Table 4. Relative effect of selected preemergence herbicides on growth of sea oats in the second experiment. Spring 1989.

Treatment	Rate (kg/ha)	Height increase[z] (cm)	Shoot wt (g)
DCPA	9.0	66 a[y]	59 ab
Isoxaben	1.1	68 a	63 ab
Oxyfluorfen	0.6	87 a	62 ab
Pronamide	2.2	67 a	61 ab
Alachlor	1.7	72 a	60 ab
Ethofumesate	1.7	83 a	76 a
Oxyfluorfen +	2.2	79 a	60 ab
Pendimethalin	1.1		
Simazine	1.1	71 a	57 b
Pendimethalin	1.1	79 a	66 ab

[z]Height increase represents the amount of increase in plant height over the indicated time interval and not the actual height of the plant.
[y]Means within columns followed by the same letter are not significantly different at the 5% level as determined by Duncan's new multiple range test.

weighed less than roots of sea oats in the untreated control. Those herbicides which reduced both plant height and shoot or root weight, with the exception of prodiamine, were eliminated from further testing. Diethatyl ethyl was deleted for unrelated reasons.

None of the herbicides reduced growth compared to the check as measured by the increase in plant height in the second experiment (Table 3). Diuron, metribuzin, metolachlor, fluometralin, prodiamine, pyrazon, oryzalin + oxyfluorfen, and trifluralin reduced sea oat shoot weight compared to the untreated control. Remaining herbicides which did not reduce growth relative to the untreated control were compared separately (Table 4). Growth (shoot weight) of simazine treated plants was lower than that of sea oats grown in pots treated with ethofumesate, but was not significantly different from that obtained with the other selected herbicides (Table 4).

Although nine herbicides were determined to be safe on sea oats, the extreme variability of plant response believed due to genetics and seed vigor may have masked what might have been a marginally acceptable herbicide. Growers wishing to evaluate herbicides for use on the ecotype of sea oats produced by them and under their cultural conditions are advised to select from those listed in Table 4 with the possible exception of simazine since it has high potential for leaching. Also, some growers use commercial potting media high in organic matter and simazine has provided poor weed control in other situations where high organic matter was encountered (Gilreath et al., 1985). Alachlor does not merit consideration because it is no longer sold in Florida. Registration of ethofumesate is questionable at this time. DCPA historically has provided erratic weed control in many cropping situations and probably is not worthy of extensive consideration. Thus, growers should focus their evaluations on isoxaben, oxyfluorfen, pronamide, pendimethalin, and the commercially available combination of oxyfluorfen and pendimethalin. Isoxaben and oxyfluorfen control mostly broadleaf weeds and provide poor control of grasses in most situations. Pronamide and pendimethalin control both grass and broadleaf weeds. Oxyfluorfen combined with pendimethalin provides good control of many weeds, especially spurges; however, this combination sometimes is too active for some crops. Data from these experiments indicate sea oats has good tolerance for these herbicides, but growers are strongly encouraged to evaluate several herbicides under their conditions before beginning wide scale use of a product.

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SEASONAL OCCURRENCE AND MANAGEMENT OF LANDSCAPE AND ORNAMENTAL PESTS IN NORTH FLORIDA AND SOUTH GEORGIA

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Abstract. **Identification and management of arthropod pests is one of the most important decisions facing the nurseryman. Understanding pest biology and predicting pest outbreaks are crucial to environmentally-sensitive and cost-effective pest suppression. The general biology, seasonal abundance and monitoring methods for pests commonly found infesting ornamental plants from south Georgia and north Florida as far south as the Orlando-Tampa area, are discussed in the context of IPM as a part of total nursery management.**

Additional index words. IPM, management, control.

Management of insect and mite pests in Florida's nurseries and landscapes is a year-round task. Florida's climate and weather provide a long growing season that produces high quality plants, but such conditions are also conducive to the development of pests. At least one or more species

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of arthropod pests are present throughout the growing season. However, pest outbreaks do not occur concomitantly because different pests are adapted to different climatic conditions. From north to central to south Florida, the same species of pests will occur at different times of the year, and different species of pests become temporally important.

Insects and mites, like most living organisms, are adapted to a favorable temperature and humidity range where they feed and reproduce at high levels. Most Florida ornamental plants are attacked by some insect and mite species that prefer one or more of the commonly observed weather conditions. Some mite species thrive during hot, dry weather and other mite species develop best under cool, wet conditions. Add to this available host plants growing under all types of cultural and management practices creating conditions that pests prefer, and you have the year-round pest problems we observe in Florida. This paper attempts to summarize the available information on pest biology and management. We also present an organizational plan for collection and synthesis of information to facilitate IPM decisionmaking in nurseries.

