particularly important in forest stands)? Has the tree been fertilized lately? What are the predominant soil and/or drainage features in the area? Have any chemical spills occurred in the area? Has a herbicide been used? Is there a source of an air pollutant nearby?

Good detectives often make good diagnosticians.

The role of environment in the development of tree disease cannot be overemphasized. It is important to understand that in every situation, environmental influences such as temperature, moisture, and soil conditions influence the biology of the tree, the activity

TABLE V. Some Common Causes of Tree Disease		
Non-Living (Abiotic) Factors	**Living (Biotic) Agents**	**Pathogens**
Temperature Extremes	Fungi*	Lower plants with threadlike (filamentous) vegetative stages (single threads being referred to as hyphae: sing., hypha). Typically reproduce via spores produced in or on various structures called fruiting bodies. Fruiting bodies range from microscopic to large (mushrooms, etc.) depending upon the particular fungi involved.
Moisture Extremes	Bacteria	Microscopic, single-celled plants with cell walls. Reproduce by fission (splitting) or budding.
Soil Compaction	Viruses	Sub-microscopic particles consisting specific nucleic acid molecules covered with protein coats.
Nutrient (Fertilizer) Deficiencies	Seed Plants	Higher plants that reproduce by seed.
Chemical Injuries (herbicides, excess fertilizers, etc.)	Mycoplasmas	Submicroscopic organisms more complex (advanced) than viruses, but less complex (lower) than bacteria. Mycoplasmas have no cell walls. Reproduce by budding or fission, and are typically found in the phloem of host plants or trees.
Air Pollutants	Nematodes	Minute to microscopic worms.
* Fungi currently constitute the largest and best known group of tree pathogens.		

of the pathogen or causal agent, and thus the development of disease. Disease development may be enhanced or retarded by changes in the surrounding environment, but the environment will influence disease. In fact, many tree diseases are more a function of environmental influences (e.g., abiotic factors) than they are of specific pathogens *per se*. In other cases, certain pathogens are able to cause disease only because of prevailing environmental influences. Always consider the environment!

Don't be fooled by the appearance of a suspicious looking fungus on or near an ailing tree. It may be a result, not a cause, or it may be totally unrelated to the tree's disease. Many fungi develop only on dead or dying trees and are not pathogens. These fungi are Saprophytes and are living on dead tree tissues or organic debris as opposed to pathogens which usually gain their sustenance from living trees as Parasites.

Other fungi, especially certain mushroom or toadstool types, are actually beneficial to trees. Many of these types of fungi form highly specialized, mutually beneficial

associations called Mycorrhizae with the roots of living trees. In these associations the fungi receive sugar and other dietary essentials from the trees, and in return enhance the tree's ability to extract phosphorus and other nutrients from the soil.

Careful application of these simple principles and concepts, together with a basic understanding of the growth or site requirements of trees being examined, provides even the novice with a sound approach for identifying many of the causes of tree disease. However, not all disease problems can be identified in the field, not even by trained experts. Some diseases require detailed laboratory analyses for positive identification of specific causal agents. The following pages provide brief and simple descriptions of some of the most common diseases affecting Florida's more important tree species. The use of these descriptions, together with appropriate consultation of trained specialists should provide the interested forester, landowner, arboriculturalist, etc., with a reasonable base of information for dealing with tree disease problems.

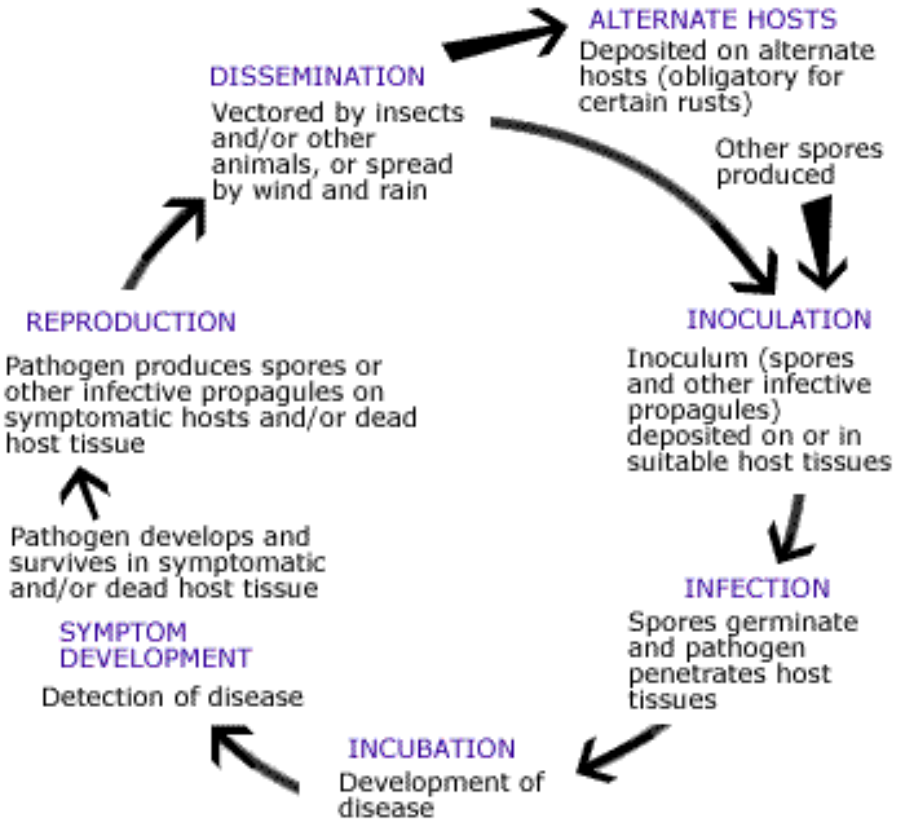
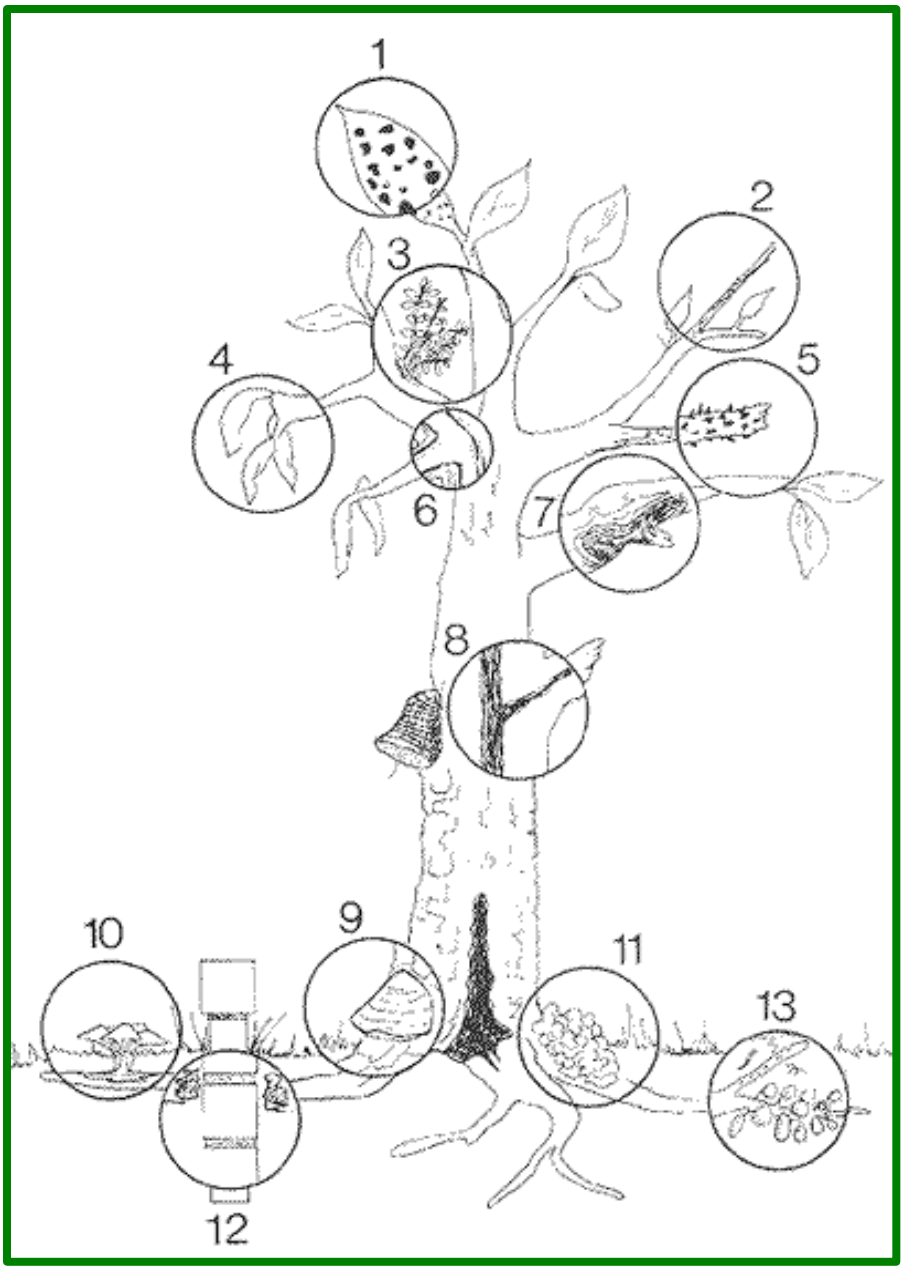


Figure 8. Generalized life cycle for tree disease pathogens

Figure 7. Some common types of disease problems affecting trees:



1. **Leaf spots** - a foliage disease

2. **Twig dieback** - evidence of cankers and/or stress and decline

3. **Mistletoe** - a parasitic seed plant

4. **Wilt** - evidence of moisture deficiency, vascular wilt disease or root rot

5. **Fruiting bodies of a canker fungus** - signs of canker infections

6. **Vascular streaking** (internal) - evidence of vascular wilt disease

7. **Branch canker** at a branch stub

8. **Heart rot** (internal) and sporophore of a heart rot fungus at a broken branch stub

9. **Sporophore** of a butt-rot fungus at base of tree

10. **Sporophores** of a root rot fungus arising from a damaged root

11. **Crown gall** - a gnarled swelling ("tumor") caused by a bacterium

12. **Severed root** resulting from construction damage - site of entry for root and butt-rot fungi

13. **Nematode damage** to small tree roots - lesions (upper) and galls (lower)

DISEASE: NEEDLE RUST

Pathogens: Various fungi Coleosporium spp.

Common Host: **Pines** *Pinus* spp.

Alternate Hosts: Various broad-leaved plants

Significance: Most species of pines in Florida can become infected with needle rust fungi. Needle rust is a common disease, often causing considerable distress to tree lovers seeing it for the first time.

Papery, white aecial pustules of a needle rust fungus on pine; appear in late spring or early summer.

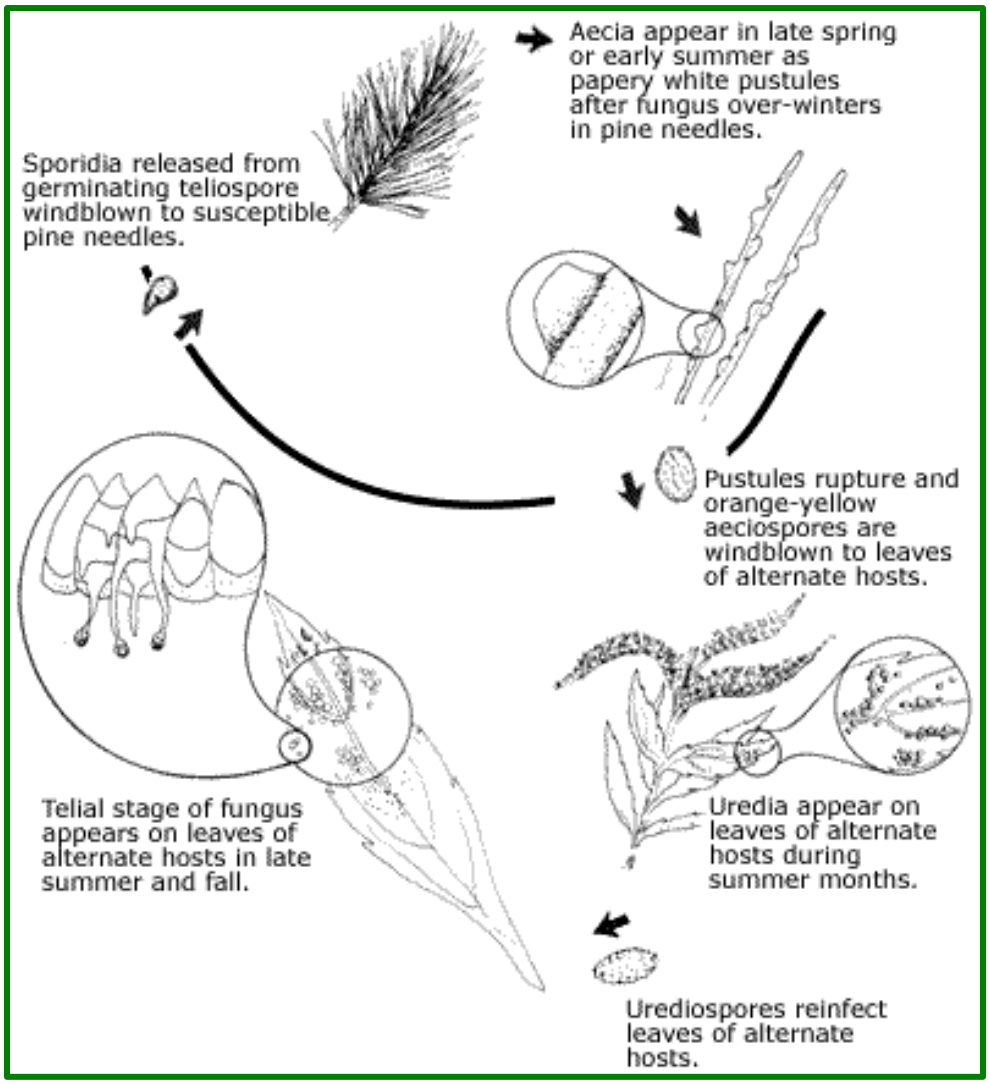


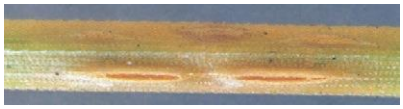
Fig. 9. Generalized life cycle of needle rust fungi

Fortunately, the disease is generally innocuous, having little, if any, impact on affected trees. Only where particularly severe infections occur in nurseries, young pine plantations, or high value ornamental plantings is this disease any more than a curiosity. (*See Figure 9: Generalized life cycle of needle rust fungi.*)

Recognition: Infections are usually first noticed in late spring or early summer when small papery white pustules begin to emerge from the surface of infected pine needles. Soon these pustules, called aecia, (sing., aecium) become filled with yellow-orange spores that are later released into the air in small puffs or clouds when the needles are jarred or shaken by wind.

Infection Biology: Spores produced on pines do not reinfect pines, but as is typical of most rust fungi, they initiate infections on other plants referred to as alternate hosts. Common alternate hosts for Coleosporium spp. include goldenrods, asters, sunflowers, morning-glories, and others, depending upon the particular species of rust fungus. A different spore type is produced later in the season on the infected leaves of the alternate host. Reinfection of susceptible pine needle tissues by these spores results in new pine infections

Control: Control of needle rusts is seldom necessary. If control is desired, fungicidal protection of vulnerable pines during late summer and fall may be useful. Otherwise, avoid planting of pines near heavy populations of the alternate host(s) and eradicate alternate host plants growing near susceptible pines where practicable.



Yellow-orange fissures in pine needle infected with a needle rust fungus: appear in late spring.

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DISEASE: NEEDLE CAST

Pathogens: Various fungi
Ploioderma spp.
Lophodermium spp.

Common Host: **Pines** *Pinus* spp.

Red-brown discoloration of pine needles typical of needle cast fungus infections.

Significance: Needle cast affects all of Florida's major pine species. In some years this disease develops to spectacular levels resulting in large numbers of trees giving the appearance of having been scorched by fire. Some degree of growth reduction due to premature loss (cast) of foliage is presumably the primary impact of this disease on infected trees. However, severe needle cast, in combination with other stresses such as drought or injury could well contribute to the vulnerability of trees to stress-related pests such as bark beetles.

In most cases, the effects of needle cast on otherwise healthy trees are negligible. See Figure 10: Life cycle of a typical needle cast fungus.

Recognition: Infected needles generally turn red to brown from their tips beginning in winter or early spring. By mid to late spring the death of infected needles is well advanced giving diseased trees a red to brown "fire-scorched" appearance. Some individual trees are highly susceptible to needle cast fungi while others possess a high degree of genetic resistance. Therefore, it is not uncommon to see severely infected and perfectly healthy trees side by side. Following actual needle cast, the remaining green needles often appear somewhat tufted at the ends of branches. Small (1-2 mm), black elongate fruiting bodies (hysterothecia; sing., hysterothecium) of needle cast fungi are sometimes visible upon close inspection of symptomatic or dead needles.

Infection Biology: Microscopic spores, called ascospores, are produced in the fruiting bodies (hysterothecia; sing., hysterothecium) of the needle cast fungi on symptomatic or dead needles. Ascospores are liberated into the air where they are then disseminated largely by wind and rain. New infections occur when the ascospores are deposited on young, emerging needles of susceptible pines during the spring and early summer.

