APPENDIX B
Seed and Cone Insect Pests and Longleaf Pine
Integrated Pest Management at the Stuart Seed Orchard
Prepared by Alex Mangini, Forest Health Protection

IMPORTANT OF LONGLEAF PINE

Longleaf pine, Pinus palustris (Mill.), is perhaps the most impressive and characteristic tree in the southeastern United States. Mature trees are tall, stately and long-lived. Longleaf savannahs and woodlands are park-like open stands. Longleaf pine is the major component of the fire-climax forest ecosystems in the southeastern Coastal Plain. These ecosystems are estimated to have occupied 60 million acres in pre-settlement times; now, however, they are less than 5% of the original area, about 4 million acres (Boyer 1990).

Longleaf pine is important in two main respects, ecologically and silviculturally. It is a key component of ecosystems. Mitchell et al. (2006) give an excellent summary of the role this species plays in savannahs and woodlands of the South. Longleaf pine ecosystems have very high biological diversity in both species richness and number of endemic species. Mitchell et al. (2006) state that, “... nearly two-thirds of all species that are recognized as declining, threatened, or endangered in the southeastern United States are associated with this [longleaf pine] ecosystem.” Frequent fire is a major factor in these ecosystems and serves to maintain diversity. The open-canopy structure of longleaf pine stands provides habitat for the Gopher Tortoise, Gopherus polyphemus (Daudin), and the Red-cockaded Woodpecker, Picoides borealis (Vieillot), both endangered species.

Longleaf has been a major component of the timber industry in the South. Its continues to be important silviculturally because of its high-quality wood and its relative resistance to insects and disease (Barnett and Pesacreta 1993). The value of the species will continue to increase because of demand for high-quality wood products in the current global market (Mitchell et al. 2006).

RESTORATION OF LONGLEAF PINE

The desirable ecological and silvicultural characteristics of longleaf pine have, in the last few years, spurred a movement to restore the species to its historical sites on USDA Forest Service land and other federal holdings. The Southern Region of the Forest Service has a program for longleaf restoration to sites that were logged and planted to loblolly pine, Pinus taeda L., or other pine species in the 1950-60's. These areas are now reaching maturity and current management is focused on restoring ecosystems that maintain biological diversity as well as timber resource (Mitchell et al. 2006). Consequently, there is an increasing demand for longleaf pine seed, especially genetically improved seed from USDA Forest Service, Southern Region orchards. This genetically improved seed has demonstrated substantial gains in height growth and resistance to brown spot needle blight caused by the fungus Scirrhia acicola (Dearn.), a major mortality factor for longleaf seedlings (Nelson et al. 2005).
However, longleaf pine silviculture has long been plagued by difficulties in seed production, cone and seed processing and storage (Barnett and Jones 1993, Barnett and Pesacreta 1993, Boyer 1990) and difficulties in artificial regeneration (Boyer 1990, Mitchell et al. 2006). Longleaf pine produces good cone crops erratically (Boyer 1990). The seed is difficult to process and store because the seed coats are porous and weak and subject to fungal infection (Barnett and Jones 1993, Barnett and Pesacreta 1993). Recently, however, improved handling has increased germination (Barnett 2002); and it is now possible to grow “containerized” seedlings in the nursery (Hainds and Barnett 2006). These containerized seedlings have made artificial regeneration of longleaf pine practical and this, then, has hastened the demand for quality seed.

LONGLEAF PINE SEED PRODUCTION – PROBLEMS

Large cone crops of longleaf pine are episodic within localized areas (Mitchell et al. 2006). Crops sufficient for natural regeneration occur roughly every four to seven years (Boyer 1990, 1998). It is possible for complete loss of a seed crop to occur. Flower (the strobilus from bud initiation to anthesis), conelet (the strobilus from anthesis to fertilization) and the cone (the strobilus after fertilization – essentially the second-year cone) all are subject to damage and loss (Boyer 1990). Loss of conelets is the primary factor in poor crops (Boyer 1987); most of these conelet losses occur in spring (Boyer 1990) but significant losses can occur in the summer (McLemore 1977).