Materials and Methods

Information for this publication was garnered from the available literature and the combined thirty years of practical experience of the authors. Information concerning pesticides registered for control of the pests is not included, but it is available from the County Extension Offices and the Insect Control Guide.

Results and Discussion

Despite the many factors favoring development and reproduction of insect and mite pests and local daily variations in climatic conditions, the seasonal occurrence of most ornamental pests can be predicted, albeit with variable precision. The major and minor nursery pests commonly observed by the authors are listed in Table 1.

If a nursery is located south of Gainesville, the times of occurrence may be slightly earlier in the season and persist for a longer period of time. Also, additional generations of the pests may occur that do not occur in north Florida. We have attempted to list, when known, the mitigating climatic conditions that affect populations of each pest species. When considering these factors, note that location in the state is important as it relates to general weather conditions. However, be aware that unseasonal conditions may occur in any one year that would in effect, make growing conditions similar to those in another area of the state. Therefore, outbreaks of uncommon pests or outbreaks of common pests at unusual times may occur.

Other cultural and management conditions at specific locations such as water and nutrient regimes, diseases, nematodes, level of sunlight, etc., can predispose plants to attack by pests. Many species of borers and beetles function in the ecosystem as both parasites and saprophytes consuming stressed, dying or dead plants. A thorough knowledge of all aspects of horticulture are often necessary to make correct pest management decisions.

The following paragraphs discuss the important biological factors known about each major and minor pest in Table 1. Most will require application of pesticides in order to achieve satisfactory levels of suppression for nursery stock. However, pesticides can be reduced or eliminated through cultural and management practices and monitoring for the presence of pests.

Twospotted spider mite, *Tetranychus urticae* Koch, is the number one pest of ornamental plants in Florida and usually prefers the hot, dry conditions of summer and fall months. However, this mite may occur at any time during the year and is often found during the winter months in north Florida on hollies. It attacks a wide range of ornamental species as well as agronomic crops and weeds. Holly cultivars with cup-shaped leaves (*Ilex crenata*) and *Pittosporum* are preferred hosts. Twospotted spider mites have a very high reproductive rate and can complete a generation in 7-10 days under warm conditions. Mites feed on the plant leaves, usually on the under side, but on all plant parts during heavy infestations. An off-color, stippled or scorched appearance indicates damage. Webbing is constructed on the plants as the mites feed. To detect mites, hold a white sheet of paper under a branch and strike the foliage, mites will fall on the paper if present. Damaged leaves do not recover from mite feeding and usually abort. Several applications of an acaricide may be necessary to control the mite. Many natural enemies feed on spider mites, but most are eliminated or suppressed by pesticides.

Southern red mite, *Oligonychus ilicis* (McGregor), is a cool weather pest that prefers azalea, although elaeagnus, camellia, pyracantha and photinia are also attacked. This mite feeds on both sides of the leaves causing them to appear bronzed or scorched. High populations occur during the winter months under mild, humid conditions. The southern red mite does not reproduce as rapidly as the twospotted spider mite and probably does not need to be controlled except on saleable stock. Populations can be found year-round on shaded or stressed landscape pyracantha, but nursery populations usually disappear with the development of new spring growth. This mite may also be detected using the paper technique. Several applications of an acaricide may be necessary to control the mite. The natural enemy situation is the same as for twospotted spider mites.

Spruce spider mite, *Oligonychus ununguis* (Jacobi), is an ubiquitous pest of juniper and other conifer species on the east and west coasts of the United States and Canada. 'San Jose' juniper and other cultivars with similar growth habitats seem to be preferred hosts. Plants under water stress are especially susceptible. It is usually a minor pest of junipers in Florida occurring in the hot, summer months. Feeding damage will cause the plants to appear off color and eventually they will turn completely brown with epidemic populations. The paper technique will also help detect this mite. Several applications of an acaricide may be necessary to control the mite. Predatory mites attack spruce spider mites, but are adversely affected by pesticides.

Sixspotted mite, *Eotetranychus sexmaculatus* (Riley), is found during the winter and spring on azalea. It infests the undersides of leaves in high numbers, but causes little damage. It is yellow in appearance and, although smaller, may be mistaken for the twospotted spider mite. It may be important as an alternate host for predatory mites.