Control: Control is unnecessary in most situations. If control is desired for cosmetic reasons, protection of newly emerging needles through June with regular applications of an appropriate fungicide may be helpful.

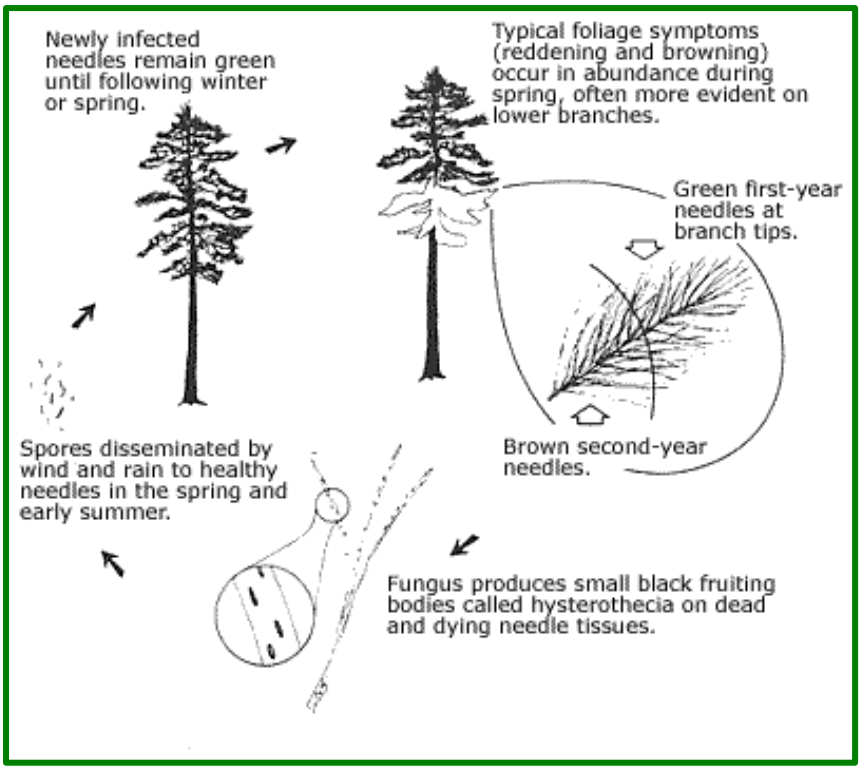


Fig. 10. Life cycle of a typical needle cast fungus.

DISEASE: BROWNSPOT NEEDLE BLIGHT

Pathogens: Fungus *Scirrhia acicola*

Common Host: **Longleaf pine** *Pinus palustris*

Grass stage longleaf pine seedling severely damaged by brown spot needle blight

Significance: Brown spot needle blight is regarded as the most serious disease affecting longleaf pine. Young, grass stage seedlings are particularly vulnerable to severe infections and may die as a result. More commonly, however, infected grass stage seedlings are stunted and grow poorly for years until they are able to outgrow the influence of the disease. Other pines and older trees, may be infected with the brown spot fungus, but the resulting infections are of little consequence.

Recognition: Typical symptoms of this disease include small (3 mm) spots on needles that vary in color from straw yellow to light brown to brown with distinct purple or amber-yellow margins. Infected needles are often green at the base, dead (brown) at the needle tip, and mottled with spots separated by definitive bands of green tissue in the middle. As needles die, they may appear to have been scorched by the heat of a fire. It is common for needles killed by brown spot needle blight to assume an embossed appearance since the live green bands of tissue often shrink more upon the death of the needles than do the symptomatic brown spots. In certain cases, brown spot symptoms and symptoms caused by certain needle cast fungi (esp. Lophodermium spp.) are identical and only laboratory analyses can be relied upon for specific diagnoses.

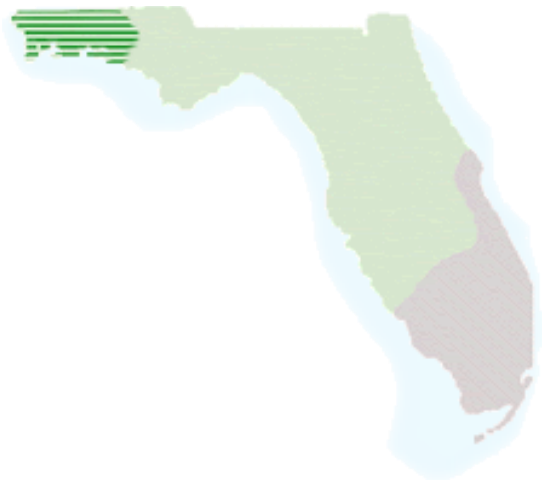
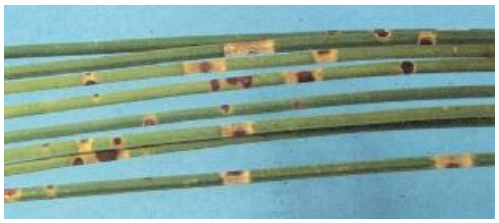


Fig. 11. Natural range of longleaf pine in Florida (green) and distribution of brown spot needle blight (striped). (Source: U.S. Forest Service)

Infection Biology: Spores of brown spot fungus are produced in two types of small (less than 1 mm), black fruiting bodies on symptomatic needles. These spores (called conida and ascospores) are liberated and spread by wind and rain. New infections may occur on longleaf pine throughout the year, but most infections occur between May and October.

Control: Brown spot needle blight can be effectively controlled in nursery and ornamental environments with carefully applied fungicidal sprays. In commercial forest situations the use of genetically resistant planting stock is

recommended. Perhaps the most effective control for this disease in commercial forestry is the use of prescribed burns. Well time (January - February) and carefully controlled fires destroy infected needles along with the brown spot fungus, thereby reducing the source of fungus inoculum as well as new infections. Although needles are scorched by fire, vigorous grass stage seedlings with root collars 1 or more centimeters in diameter are particularly fire resistant, and able to survive quite well. Controlled burns may also be useful as a sanitation or eradication measure before planting longleaf seedlings in previously infected areas.



Typical brown spots on needles of longleaf pine resulting from infection by Scirrhia acicola.

DISEASE: SOUTHERN CONE RUST

Pathogens: Fungus *Cronartium strobilinum*

Common Host:

- **Slash pine** *Pinus elliottii*
- **Longleaf pine** *Pinus palustris*
- **Various Evergreen Oaks**

Swollen first-year conelets of slash pine infected with the southern cone rust fungus. Note brightly-colored (yellow) aeciospores.

Alternate Significance: Southern cone rust is generally insignificant as a damaging disease of pines. It can, however, be of some economic importance in commercial forestry operations as a destroyer of cones and highly valuable, genetically improved seed in seed orchards and seed production areas. The disease is common in Florida, although it varies from year to year in its incidence and distribution. In particularly active outbreaks, southern cone rust is often very showy as the swollen, diseased cones on infected pines produce masses of bright yellow-orange spores.

Recognition: Infected, first-year conelets of susceptible pines swell rapidly and by April are often three to four times larger than their disease-free counterparts. The scales of infected cones typically exude a sweet, sticky fluid (actually a spore stage of the pathogen) which is attractive to nectar-loving insects (especially cone moths, *Dioryctria* spp.). In the late spring (April - June) infected cones become readily visible, even at long

distance, due to production of large powdery masses of yellow-orange spores (aeciospores) on their surfaces.

Infection Biology: First-year female flowers (young pine cones) of host pines are susceptible to infections by the southern cone rust fungus from the time they emerge from bud scales until the end of the natural pollination season (late January to mid-February for slash pine). Infections are initiated by minute airborne spores called sporidia. Sporidia are produced on the infected foliage of several evergreen oaks including live oak, running oak, and dwarf live oak which serve as alternate hosts of the pathogen. As the disease progresses on infected cones, the showy masses of fungal aeciospores are produced. Aeciospores initiate new infections on the foliage of alternate host oaks.

Control: In most situations controls are not necessary. In high value seed orchards or seed production areas southern cone rust can be controlled adequately through the regular application of certain fungicides during the period of conelet susceptibility (January - February).

DISEASE: FOLIAGE BLIGHTS OF JUNIPERS AND RELATED CONIFERS

Pathogens: Various fungi
Phomopsis juniperovora
Cercospora sequoiae

Redcedar severely blighted by Phomopsis juniperovora. Note grayish color and hooking of tips of branches.

Common Host:

- **Eastern Redcedars** *Juniperus virginiana*
- **Southern Redcedars** *Juniperus silicicola*
- **Italian Cypress** *Cupressus sempervirens*
- **Arizona Cypress** *Cupressus arizonica*
- **Related Conifers**

Significance: Junipers and related conifers are often severely damaged by a variety of foliage blights. Infections are usually most severe where the foliage of susceptible hosts is subjected to poor aeration or excessive foliage moisture (rain, lawn sprinklers, etc.). In most cases damage is limited to the discoloration and loss of foliage. However, severe infections can result in a substantial disfiguring of infected branches. Infected ornamentals or trees in Christmas tree planting are often rendered so unsightly by foliage blights as to become aesthetically undesirable, resulting in substantial economic losses.

Recognition: Foliage blights are readily identified by the progressive discoloration of infected tissues. Infected foliage first lightens in color to a yellow or yellow-brown and

progresses to a red-brown or brown. Infections caused by Phomopsis juniperovora typically begin at branch tips and progress downward and inward. These infections often result in the death of small branches in addition to the death of the foliage. Phomopsis infections are frequently characterized in advanced stages of disease development by ashen gray branch tips that sometimes tend to hook or curl inward. Cercospora infections, on the other hand, generally begin on the inner or lower foliage and progress upward and outward, often leaving tufts of green foliage at the tips of infected branches. Small (less than 1 mm) dark fruiting bodies (sporebearing structures) of the various fungal pathogens can frequently be seen upon close examination of infected plant parts (best seen with a hand lens). Those of Phomopsis appear pimple-like while those of Cercospora appear as dense tufts of minute, hair-like projections.

(NOTE: Although the symptoms and signs described are typical of the blights caused by the pathogens indicated, hasty diagnose without laboratory confirmation may lead to faulty identifications. The potential variability of symptoms and the wide variety of fungi capable of causing similar diseases, including many not identified above, make caution an advisable policy).

Infection Biology: Infections occur at all times of the year provided temperatures are warm enough and adequate moisture is available. Spores of the various pathogens are spread by wind, rain, insects, and man. Cercospora infections are limited to foliage tissues, but infections caused by Phomopsis juniperovora involve the woody tissues of small (less than 1 cm) twigs and branches. Conditions favorable to the creation or retention of foliage moisture often dramatically increase the incidence and severity of foliage blight.

Control: The best methods of controlling foliage blights on junipers and related conifers are to promote foliage aeration and to avoid unnecessary watering of foliage (overhead irrigation, lawn sprinklers, etc.). Where practical and cosmetically acceptable, the pruning and discarding of infected plant parts to reduce local inoculum (fungus spores) and prevent disease spread are recommended. The careful application of certain fungicides can provide good protection against infections in certain situations.

DISEASE: CEDAR APPLE RUST

Pathogens: Various Fungi Gymnosporangium spp., especially *G. juniperi- virginianae*

Common Host:

- Eastern Redcedars *Juniperus virginiana*
- Southern Redcedars *Juniperus silicicola*

Alternate Host: Rosaceae family members including:

- Apple *Malus* spp.
- Hawthorn *Crataegus* spp.
- Pear *Pyrus* spp.

Brightly-colored telial horns of the cedar-apple rust fungus Gymnosporangium juniperi virginianae.

Significance: Cedar-apple rusts are not diseases of serious magnitude in Florida. They are, however, fairly common in parts of the state and may, under certain circumstances, represent a potential threat to redcedars being grown as ornamentals or Christmas trees. In other situations, the problem may be the damage caused by cedar-apple rust fungi on the leaves and/or fruit of apples, pears, hawthorns, or other pomaceous (apple-like) trees which serve as alternate hosts in the pathogens' life cycles. Damage on redcedars is usually a disfiguring of infected foliage and branches, generally involving various types of swellings - galls (hypertrophies) and witches brooms on infected tissues. The fungus G. juniperi-virginianae causes the distinctive and rather well-known cedar apples on infected redcedars. Damage on the alternate, pomaceous hosts includes the spotting, yellowing, or deformation of infected foliage and the blemishing or loss of infected fruits.

Recognition: Infected redcedars typically display some type of swelling or hypertrophy and occasionally witches brooms in infected wood tissues (branch, twig or stem) or the typical gall-like structures called cedar apples which sometimes reach 5 centimeters in diameter. Immature, first-year galls, or cedar apples, are typically greenish brown and have small pit-like depressions on their surfaces. Mature, second-year and older inactive galls are reddish brown to dark brown. During rainy weather, particularly during the spring and early summer, mature second-year galls give rise to gelatinous, yellow-orange to orange-brown finger-like projections (tendrils) called telial horns, a spore stage typical of rust fungi. Telial sori (masses or heaps) of Gymnosporangium spp. causing branch or stem swellings are similarly colored, but appear as irregular or elongated gelatinous masses, ridges or flaps on the surface of the woody galls. At this time infections are showy and unmistakable. In dry weather telial horns shrivel, become dark brown in color, harden and remain inactive until sufficient moisture is available for their revival. Infected foliage on the pomaceous, alternate hosts appears during the summer or fall and is characterized by spots or large areas of yellow-orange discoloration and varying degrees of deformation. Small blackish fruiting bodies

Branch swelling and telial sporulation on red cedar resulting from infection by Gymnosporangium nidus-avis.

(less than 1 mm) called pycnia (sing., pycnium) may often be seen embedded in the discolored leaf tissue on the upper surface of the leaves. On the lower leaf surfaces small yellow-orange blisters or pustules called aecia (sing., aecium) are often readily visible, but these generally appear after the formation of the pycnia on the upper leaf surfaces. Infected fruits are blemished and disfigured, and may sometimes shrivel completely and fall from the tree.

Infection Biology: Microscopic spores called sporidia or basidiospores are produced during the spring and early summer by the gelatinous telia horn or sori (sing., sorus) on infected redcedar tissues. Those spores are windblown to the surfaces of susceptible alternate host leaves or fruit where the pathogens initiate their alternate infections by direct penetration. Later, during the summer and fall, another type of spore (aecispores) is produced in the aecia on the underside of infected foliage of the pomaceous, alternate hosts. These spores are again wind-carried to susceptible redcedar tissues where new infections are then initiated. Rust fungi survive perennially in the bark of infected redcedars (stem and branch infections) and are capable of producing telial horns and sporidia year after year under suitable weather conditions G. juniperi-virginianae, the primary cause of the typical cedar apples, survives in the gall tissue only two years. After its second and spore-producing year, this fungus dies in the galled tissues. On the alternate, pomaceous hosts the fungi survive for only a matter of months, long enough to generate spores for new redcedar infections. Cedar-apple rust fungi cannot complete their life cycle without passing through both types of hosts. Spores produced on redcedars cannot reinfect redcedars, and spores produced on pomaceous hosts cannot reinfect pomaceous hosts.

Fig. 12. Generalized life cycle of the cedar-apple rust fungi.

Control: The best method of controlling cedar apple rust infections is to avoid growing redcedars and the pathogen's pomaceous alternate hosts in close proximity to one another. By eliminating either redcedars or the broad-leaved alternate hosts (choice dependent upon the tree crop preferred) the pathogens are unable to complete their life cycles. Hence there can be no intensification or spread of the disease. Both redcedars and the alternate, broad-leaved hosts of cedar-apple rusts can be protected with the carefully timed application of certain fungicides if alternate host eradication is not feasible or desired. Infected and deformed branches of redcedars can simply be pruned and discarded where cosmetically acceptable and economically justified.

HARDWOOD FOLIAGE DISEASES

DISEASE: HARDWOOD FOLIAGE DISEASES

Causal Agents: Various Organisms and Abiotic Factors

Common Hosts: Hardwoods

Significance: Leaves are among the most conspicuous features of hardwood trees and are often the reason certain trees are planted as ornamentals. As a result, foliage abnormalities (symptoms) are often more readily observed than other types of tree disease problems, especially by the layman. Many FOLIAGE DISEASES are just that - diseases resulting from foliage infections or injuries of one type or another. In other cases, foliage symptoms (color irregularities, wilting, etc.) are not actually the result of foliage diseases, but are INDICATORS of other problems such as nutritional imbalances, root diseases (refer to index), chemical injuries, or environmental stresses that are affecting the tree as a whole. As a rule, foliage diseases do not constitute a serious threat to Florida's hardwoods, although in situations where blemish-free foliage is necessary or desirable (ornamental nurseries, etc.) they can be troublesome. When foliage symptoms are indicators of other problems, the significance of the indicated problem is often of greater potential consequence. By the time indicator symptoms are expressed by the foliage the tree has already sustained serious injury or is in an advanced stage of disease development.

Recognition: Foliage diseases are exhibited in a variety of ways on hardwoods in Florida. Table VI outlines the more typical symptoms types, together with their related causes and most common hosts.

Infection Biology: The fungi that cause foliage infections (true foliage diseases) produce spores on symptomatic leaf tissues in or on various types of small fruiting bodies when temperature and moisture conditions are favorable. Spores are disseminated largely by wind and rain-splash to the surfaces of newly emerging and/or disease-free leaves. In most cases, spore survival and germination require several hours of high relative humidity, water droplets, or a water film on the host leaf tissues. Following spore germination, the fungi penetrate the leaves directly or through minute pores (stomates) on the leaf surface.