Numerous explanations have been posited for conelet loss in longleaf pine. These include insects, weather, lack of pollen, poor pollen-tube development, competition from rapidly growing shoots and needles, production of ethylene by shoots and needles, nutrient imbalance and pitch canker infection.

Wet spring and early summer conditions followed by a dry late summer promote conelet production the following spring (Boyer 1990). Frost near the time of anthesis can kill flowers (White et al. 1977). The effects of poor pollen production and pollination are problematic. McCall and Kellison (1981) stated that lack of pollen in longleaf flowers and failure of pollen to germinate did not cause conelet abortion. Similar results were seen by White et al. (1977). However, Boyer (1990) maintains that insufficient pollen is a factor in longleaf conelet loss. Rapid growth of shoots and needles may cause abortion due to competition with conelets for carbohydrates (Kossuth 1982, McCall and Kellison 1981 and White et al. 1977). Conelet abortion tends to occur at or near the same time as the second flush of needle growth in longleaf pine (McCall and Kellison 1981). The tree may not be able to produce adequate energy for both conelet and vegetative growth.

Hare (1987) states that the “physiological drop” of longleaf pine conelets results from the production of ethylene by rapidly growing foliage and shoots. Ethylene promotes the production of abscissic acid that causes an abscission layer to form resulting in abortion of the conelet (DeBarr and Kormanik 1975). Application of anti-ethylene compounds shortly after anthesis reduced conelet loss as did application of boric acid and cytokinin compounds (Hare 1987). Nutrient imbalances may also play a factor in this “physiological drop”. Boron seems to
counteract the effects of ethylene. When imbalances occur, such as after high doses of NPK fertilizer, boron may be unavailable to the tree and conelet abortion results (McCall and Kellison 1981). Heavy fertilization may result in conelet abortion because it stimulates vegetative growth which competes with the conelets (White et al. 1977).

Pitch canker is a disease of pines caused by the fungus *Fusarium circinatum* Nirenberg and O’Donnell. The disease can be a serious problem in pine seed orchards because wounds in the trees serve as infection courts for establishment of the fungus (Dwinell and Barrows-Broaddus 1981). Pruning wounds, scars from cone removal, damage from tree-shakers and other wounds are often the source of infection. Resinous cankers form at infection sites and shoot or crown dieback can also occur. Shoot dieback can kill all cones on a branch. The fungus can also cause abortion of female flowers and conelets, kill cones and infect seed (Dwinell and Barrows-Broaddus 1981).

Finally, insects take a toll of developing conelets and cones. Although some studies have indicated little or no effect on conelet loss by insects (Hare 1987, Kossuth 1982, White et al. 1977), much research has been done on the effects of seed and cone impacts and their effect on crop survival in southern pines (DeBarr 1971, 1981, 1993, DeBarr and Ebel 1973, Fatzinger et al. 1980, and Godbee et al. 1977). The impact of seed and cone insects on forest productivity in the South is comparable to that caused by the southern pine beetle, *Dendroctonus frontalis* Zimm., although not as dramatically apparent (Weir 1975). Seed bugs can cause conelet abortion and seed destruction (DeBarr and Ebel 1973); coneworms can destroy cones completely (Ebel et al 1980). The impact of seed and cone insects on southern pines will be discussed in detail in the next section.

In summary, many factors contribute to the erratic production on cone crops in longleaf pine. Also, even if cones are produced in large numbers, there is no guarantee that all seeds will be viable. In any given year, and at any location, longleaf seed production may be dramatically affected by of the factors mentioned; this is also true for longleaf pine in seed orchards.