Azalea leafminer, *Caloptilia azaleella* (Brants), is a moth that attacks only azaleas. Newly-hatched larvae bore into the leaf and mine the tissue. This damage first appears as

Table 1. The seasonal occurrence of nursery pests in north Florida and south Georgia.

Pests	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Twospotted spider mite	□□□□□	□□□□□	□□□□□	□□□□□	□□□□□	□□□□□	*■■■■	*■■■■	■■■■*	■■■■*	■■■■■	*■■■■
Southern red mite	□□□□■	■■■■■	■■■■■	*■■■■	■■■■*	■■■■*	■■■■■	*■■□□	□□□□□	□□□□□	□□□□□	□□□□□
Spruce spider mite							*■	■■■■■	■■■■■	■■■■■	□□□□□	□□□□□
Sixspotted spider mite	□□□	□□■■■	■■■■■	■■■■■	■■■■■	■■■■□	□□					
Yaupon psyllid	□□□	□□□■■	■■■■■	■■*■■	■■■■■	■■□□□						
Yaupon holly leafminer	□□□□	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	□□□□□					
Platynota rostralis						□□■■■	■■■■■	■■■■□	□□□			
Oriental fruit moth	□□□□					□□□□□	□□□□	□□□□□	■■■■■	■■■■■	■■■■■	■■■□□
Glyphidocera - webworm	■■*■■	□□□□□	□□□□□	□□□□□	□□□□□	□□□□□	□□□□□	□□□□□	□□□□□	■■■■■	*■■■■	*■■■■
Epismus tyrius							□□□□■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
Nantucket pine tip moth	□□□□			□□□□■	*■■■■	■■■■■	■■*■■	■■*■■	■■*■■	■■■■■	■■■■■	■■■■■
Pyracantha leaf crumpler					■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
Bagworm						□□□□□	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
Forest tent caterpillar				□□□■■	■■■■■	■■■□□	□□					
Fall webworm						□□□□□	■■■■■	■■■■■	□□□□□	■■■■■	■■■■■	□□□□□
Altica foliacea					□□□□□	□□■■■	■■■■■	■■■■■	■■■■■	□□□□□		
Colaspis spp.					□□□□□	■■■■■	■■■■■	■■■■■	■■■■■	□□□□□		
Whiteflies	□□□□□	□□□□□	□□□□□	□□□□□	□□□□□	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
Whitefringed beetle							■■■■■	■■■■■	■■■■■	■■■■■		
Aphids[4]	□□□□□	□□□□□	□□□□□	□□□□□	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
Crapemyrtle aphid	□□						□□□	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
Scales	■■*■■	■■□□□	□□□□□	□□*□□	□□*■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■
Striped mealy bug	□□□□□	□□□□□	□□□□□	□□□□□	■■■■*	■■*■■	■■*■■	■■*■■	■■*■■	■■■■■	■■■■■	■■■■■
Azalea leafminer	□□□□□	■■■■■	■■*■■	■■*■■	■■*■■	■■■■■	■□□□□	□□□				
Azalea lacebug[5]	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	□□□□□	□□□□□	□□□□□	□□□□□	□□□□□	□□□□□
Azalea caterpillar							□□□□□	□■■■■	■■■■■	□□□□■	■■■■■	■■■□□
Red imported fire ant	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■■■■■	■.■■■
Peachtree borer	□□□					□□□□□	■■■■■	■*■■■	■■■■■	■■■■■	*■■■■	■■■■■
Lesser peachtree borer	■□□□□	□□□□□	□□□□□	□□□□□	□□□□□	□□□□*	■■■■■	■■■■■	■■■■■	□□□□□	■■■■■	■■■■■
Elm borer	□□□□□				□□□□□	□□■■■	■■■■■	□□□□□	□□□□□	■■■■■	□□□□□	■■■■■
Magnolia borer				*■■■■	■■□□□	□□□□□	□□□□□	□□□□□	□□□□□	■■*■■	■■■■■	■■■■■
Flatheaded appletree borer					□□□□□	□□□□□	■■■■■	■■■■■	■■■■■	■■■■■	□□□□□	□□□□□
Maple callus borer						*■■■■	■■■■■	■■■■■	□□□□□	□□□□□	■■■■■	■■■■■
Ash borer					□□□□□	□□□■■	■■■■■	■■■■■	□□□□□	□□□□□		
Dogwood borer	□□□□□	□□			□□□□□	■■■■■	■■■■■	□□□□□	□□■■■	■■■■■	■■■■■	□□□□□
Dogwood twig borer						□□□□□	■■■■■	■■■■■	□□□□□			