With the exception of powdery mildews and sooty molds, the fungi causing foliage disease typically develop parasitically within host leaf tissues, eventually giving rise to their associated symptoms (leaf spots, blotches, etc.). The powdery mildews develop on the surface of host leaves and establish their parasitism by producing microscopic penetration pegs called haustoria (sing., haustorium) which penetrate into individual leaf

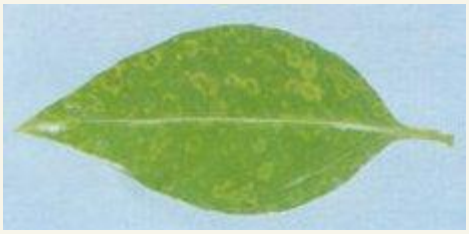
cells. These haustoria serve as absorption structures to provide the pathogens' needed nutrition. In contrast, sooty molds do not actually parasitize leaves at all. These fungi are superficial nuisances that typically feed on the honeydew of aphids and excretions of certain scales or other insects, although naturally secreted exudates are also fed upon in certain host plants as well.

Table VI. Common Foliage Diseases of Florida Hardwoods

Symptom/Description	Common Host	Cause
Algal Leaf Spot: ("Green Scurf"): RAISED greenish-brown to rusty spots 	Magnolias *Magnolia* spp Live oak *Quercus virginiana* Avocado *Persea americana* Other "leathery" leafed trees	Algal leaf spots, or green scurf, caused by *Cephaleuros virescens* on the leaves of magnolia (green-orange patches). Grayish-white and darker "crusts" are lichens of the genus *Strigula* resulting from fungal colonization of the alga.
Anthracnose: Large, irregular blotches of necrotic (dead) tissue, often along or delimited by veins in leaf tissue 	White oak *Quercus* alba Other oaks *Quercus* spp. Sycamore *Platanus occidentalis* Elms *Ulmus* spp	Fungus *Gnomonia quercina* (Asexual stage: *Gloeosporium quercinum*) Fungus *Gnomonia platani* (Asexual stage: *Discula platani*) Fungus *Gnomonia ulmea* (Asexual stage: *Gloeosporium ulmeum*)

Blight: Rapid discoloration and death of foliage, often most serious on younger foliage at branch tips 	Pears *Pyrus* spp. Loquat *Eriobotrya japonica* Other hardwoods Various hardwoods	Bacterium *Erwinia amylovora* Unseasonal frost or freeze, chemical damage, certain fungi.
Blister: Irregular, raised or wrinkled blisters on otherwise green foliage 	Oaks *Quercus* spp. Peach *Prunus persica*	Fungus *Taphrina caerulescens* Fungus *Taphrina deformans*
Chlorosis: General or interveinal yellowing of foliage tissue	Oaks *Quercus* spp. Various hardwoods	Nutritional imbalance or deficiency often related to soil conditions (esp. high soil pH), root disease (including nematode infections), certain types of herbicide damage, vascular dysfunction, etc.

		
Leaf Spots: Discrete circular to irregular, variably colored spots on otherwise green leaves 	Various hardwoods	Miscellaneous fungi. Some bacteria.
Marginal Scorch or Necrosis: Narrow to wide bands or patches of dry (papery), brown, dead leaf tissue at tips or margins of leaves 	Various hardwoods	Drought, root disease, vascular dysfunction, salt water intrusion, excessive fertilizer, etc.

		
Mottling, flecking variegation or Ring Spots: Discrete patterns of tissue yellowing in otherwise green leaves 	Various hardwoods	Certain types of air pollution, chemical injuries, viruses.
Powdery Mildew: White, powdery to chalky or mealy fungus growth on the surface of green and sometimes slightly shriveled, distorted or malformed leaves. 	Elms *Ulmus* spp. Crape myrtle *Lagerstroemia speciosa* Various hardwoods	Powdery mildew fungi including *Uncinula macrospora* (elm) and *Erysiphe lagerstroemia* (crape myrtle).
Sooty Mold: Dark mealy or spongy to somewhat crusty fungus growth on leaves (and sometimes stems.	Various hardwoods	Various dark pigmented fungi.

		
Tar Spots: Hard, black, raised tar-like or crusty fungus growths on the upper surface of infected leaves. 	Yellow poplar *Liriodendron tulipifera* Elms *Ulmus* spp. Maples *Acer* spp Various hardwoods	Fungi *Rhytisma* spp. including *R. acerinum* (maples).
Wilt: a drooping and flaccid (limp) appearance of leaves, may be accompanied by degrees of chlorosis and marginal scorch or necrosis (above).	Various hardwoods	Drought, root disease Vascular dysfunction, etc. Comments: Indicative of a lack of water to the foliage.

The Fire Blight Bacterium (Table VI) survives throughout the winter in a dormant condition within blighted twigs and branches of infected hosts. With the onset of warm spring rains the pathogen becomes active and produces a bacterial ooze which is picked up by various types of insects, especially bees. Through their normal activity these insects carry bacteria to susceptible uninfected host tissues (blossoms, leaves, twigs) where new infections are initiated. Other infections result from simple rain splash of the bacterial ooze. The bacterial pathogen enters host tissues through natural

openings (stomates, lenticels, etc.), insect-created injuries or man-made openings (pruning scars, etc.).

The infection biologies for the indicator type of foliage diseases are related directly to their specific causes and can be best understood by referring to other sections of this book (root diseases, etc.).

Control: In most cases foliage diseases have very little impact on infected trees. Accordingly, control measures are often unnecessary. In other cases some foliage diseases may be quite damaging. If control is warranted, most foliage diseases can be effectively controlled with carefully applied applications of suitable fungicides or bactericides. In addition, raking up and destroying fallen, infected leaves is recommended. This practice reduces chances of new, disease-free foliage sustaining infections via spores produced on the previously infected leaves. In the same vein, selective pruning of diseased foliage and/or branches may be helpful in some situations. Providing adequate aeration and/or minimizing excessive moisture accumulation (via lawn sprinklers, etc.) on the leaves of shade trees is advisable also. Moisture is a necessary ingredient for most foliage infections.

DISEASE: PITCH CANKER

Resin oozing from slash pine stem infected with the pitch canker fungus.

Pathogens: Fungus Fusarium *moniliforme* var. *subglutinans*

Common Host:

- Slash Pine *Pinus elliottii*
- Other Pines *Pinus* spp.

Significance: Pitch canker affects most native species of pines in Florida, but it is most common on slash pine. Severe outbreaks of pitch canker are known to occur periodically and can result in significant stem and crown damage as well as mortality to slash pines in commercial forest plantations and urban environments. Trees of all ages are susceptible to pitch canker, but infections are most common in trees 10 years of age or older. Infected seedlings in forest tree nurseries are usually killed by the disease. To date, outbreaks of pitch canker in nursery seedling crops have not reached economically important levels. Pitch canker is usually of little consequence on species other than slash pine, although considerable damage to loblolly pine in seed orchards is not uncommon. In addition to damaging trees per se, the pitch canker fungus is also capable of infecting and damaging pine cones and seed.

Typical "flagging" of slash pine branches and terminals infected with the pitch canker fungus.

Recognition: Pitch canker is usually first recognized by the appearance of definitive reddening or "flagging" of infected terminal or lateral shoots. These dying shoots appear most frequently from late fall through the following spring. Close examination of infected shoots typically reveals the presence of abundant pitch (resin) exuding from slightly depressed cankers (areas of restricted diameter growth due to death of the cambium) at the point of infection. Depressed cankers are frequently not present on small diameter shoots. Wood beneath cankers is characteristically soaked with pitch. Infected shoots usually die within a matter of months. Old infections are readily identified by the dull gray-brown appearance of the dead shoots and needles. Needles frequently adhere for long periods of time to pitch canker-killed shoots because they are matted and stuck in the exuded pitch. The most

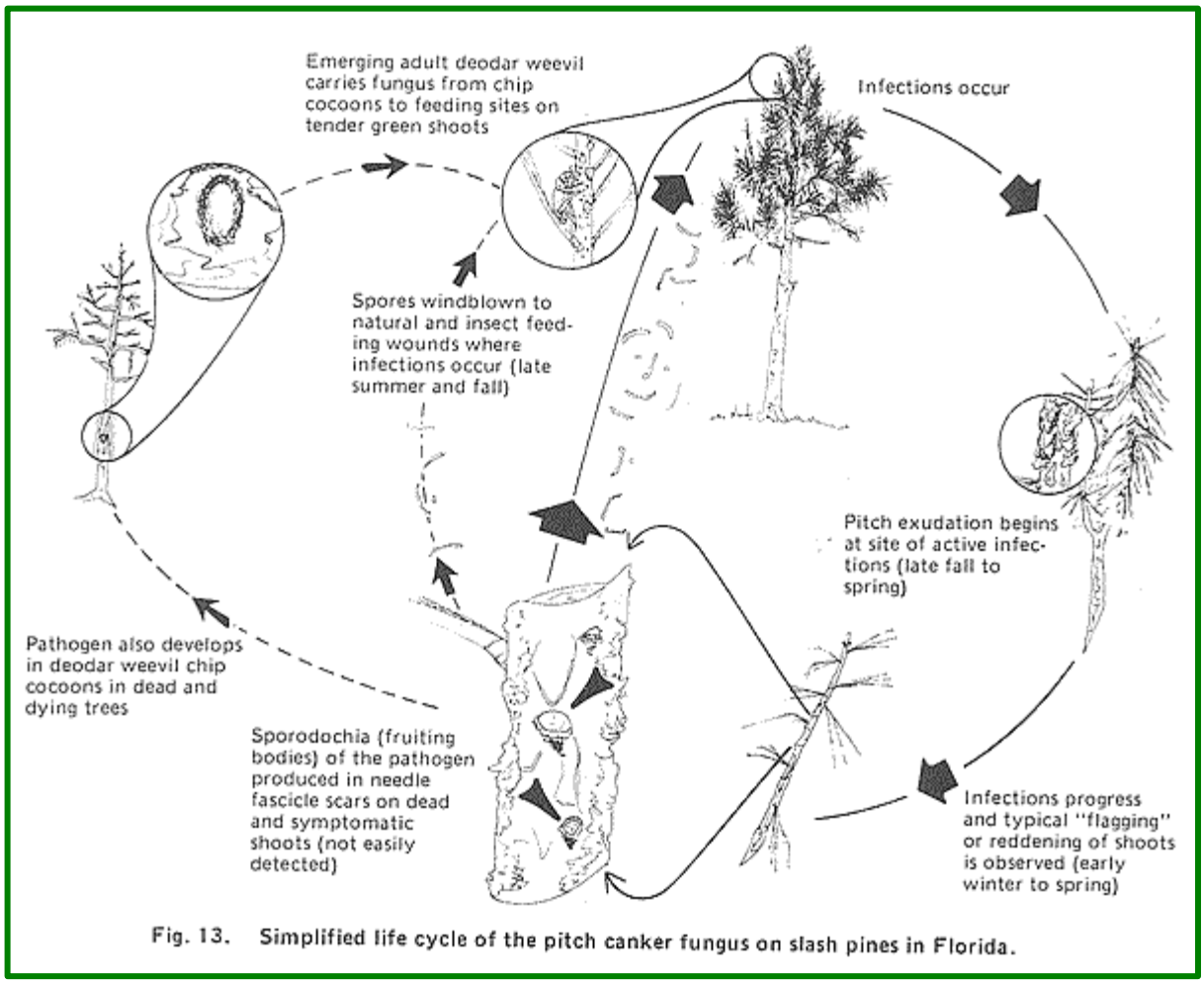


Fig. 13. Simplified life cycle of the pitch canker fungus on slash pines in Florida.

characteristic symptom of pitch canker infection is nursery seedlings is an internal pitch-soaking of the seedling stem at or near the soil line. Small clumps of resin-soaked soil often adhere to infected stems near the point of infection.

Infection Biology: Pitch canker infections are initiated by microscopic spores called conidia (sing., conidium). The fungus enters susceptible tissues through natural, man-made, or insect-created wounds and normally does not penetrate intact tissues. Infections may occur throughout the year but are most commonly occur during the late summer and fall. At that time of year in Florida, violent thunderstorms are common

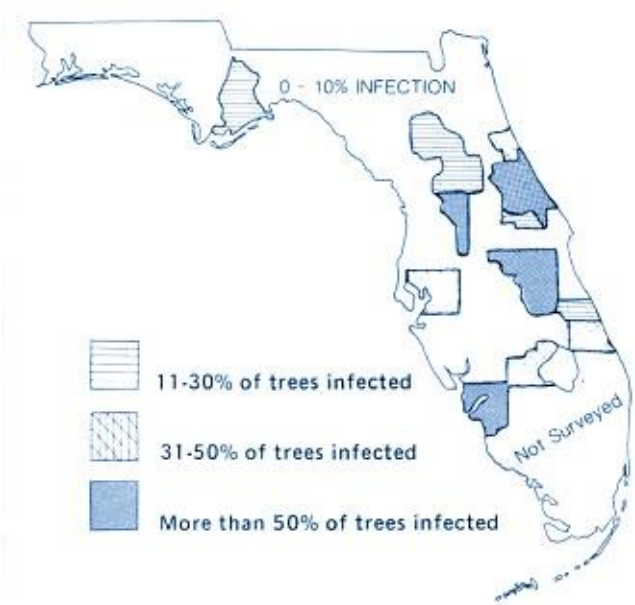


Fig. 14. Incidence and distribution of pitch canker infections in slash pine plantations — 1976. (Source: U.S. Forest Service)

and spore dispersal is greatly enhanced by the action of the accompanying wind and rain. It is also during that time of year that the deodar weevil feeds on the susceptible green shoots of slash pine. The deodar weevil is known to carry (vector) the pitch canker fungus and introduce the pathogen into its feeding wounds. Following disease development, small (less than 3 mm), salmon-orange, wart like fruiting bodies (sporodochia; sing., sporodochium) are produced on dead or dying branches, most typically in needle fasicle scars. These fruiting bodies produce large masses of conidia, and the cycle is completed. The pitch canker fungus is apparently introduced into forest tree nurseries on infected or contaminated seeds, although introduction via airborne spores is probable as well.

Control: Simple, effective controls for pitch canker are unknown. Planting pines on suitable sites and in suitable geographic locations is recommended. Avoid unnecessary wounds to susceptible pine species. Reduce local fungus inoculum (spores) by removing and destroying diseased trees and/or branch material. Minimize the potential for introduction of the pathogen into forest tree nurseries by maintaining clean (disease free) seed orchards and seed production areas. This practice will reduce potential for infected or contaminated seed.

DISEASE: FUSIFORM RUST

Pathogens: Fungus *Cronartium quercuum f.* sp. *fusiforme* (formerly, *Cronartium fusiforme*)

Common Host:

- **Loblolly Pine** *Pinus taeda*
- **Slash Pine** *Pinus elliottii*
- **Other Pines** *Pinus* spp.

Alternate Hosts: Oaks *Quercus* spp.

Significance: Fusiform rust is regarded as the most serious disease affecting pines in the southern United States. Estimates of timber losses to this disease in Florida alone have been placed as high as several million dollars annually. Fusiform rust attacks most of Florida's native pine species, but is generally inconsequential, except on loblolly and

Spindle-shaped (fusiform) gall of fusiform rust on the stem of an infected pine. Note bright yellow aecial pustules of the pathogen on the surface (aecial pustules occur only in the early spring).

slash pines. The disease affects seedlings in commercial forest and ornamental nurseries as well as trees in field situations. Severe outbreaks of fusiform rust in commercial forest nurseries within the state in 1979 and 1980 resulted in losses of millions of seedlings valued at nearly $150,000. Infected seedlings are rarely killed in the nursery by fusiform rust infections. Instead, they are rendered useless essentially useless because they will often die within 2-to-3 years following outplanting. If they survive, they are generally deformed, grow poorly, and frequently break off at the point of infection several years later.

Recognition: Fusiform rust infections typically result in definitive swellings called galls on infected branches and stems. Galls vary in appearance, but are most often spindle or fusiform in shape. On older trees, it is not uncommon for galls to appear somewhat depressed and canker-like on one or more sides of the stem. Witches brooms or marked proliferation of small branches are often associated with galled tissues. Stem galls are often associated with branches or branch stubs as a result of the rust fungus growing from infected branches into the main stems. Sometimes branches and stems are killed beyond the point of the galls. Stem breakage at galls is common. Pitch exudation is often associated with fusiform rust galls due to infestation by certain insects and/or infection by the pitch canker fungus. In the early spring, masses of showy, yellow-orange blisters called aecia (sing., aecium) appear on the surface of active galls. The aecia soon rupture and expose masses of powdery yellow-orange spores (aeciospores).

Fusiform rust infections on first year nursery seedlings appear as distinct knots or elongated swellings (galls) at or near the bases of seedlings. These galls are often accompanied by abnormal branch shoots (branchlets) which occur singly or in tufts. Occasionally, galls occur below the soil line in commercial forest nurseries and are therefore hidden from view. In general, seedling galls are not well developed until late in the growing season (fall or early winter). Latent gall development, in which galls do not develop until after seedlings are lifted and outplanted in forest plantations, is common.