**THE INSECTS – CONEWORMS AND SEED BUGS**

**Impact on Cone Crops**

Insects can cause serious damage to pine seed crops. In the South, the major seed and cone pests are coneworms and seed bugs. Collectively, these two groups of insects can severely limit seed production in pine seed orchards and have been known to cause up to 90% loss of a seed crop (Fatzinger et al. 1980). Studies conducted at the Stuart Seed Orchard indicated significant losses to insects for the four species of pine present in the orchard, longleaf, loblolly, shortleaf, *Pinus echinata* Mill., and slash pine, *Pinus elliotti* Engelm. (Fatzinger et al. 1980, McLemore 1977). Species of *Dioryctria* were the primary mortality factor for longleaf pine conelets in 1973 and 1974 (McLemore 1977). Fatzinger et al. (1980) conducted a survey of factors causing mortality of cones and reduction in seed quality from 1973 to 1976 at the Stuart Seed Orchard and other orchards. Life table analyses of the data indicated that conelet abortion occurred on longleaf and shortleaf pines. Coneworms killed 16.7% of the longleaf pine conelets. Coneworm-caused
mortality was about 16% in the “flower to early conelet” stage of development, about 10% in the “early conelet to green cone” stage and minimal in the “green cone to ripe cone” stage at the Stuart (Fatzinger et al. 1980).

DeBarr and Ebel (1973) used screen-wire cages to prevent feeding by seed bugs on conelets of shortleaf pine. Selected clusters were randomly infested with seed bug nymphs and adults (leaf-footed pine seed bug) at various times during conelet development. Most of the conelets subjected to nymphal feeding aborted. There was a 2.5-fold increase of sound seed by excluding seed bugs in the second growing season in loblolly pine. Second-year cones fed on by seed bugs had fewer seeds and less viable seed.

**Biology of Coneworms**

Moths of the genus *Dioryctria*, commonly called coneworms, are small, gray or brown-orange moths with crossbands on the forewings. Four sympatric species infest pines in the South: the southern pine coneworm, *D. amatella* (Hulst); the blister coneworm, *D. clarioralis* (Walker); the webbing coneworm, *D. disclusa* Heinrich; and the loblolly pine coneworm, *D. merkeli* Mutuura and Monroe. Coneworm larvae feed in the conelets, cones and stems of pines. Infested cones are destroyed making coneworms major pests in seed orchards (Ebel et al. 1980).

**The Southern Pine Coneworm – *D. amatella***. This species occurs throughout the South and frequently infests longleaf pine. This species is consistently one of the most serious pests pine cones (Ebel et al. 1980). It has several generations in a season and there is overlapping of generations. The main emergence of adults occurs in the spring. On slash and longleaf pines, the early-season infestations occur in the flowers and shoots. The larvae may also be found in fusiform rust galls. The second and subsequent generations occur in cones. First-instar larvae overwinter (Ebel et al 1980). In the spring, the small larvae feed on male and female flower buds. Damage caused to second-year cones early in the season is caused by *D. amatella*. At the Stuart Seed Orchard there are historically three emergence periods, mid- to late-April, mid- to late-June and through most of September (Weatherby and Wallace 1982). Most cone damage at the Stuart Seed Orchard in 1982 and 1983 was attributed to this species (Weatherby et al. 1983).

**The Blister Coneworm – *D. clarioralis***. This species has a wide range including most of the southern states. It also ranges up into the mid-Atlantic states. In general, the species causes less damage than the southern pine coneworm. The blister coneworm has three generations per year in the southern states. It attacks flowers, buds and shoots as well as conelets. It is frequently found on longleaf pine. Infested material has a typical resin, silk and frass blister covering the entrance hole of the larva (Ebel et al. 1980). The mature larva of the last generation overwinters. In 1982, this species was considered the primary pest at the Stuart Seed Orchard (Weatherby and Wallace 1982). The first blister coneworm emergence occurred from early May to May 20. The mid-season emergence was not detected and the third generation occurred over an extended period from mid-September until cone harvest (Weatherby and Wallace 1982).