[1]□□□ May be present, monitor.
[2]* Control may be needed.
[3]■■■ Time when high population may occur.
[4]Many species of aphids infest ornamentals, see text.
[5]Most other species of lacebug occur during summer and fall.

a blister on the underside of the leaf, but later is visible from both sides of the leaf. Mid-size larvae exit the leaf interior, move to the tip and form a roll in which they feed. Mature larvae exit the roll and spin a pupal case on the lower side of the leaf. Azalea leafminer is an introduced pest, but is attacked by many native parasites which appear to control it throughout the year except in winter. Therefore, it is usually a winter and spring pest. However, the damage is only aesthetic, as growth is not affected (Mizell and Schiffhauer 1991). Control is only necessary on saleable material and is best timed to the presence of the adult moths. To detect leafminers the foliage must be examined closely, rolls made by larger larvae will be visible on the exterior leaves. The brown mines are commonly mistaken for disease damage.

The azalea caterpillar is the larvae of the moth, *Datana major* Grote and Robinson. It feeds on azalea as well as apple, blueberry, and red oak. There are one to two generations per year and the larvae feed gregariously on the leaves, defoliating the plant. They are often found infesting the same azaleas year after year. Hand removal and destruction of the larvae can be used to eliminate this pest. The effect of natural enemies is unknown.

The bagworm, *Thyridopteryx ephemeraeformis* (Haworth),

is primarily a landscape pest. It is a moth larva that feeds out of a bag it weaves together from needles and debris. The bag is enlarged in size as the larva grows. The eggs overwinter in the bag and the larvae hatch in early summer. Bagworm larvae feed on a variety of species, but conifers, particularly arborvitae, are most susceptible. The effect of natural enemies is unknown. High populations can severely defoliate infested plants. Hand removal and destruction of the bags can be used to eliminate this pest.

Holly leafminers and holly psyllid. There are several species of leafmining flies that attack hollies. The holly leafminer, *Phytomyza ilicicola* Loew, attacks American holly, *Ilex opaca* Aiton, and is not usually a pest of nursery stock. The leafminer attacking *I. vomitoria*, yaupon holly, is *Phytomyza vomitoriae* Kulp, and does not have an approved common name. This leafminer is a cool weather pest, but usually only causes minor problems. When nurseries cover *I. vomitoria* with material for freeze protection, large populations of this pest often develop in the protected plants and emerge in spring when the material is removed. Parasites usually prevent this leafminer from reaching high populations in landscape situations. The mines are visible on the leaves as brown splotches. The yaupon psyllid, *Gyropsylla ilicis* (Ashmead), causes young leaves of yaupon holly to deform into galls. It is a minor pest with one generation per year that occurs from mid-November to mid-April. Peak numbers occur during February in north Florida (Mead, 1983). Removal of the galls by pruning is probably the best way to eliminate the damage.

Platynotus rostralis (Wlk.) is a leafrolling moth found feeding on the terminal leaves of *Photinia* in May. The larvae roll and feed on the developing leaves in the terminals. Little is know about this uncommon insect and it appears to be a minor pest. Pruning will eliminate the damage.

Oriental fruit moth, *Grapholitha molesta* (Busck), is a minor pest of *Photinia*. The larvae bore into the tips of developing stems where they feed. The damage first appears as a few dying or black leaves, followed by the death of the last 1-2 inches of the stem terminal. Plants may at first appear unsightly and damage by the moth leads to increased branching (perhaps beneficial). Little is known about the oriental fruit moth in *Photinia*, but high populations have been observed in the fall in south Georgia and North Florida. Parasites have been found attacking the larvae in large numbers in the fall (Mizell, unpublished data 1991). Controls are probably unnecessary.

Glyphidocera juniperella Adamski (no approved common name) is a webworm infesting juniper and sometimes other plant species. The larvae of this moth prefer moist conditions and usually infest prostrate growing junipers such as *Juniperus chinensis* var *procumbens* 'Nana', *J. horizontalis* 'Wiltonii' (Blue rug), 'Prince of Wales' and 'Andorra compacta'. They also will feed on the dead leaves collecting in the limb crotches of azalea. The larvae feed on dead or living foliage and web the foliage along with the soil media. The larvae are tan to dark brown in color and about 0.5-0.75 inches long at maturity. In the winter the larvae feed on the bark and girdle small stems at the base of the plant. These stems turn red in the spring and require removal before sale. Larval populations should be controlled in fall to remove the overwintering larvae (see Mizell and Schiffhauer, 1987 for methods). Little or no damage is done to the plants at other times of the year. Infestations are readily detected by lifting the plant foliage off the potting media. If the plants are infested, the foliage and the media will be webbed together at the soil surface. Several parasites are known to attack the larvae and pupae (Schiffhauer and Mizell, 1987).