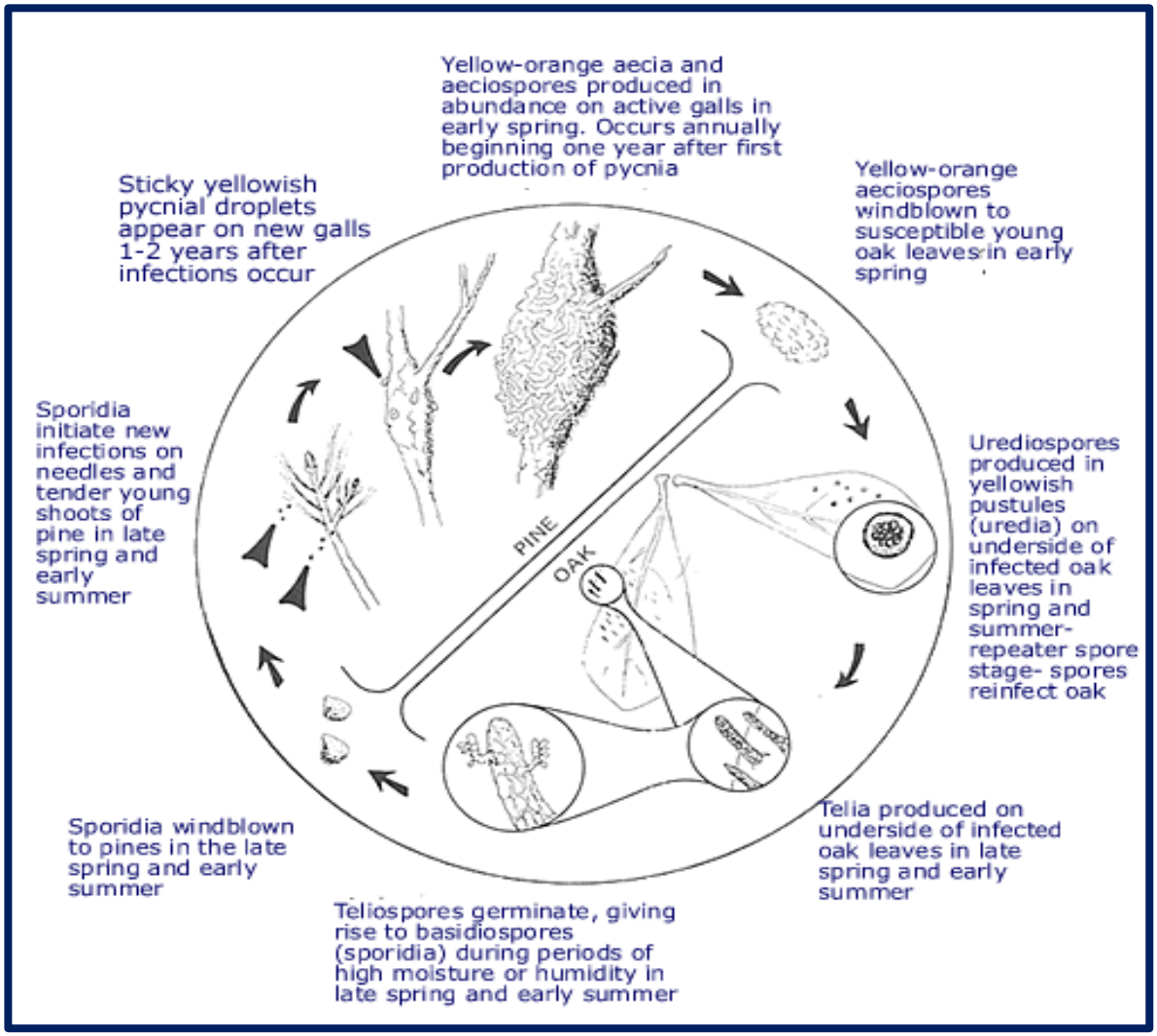
Infection Biology: Aeciospores produced on infected pines do not reinfect other pines. Instead, they are disseminated by wind and initiate infections on the tender young leaves of a variety of oaks. Oaks in the red or black oak group are particularly susceptible as alternate hosts, with water, willow, and laurel oaks heading the list. Later, in the spring and early summer, two different spore types (urediospores and teliospores) are produced on the undersurface of infected oak leaves. Urediospores are produced first and are often called repeaters, because they serve to initiate new infections on the leaves of susceptible oaks, thus repeating the infection cycle on the oaks.

Teliospores are produced later in red-brown, hair-like structures called telial columns, telial horns, or simply telia (sing., telium). Under conditions of warm temperatures and high relative humidities (60-80° F & 97-100% RH) the teliospores germinate, giving rise to minute spores called basidiospores or sporidia. Sporidia are wind-disseminated and

thus initiate new pine infections on susceptible pine tissues including needles and succulent green bark. Sporidia are extremely delicate and can quickly lose their ability to cause infections if weather conditions are excessively dry. However, only a few hours of warm temperatures and adequate moisture on the surface of susceptible tissues are required for infection to occur.

Control: Fusiform rust is readily controlled in seedling nurseries with the careful application of appropriately registered fungicides. Planting pines which are genetically resistant to fusiform rust infections is recommended in commercial forestry operations, especially in high hazard areas (see below, Figure 16). Avoid excessive site preparation when establishing pine plantations because this sometimes increases the incidence of infections, apparently by stimulating the growth of trees and resulting in either greater susceptibility, or larger target areas for infection (shoots of tender, succulent tissues). Delaying fertilization of young pine stands in high hazard areas until pines have grown

FIG 15- Life cycle of fusiform rust fungus



beyond the size of critical vulnerability (about 8 years of age) is often advisable for similar reasons. Stem infections occurring after this period are usually located in the upper crown and are of little consequence. Reduction of oak populations where economy and management allow may be effective in reducing pine infections on a local scale. Salvage thinnings or complete harvests should be considered in severely diseased stands of marketable age. Destroy severely infected young stands and reestablish stands with either less susceptible species, or genetically resistant planting stock. Avoid outplanting infected nursery stock. This practice probably enhances the overall spread and intensification of the disease.

In urban areas, remove infected trees that represent stem breakage hazards. Prune infected branches, especially if galls are within 30 cm of the main stem. Branch galls more than 30 cm from the stem are unlikely to pose a significant threat to the stems. Branches with these types of infections are likely to die, killing the fungus at the same time, before the pathogen can grow into the stem. Careful surgery, removing the bark around galls encompassing less than 50% of the circumference of an infected stem, is an apparently effective treatment in certain cases.

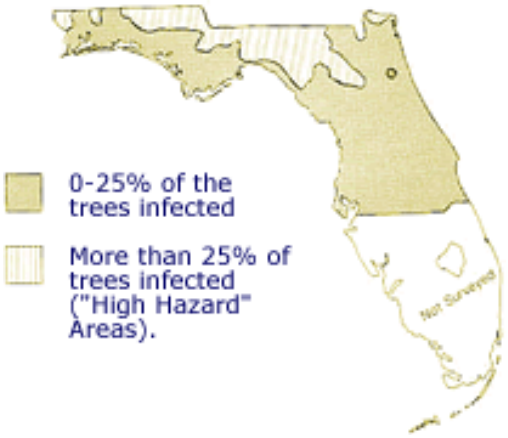


Fig. 16. Incidence and distribution of fusiform rust in 8-12 year old slash pine plantations- 1973.

DISEASE: EASTERN GALL RUST

Pathogens: Fungus *Cronartium quercuum*

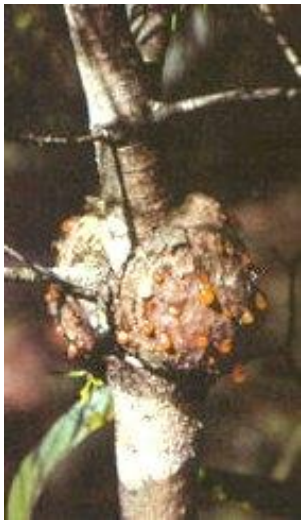
Common Host:

- **Sand pine** *Pinus clausa*
- **Shortleaf pine** *Pinus echinata*
- **Other pines** *Pinus* spp

Alternate Hosts: **Various Oaks** *Quercus* spp

Significance: Eastern gall rust is a very close relative of fusiform rust. Although many similarities exist between these two pine rust diseases, eastern gall rust is far less damaging than its fusiform rust cousin. Although occurring less frequently than fusiform, eastern gall rust is found in abundance on sand pine in Florida. It also occurs on shortleaf, loblolly, and slash pines. For the most part, eastern gall rust is of little

economic significance. Stem and branch deformations resulting from infections may be a problem in some cases, however, especially in certain urban or shade tree situations. Occasionally stem or branch breakage may occur at the points of infection, often as a result of associated wood decay organisms.



Spherical gall of eastern gall rust on the branch of a sand pine. Orange droplets are the pycnial spore stage of the pathogen which is seen only on rare occasions.

Recognition: This disease is most readily recognized by the distinct globose (spherical) to subglobose swellings or galls it produces on infected hosts. Galls may occur on branches or stems. Witches' brooms - proliferation of small branches - often accompany the galls. The production of bright yellow spore sacs (aecia) and their masses of yellow to orange spores (aeciospores) on the gall surfaces during the spring renders this disease quite striking. The distinctive spore sacs, together with the shape of the galls, sometimes results in galls being cerebroid or brain-like in appearance.

Infection Biology: As in fusiform rust, the eastern gall rust fungus produces alternate infections between susceptible pines and a variety of alternate host oaks. For all practical purposes, the life cycles of the two different pathogens are the same (Figure 15). Eastern gall rust infections, in contract to those of fusiform rust, tend to be more localized, remaining restricted to the locus of initial infection. The eastern gall rust fungus is less apt to grow from an infected branch into a larger branch or main stem than is its fusiform counterpart.

Control: Practical controls for eastern gall rust in commercial forest stands are few. Infected trees, especially those with infected stems, should be removed from pine stands during thinning operations where practicable. Pruning of infected branches may be useful in ornamental plantings. If nursery infections are a problem, the use of a appropriately registered fungicides should provide good protection for disease-free seedlings.

DISEASE: RED HEART OF PINE

Pathogens: **Fungus** *Phellinus pini* (formerly, *Fomes pini*)

Common Host: **Pines** *Pinus* spp.

Significance: Although red heart affects all of Florida's pine species, it is a disease of serious magnitude only in mature or over-mature trees. In such trees it can result in

significant timber losses due to wood decay (heart rot) resulting from infection by the pathogen. Red heart can be found in pines in both landscape and forest environments. This disease does not kill trees, since the pathogen only attacks the internal, physiologically inactive (non?living) heartwood. Trees with advanced infections, however, are subject to wind breakage due to the structurally debilitating effects of the associated wood decay. Rarely, if ever, is red heart a problem on younger trees.

Sporophore of Phellinus pini on the stem of an old-growth sand pine. Cut-away portion shows typical "red heart" decay.

Recognition: Red heart is most readily detected on standing trees by the appearance of fungal conks (sporophores) of the pathogen on the stems of the infected trees. Conks are bracket-shaped or hoof-shaped, usually several centimeters across, brown or brownish black on upper surfaces, and often have concentric grooves paralleling their typically lighter, golden-brown margins. The undersurface of conks is grayish-brown to brown and minutely porous. Conks are usually woody, and located predominately at knots or branch stubs. They are also perennial, remaining attached and active (i.e., producing spores) for years. Internally, old conks often exhibit annual layers of spore-producing tubes (pores), which are similar to the annual rings produced by most tree species. Hence, it is sometimes possible to determine the approximate age of certain sporophores. Old conks are sometimes covered with moss on their upper surface. Internally, heartwood in the beginning stages of decay is typically stained reddish or reddish-brown. Advanced decay is characterized by elongated white pockets or flecks separated by apparently sound, sometimes resin-soaked wood.

Infection Biology: Red heart infections occur primarily through dead branch stubs and presumably, in certain cases, through deep stem wounds. Airborne spores of the pathogen are deposited on or close to these points of entry and germinate when conditions (moisture, temperature, etc.) are suitable, allowing the fungus to penetrate into the susceptible wood tissues. Following sufficient development and decay by the fungus in the heartwood tissues (many years in most cases), the pathogen produces its typical conks or sporophores at branch stubs on the surface of infected stems. New infections can then be initiated via spores produced in the porous undersurface of these new sporophores. Additional new infections can at the same time arise from spores produced by older, perennially active conks on the same or other trees.

Control: Once established, red heart infections cannot be effectively or practically treated. Prevention of infections by avoiding unnecessary damage or injuries and properly pruning pines is recommended. Proper pruning involves the removal of dead

branches and branch stubs with clean cuts, just outside their somewhat swollen or callused branch collars at the trunk of the tree. Timber losses due to decay-induced lumber or product degrade can be minimized by harvesting pine stands before they sustain significant losses. The harvest of mature or overmature timber thus should not be delayed.

HARDWOOD STEM DISEASES

DISEASE: WOOD DECAY AND HEART ROTS OF HARDWOODS

Pathogens: **Various fungi** especially *Polyporus* and *Fomes* spp.

Common Host: All Hardwoods

Typical sporophores (conks) of a heart rot fungus (Fomes sp.) on the stems of oak. (Note broken branch stub on tree on the left.)

Significance: Wood decay and heart rots of hardwoods are extremely common in all parts of the world. Diseases of this type are often highly visible, not necessarily because of the decayed or rotted wood, but by virtue of the various and conspicuous conks or sporophores (fruiting bodies) produced by the pathogens on decaying or rotting stems and branches. Losses to wood decay and heart rots can be significant in terms of timber degrade or culls; decayed wood isn't worth much. In addition, trees with advanced or extensive decay represent aesthetic and safety liabilities from the standpoint of branch or stem breakage.

Recognition: The presence of various types of fungus conks or sporophores on the stems and branches of hardwoods is often a good indicator of wood decay or heart rot. Conks appear in various colors, and are bracket or shelf-like, hoof-shaped, or flattened to the stem, and are often porous on their lower, spore-bearing surfaces (hymenia, sing., hymenium).

The spore-bearing surfaces of other wood decay fungi are smooth (Stereum spp., etc.), gilled (Lenzites spp., etc.) or toothed (Irpex spp., etc.) on their spore-bearing surfaces. Conks frequently occur on dead branches or branch stubs and at or near wounds. Sometimes conks appear on the surface of stems or branches that appear normal. Some conks may appear for a short time and disappear; others remain attached to infected trees for years.

Those of Polyporous spp. are typically annual, appearing and disappearing the same year, and are usually fleshy, spongy, corky, leathery, or rubbery in texture. Conks of Fomes spp., on the other hand, are characteristically perennial, and are hard and woody in texture.

Internally, wood infected with decay or heart rot fungi is initially discolored or stained. As decay progresses, infected wood becomes progressively softer and punky, and breaks, crumbles, or shreds easily when examined.

Infection Biology: Infections occur when spores, aerially disseminated spores from conks of the various decay fungi, are deposited on or near wounds, pruning scars, fire scars, or dead branch stubs of susceptible hosts. Moisture and temperature conditions permitting the spores germinate, and the fungi grow slowly into the vulnerable wood tissues. Some fungi produce predominantly or solely heart rot, invading only the tree's central column of physiologically inactive (nonliving) heartwood. Heart rot fungi are common on old, mature to over-mature trees, especially if they have sustained significant branch or stem injury during their lifetime. Other fungi called sap rotters typically decay the outer layers of weakened or dead sapwood associated with wounds, broken branch stubs, and the like. Rarely do wood decay fungi invade healthy, uninjured wood tissues. Following sufficient development in infected wood tissues, a process sometimes taking years, the decay fungi produce their characteristic conks on the tree's external surfaces.

Control: No effective or practical control measures exist for treatment of existing heart rot or decay. Prevention of decay by avoiding injuries to trees is the most effective method of minimizing damage. Healthy, vigorously growing trees are usually capable of "compartmentalizing" (walling off) decay in wood tissues present at the time wounds are sustained. Thus, promoting the vigor of trees through timely fertilization and irrigation enhances their ability to compartmentalize decay. (Fertilizing and watering has the added benefit of enhancing the structural strength of wounded or damaged trees by stimulating the growth of a new decay-free wood tissues). Compartmentalization is further enhanced by proper pruning of branches and dead branch stubs, a practice that facilitates the tree's natural callusing and wound closure processes. When pruning branches and branch stubs, make clean cuts immediately outside the swollen or callused branch collars at the base of branches or stubs being removed. Do not injure branch collars in the pruning process as these collars are healthy, growing wood tissues, and wound closure is more rapid if these tissues are left intact. Broken or otherwise projecting branch stubs (poorly pruned branches, etc.) inhibit wound closure, and therefore often provide decay organisms with easy and prolonged access to vulnerable wood tissues and/or a ready supply of necessary air and moisture. Trunk and major branch wounds callus over and close faster and more effectively if the surrounding, damaged bark is carefully scribed in the shape of vertical ellipse (like a blunt football standing on end). Badly decayed branches and trees with extensive heart rot in urban settings should be removed since they often represent safety hazards.

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DISEASE: HISPIDUS CANKER

Pathogens: Fungus *Inonotus hispidus* (formerly *Polyporus hispidus*)

Common Host:

- **Oaks** *Quercus* spp.
- **Other Hardwoods**

Significance: Hispidus cankers are a noteworthy example of a group of tree diseases referred to as canker rots. These diseases are so named because they result in both internal stem decay (heart rot) and external cankers (flattened or depressed areas in the bark resulting from death of the cambium). Hispidus cankers are common in Florida, especially on laurel, southern red, and turkey oaks. Generally, hispidus cankers are not

a significant forestry problem, but they often cause substantial damage to individual trees. The heart rot associated with hispidus cankers frequently renders infected trees vulnerable to stem breakage. Severely infected shade trees are often safety hazards.

Typical sporophores (conks) of Inonotus hispidus and callus folds or ridges of hispidus canker on the stem of an oak. (Old sporophore appears as dark brown mass at top of canker.)