**The Loblolly Pine Coneworm – *D. merkeli***. The loblolly pine coneworm has an extensive range similar to that of the blister coneworm. The loblolly pine coneworm has only one generation per year. Young larvae overwinter and then infest flowers and shoots of pines in the spring. Some
larvae complete development in the shoots; others move to cones. Mature larvae remain inactive in shoots or cones throughout the summer. Pupation and adult emergence occur from August to October. This species causes considerable damage to loblolly pine but can occur in large numbers on other pine species (Ebel et al. 1980). At the Stuart Seed Orchard, shoot attacks are usually the earliest visible coneworm damage; these shoot attacks can be attributed to the overwintering young larvae of *D. merkeli* (Weatherby and Wallace 1982).

**The Webbing Cone Worm – *D. disclusa***. This species has a large distribution throughout the eastern half of the United States. It tends to occur sporadically in localized infestations. However, these infestations can be dramatic, sometimes causing complete loss of cone crops (G. DeBarr, personal communication). The webbing coneworm has a single generation per year. Adults emerge in late spring and early summer and lay eggs. The eggs hatch and the early-instar larvae diapause until the following spring. The young larvae feed initially in the male flowers. When the male catkins dry, the larvae move to the second-year cones, early in the season. These cones are killed by the larvae before they start to grow. The larvae pupate in the dead cones (Ebel et al. 1980). Although this species has been collected at the Stuart Seed Orchard, it does not appear to as important as the other three species at this location (Weatherby and Wallace 1982).

**Biology of Seed Bugs**

Adults and nymphs of the leaffooted seed bug, *Leptoglossus corculus* (Say) and the shieldbacked seed bug, *Tetyra bipunctata* (Herrich-Schaffer) use their piercing-sucking mouthparts to suck out the contents of developing seeds in cones and conelets (Ebel et al. 1980). Unlike coneworms, seed bugs have incomplete metamorphosis and the immature insects (nymphs) look like miniature versions of the adults. Larva and pupae do not occur. Also, unlike coneworm larvae which spend most of their life cycles within the cones, seed bugs move freely from one cone cluster to another. They are highly mobile within tree crowns and are strong fliers (Ebel et al. 1980).

**The Leaffooted Pine Seed Bug – *Leptoglossus corculus***. The leaffooted pine seed bug is distributed throughout the eastern United States. Adults are large, conspicuous bugs about one inch long. Adults are brown with a white zig-zag marking across the back. Both adults and late-instar nymphs have leaf-like expansions on the hind legs. Adults overwinter. Eggs are laid on pine needles in the spring. Second-stage nymphs feed on conelets. Older nymphs and adults feed on seed in elongating cones. Several generations occur in a season and all life stages can be found through most of the growing season (Ebel et al. 1980). Typical damage is conelet abortion caused mostly by nymphs feeding on developing ovules (DeBarr and Ebel 1973). Feeding by adults is usually estimated examination of radiographed seed samples (Ebel et al. 1980). Populations of *L. corculus* vary widely among seed orchards and at a given location numbers can increase dramatically through the season (Weatherby and Wallace 1982).

The leaffooted pine seed bug is a major pest. All species of pine grown in seed orchards in the South are attacked. Because it is active throughout the growing season, has multiple generations in a season, and is highly mobile, relatively few *L. corculus* per tree can cause extensive losses.
When large numbers of this species are observed at cone harvest, the damage has already occurred (Ebel et al. 1980).