Episimus tyrius Heinrich is a leaftier that is found infesting the terminal leaves of cherry laurel. The larvae are bright orange in color and move quickly when disturbed. Feeding by the larvae produces dead leaves at the branch tips on both nursery and landscape plants. When present, the larvae are readily visible in the terminal leaves which they web together to form a nest. The impact of natural enemies is unknown.

Nantucket pine tip moth, *Rhyacionia frustrana* (Comstock), is an important pests of pines. More than 20 species of pines including loblolly, shortleaf, sand and slash pine have been recorded as hosts of the moth (Dixon, 1987). Eggs are laid on the new shoots and tip moth larvae feed for a short period of time on the new growth and then bore into the shoot tips, buds and conelets. Shoots infested by tip moth will have dying needles, beads of resin and often silky webbing in the tips. Larvae, pupae or empty tunnels may be present when the shoot is examined. Tip moths emerge in spring as early as February and may have 4-5 generations per year depending upon temperature. Many natural enemies of tip moths are known, but outbreaks in nursery stock usually require insecticide applications targeted to the egg and early larva stage. Pheromone traps are available to monitor for the adults to optimize timing of insecticides.

Altica foliacea LeConte is a metallic blue-green flea beetle that often severely damages crape myrtle. This beetle emerges in early spring when the adults and larvae develop in high numbers on the weed, evening primrose, *Oenotheria* spp. As the beetles mature and the evening primrose is consumed or dies, May-June in north Florida, the beetles disperse to other plants. They are often seen on many species of plants, but feeding damage is primarily on crape myrtle in June. The adult beetles scrape the undersurface of the leaves leaving unsightly brown splotches. The beetles jump if disturbed and are easily detected. Several insecticide applications to saleable nursery stock and targeted to the beetle adults are often necessary. Natural enemies prey upon the beetle on its weed host, but probably have little impact on other hosts.

Another species complex of flea beetles, *Colaspis* spp. also attacks many species of plants, grape and crape myrtle among others, in spring and summer. These beetles are brown to tan in color and some have narrow white stripes. They feed on the developing leaves by cutting small holes, making the leaves unsightly. The damage is easily detected, as are the feeding beetles, which jump when disturbed. Little else is known about these beetles in nursery stock.

Whiteflies are persistent pests of ornamental plants throughout Florida. High populations may occur locally from spring to fall outdoors. The citrus whitefly, *Dialeurodes citri* (Ashmead), infests gardenia, ligustrum and viburnum. The sweetpotato whitefly, *Bemisia tabaci* Gennadius, attacks hundreds of plant species, most importantly nursery-grown perennials and *Nandina* cultivars. Many other species of whiteflies are important pests in Florida. Whiteflies usually can be found on the undersides of the leaves as immatures, while the small, white-colored adults can be found on any plant part. Most species have

continuous generations throughout the warm months of the year. The adults will make short flights when disturbed and are easily detected. Telltale signs of the immatures are honeydew and sooty mold on the foliage. Several applications of insecticides are usually necessary to suppress whitefly populations. Many natural enemies of whiteflies are known and they are important in suppressing these destructive pests.

Whitefringed beetle, *Graphognathus* spp., is a complex of several species accidently introduced into the United States from South America. The beetles cannot fly and only females of the species are known. The larvae feed in the soil on plant roots and the adults feed on foliage. Hundreds of plants are hosts to this pest. Populations are sporadic and very localized. Seedling trees planted in the soil of old fields are often attacked. The adults damage nursery stock by notching foliage and can be controlled with an insecticide. Adults emerge from the soil in summer, feed on foliage and oviposit in the soil. There is one generation per year. When present during the day, the adults can be found hiding on the leaves and stems. The larvae are in the soil and not easily detected until after the plants show signs of damage. Controlling the larvae is difficult. Diseases attack the larvae but natural enemies have little effect that can be exploited in the nursery.