Recognition: Hispidus cankers generally appear as vertically elongate, flat or sunken areas (cankers) on the trunks of infected trees. The bark of these cankers faces usually remains firmly attached and conspicuous callus folds typically develop around the canker margin, giving infected stems an overall swollen appearance. Branch stubs or scars are common, although not necessarily detectable at or near the center of canker faces. During the late summer, fall, and early winter the pathogen produces large, spongy, bracket-shaped conks (sporophores) on the canker faces. Conks are yellowish-brown to rusty red or brown and somewhat watery when fresh. Dense, somewhat stiff, tufted, or matted hairs cover the upper surface of the conks. The lower, spore-bearing surface is porous. As the conks age they shrink, darken to nearly black, harden, and often fall from the tree. Remnants of old conks are often detectable months later, either still attached to canker faces or lying on the ground at the bases of infected trees.

Infection Biology: Hispidus infections occur primarily through dead branch stubs on the stems of susceptible hosts by means of aerially disseminated spores. Presumably, some infections occur through trunk and branch wounds as well. The fungus develops first in the heartwood of its hosts and later grows outward into the cambium, killing it and causing the readily visible, characteristic cankers. Spores for the initiation of new infections are produced in the pores on the undersurfaces of the typical conks produced later on the canker faces.

Control: No effective therapeutic treatment is known for trees infected with Inonotus hispidus. Control strategies in both forest and urban settings must be based on the concepts of prevention, sanitation, and salvage. In forestry operations, harvest and salvage infected stems where practicable. In timber stand improvement operations, fell infected trees to minimize sporophore production and spore dispersal. Removal or felling of infected trees provides the additional benefits of reducing competition for the more desirable, disease-free trees and reducing the risk of injury to healthy trees through stem breakage and falling of cankered trees. Avoid unnecessary logging or other injury to stems of susceptible host species

In urban or landscape situations, identify and remove trees with hispidus cankers as hazard trees with respect to stem breakage and inoculum reservoirs (i.e., sources of infectious spores). Time pruning of host tree species so as to minimize exposure of susceptible tissues: (a) prune stem branches when sufficiently small to facilitate the healing process of callus formation; (b) perform such pruning in late winter or spring when spores of the pathogen are not being disseminated. Avoid unnecessary injuries to stems of susceptible trees.

DISEASE: HYPOXYLON CANKERS

Pathogens: Fungi *Hypoxylon* spp., especially *Hypoxylon atropunctatum* and *Hypoxylon truncatum*

Common Host:

- **Oaks** *Quercus* spp.
- **Other Hardwoods**

Silver-gray crust-like stromata of Hypoxylon atropunctatum on the stem of a dying oak.

Significance: Hypoxylon cankers are prevalent and highly visible disease problems affecting oaks and other hardwoods in Florida. *Hypoxylon* spp. are not considered aggressive killers. Instead, they are usually secondary in that they take advantage of trees suffering from any number of injuries of stresses. Hypoxylon cankers are often the finishing blow to oaks suffering from water stress, root disease, soil compaction, construction damage or other, related injuries.

Recognition: Trees infected with *Hypoxylon* spp. often show evidence of either severe injuries on the branches or stem and/or advanced dieback or decline. The bark of infected trees typically sloughs off, often near injuries or along the trunk and major branches, revealing one of two types of fungal signs. In the spring or early summer, conspicuous, powdery, greenish to brown masses of spores called conidia (sing., conidium) are produced on the surface of crusty sheets of fungus tissue called stromata (sing., stroma). Later in the summer or fall, after the powdery conidia are gone, the fungal stromata thicken, become very hard and assume a silver-gray, brownish, or black color, depending upon the particular fungus involved. In many cases, minute (less than 1 mm), slightly-raised dots or bumps may be observed on the surfaces of these late-season stromata. These dots are the tops of small cavities or locules called perithecia (sing., perithecium) embedded in the fungal stromata in which the pathogens produce another type of spores (ascospores). Stromata vary from a few centimeters across to

several meters in length up and down the trunks of infected trees and are the most readily recognizable indicator of Hypoxylon infections.

Infection Biology: Hypoxylon infections originate when ascopores of the various pathogens come into contact with injured or severely stressed tissues of susceptible hosts during the late summer, fall or winter. Spores are spread via wind and splashing rain and presumably by certain insects, birds, and rodents. The fungus develops in the bark and wood tissues and the following spring or summer the bark is sloughed, revealing the typical powdery masses of conidia. Conidia apparently play a limited (if any) role in initiating new infections, but perhaps perform some type of sexual function which results in the production of the infective ascospores later in the summer or fall.

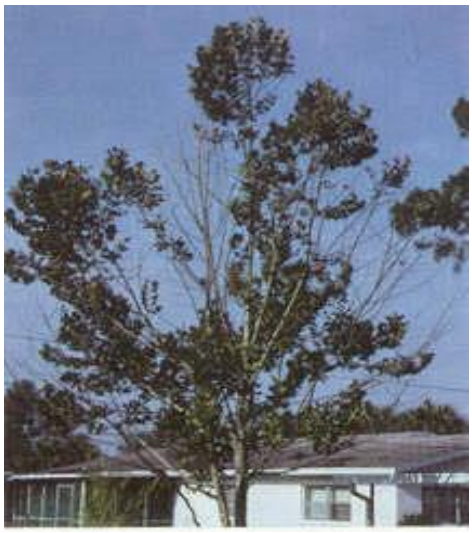
Control: Trees with extensive Hypoxylon infections are usually beyond repair. Removal of severely infected trees to reduce local sources of inoculum (i.e., infectious spores) is recommended. Careful pruning of branches that have localized infections should help prevent advancement of the fungus within the infected trees. Prevention of infections through avoiding wounds, root damage, etc., and providing adequate moisture via irrigation to susceptible trees during prolonged periods of dry weather is the best method of control. The presence of Hypoxylon cankers is usually an indicator of severe stress and often a warning to take precautions to reduce stresses (if they can be identified and reduced) affecting nearby trees of the same species.

DISEASE: BRANCH AND STEM CANKERS OF SYCAMORE

Pathogens:

- Fungus *Botryodiplodia theobromae*
- Other fungi including:
  - *Dothiorella* spp. (asexual stage of *Botryosphaeria* spp.),
  - *Phomopsis* spp. *Hypoxylon tinctor*
  - *Massaria platani*

Common Host: **American Sycamore** *Plantanus occidentalis*



Typical branch dieback in sycamore infected with the canker fungus Botryodiplodia theobromae.

Significance: Branch and stem cankers of sycamore are a common, readily visible, and sometimes lethal problem in many parts of Florida. Cankers are usually most prevalent and serious on

trees which have been injured, by construction for example, or trees which have been exposed to certain environmental stresses such as extreme temperatures or drought. Many fungi are capable of causing cankers on sycamore, and it is common in Florida to find two or more fungi acting in combination. However, Botryodiplodia theobromae is perhaps the most common. Branch and stem cankers may well be the most serious disease affecting sycamores in Florida.

Recognition: The most readily recognizable symptom of this disease problem is a localized branch mortality (i.e., in one portion of the tree's crown). In the very early stages of disease development the leaves on infected branches may be reduced in size, discolored, (yellow to brown), or shriveled. As infections advance typically from the upper to lower or smaller to larger branches, the crowns progressively thin, from the top down or inward from the outside. Close examination of infected stems or branches reveals typical cankers in the bark tissues (flattened or depressed areas due to the death of the cambium). Cankers are usually elongated, often associated with branch stubs, and may be surrounded by distinct callus ridges at their margin. Callus ridges are usually indicative of older, inactive cankers. Young or actively growing cankers, on the other hand, are usually free of callus margins and may be more difficult to detect. The wood behind cankered bark tissues is usually dead, especially in older cankers, and presents a wedge or pie-shaped appearance when viewed end-on in cross-section. Small, black fruiting bodies called pycnidia (sing., pycnidium; asexual stage) or perithecia (sexual stage), depending upon the particular fungus or fungi involved, are often visible on or near the diseased tissues. These fruiting bodies are generally about the size of a pin head and may appear to sit on top of the bark or to be partially embedded therein. The similarity between the fruiting bodies produced by many of the sycamore canker fungi usually makes microscopic examination of the spores produced within these structures a requirement for specific identifications.

The fruiting bodies of *Hypoxylon tinctor* are distinctive and readily recognizable. This fungus produces its spores in a dark brown to black, hard, crusty, structure called a stroma (pl., stromata) on the surface of stems and larger limbs. Stromata may reach as much as 15 cm in length.

Pimple-like fruiting bodies of Botryodiplodia theobromae on an infected sycamore branch.

Infection Biology: Spores of the various canker fungi are spread by wind, splashing rain, insects, and sometimes man, to susceptible host tissues where they initiate new infections. Infections frequently begin at wounded or broken twigs or branch stubs, and then progress downward into larger limbs and eventually the main stem. In time, and under suitable environmental conditions, the fungi produce

their characteristic spore-bearing structures (fruiting bodies) on infected trees, and the cycle continues.

Control: Damage resulting from sycamore cankers can be minimized by planting sycamores on sites with adequate moisture and nutrients. Timely irrigation in hot, dry weather reduces water stress and susceptibility to infection in urban and shade trees. Fertilizing sycamores to maintain good tree vigor is suggested. Prune cankered branches by cutting well below the advancing margin of cankers to limit spread in infected trees. Remove severely diseased trees and/or branches to reduce local inoculum (i.e., fungus available to initiate new infections) and avoid wounding sycamores, especially those under moisture or other environmental stress.

DISEASE: OTHER STEM, BRANCH AND TWIG CANKERS OF HARDWOODS

(see Hypoxylon cankers, and Branch and Stem Cankers of Sycamore)

Pathogens: Various fungi

- *Botryosphaeria* spp.,
- *Botryodiplodia* spp.,
- *Endothia* spp.,
- *Diplodia* spp.,
- *Dothiorella* spp.,
- *Phomopsis* spp.

Common Host: Hardwoods

Significance: This miscellaneous group of diseases is caused by a wide variety of fungi acting alone or in combination, under a broad range of influencing circumstances. By and large, these diseases are not serious, but when trees are injured or weakened by environmental stresses, infections can cause significant damage. These diseases are generally a concern in urban or ornamental situations as opposed to commercial forest stands. Some cankers can be a problem however, in commercial forestry operations where hardwoods are intensively managed in plantations.

Recognition: Cankers, by definition, are flattened, sunken or depressed areas in the bark resulting from the death of the underlying cambium. Cankers often appear at dead branch stubs, the result of the progression of infections from smaller to larger branches. Cankers may be circular or somewhat target-shaped around old branch stubs, they may entirely girdle infected stems, or they may be narrow and elongated along one or more sides of infected stems. Cankered tissues often appear depressed as the surrounding live tissues tend to grow around the dead, cankered bark tissues. Pidges of folds of callus tissue are frequently present at the margins of cankered tissues. Terminal

cankers (infections at the end of branches or twigs) commonly result in varying degrees of branch or crown dieback, accompanied by localized wilting or loss of foliage. Eventually, the canker-producing fungi produce small, dark or brightly colored (depending on the particular pathogen) pimple-like fruiting bodies on or embedded in the affected bark tissues. These structures are best seen with a hand lens, but may also be seen readily, in most cases, with the naked eye. Wood behind cankered bark tissues is usually discolored and often becomes decayed as a result of the ingress of wood decay fungi.

Infection Biology: Spores of the various canker fungi are spread through the action of wind, rain insects, and possibly rodents and birds, as well as man. Infections occur at wounds, large and small, whenever the intact bark is broken, exposing the susceptible cambium tissues beneath. Other infections occur by direct penetration of the pathogens through intact bark tissues. This latter type of infection is particularly common where tissues are stressed by extreme temperatures or moisture deficiency. Spore production on infected tissues presumably occurs at any time of year when temperatures and moisture are adequate.

Control: Control of stem and branch cankers is best achieved by prevention. Avoid injuries to trees and avert unnecessary stresses by providing adequate fertilizer and moisture to shade trees. Canker branches should be removed to reduce local fungus inoculum (spores) and prevent progression of the pathogen(s) into larger branches or stems. When removing cankered branches, make cuts well below the visible canker symptoms.

DISEASE: WETWOOD AND SLIME FLUX

Pathogens:

- **Bacterium** *Enterobacter cloacae*
- Other associated bacteria:
- *Bacillus megaterium*
- *Pseudomonas fluorescens*

Common Host:

- **Elms** *Ulmus* spp.,
- **Oaks** *Quercus* spp.,

Significance: Wetwood and slime flux are poorly understood tree disease problems. Wetwood is an internal bacterial infection in the

Typically discolored bark symptomatic of slime flux on a mature oak. Note branch scar serving as the "source" of the slime flux (extreme top of photo).

wood of host trees. Slime flux is an external bleeding of sap typically associated with such infections. In general, these are not major problems in Florida, but occasionally cause considerable alarm due to the unsightly, villainous appearance of slime flux. Concern is sometimes justified as wetwood and slime flux can cause noteworthy debilitating effects on infected trees including some dieback or decline, and an inability for wounds or pruning scars to form callus tissue for healing.

Recognition: Wetwood and slime flux are most often recognized by the oozing, bleeding, or fluxing of sap from bark fissures, pruning scars or wounds on the stems or branches of infected trees. Fluxing often occurs in branch crotches resulting from the tearing of tissues at these junctures by excessive branch weight, wind, etc. The oozing sap is usually dark brown, frothy or slimy and foul smelling soon after it is exposed to the air due to the activity of certain bacteria, yeast and other fungi by which it is rapidly colonized - hence the name slime flux. Slime flux, when profuse, characteristically flows downward from its points of emergence, and upon drying leaves a light gray to whitish incrustation on the surface of the bark. Due to its oftentimes highly alkaline nature, slime flux frequently results in the death of turf, shrubs, and plants on which it drips beneath infected trees.

Internally, wetwood is typically characterized by dark brown discolored wood which appears circular in cross section and wet or water-soaked. This wet wood is also characteristically malodorous, much like the normally associated slime flux.

Infection Biology: The bacteria associated with wetwood and slime flux are common soil and water inhabitants. These organisms presumably gain entry into susceptible stem-wood tissues through wounds or pruning scars via certain insects, pruning tools, birds, and wind. Additional infections appear to be possible through direct root penetration or colonization of root wounds. Once established within the host the bacteria multiply and colonize the tree's central heartwood core. To a limited extent, the bacteria may also colonize portions of the outer, sapwood tissues. The metabolic activities of the bacteria within infected wood tissues generate a variety of gases, predominantly methane, nitrogen, and carbon dioxide. These gases, when confined within the wood tissues, produce unusually high pressures which force the sap outward through wounds and branch stubs giving rise to the readily identifiable, external slime flux.

Control: Control of wetwood and slime flux in forest tree stands is impractical. Infected ornamental trees may be helped by pruning declining branches, and fertilizing to promote tree vigor and wound closure. Installation of copper or semi-rigid plastic drain tubes to lower stem pressures and drain excess fluid or sap has been useful in many cases. Drain tubes should be tightly fitted and installed on an upward slant into the infected wood well below bleeding wounds or branch scars to a depth nearly reaching the tree's opposite side. Tubes should extend outward far enough to prevent dripping on the bark of the tree. Presumably, some type of small holes or perforations on the upper

sides of drain tubes will aid the pressure release and draining processes. Avoiding tree injuries and pruning trees properly with clean, uncontaminated pruning equipment are also recommended for minimizing wetwood and slime flux infections.

CONIFER ROOT DISEASES

DISEASE: ANNOSUM

Severe crown thinning in slash pines resulting from annosum root rot in a thinned plantation.

Pathogens: Fungus *Heterobasidion annosum* (formerly, *Fomes annosus*)

Common Host:

- **Pines** *Pinus* spp.
- **Redcedars** *Juniperus* spp.

Significance: Annosum root rot is one of the most serious diseases affecting coniferous tree species in the north temperate regions of the world. It is a problem predominantly associated with thinned plantations of conifers due to the pathogen's stump colonization habit. Trees of all ages are susceptible to infection by the pathogen. In many parts of Florida this disease has caused abundant mortality and growth loss in thinned pine plantations. Young trees in newly planted pine stands are sometimes killed by annosum root rot as a result of stump and root infections sustained during the harvest of previous pine stands. Most conifers are susceptible to infection, but longleaf pine appears to possess considerable resistance. Infected trees suffer considerable stress, and as a result, frequently fall victim to other stress-related pests such as pine bark beetles.

Recognition: Infected trees occur primarily in previously thinned pine plantations. They are characterized by a generally unhealthy appearance, thin, offcolor foliage, and mortality.

Infected trees are often leaning or completely uprooted while still alive due to loss of structural support roots, a result of the decay action of the pathogen. Infected trees tend to occur in groups or clusters referred to as infection centers which, without careful scrutiny, are sometimes mistakenly identified as bark beetle spot kills. Conks (sporophores) of the pathogen can often be detected on infected roots and stumps, or at the bases of infected trees in the duff or needle litter. In general, only a small percentage of infected trees actually support conks at any given time. In fact, conks are not always produced on infected trees. Therefore, the absences of conks does not necessarily mean the absence of infection. Sprophores are typically leathery in texture, with grayish

brown to dark brown upper surfaces and, when actively growing, have creamy white, minutely porous undersurfaces.