The Shieldbacked Pine Seed Bug – *Tettyra bipunctata*. This species is distributed across most of the eastern and southern United States. The adults and nymphs have a shield-like “stink bug” shape and are usually gray to reddish-brown in color. Eggs are small, bright-green spheres laid in clusters on needles and cones. The shieldbacked pine seed bug overwinters as an adult in the litter under trees (Ebel et al. 1980). There is apparently an obligate diapause because adults do not usually appear until mid-summer (DeBarr and Ebel 1973). Consequently, there is only one generation per year. Feeding by both nymphs and adults is limited to nearly mature seed in second-year cones. The species occurs on all major pine species. Peak populations coincide with cone harvest; at this time they are most frequently observed (Ebel et al. 1980). The damage potential of *T. bipunctata* is not considered to be as great as that of *L. corculus* because the shieldbacked pine seed bug has only one generation per year and its feeding is limited to nearly mature seed (DeBarr and Ebel 1973, Ebel et al. 1980).

**The FHP Longleaf Inventory at the Stuart Seed Orchard**

The Stuart Seed Orchard (now called the Stuart Genetic Resources Management Area, or Stuart GRMA) was established in the mid-1960's under the term of Supervisor Ray Brandt. The area had been a nursery since the 1930's. Nursery operations were moved to Mississippi and the area was planted to grafted loblolly, longleaf, shortleaf and slash pines. The grafted trees were from superior trees collected from districts in Louisiana and Mississippi. The intent was to provide quality seed for these districts (Burns 1994).

Since then, genetic breeding work has been done at the Stuart Seed Orchard. In addition to the first-generation orchard blocks established in the 1960's, there are now second-breeding cycle blocks of loblolly, longleaf and shortleaf pines and clone banks of trees from other provenances such as Mississippi.

Entomologists and Plant Pathologists from the Alexandria Field Office of Forest Health Protection (Southern Region State and Private Forestry) (FHP) have worked with the staff at the orchard for many years to monitor and evaluate seed and cone insect and disease problems and make recommendations for management, for example (Weatherby and Wallace 1982, Weatherby et al. 1983, Negron et al. 1990).

**Tagged Flower/Cone Survival Counts.** Since the mid-1980's, FHP has continuously monitored seed and cone insect levels at the Stuart Seed Orchard. The purpose of the inventory-monitoring work at the Stuart Seed Orchard is to 1) quantify the losses attributed to major mortality factors, 2) determine the periods when the mortality occurs, 3) determine the effect that the losses will have on the projected cone crop, and 4) identify areas where the pest management strategy can be adapted to better respond to pest pressures (Weatherby and Wallace 1982).

During the 1980's and early 1990's, the Stuart Orchard was actively managed and pesticides were applied routinely. The inventory process enabled the entomologist to recommend adjustments in products and rates to the orchard manager for control (Weatherby and Wallace 1982, Weatherby
et al. 1983). Since the mid-1990's, the agency has reduced artificial regeneration and reduced its demand for seed other than longleaf pine. Responding to this, FHP has monitored only the Louisiana longleaf pine orchard block.

The procedure used by FHP is a modified life-table inventory monitoring system first used by Fatzinger et al. (1980) and refined by Bramlett and Godbee (1982). In the Louisiana longleaf pine source, six clones are selected from the high production class, medium production class and low production class. Three ramets (two since 1989) are sampled from each clone for a total of 48 ramets (36 since 1989) (Negron et al 1990). In the southeastern quadrant of each ramet, eighteen clusters of cones are chosen and individually tagged using an aluminum nursery tag attached with flexible wire. Tagging allows identification of individual flowers and enables FHP personnel to find the clusters in subsequent visits (Weatherby and Wallace 1982, Weatherby et al 1983). Number of flowers is recorded for each cluster. Tagging is done in late March or early April, after the expanding flower buds are easily visible.

Each ramet is revisited four to six times as the tagged flowers develop to mature cones the following year. Thus, there are two cone crops being monitored – the flowers of the present year and the cones from the previous year. At each visit, health of conelets/cones is evaluated and a causal agent determined, if possible. The major categories are: healthy, coneworm (green, dead and shoot attack), unknown, missing and pitch canker. Upon completion of the survey for a given year, damage estimates and cone crop survival curves can be prepared.