Aphids: A large number of aphid species attack ornamental plants from spring to fall and a few species are important throughout the year. Common nursery pests include the green peach aphid, *Myzus persicae* Sulzer; the cotton aphid, *Aphis gossypii* Glover, and the spirea aphid, *A. spiraecola* Patch. These aphids attack many species of plants. The green peach aphid may be found throughout the year while the others are primarily found in spring and summer. The crapemyrtle aphid, *Tinocallis kahawaluokalani* (Kirkaldy) is host specific to crape myrtle, *Lagerstroemia indica* L. Crapemyrtle aphids occur from late May until plants defoliate in fall. Aphids usually have continuous generations and may injure plants by distorting growth, causing defoliation or discoloring plants with their honeydew/sooty mold. Look for honeydew and sooty mold to detect leaf feeders and examine new shoots for aphids that aggregate and feed in the terminals. Several applications of insecticides are usually necessary to suppress aphid populations. Many natural enemies feed on crapemyrtle aphids and the presence of infested crape myrtle may serve to enhance biological control in other areas of the nursery and landscape.

Scales: Almost all ornamental plants in Florida may be attacked by one or more species of scale insects. Both armored and soft scale species are common and can reach high populations in a few generations. White peach scale, *Pseudaulacaspis pentagona* Targioni-Tozetti, on rhododendron; wax scales, *Ceroplastyes* spp., on holly and other orna-

Table 2: Decision-making factors in IPM. An outline for collecting and organizing available information to make informed pest management decisions.

I. BIOLOGICAL FACTORS (Under control of the pest)
- A. Damage Potential
  - 1. As species
    - a. High
    - b. Low
  - 2. Effect on plant
    - a. Quality only
    - b. Mortality
- B. Reproductory Rate of Pest
  - 1. High/low
  - 2. Time of year
    - a. Winter (rapid or slow, species dependent)
    - b. Summer (rapid or slow, species dependent)
    - c. Spring or Fall (variable related to temperature)
  - 3. Host plant species
    - a. Preferred (rapid growth)
    - b. Non-preferred (slower growth)
  - 4. Plant stress (favoring pest)
    - a. Injury
    - b. Water
    - c. Nutrients
    - d. Other
  - 5. Current infestation (judgment on population growth)
    - a. Increasing
    - b. Static
    - c. Decreasing
- C. Host Range (threat of population to spread)
  - 1. Broad/general
  - 2. Narrow/specific
- D. Natural Enemies (predatory mites, diseases, etc.)
  - 1. Positive impact
  - 2. Little or unknown impact

II. OPERATIONAL FACTORS (Under control of the grower):
- A. Survey and Detection (population monitored adequately)
  - 1. Quantative methods available (numbers meaningful)
  - 2. Qualitative methods only (presence or absence)
  - 3. Monitoring intensity (scouting frequency)
- B. Cultural Practices Scheduled (related to control needs)
  - 1. Pruning in near future (could remove pest mechanically)
  - 2. Fungicide next treatment (could add insecticide if needed)
- C. Plant Value
  - 1. Inherent
    - a. Species
    - b. Size/investment
    - c. Market
  - 2. Plant sales status (relative to damage threshold)
    - a. Immediate
    - b. After growth flush
    - c. Uncertain, but in future
- D. Choice of Control (when and what to use)
  - 1. Legal factors
    - a. Regulatory (FDACS-DPI/APHIS) Guidelines
    - b. Legally limited: only chemical labeled (see pesticide label or consult local extension office)
    - c. Safety (worker reentry, see pesticide label)
  - 2. Logistics
    - a. Critical timing required
      - (1) Preventative
      - (2) Remedial
    - b. Scheduling around other chores
    - c. Weather limitations
  - 3. Efficacy (expected % mortality)
    - a. Ease of control
    - b. Chemical's properties
      - (1) Kills all stages
      - (2) Does not kill all stages
    - c. Number of applications needed
    - d. Applicator's efficiency - coverage
  - 4. Economics
    - a. Relative cost (per application × days of residual)
    - b. Residual activity (days) (see label)
    - c. Previous controls (rotation or change of chemicals)
    - d. Availability and cost of alternative tactics
    - e. Spectrum of pesticide activity (if more than one pest present)
    - f. Risk of pesticide resistance
  - 5. Environmental
    - a. Impact on nontarget organisms
    - b. Available alternative chemicals or practices
    - c. Environmental risk factors (pollution)(see Butler et al., 1991)
- E. Decision-making Confidence (knowledge × application)
  - 1. Experienced
  - 2. Novice

mentals; tea scale, *Fiorinia theae* Green, on camellia and holly; and euonymus scale, *Unaspis euonymi* (Comstock), on euonymus, are some of the most common species. Feeding by scales can kill branches and degrade plant quality. Controls (two applications 10-14 days apart) are best targeted to the crawler stage or apply one application during the winter dormant period. Some scales are easily detected because they produce colorful armor or hairy filaments. Some excrete honeydew which usually becomes covered with sooty mold. Many scale species are held in check by their natural parasites and predators. Pheromone traps are available to monitor for the adults of some scale species.