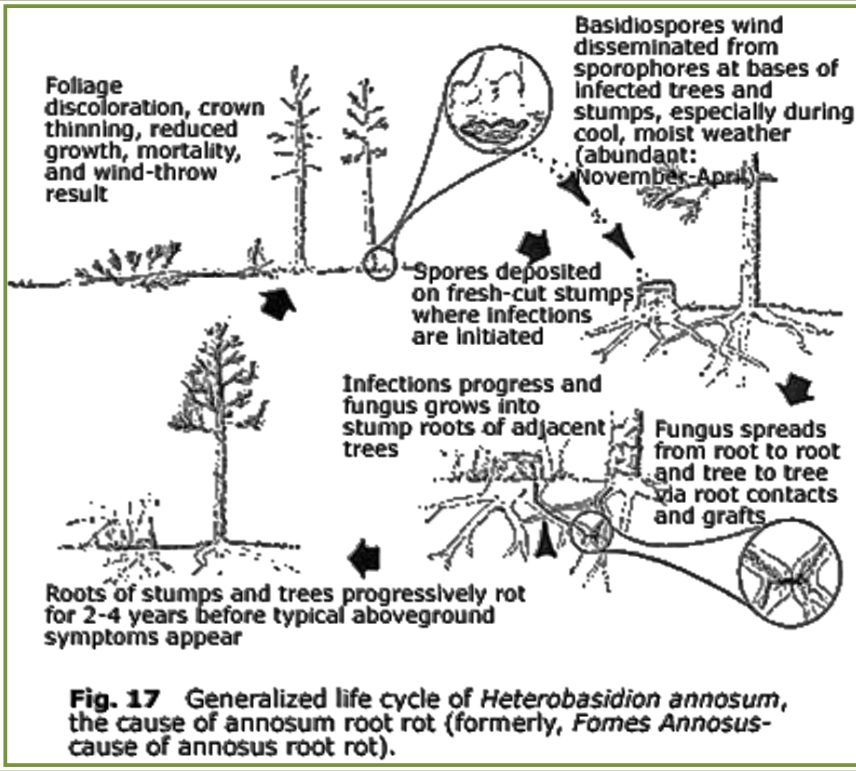


Fig. 17 Generalized life cycle of *Heterobasidion annosum*, the cause of annosum root rot (formerly, *Fomes Annosus*- cause of annosus root rot).

Conks vary from smooth to deeply wrinkled and may occur as small pustules (buttons), or as brackets up to several centimeters across. Internally, infected roots display varying patterns of discoloration or staining, resin soaking, and decay, depending upon host and stage of disease development. Large clumps of soil often adhere to infected roots due to the frequent bleeding or resin exudation associated with infection. Advanced decay is characterized by small elongated white pockets, sometimes with attendant black spots or flecks, that eventually coalesce and reduce roots to a shredded or stringy condition. In the absence of conks or typically decayed roots, laboratory analysis is recommended for positive identification.

Infection Biology: Annosum root rot is spread over long distances by way of airborne spores produced in the conks of the pathogen. Conks and spores are produced at various times during the year, but production is most abundant from fall to spring. Historical evidence suggests that spore production during the summer months is drastically reduced. Most infections are initiated as a result of spores being deposited on the surfaces of freshly cut stumps of susceptible host species, thus the intimate association between this disease and thinned plantations of pines.

Under suitable conditions of temperature and moisture newly deposited spores germinate and the fungus grows downward into the stumps and their attached roots. This infection process is severely limited by hot, dry weather which results in the rapid death of the very delicate spores. Once established in the stumps and roots the fungus continues its development and grows into the roots of adjacent standing trees which are near, in contact with, or grafted to the roots of the decaying stumps. The pathogen advances via this process at a rate of about 1-2 meters per year, often giving rise to

pockets of infected trees which increase in diameter over time. A limited number of infections arise from direct root penetration by germinating spores which have washed into the soil through the action of rainfall.

Conk of Heterobasidion annosum at base of infected pine (needle litter and soil removed to expose conk). Note white undersurface of conk at tip of knife blade.

Infections are usually present and active for 2-3 years prior to the onset of typical, aboveground symptoms. Sites characterized by deep, well drained sand or sandy loam soils with little clay and organic matter are considered high hazard for annosum root rot infections. Infections in stands on these types of sites are usually more frequent and more serious than on sites with shallow, poorly drained soils with high seasonal water tables and abundant clay and organic matter.

Control: Annosum root rot infections can be prevented by simply applying granular borax to the surfaces of freshly cut stumps during thinning operations in commercial forest plantations or in tree removal operations in urban environments. Borax is toxic to the germinating spores of the pathogen and is very effective in preventing stump colonization. This practice is especially important when cuttings are performed during the fall, winter, and spring as these are the seasons when stump infections are most likely to occur.

Other control practices which are recommended for commercial forest stands on high hazards sites include: (a) thinning stands during low risk summer months (caution advised here due to potential hazards posed by bark beetles), (b) encouraging silvicultural prescribed burns to minimize the potential for buildup of fungus inoculum, (c) salvaging timber in severely diseased stands, (d) using less susceptible species (e.g., longleaf pine) when regenerating sites infested with the pathogen, or delaying regeneration of such sites for 1-2 years to reduce potential regeneration infections, (e) minimizing the number of thinnings during a stand rotation on high hazard sites, and (f) applying Phlebia gigantea (formerly, Peniophora gigantea), a commercially available, competitive fungus that reduces pathogen activity to stumps when thinning or harvesting stands already infected with *Heterobasidion annosum*.

DISEASE: SAND PINE ROOT DISEASE

Pathogens: Various fungi

Foliage thinning and discoloration typical of sand pines with root disease.

Common Host:

- **Choctawhatchee Sand Pine** *Pinus clausa* var. *immuginata*
- **Ocala Sand Pine** *Pinus clausa* var. *clausa*

Significance: Sand pine root disease is the most serious disease affecting sand pine in Florida. It is a disease complex in that two or more pathogens are usually involved, apparently acting in sequence or combination. In certain cases, however, only one pathogen is involved. A 1979 estimated place timber losses to this disease in Florida at between $1.5 and $2.5 million annually.

Sand pine is vulnerable to root disease in virtually all environments, but the disease is far worse where water tables or impermeable soil layers are shallow or soils poorly drained. Surveys have shown a significantly greater level of root disease in Ocala variety sand pine as in compared to the Choctawhatchee variety. As a rule, damage caused by sand pine root disease increases with tree or stand age. Root disease typically results in eventual death of infected sand pines. Death of infected trees may occur rapidly (within 1 to several years) or many years following infection depending on the fungus or fungi involved, local site conditions, age of affected trees, weather conditions, and other related factors.

Recognition: Infected trees exhibit varying degrees of crown or foliage thinning and/or discoloration (yellowing, reddening, etc.) and frequently lean to one side due to the failure of structural root support. Mortality is common, and infected trees often exhibit some degree of resinosis (exudation of resin) at or near the ground line. Internally, diseased woody roots are discolored and usually saturated with resin. In some cases, infected woody roots are watersoaked.

Table VII. Fungi Associated with Sand Pine Root Disease in Florida

Armillariella tabescens (formerly, *Clitocybe tabescens*):

The cause of Mushroom Root Rot. Common on sand pine of all ages under a variety of field conditions in both planted and natural stands. Appears to act an an opportunist, primarily attacking trees infected with one or more other fungi or trees suffering from other stresses or injuries. Produces clusters of fleshy, tan to brown toadstool-like mushrooms, most often in the fall, which are gilled on the undersurface of the caps. Also frequently produces characteristic sheets or mats of fungus tissue beneath the bark of infected roots and tree bases. Mats are often perforated with small holes throughout. Often found on water-soaked roots some distance from the base of infected trees. Laboratory analysis recommended for positive identification in the absence of sporophores or the characteristic fungus mats.

Fungal mat (mycelial felt) of Armillariella tabescens beneath the bark of an infected sand pine root. Note minute perforations in fungus tissue.

Inonotus circinatus (formerly, *Polyporus tomentosus* var. *circinatus*):

The cause of Red Root and Butt Rot. A major pathogen, especially on older (more than 20 years of age) sand pines in both planted and natural stands, including commercial seed orchards. Produces stalked (on the ground above decayed roots) or bracket-like (on the tree) sporophores with porous undersurface at or near the base of infected trees. Sporophores produced at various times, but most commonly during late fall or winter. Sporophores light yellow-brown to brown, spongy or slightly leathery. Decayed wood and roots exhibit reddish to red-brown discoloration and eventually a rot flecked with small elliptical white pockets. Laboratory confirmation suggested when sporophores are missing

Typical conks (sporophores) of Inonotus circinatus at the base of an infected, old-growth sand pine.

Heterobasidion annosum (formerly, *Fomes annosus*, Ref. Annosum Root Rot)

Not common on sand pine, but does occur, especially in thinned plantations due primarily to the stump colonization habit of the fungus. Tough, leathery sporophores produced on infected roots or in the duff or litter layers at bases of infected trees. Mature sporophores grayish to brown on top and white to cream-colored on the porous under- surface. Internal root decay typically yellowish and stringy in advanced stages. Laboratory confirmation recommended when sporophores are absent.

Macrophomina phaseolina:

The cause of Charcoal Root Rot. Occurs in forest tree nurseries where it can be a destructive pathogen on seedling sand pine. Occasionally detected on roots of young, dying trees in commercial forest plantations. Apparently not a major factor in the overall sand pine root disease syndrome. Often produces hard, minute (less than ½ mm), black granules called microsclerotia beneath the bark and cortex of infected seedling root collars and roots. Microsclerotia may be seen with the naked eye and are readily visible with a hand lens. Laboratory confirmation suggested to confirm diagnoses.

Small black microsclerotia of Macrophomina phaseolina as seen with a hand lens beneath the bark of infected sand pine roots (diagnostic for charcoal root rot).

Phaeolus schweinitzii (formerly, *Polyporus schweinitzii*):

The cause of Brown Cubicle Root and Butt Rot. Typically occurs on old to overmature trees, but not limited to trees of older ages. A significant, but not major component in the sand pine root disease complex. Produces bracket-like (at tree bases) or stalked (on the soil above decayed roots) fruiting bodies (sporophores). Upper surface of fresh sporophores velvety, concentrically zoned, reddish-brown with a yellow margin (when fresh). Under surface dark colored (olive) with large irregularly shaped pores. Decayed wood and roots eventually become brittle and break into large yellow-brown to reddish-brown cubes. Laboratory confirmation advised in the absence of sporophores or typical decay.

Sporophore of Phaeolus schweinitzii near the base of an infected old-growth sand pine.

Phytophthora cinnamomi:

A water mold fungus. One cause of Phytophthora Root Rot. Well known to foresters as the cause of littleleaf disease of shortleaf pine in other parts of the Southern U.S. Especially damaging in shallow or poorly drained soils. Occurs in forest and ornamental nurseries and in commercial forest seed orchards. Predominant pathogen in young sand pine plantations. To date, unknown in natural stands of sand pine. Likely moved into field plantings via infected nursery stock, contaminated equipment, or infested soil. Infects primarily smaller, feeder roots. Cortex of feeder roots apt to slough when pulled between fingers. No visible signs (sporophores or other structures) produced in the field. Diagnosed only by laboratory analysis.

Phytophthora parasitica:

A water mold fungus. One cause of Phytophthora Root Rot. On sand pine to date, known only in forest and ornamental nurseries. A problem under poorly drained soil conditions. Apparently a minor component of the sand pine root disease complex. No visible signs produced. Diagnosed only by laboratory analysis.

Verticicladiella procera:

Role of this potential sand pine root pathogen not well understood. A known pathogen on other pines in other parts of the United States and is frequently recovered from diseased sand pine roots. Sometimes associated with mechanical and/or apparent insect damage on roots. No visible fungus structures produced in the field, nor are symptoms definitive. Laboratory analysis required for positive identification.

In the advanced stages of root disease some roots exhibit decay patterns typical of specific fungus pathogens (white pocket rot, brown cubicle rot, etc.). Depending upon the particular fungus or fungi involved and the stage of disease development, diseased woody roots frequently exhibit characteristic patterns of decay. Infected feeder roots are simply necrotic (dead). Sloughing of the root cortex (external tissues) on infected feeder roots is common. This symptom can often be detected by pinching and sliding suspect feeder roots between the thumb and forefinger.

The accumulation of clumps or cakes of soil around diseased roots of all sizes is common as a result of the bleeding or exudation of resin by diseased roots. Fungal conks or sporophores at or near the bases of trees are often a useful indicator of root disease, depending of course on the identity of the particular fungus.

Infection Biology: Many of the fungi which cause root disease on sand pine are disseminated by airborne spores (basidiospores) produced at various times of the year in above-ground fruiting bodies (sporophores). Other root disease fungi are soil-borne and do not produce aerially disseminated spores.

In the first group, infections are likely to occur when basidiospores are deposited on wounds at the bases of trees, adjacent stumps of cut trees, or on the surface of injured or intact roots. Spores are presumably washed downward into the soil by rainwater. In the latter group, infections result as the growing roots of susceptible pines come into contact with either a resting stage (various types of spores) or the actively growing, vegetative stage of a soil-borne fungus in infested soil. Conceivably, both groups of fungi are capable of infecting root wounds created perhaps by various small animals or insects. Local spread of root disease is effected by root-to-root growth of the various pathogens directly through the soil or through root grafts or root contacts.

Old dead stumps and roots may harbor one or more root disease fungi from previous infections and serve as potentially dangerous sources of inoculum, resulting in associated pockets of diseased trees . Infections and disease development are largely enhanced by adverse soil conditions, including poor drainage and shallow water tables or impervious soil layers.

Control: No effective control measures are known for sand pine root disease in field situations once the disease has become established. Soil fumigation with methyl bromide in forest tree nurseries provides effective control of seedling root diseases. Methyl bromide or steam sterilization of potting soils, together with appropriate cultural practices (clean pots, tools, etc.) are recommended for ornamental nurseries. Excessive watering of seedlings should be avoided. Certain types of soil fungicides may prove helpful in some nursery situations.

Losses to sand pine root disease in commercial forest stands can be minimized by applying the following guidelines. Be sure planting sites are good sand pine sites; a deep, well-drained sand. Consider alternative species (for example, Longleaf pine) on marginal or questionable sites. Avoid planting nursery stock infested with *Phytophthora* spp. or *Macrophomina phaseolina.*

Do not replant sand pine on sites with a previous history of severe sand pine root disease problems, especially if *Phytophthora cinnamomi* was involved. Avoiding sites where *P. cinnamomi* is known to be present or has previously been a problem on other crops is also advisable. Avoid, as practicable, the movement of site preparation and planting equipment, etc., from sites where *Phytophthora cinnamomi* is known (little leaf disease sites, etc.) to sand pine sites. Such equipment could be contaminated with *Phytophthora cinnamomi*-infested soil and result in the unwanted introduction of the pathogen into sand pine stands. Harvest stands on an early rotation schedule because older and over-mature stands tend to sustain increased losses to root disease fungi, especially *Inonontus circinatus* and *Phaeolus schweinitzii*.

Basal resinosis indicating root disease infection in sand pine.

The use of clean planting stock, good site selection, and minimum irrigation is recommended for sand pines in urban or ornamental situations. Also, avoid injuries to roots and bases of ornamental pines.

DISEASE: OTHER ROOT ROTS OF PINES

Pathogens: Various fungi

Common Host: **Pines** *Pinus* spp.

Significance: Numerous fungi are capable of causing root diseases on Florida's pines. With the exceptions of the root diseases already discussed (sand pine root disease and annosum root rot) however, root diseases of pines are usually of little consequence. Nonetheless, some fungi can be significant problems in nursery situations, for example, while others can cause substantial damage in certain field situations.

Recognition: Pines with root disease problems appear generally unhealthy and exhibit varying degrees of foliage thinning and/or discoloration. Infected trees may die or become uprooted. Diseased roots typically exhibit varying degrees and types of resin exudation (resinosis), staining, and/or decay. Conks or sporophores of certain pathogenic fungi may appear at or near the bases of infected trees at various times of the year. Other pathogenic fungi sometimes produce characteristic spore forms or vegetative structures which can be detected in or on infected roots.

Infection Biology: As with most root rot fungi, those affecting pines are apt to take advantage of root or basal injuries to gain entry into susceptible root systems. Many infections result from the deposition of airborne spores of the pathogens on wounded tissues or the intact surface of vulnerable roots. These spores germinate and the fungi grow into the roots causing disease and decay.

Other infections occur as a result of susceptible roots growing in close proximity to resting spores of certain pathogens in infested soil. Resting spores are of different types, but all function as an aid to the pathogens' survival in the soil in the absence of suitable hosts or growing conditions. Such spores are stimulated to germinate when suitable host root tissues grow nearby. Still other infections result from root contacts or grafts between healthy trees and adjacent infected trees or stumps.

Control: Control methods for pine root diseases vary with the type of disease and the particular location of the problem. Soil sterilization using steam or an appropriate methyl bromide formulation is highly effective for controlling most nursery root rot problems. Certain fungicides may also be useful in nursery situations. Curing diseased trees in the field is a fallacy. The life of infected trees may be prolonged, especially in urban situations, by providing adequate water and fertilizer to debilitated root systems.

Prevention of root disease by avoiding root and basal injuries to tree is the best method of control in urban or shade tree settings. In commercial forest stands timber losses can be reduced in severely diseased stands by salvage cuttings. Be wary of planting pines near old dead pine stumps because such stumps often harbor root disease fungi which can pose a threat to newly planted trees.