**Seed Bug Damage Estimated by Radiography.** In addition to tagged survival counts, at cone harvest, six healthy cones from each survey ramet are collected. The cones are placed in kraft paper bags, one per ramet. The bags are placed under an equipment storage pole shed at the orchard and allowed to air dry from harvest until early January. At this time, the bags are placed in a kiln and dried for at least sixteen hours at 110°F. This causes the cones in the bags to open. The seeds are extracted and 100 seeds from each ramet are dewinged by hand, placed in small coin envelope and radiographed (Negron et al. 1990). The radiographs are examined to determine seed quality. The quality categories are: healthy (full), empty, seed bug damaged, aborted (first-year), seed worm damaged, other. Estimates of seed bug damage can be made (Bramlett et al. 1977).

**Estimating Coneworm Populations Using Traps.** Adults of the four coneworm species are nocturnally active and fly in the crowns of the pine trees. The female moths release a mixture of volatile chemicals that act as an attractant (pheromone) for the males. This enables males to locate females for mating. In the 1980's the coneworm pheromone components were isolated and identified (DeBarr et al. 2000). The pheromones can be produced synthetically and placed in a bait that can be attached to a conventional sticky trap. The males are attracted to the bait and trapped in the sticky material. Routine examination of the traps allows the estimation of species present, relative numbers and periods of activity for the four coneworm species (DeBarr et al. 2000). The technique is inexpensive, easy to deploy and species-specific (DeBarr 1981, Weatherby et al. 1985).

trapping was conducted by orchard personnel for several years after that (Jack Garner, personal communication). Pheromone traps were used by FHP to monitor coneworm populations in 2006 and 2007. These traps are placed in the Mississippi loblolly pine clone bank and the second-generation loblolly pine production block.

**THE FHP LONGLEAF INVENTORY DATA**

**Tagged Flower/Cone Survival Counts.** Analysis of tagged cone survival data collected from the Louisiana longleaf source from 1996 through 2008 indicate that the mortality factors and temporal occurrence of the mortality are consistent with past studies of longleaf pine (Boyer 1998, Fatzinger et al. 1977); there are often dramatic losses that occur in the first weeks after anthesis.

Separation of the “good” cone crop years (those with more than ten percent healthy cones) from the “bad” cone crop years (Table 1) shows that coneworm damage is noticeably higher in good crop years with an average of 27.5 percent. This compares to only 8.6 percent in bad seasons when little or no healthy cones remain. In contrast, the unknown and missing categories have substantially higher percentages in the bad years. Most of the “unknown” and “missing” mortality occurs in the first year within two months of anthesis; consistent with the reports of longleaf pine conelet abortion (see above, Longleaf Pine Seed Production – Problems).

**Table 1.** Comparison of cone crops and mortality factors for the Louisiana longleaf pine seed source, USDA Forest Service Stuart Seed Orchard, Pollock, LA, from 1996 through 2007.

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<td>28.6</td>
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</tbody>
</table>
In years when “physiological drop” occurs, due to whatever cause, coneworms are unable to exploit the resource because it is not there. In good years, sufficient conelets survive the first year to allow coneworms to infest them, they then infest the elongating cones the second year, and the result is a large amount of coneworm damage. However, because conelet survival is good, many cones remain healthy through to harvest; the coneworms cannot reproduce fast enough to exploit these cones.

**Seed Bug Damage Estimated by Radiography.** Examination of radiographs of extracted seed shows most seed being healthy in most years. However when seed bug damage is combined with “empty” seed, the true impact of seed bug is apparent (DeBarr and Ebel 1973). Seed bug destroys roughly 20-25 percent of the extracted seed. In addition to this, the impact of *L. corculus* nymphs on conelet abortion must also be considered.