Mealybugs are close relatives of scale and are also common in Florida on ornamentals. Most species prefer moist, shady conditions. Nursery plants with compact growth habits such as *Ilex helleri* and azaleas are often attacked by *Ferrisia virgata* (Cockerell), the striped mealy bug. Many other species are pests and controls for scale should also be effective for mealybugs. Detection methods for mealybugs are similar to those for scale.

Lacebugs: The azalea lacebug, *Stephanitis pyriodes* (Scott), attacks azalea and *Rhododendron* spp. Azalea lacebugs feed on the leaf mesophyll tissue causing the plant to appear mottled and off-color. Azalea lacebugs more frequently attack azaleas in the sunlight, but damage other azaleas also. They are pests more often in the landscape than the nursery. Four or more generations of azalea lacebug occur in Florida, but the most severe damage occurs during the cool months from fall to spring. Lacebugs are not easily detected until their feeding mottles the leaves. The adults are grayish in color with lacelike wings. Infested leaves will have large, dark drops of excreta on the undersides. Many other species of lacebugs attack various ornamental plants. The sycamore lacebug, *Corythuca ciliata* Say, is an important summer and fall pest of sycamore. The fringetree lace bug, *Leptoypha mutica* (Say) is a pest of fringetree, *Chilionanthus virginicus* L. and ash, *Fraxinus* spp. (Mead, 1975). The hawthorn lacebug, *C. cydoniae* (Fitch) causes severe leaf damage to firethorn, *Pyracantha coccinea* Roemer, as well as many other rosaceous plants (Mead, 1972). Lacebugs can be controlled easily with one or two insecticide applications. Natural enemies are known to feed on lacebugs, but their impact is unknown.

Pyracantha leaf crumpler, *Acrobasis indigenella* (Zeller), is mainly a pest of landscape pyracantha. The larvae feed on leaves and surround themselves in a tube shelter covered with dead leaves and feces. The larvae overwinter on the plant in the tubes and begin feeding on the new leaves at budbreak. They damage the foliage and the feeding tubes are unsightly when found in high numbers. The larval nests are easily detected along the stems and branches. Little is known of the biology of this minor pest. Natural enemies do attack the larvae in Florida (Mizell unpublished data, 1991).

Red imported fire ants, *Solenopsis invicta* Buren, occur throughout the year, but are most active in the warm months. They are a nuisance pest whose bites can be hazardous to workers. Because of the quarantine regulations, fire ants have been elevated to a status of primary importance. Every nursery grower who sells outside the quarantine zone must be familiar with and follow the current regulations to meet certification. Your local plant inspector can provide the current quarantine regulations.

Borers: Many species of boring insects attack the trunk, stems, bark, and roots of ornamental plants in both the nursery and landscape. Adult clearwing borers are moths that resemble bees and wasps. Most of these species can attack healthy as well as weak or injured trees, but are more commonly found associated with stressed plants. Most species of hardwood trees are attacked by some species of borer. The dogwood borer, *S. scitula* (Harris), is the most destructive pest of dogwood. Damage by this borer is related to trunk injury and sun exposure. Larvae tunnel under the bark in the phloem and feeding damage may result in limb dieback, unthrifty or dead trees. There is one generation a year and adults emerge in spring or early summer. The magnolia borer, *Euzophera magnolialis* Capps, (not a clearwing) infests container magnolia. The larvae mine the roots and destroy the phloem tissue. The eggs are laid on the tree and the larvae move into the media to find a root. As they feed they move toward the root collar. At maturity they can be found feeding in the zone of the trunk about two inches from the media. The bark will appear spongy to the touch and frass may be observed in the area. Two to three generations occur per year. (Dr. G. Liebee is researching this species at Sanford AREC). The peachtree borer, *Synanthedon exitiosa* (Say), along with the lesser peachtree borer, *S. pictipes* (Grote and Robinson), attack most species of *Prunus*. They feed in the phloem under the bark and girdle the trunk or branches of these fruit trees. Pheromones have been identified for many clearwing borers and can be used to monitor for them (Sharpe et al., 1978; Sharpe and Eichlin, 1979; Snow et al., 1985). The elm borer, *S. geliformis* (Wlk.), attacks a variety of hardwood trees including chinese elm, pecan, hickory, oak, pine, and dogwood. It can be an important pest of elm nursery stock where it feeds under the bark and girdles the trunk. The maple callus borer, *S. acerni* (Clemens), attacks red and white maple. The ash borer, *Podesia syringae* (Harris), is a common pest of ash throughout the United States. Natural enemies attack borers, but do not regulate them to low levels.