Table VIII: Some Fungi Associated with Other Root Rots of Pine in Florida

Phaeolus schweinitzii (formerly, *Polyporus schweinitzii*):	**The cause of Brown Cubicle Root and Butt Rot.**	Not a major problem on pines in Florida, but frequent on old or overmature trees. Sometimes causes distinct pockets or centers of root disease in younger, 10-20-year-old slash pine stands, frequently in association with residual, resin- impregnated (lightered) stumps from previous naval stores operations. See Table VII for other details.
Inonotus circinatus (formerly *Polyporus tomentosus* var. *circinatus*):	**The cause of Red Root and Butt Rot**	Not a major problem on most pines in Florida. Frequently occurs in association with basal fusiform rust cankers on slash pine, but not limited to this habit. See Table VII for other details.
Macrophomina phaseolina:	**The cause of Charcoal Root Rot.**	Historically and potentially a major root disease problem on pines in commercial forest nurseries. Infects primarily small feeder roots and seedling tap roots. Sometimes involved in plantation failures as a result of planting infected planting stock. Swelling, cracking and blackening of infected tap roots are common in advanced infections. The occurrence of microsclerotia beneath the bark of infected roots is a key diagnostic feature. See Table VII for other details.
Armillariella tabescens (formerly, Clitocybe tabescens):	**The cause of Mushroom Root Rot.**	Common on a variety of pines, but of no serious consequence, except perhaps on sand pine. See Table VII for details.
Fusarium spp.:	**Cause of Fusarium Root Rot (sometimes called Black Root Rot).**	Infrequent, but occasionally causes root disease problems in nurseries and young plantations. Primarily affect feeder roots and seedling tap roots. Varying degrees of resin impregnation in infected tap roots sometimes present. No visible fruiting bodies or other fungal structures with the exception of sporodochia of the pitch canker fungus which are sometimes present on infected tap roots and lower stems.

HARDWOOD ROOT DISEASES

DISEASE: ROOT AND BUTT ROTS

Thinning foliage of a hardwood tree infected with a root rot fungus.

Pathogens: Various fungi

Common Host: Hardwood

Significance: Root rots are perhaps the most serious diseases affecting hardwoods in Florida. Many fungi are capable of causing root rots and some cause considerable decay of the butts of trees as well. Root rots are common on older trees, and trees which have sustained root or basal injury during construction or similar site disturbance. Most if not all root rots are aggravated by poor soil conditions (excessive moisture, poor aeration due to soil compaction, etc.). In addition, trees with extensive root rot are far less able to tolerate extreme weather conditions like extended droughts, long periods of heavy rain, or unusually high temperatures than are their disease-free counterparts.

Recognition: Trees with root and butt rots characteristically exhibit varying degrees and combinations of crown dieback, loss and/or discoloration of foliage, and a generally unhealthy appearance. Internally, diseased roots exhibit varying degrees and patterns of discoloration and decay. It is not uncommon for diseased trees to live for years with little expression of symptoms by the crown. More commonly, however, trees with extensive root rot progressively decline and eventually die in a matter of several years. Stagheading, a dieback of crown branches resulting in a "deer antler" appearance, is sometimes common on trees with extensive root disease. In certain situations, where trees are exposed to severe weather conditions, for example, diseased trees may die in a matter of days or weeks. Conks or sporophores (fruiting bodies) at or near the base of declining trees are usually excellent indicators of root rot, but the identity of the fungus must be established to verify the diagnosis

Infection Biology: Most root and butt rot fungi affecting hardwoods are disseminated over long distances by means of airborne spores (basidiospores) produced by their respective sporophores. Sporophores are produced in many cases throughout the year in response to favorable conditions of temperature and moisture. Most root and butt rot fungi, however, tend to produce sporophores on a somewhat seasonal basis.

Basidiospores preferentially infect injured tree bases and roots. As a result, basal scars and root damage stemming from construction or similar activities are often the sources of root disease. On a local scale, root disease fungi often spread from tree to tree by vegetative (hyphal or mycelial) growth from root-to-root via root contacts or grafts, or directly through the soil itself.

Control: Control of root diseases in trees is a matter of prevention. Effective treatments for curing established root diseases in trees are unknown. Sometimes careful crown reduction via pruning in conjunction with fertilization may prolong the life of diseased trees by reducing the transpirational demand on ailing root systems and promoting overall tree vigor. Prevent root diseases by avoiding root damage and wounds to the lower trunks of trees. When planting trees in areas where trees have previously succumbed to root disease, first remove old stumps and roots to reduce the local fungus inoculum potential. Consider soil sterilization with an appropriate pesticide such as methyl bromide or vapam, according to local demands and conditions, (always following label recommendations).

Table IX. Fungi Commonly Associated with Root Rots on Hardwood Trees in Florida

Ganoderma spp.:

The cause of Ganoderma Root Rot. Common on a variety of hardwoods, particularly oaks. Sporophores produced at various times, but commonly around May. Sporophores typically near base of diseased or dead trees, stalked or non-stalked and tough, usually with a yellow to red-brown, lacquered upper surface, white and porous beneath when fresh. Immature sporophores appear as white to yellow knobs.

Fresh young (immature) sporophore of a Ganoderma sp. at the base of an infected oak. Note pure white cap and yellowish stalk.

Shiny, mahogany-red bracket-like (non-stalked) conks of a Ganoderma sp. at the base of an infected American Beech. Note injury to base of tree at right.

Polyporus spp.:

The cause of various Root and Butt Rots. Common on several hardwoods. Sporophores variously colored and shaped, porous on the undersurface, often attached as brackets to the base of diseased trees.

Typical bracket-like conks of a hardwood root and butt rot fungus (Polyporus ludovicianus) at the base of an oak. Blue-green flake-like plants on bark are lichens.

Armillariella tabescens (formerly, *Clitocybe tabescens*):

The cause of Mushroom Root Rot. Common on a variety of hardwoods. Sporophores produced at various times, but most commonly in the fall. Sporophores fleshy and short-lived, light brown to tan in color with gills beneath, produced in clusters from a common base at or near diseased or dead trees. Characteristic mats of fungus tissue often produced beneath the bark of infected roots and tree bases, mats frequently perforated.

See Table VII. Fungi Associated with Sand Pine Root Disease in Florida

PHOTO: Typical mushroom cluster of Armillariella tabescens at the base of an infected oak.

Endothia gyrosa:

More typically a Branch or Twig Canker Fungus. However, commonly observed on oak roots at soil surface when lawn mower or other damage is prevalent. Typically appears as clusters of small (about 1 mm) orange-red warts in or on bark tissues or near wounded portions of roots.

Minute reddish-orange fruiting bodies of Endothia gyrosa, a common twig and branch canker fungus that frequently infects oak roots damaged by lawn mowers or other mechanical agents.

DISEASE: MIMOSA WILT

Pathogens: *Fungus Fusarium oxysporum f.* sp. *perniciosum*

Common Host: **Mimosa** *Albizia julibrissin*

Typical symptoms and decline for mimosa trees infected with the vascular wilt pathogen, Fusarium oxysporum f. sp. perniciosum.

Significance: Mimosa wilt has not been extensively evaluated in Florida. It is known to occur in parts of the state, however, and it is usually very damaging or lethal to its victims. The frequent use of the graceful and seasonally showy mimosa as an ornamental tree could render this disease more important in the future. Mimosa wilt is an excellent example of a group of diseases referred to as vascular wilts which includes, among others, the well known dutch elm disease currently causing so much damage to elms across the United States and Canada.

Recognition: The first expression of symptoms by trees infected with the mimosa wilt fungus is a conspicuous paling and drooping of leaves, initially appearing on a single branch. As the disease progresses, drooping leaves turn yellow, dry out, and fall from the tree. In time, this process repeats itself throughout the crowns of infected trees, and death of the trees may result within a year of the time symptoms are first observed.

In many cases, root systems are not rapidly killed, and suckers (sprout-like growths) are produced repeatedly for several years from root collars at the base of disease-killed trunks. Some bark fissuring or splitting, accompanied by varying degrees of bleeding or exudation and sometimes gummosis (the oozing of gummy or rubbery excretions along the bark) may appear on infected trunks and major branches.

Internally, the wood of infected branches and stems usually exhibits a characteristic brownish discoloration, typically in the outermost layers of the sapwood. This vascular streaking may encompass the entire circumference or only portions of infected tree parts.

Infection Biology: Mimosa wilt infections arise as a result of direct penetration of roots by the fungus pathogen. Once inside the host root, the pathogen grows into roots of ever increasing size, ultimately into the tap root, and from there into the stem and branches of the tree. This progressive development of the pathogen occurs in the vascular tissues of the host resulting in the death and/or blockage of the critical, water conducting cells. As a result, the tree wilts and eventually dies.

Unlike certain other vascular wilt diseases such as Dutch elm disease, mimosa wilt has no known insect vector (an insect that carries the pathogen from tree to tree, often introducing it into a healthy tree). The pathogen can be spread in infested soil or through moving infected wood or seedlings from place to place. Local spread of the mimosa wilt fungus is accomplished through the root-to-root growth of the pathogen.

Although root wounds are not necessary for infection, it is presumed that wounds might aid the pathogen's entry. Root damage caused by certain nematodes has been shown to increase the severity of mimosa wilt infections.

Control: No proven treatment for infected trees is known. Preventive measures include avoiding the movement of infested soils or infected seedlings or trees. Treat soils with an appropriate biocide (methyl bromide, etc.) before planting mimosa in areas of known parasitic nematode populations or previous history of mimosa wilt. Don't prune infected trees and then healthy trees without first sterilizing pruning shears, saws, etc. Utilize resistant mimosa varieties when planting ornamentals, if available.

NEMATODES

DISEASE: ROOT PARASITIC NEMATODES

Pathogens: Various Nematodes

Common Host: Many Species of Trees

Galls on roots of dogwood parasitized by the root-knot nematode, Meloidogyne incognita.

Significance: Several types of nematodes are parasitic on the roots of various plant species. These soil-borne parasites cause considerable damage to a variety of agronomic crops including citrus in Florida. Nematodes are perhaps best known to the backyard gardener by way of their ability to infect the roots of tomato plants and other garden favorites. Not a great deal is known regarding the effects of nematodes on trees. However, certain species of nematodes do infect the roots of various trees and can result in reduced vigor and stunting of infected hosts when infections are severe. Nematode infections rarely result in the death of infected hosts, but it is not uncommon for certain root disease fungi to infect nematode-damaged roots, resulting in further damage, and even mortality in some cases. Some nematodes serve as vectors (carriers) for certain plant viruses, carrying these infectious, sub-microscopic particles from host to host as they feed. Both conifers and hardwood are susceptible to nematode infections.

Recognition: Most nematodes are invisible to the naked eye. Nematode damage is recognized primarily through observation of suspect trees, careful examination of their roots (especially the smaller, feeder roots), and analysis of the soil surrounding the roots. Definitive nematological evaluations are best performed in specially equipped laboratories by trained nematologists. In the field, nematode damage might be suspected when (a) trees exhibit poor growth and/or stunting, (b) foliage is chlorotic (pale or yellow) and smaller then normal, (c) smaller, feeder roots are necrotic (dead or dying), stunted, stubby, knotted (galled), or displaying definitive lesions, (d) other explanations for the poor performance of suspect trees are lacking.

Infection Biology: Root parasitic nematodes are soil borne, and although they migrate short distances within infected roots or infested soil, long distance movement occurs primarily through the movement of infected root material or infested soil. Many

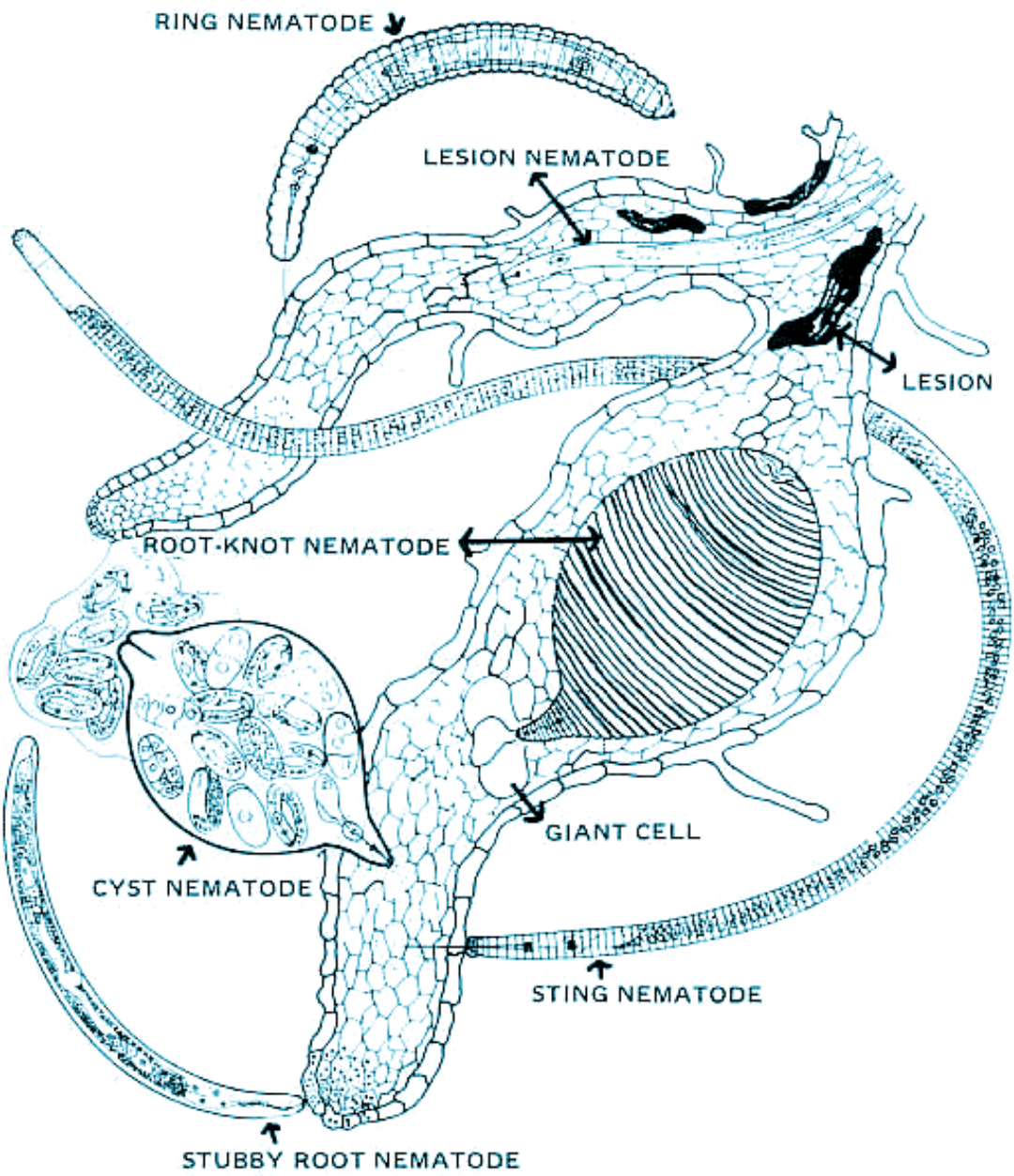


Fig. 18 Illustration of how nematodes parasitize and damage roots. (Courtesy, R.E. Esser)

nematodes are capable of survival for several years in soil without suitable host root material on which to feed. When host plants are present and other conditions are suitable, nematodes reproduce, often completing several life cycles a year, and populations can quickly build up to damaging levels. Some nematodes (Endoparasities) feed on roots by actually burrowing into susceptible root tissues. Others (Ectoparasites) do not burrow into roots, but feed by piercing root cells with their retractable, needle-like mouthparts called stylets (see Fig. 18).

Control: Control of root parasitic nematodes on established plants or trees is difficult to achieve. Maintaining host plants in a state of vigor by appropriate fertilization, watering, mulching, etc., is recommended, and in most cases such cultural practices are sufficient to enable the infected hosts to tolerate the parasites. Soil sterilization using methyl bromide or other appropriate soil fumigant (liquid or gas) is recommended when planting susceptible host species in soils with a history of nematode problems. Avoid movement of infected roots, infested soil, or contaminated equipment (shovels, roto-tillers, etc.) into areas where susceptible hosts will be planted.

DISEASE: PINE WILT

Pathogens: Pine Wood Nematode *Bursaphelenchus xylophilius*, together with related stresses and/or microorganisms

Common Host: **Pine** *Pinus* spp

Significance: In recent years the pine wood nematode has received considerable attention in Florida as well as the country as a whole. The pine wood nematode was initially thought by many to have been introduced into the United States. This caused considerable alarm since native tree species often have little innate resistance to introduced pests. However, recent evidence indicates that it is likely that the pine wood nematode is a native of North America. In Japan, where it may very well have been introduced, the pine wood nematode is responsible for the death of pines over vast acreages over the past 30 or more years.

Today the pine wood nematode is known to occur throughout Florida and in much of the U.S. It has been detected in the recently dead and dying stems and branches of several species of pines. The role of the pine wood nematode is the death of the trees (pine wilt) is still not well understood. In the United States, it appears that, in general, the pine wood nematode is not a primary, aggressive killer, but rather a secondary, contributing factor, perhaps working in concert with other microorganisms to finish off trees which have been injured or stressed by environmental or other agents. However, the pine wood nematode has been reported as a primary pathogen on certain exotic (introduced) pine species, and it appears likely that it may play a similar role on native pines in certain situations.