### Seed and Cone Insect IPM

**Historical Background**

Throughout the 1970-80's, the standard method for controlling seed and cone insects in pine seed orchards throughout the South was routine monthly sprays of Guthion® (azinphosmethyl) at 3 pounds active ingredient (AI) per acre. This was a lot of chemical; and a chemical that, as an organo-phosphate, was highly toxic to mammals and birds as well as insects. This method of control was used for years at the Stuart Seed Orchard (H.N. Wallace, personal communication).

In the last twenty years, however, pine seed orchardists have moved away from such routine applications of “hard” pesticides to an approach called Integrated Pest Management (IPM) (DeBarr 1981, Mangini et al. 2003). IPM is the use of “...all suitable techniques in an organized way, to reduce pest populations and maintain them at levels low enough so that losses can be tolerated” (DeBarr 1981). Essentially, the adoption of IPM is a change in management philosophy from emphasis on “killing pests” to “reducing losses from pests” by using all available tools, including pesticides when appropriate, to reduce pest populations below a damage threshold while minimizing the impact on the environment (Pedigo and Rice 2005).

In 1996, Kenneth R. Johnson, Supervisor, National Forests in Mississippi, made IPM the accepted method of pest control for the G.F. Erambert and Black Creek Seed Orchards by signing the Record of Decision (ROD) on the Final Environmental Impact Statement (FEIS) prepared for pest management activities on these two orchards. In the ROD, it is stated that IPM for [USDA Forest Service] forest seed orchards is “... the maintenance of pests at tolerable levels by a variety of preventative, suppressive, or regulatory methods (including no action) consistent with seed orchard management goals.” Since 1996, IPM has been accepted for all other seed orchards in the Southern Region including the Stuart Seed Orchard.

| Mean     | 1.4 | 8.6 | 69.1 | 17.4 |
Seed and Cone Insect IPM at the Stuart Seed Orchard

Currently, there are six products registered for use on cone and seed insects. Four of these are pyrethroid-insecticides which have been widely used in agriculture for years. One, Confirm® 2F, has tebufenozide as the active ingredient. This compound mimics the insect molting hormone, ecdysone. It causes larvae to molt prematurely and prevents further development. This product is specific to lepidopteran pests such as the coneworms. Additionally, it has very low avian and mammalian toxicity.

Site-specific Issues at the Stuart Seed Orchard

Red-cockaded Woodpecker. The endangered red-cockaded woodpecker is present on the Catahoula Ranger District where the Stuart Seed Orchard is located. There is an active cluster of woodpecker-inhabited trees near the work center buildings on the orchard site. The woodpeckers forage for insects and other prey on the trunks of the larger trees in and around the orchard site. Consequently, insect pest management activities must take into account this species.

Limitation to Ground Application Methods. Currently, aerial application of pesticides to seed orchards in not an option for USDA Forest Service orchards. Even if this limitation did not exist, however, it is unlikely that aerial application would be used to apply insecticides to the Louisiana and Texas longleaf sources at the Stuart Seed Orchard because of the proximity of private homes to the orchard.

Ground application of insecticides can be done effectively. Ground application using a mist blower is an effective method of control; modern mist blowers provide a high degree of control over spray properties.

Use of Confirm® 2F

Use of this product alone is the current preferred control option for seed and cone IPM at the Stuart Seed Orchard. Coneworms are controlled by this product; and, the FHP inventory data indicate that between coneworms and seed bugs, coneworms are the more serious threat to the longleaf pine cone crop. Seed bug damage is fairly consistent over time. However, as indicated above, coneworm damage varies dramatically from year to year.

The best strategy is to use Confirm® 2F applications to protect expected “good” crops; conversely, pesticide application is not necessary to protect “bad” crops. Because the “physiological drop” that causes poor or no longleaf pine cone production almost always occurs in the weeks after anthesis in the first year of the crop, it should be relatively clear when a “bad” crop will occur. Consistent monitoring of the cone crops from year to year is necessary.
LITERATURE CITED