Boring Beetles: Other families of borers commonly attack hardwood and conifer trees. The metallic wood borers such as the flatheaded appletree borer, ambrosia beetles, shothole borers such as, *Xyleborus* spp. and *Xylosandrus* spp., and engraver beetles, *Dendroctonus* spp. and *Ips* spp., may attack trees growing under stressed or injured conditions. "Healthy" trees are also occasionally attacked. Typically, borers must be controlled with preventative insecticide treatments, because, once the insects are under the bark, they are difficult to control. Pay particular attention to plants showing signs of stress such as wilting, disease infection or injury from equipment. Borers of one species or another will successfully attack such trees usually during the summer months. Small holes in the trunk or limbs with fine sawdust indicate the presence of these beetles. The dogwood twig borer, *Oberea tripunctata* (Swederes), is a longhorn beetle that infests elm, viburnum, azalea, sourwood and fruit trees (*Prunus* sp., *Malus* sp.), but dogwood is the most common host. The larvae tunnel through the terminal twigs and cut small holes to the outside from which they expel sawdust and feces. Infested twigs are girdled and killed by the female when she oviposits. Infested twigs wilt and hang on the tree or drop to the ground. Natural enemies attack boring beetles, but do not reduce them to low levels in nursery stock.

Fall webworms are the larvae of the moth, *Hyphantia cunea* (Drury). The larvae feed gregariously on foliage of many different host species from inside an unsightly web. The larvae are hairy and tan to brown in color. Pecan and other hardwoods are preferred host plants. Two to five generations occur each year. Two generations occur on pecan, one in May-June and another in July-August. Nursery trees are usually attacked in September-October. The larvae are heavily parasitized, but may completely defoliate small trees in a short time. Removal of the larvae in the web or by pruning is an alternative to control with insecticides.

The forest tent caterpillar is the larvae of the moth, *Malacosoma disstria* Hubner, and is closely related to the eastern tent caterpillar. However, the forest tent caterpillar does not feed in a webbed tent. The larvae are black and somewhat hairy with a row of yellow and blue keyhole-shaped spots down the center of the back. Single larva are often found in early spring feeding on the buds or new leaves of a variety of deciduous plant species which they may severely damage. Application of an insecticide at budbreak may be necessary to suppress the damage from this pest.

There are many gaps in our knowledge of these pests of ornamentals. Table 2 is an outline of the biological and operational information that are important from an entomologist's point of view and lists the types of information that should be considered in making the best IPM decision. Many factors are related to characteristics of the pests and must be considered along with those operational factors that are controlled by the nurseryman. The relative importance allocated to each of the factors is for the judgment of the nurseryman. The table should help the decision maker to gather information in a systematic way and then to analyze the information within the constraints of his or her management objectives and the law. Many factors such as plant protection and quarantine laws, pesticide labels, etc., are beyond the control of the manager, e.g. fireant certification, and may override any other choices in the management plan. However, in 1991 these types of decisions by nurserymen from day to day are probably the exception rather than the rule. In the future it is probable that fewer tools and more outside regulations will affect IPM decisions. For this reason it is important that nurserymen constantly update their strategies and tactics. The environmentally-sound IPM approach will require much more intensive management of resources and information. Table 2 is a first step towards the organization of a variety of information into a quantitative, objective outline in which data can be collected, synthesized and applied for successful decisionmaking.

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ABNORMAL STOMATA IN VITRIFIED PLANTS FORMED *IN VITRO*

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Abstract. **Vitrification is a physiological disorder which can be a serious problem in plant micropropagation. Vitrified microplants lose their ability to propagate and/or present difficulties of *ex vitro* acclimatization. Scanning electron microscopic observations of leaf surfaces of vitrified and non-vitrified shoots of soybean, chicory witloof, and carnation were conducted. Vitrified leaves had fewer stomata per unit area than non-vitrified leaves. Distorted, occluded and closed stomata were observed in vitrified leaves. Surface epidermal cells in vitrified leaves were elongated and twisted. It is suggested that modifications in stomata and leaf surfaces observed in vitrified microplants reduce water loss through transpiration leading to water accumulation in the lacunae and ultimately to vitrification disorders.**

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