Recognition: Trees affected by pine wilt characteristically exhibit a fairly rapid foliage color change from green to yellow-green to reddish or brown. This usually occurs during

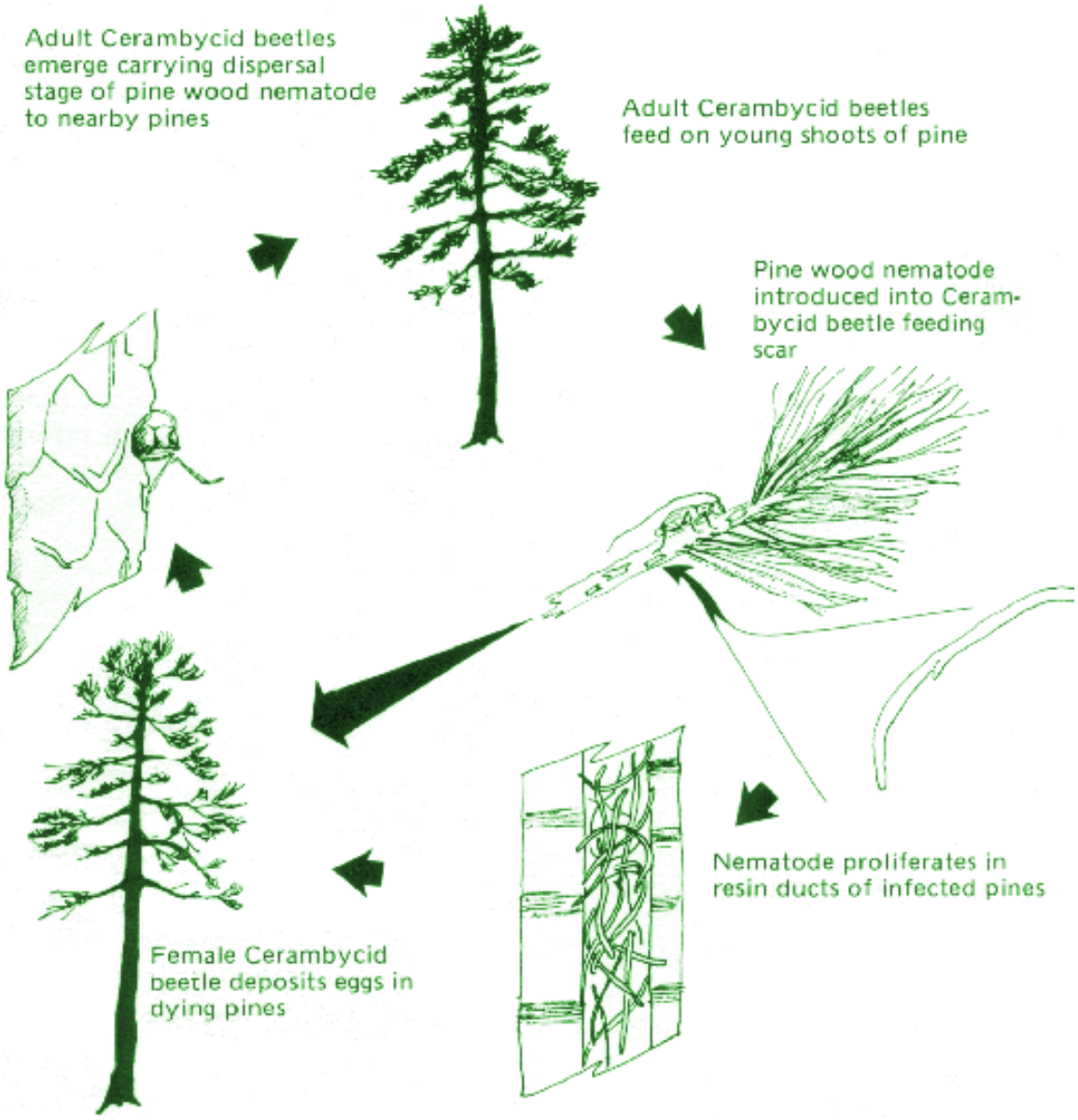


Fig. 19. Generalized life cycle of the pine wood nematode.

the mid to late summer. A key feature of this disease phenomenon is a concomitant marked reduction in resin flow within the sapwood of symptomatic trees (determined by cutting a branch or into the trunk for examination). Death of affected trees is rapid. Pine wilt symptoms are frequently related to and often follow severe injuries or stresses sustained by pines such as lightning, fire, construction damage, soil compaction or drought.

Pine wood nematodes are small (less than 1 mm in length) and difficult to see with the unaided eye. However, placing small segments of suspect branch or wood samples in a

jar of water overnight (samples submerged) provides a useful detection aid. If the nematode is present, hundreds to thousands of the nematodes will swim into the water and can be seen readily as clouds upon swirling the container (laboratory confirmation of specific identity is advised).

Infection Biology: The pine wood nematode reproduces and proliferates rapidly (one generation every 4-5 days with each female laying up to 80 eggs) in the resin ducts within the wood of infected, dead and dying pines. It is in just such pines that the larvae of the nematode's insect vectors (various longhorn beetles; Coleoptera, Cerambycidae) develop and mature. Mature longhorn beetles emerge from the dean and dying trees in the late spring carrying the dispersal stage of the pine wood nematode. The nematode is introduced into the xylem of susceptible pines as the beetles strip the bark from branches in order to feed. Following its maturation feeding the adult female beetle finds a suitable declining pine in which to lay her eggs. If the pine is infected with the pine wood nematode the cycle is set to repeat.

Control: Practical controls for the pine wilt disease and its apparent causal agents (*Bursaphelenchus xylophilus*, etc.) are lacking. Where practicable, keeping insect vector activity at a minimum by destroying breeding habitat (fresh cut or fallen logs, recently dead or dying trees, severely injured trees, etc.) would presumably be advisable.

PLANTS AS TREE PATHOGENS

Pathogens: Various Higher Plants and Lichens

Common Hosts: Various Trees

Significance: Plants growing in or on trees are often distinctive and highly visible. To some, the presence of plants attached to or hanging from the trunks and branches of yard trees is often disconcerting. In certain cases, concern may be justified, while in others there is little, if any, reason for alarm. Some higher plants actually attach themselves to and draw all or part of their sustenance from their host trees (Parasites). Others simply hang from or grow on their hosts while manufacturing (producing carbohydrates via photosynthesis) or acquiring their nutritional requirements independently (Epiphytes). A third group of plants which often represents problems for trees consist of vines which root in the soil, manufacture their own food via photosynthesis, but climb on available trees (Climbers). Parasitic plants are often harmful to their hosts, especially if present in abundance. Epiphytes, on the other hand are rarely harmful. Climbing vines are usually harmless when small, but can, over time, develop into real problems as they grow around the trunks and throughout the crowns of trees. Any plant that develops to the point of significantly shading the foliage of its host tree should be considered harmful.

Recognition: Plants growing in or on trees in Florida come in varying sizes, shapes, and colors.

- The common Mistletoe is readily recognized in the winter on hardwoods which have lost their leaves by the globose (spherical) growth habit of the evergreen, leafy plants. Close inspection of this parasitic plant reveals typical attachments to host branches at the base of repeatedly branched, central stems.
- Spanish Moss, perhaps Florida's best known epiphyte, is recognized easily by the hanging or draped appearance of its gray-green foliage.
- Ball Moss, a bromeliad similar to Spanish moss, occurs in ball-like clusters, as opposed to the hanging or shroud-like habit of the latter.
- Other Bromeliads, are vase-like in appearance and resemble their well-known cousin, the pineapple.
- Epiphytic Lichens typically appear as masses or patches of small gray-green, blue-green, or reddish-green flakes or bushes along the branches of their hardwood hosts.
- Root Parasites vary from chlorophyllous (green, having chlorophyll) plants with brightly colored and distinctive, seasonal flowers (for example, senna seymeria

on pines) to drab brown, achlorophyllous (not green, lacking chlorophyll) plants with inconspicuous foliage and flowers (for example, beechdrops on beech and squawroot on oaks).

- Climbers, of course, are simply vines of various descriptions.

Infection Biology: Most plants growing in or on trees in Florida reproduce by seed. Lichens and Resurrection Ferns are exceptions, however, in that these plants reproduce by means of minute, wind-disseminated spores. Some lichens also spread by means of small vegetative fragments (flakes) which break off from parent plants and are disseminated by the splattering action of rain. Mistletoe is typically spread from tree to tree by birds that feed on its seed only to deposit them later through their excrement or by wiping the sticky seeds from their beaks onto host branches. The seeds of Bromeliads (Spanish moss, etc.) are spread through the air by the wind, and to some extent the splashing of rain. Seeds produced by Climbers (vines) and Root Parasites are spread by a variety of agents including wind, water, birds, and rodents.

Epiphytes (bromeliads, lichens, resurrection ferns, etc.) simply use their hosts for support. They do not draw sustenance by way of parasitism from their hosts. These plants obtain their nutritional requirements from the air or rainwater and manufacture their own carbohydrates via photosynthesis. Climbers likewise manufacture their own carbohydrates through photosynthesis, but these plants draw their mineral supplies, from the soil where they are rooted. In contrast, Parasitic plants draw all or part of their nutritional requirements directly from their hosts. Mistletoes attach themselves to their hosts and produce a root system (haustorium; pl. haustauria) within the woody tissues of infected branches. Through these haustoria the mistletoes draw water and mineral nutrients, at the expense of their hosts. In a similar vein, root parasites attach themselves to host roots by means of haustoria and extract water and nutrients from the roots of their hosts.

Control: See Table X.

TABLE X. SOME COMMON TYPES OF HIGH PLANTS GROWING IN OR ON TREES IN FLORIDA

Parasite

Type/Examples	Common Hosts	Control
Mistletoe *Phoradendron serotinum* (formerly, *Phoradendron flavescens*)  *PHOTO: Typical, globose plants of mistletoes, a parasite, as seen in hardwood trees during the winter months.*	Pecans *Carya illinoensis* Oaks *Quercus* spp. Hickories *Carya* spp. Other hardwoods	If control is desired or considered expedient prune infected branches at least one foot below points of mistletoe attachment

Root Parasites

Type/Examples	Common Hosts	Control
Senna *Seymeria Seymeria cassioides*	Pines *Pinus* spp.	Prescribed or controlled burns may be helpful in severely infected, young pine plantations. Fires should be timed after spring seed germination, but before flowers appear.

Squawroot or Cancer Root *Conopholis americana*	Red oaks *Quercus* spp.	No practical control.
Beechdrops *Epifagus virginiana*	American Beech *Fagus grandifolia*	No practical control.

Yellow-flowered senna seymeria, a root parasite, growing near the base of a young slash pine. This plant is attached to and draws water and nutrients from the roots of the pine.

Epiphytes

Type/Examples	Common Hosts	Control
Resurrection Fern- *Polypodium polypodioides* Bromeliads- Spanish Moss *Tillandsia usneoides* Ball Moss *Tillandsia recurvata* Cardinal Air Plant *Tillandsia fasciculata* Lichens- "Fruticose" or Branched or Bush-like *Usnea* spp. "Foliose" or Leaf-like *Parmelia* spp.	Most trees. Often less common on pines due to the flaking or shedding nature of pine bark.	Control unnecessary in most situations. If desired, mechanically remove plants by hand or with a hooked pole. Cooper sprays such as Bordeaux mixture provide some control of bromeliads and lichens.

"Crustose" or Crust-like *Pyrenula* spp.

Lichens growing on the bark of a silver maple.

Resurrection fern, another epiphyte, often provides its own particular beauty when abundant on the branches of live oak.

Live oak branches adorned with the very prevalent epiphyte, Spanish moss.

Ball moss, another epiphyte, and a close relative of Spanish moss, as seen in the crown of a young live oak.

Climbers

Type/Examples	Common Hosts	Control
Grapevines *Vitis* spp. Kudzu *Pueraria lobata* Wisteria *Wisteria sinensis* Greenbrier *Smilax* spp. Poison-ivy *Rhus radicans* Virginia creeper *Parthenocissus quinquefolia* Trumpet creeper *Campsis radicans* Carolina jessamine *Gelsemium sempervirens* Japanese honeysuckle *Lonicera japonica* Crossvine *Bignonia capreolata*	Most trees. Climbers are not host specific	Do not allow climbers to develop in highly valued ornamentals. Mechanically remove young vines taking care to pull roots where practical to prevent regrowth. Cut older established climbers near the ground and pull from trees following death and deterioration of the vines.

Kudzu, a climber, is particularly aggressive. It can seriously harm trees when allowed to grow unchecked.

MYCORRHIZAE

DISEASE: MYCORRHIZAE

Ectomycorrhizae on pine roots showing branching habit and external fungus growth (mantle and hyphal threads). Each rootlet is about the size of a pencil point.

Various Fungi

Common Host: Most, if not all trees

Significance: Mycorrhizae are mutually beneficial associations between certain highly specialized fungi and the roots of plants (and trees). In these associations the fungi and the host plant roots grow together in such an intimate relationship as to literally form "fungus-roots" (i.e., mycorrhizae), entities distinctly separate from either the fungi or the roots alone. The roots are roots, the fungi are fungi, and together they from mycorrhizae. The fungi benefit by way of receiving carbohydrates and certain other necessities (for example, vitamins) from their hosts. In turn, the fungi enhance the host roots' ability to absorb nutrients (esp. phosphorus) from the soil. Indeed, in certain cases the fungi literally feed nutrients from the soil to their host root systems. Sometimes the presence of mycorrhizal fungi imparts a degree of protection or resistance against certain root disease microorganisms (e.g., nematodes, fungi). In general, plants and trees with mycorrhizae are healthier than those without.

Sporophores of Thelephora terrestris, a common ectomycorrhizal fungus on pines. Very common in forest and ornamental nurseries.

Mycorrhizae are the rule, not the exception in nature. Only a few plant species and fewer, if any, trees are known to be nonmycorrhizal. In Florida, it would be safe to say that one would be hard pressed to find a nonmycorrhizal tree. Only in special situations such as disturbed or chemically treated (e.g., fumigated) soils are mycorrhizal deficiencies likely to occur. Such deficiencies are often accompanied by stunting and/or poor growth of the host.

Recognition: Mycorrhizae are generally divided into two large groups. Ectomycorrhizae occur on pines and other

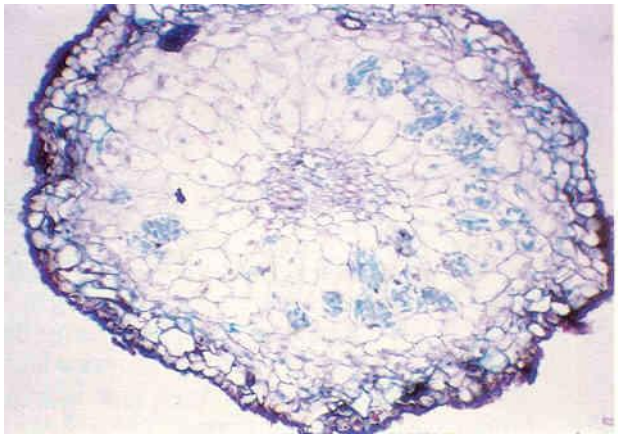
conifers as well as oaks, eucalyptus, beech, and birches. Ectomycorrhizae are characterized by the presence of an external fungal sheath or "mantle" on the surface of infected feeder roots. Mantles can vary in color from white to black, often a function of the particular fungus involved. Ectomycorrhizal fungi also grow between the cortex cells of their hoot roots, forming what is referred to as a "hartig net" (visible only with a microscope).

Ectomycorrhizae on pines are often forked or branched (bifurcate), but may occur unbranched (monopodial) or repeatedly branched (coralloid) as well. At certain times of the year many ectomycorrhizal fungi produce distinctive sporophores (mushrooms, toadstools, puffballs, etc.) on the ground, always in association with the roots of their host.

Endomycorrhizae, as a rule, cannot be detected with the naked eye. Endomycorrhizal fungi do not form a mantle on the surface of the infected roots. Growth of these fungi is primarily within (in contrast to ectomycorrhizae) the cortex cells of their host roots. Distinctive changes in root morphology (branching, etc.) do not occur with the formation of endomycorrhizae. Microscopic observation is required to observe endomycorrhizal infections.

Endomycorrhizal tree species include maples, oaks, sycamore, dogwoods, yellow-poplar and sweetgum.

Infection Biology: Mycorrhizal fungi reproduce by means of various kinds of spores. Those of ectomycorrhizal fungi are most frequently produced in aboveground sporophores (mushrooms, toadstools, puffballs, etc.) and are disseminated by the wind. Accordingly, it is usually not long before ectomycorrhizae "reappear" in soil disturbed by practices such as methyl bromide fumigation in forest tree nurseries. Nearby forest and shade trees usually support sufficient ectomycorrhizae (and sporophores of the ectomycorrhizal fungi) to insure recolonization of disturbed soils in a matter of months.



Photomicrograph showing endomycorrhizal fungus colonization (blue-green stain) inside root cells of yellow poplar (seen only with a microscope).

In contrast, the spores of most endomycorrhizal fungi are produced underground in association with their host roots. These spores are not aerially disseminated and, as a result, the build up of endomycorrhizae in disturbed soils is not uncommonly a slow process. Endomycorrhizal deficiencies are

occasionally a problem in nurseries where soil is regularly sterilized or fumigated as cultural practice.

Both ectomycorrhizal and endomycorrhizal fungi are moved in infested soils and on (in) the roots of mycorrhizal plants. Both types of mycorrhizal fungi are also capable of vegetative growth from root to root within and between host plants or trees. In trees, mycorrhizal infections are limited to fine, feeder roots less than 1-2 mm in diameter.