Forest Health Evaluation

Of

Southern Pine Beetle Infestations

In

Southern New Jersey

(2003 - Year 2)

March 5, 2004

Prepared by:

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New Jersey Forest Service
State and Private Forestry | Forest Health Program

http://www.nj.gov/dep/parksandforests/forest/njfs_spb.html

Abstract

New Jersey experienced a second consecutive year (2002 & 2003) of southern pine beetle *(Dendroctonus frontalis* Zimm.*)* infestations. These infestations are concentrated in Atlantic, Cape May and Cumberland Counties with isolated outbreaks in Burlington and Ocean Counties. Tree species infested are pitch pine *(Pinus rigida)*, shortleaf *(P. echinata)*, Virginia *(P. virginiana)*, loblolly *(P. taeda)*, red *(P. resinosa)*, and white *(P. strobus)*. Ornamental Norway spruce *(Picea abies)* has also been infested. Digital Aerial Sketchmapping (D-ASM), color infrared (CIR) photography and ground reconnaissance indicated SPB doubled in size from 1,270 to 2,508 acres in 2002 and 2003, respectively. Because of the infestation, the NJ Forest Service (NJFS) enacted a pilot suppression program to assist in halting the spread of SPB in designated areas. A total of eleven –(11) sites were selected for this pilot program with nine –(9) being approved for implementation. All sites will be evaluated in spring – summer 2004 for effectiveness. A spring Billings Trap Survey performed in cooperation with the USDA Forest Service resulted in low to declining projected SPB populations for 2003. However, in year 2002, the trap data indicated the same projections and the outbreak was epidemic. SPB monitoring and timing of trap deployment continue to be refined.

I. Introduction

This report is the second of what will be a series New Jersey Forest Service Forest Health Program updates regarding southern pine beetle (SPB). The first report: Forest Health Evaluation of Southern Pine Beetle Infestations in New Jersey (2002 Year 1) provides supplemental information regarding SPB. These two reports can be downloaded in PDF format from the NJFS web site at*: http://www.nj.gov/dep/parksandforests/forest/njfs_forest_health.html.*

During spring, the adult SPB breaks dormancy, exits the host trees and infests additional pine trees. Consequently, the NJFS in cooperation with the USFS (Northeastern Region) entomologists commenced trapping SPB in April 2003. There were eighteen -(18) traps deployed throughout the NJ pinelands region. The NJFS also performed various helicopter and fixed-wing reconnaissance flights and ground truthing to determine the extent of SPB infestations. These monitoring activities help determine when and where to begin an extensive aerial survey of the New Jersey Pinelands. Aerial reconnaissance determined that the aerial survey should commence in early fall 2003 to give the best representation of infestation.

Surveys indicated SPB infestations are occurring on federal, state, county and private lands. Concentrations are located where Atlantic, Cape May and Cumberland Counties adjoin and range from sub-acre to hundreds of acres in size. The largest infestation, 305 acres, is located on Peaslee Wildlife Management Area (WMA). This area increased 55 acres from 2002 to 2003.

Suppressing SPB infestations, salvaging effected trees and restoring the tree community is a priority stewardship goal of the NJFS. Without silvicultural operations, tree mortality created due to SPB infestations are expected to cause a range of problems in the following years. Dead pine trees lose their needles and tree canopies fragment thereby creating a serious and extensive fire hazard due to the accumulation of excessive forest fuels, increased solar radiation and fuel 'laddering' effects. Loss of canopy creates favorable conditions for understory vegetation such as shrubs and vines to increase colonization of the site without tree regeneration. These affects can cause extensive wildlife habitat alteration, degradation and destruction. Large expanses of dying and temporary standing dead trees compromise aesthetic and recreational uses of the forest by creating environments which may be unsafe for public use. In addition, roads and utility lines/right-of-ways will require special and costly maintenance as dead pine trees begin to fall or snap off.

II. Technical Information

The SPB continues to be the most destructive forest insect pest in the southern and the southeastern United States. In 2002, a record setting 93,000+ multiple-tree infestations were detected on federal, state and private forest lands

throughout the South, resulting in the loss of millions of dollars worth of resources (Upton and Billings 2003). Since its migration to southern New Jersey, it has been shown to attack all pine species growing in the pinelands region. New Jersey forest communities infested are pine, pine-hardwood (upland/lowland), pitch pine lowlands, pine/pine-oak; Civilian Conservation Corps (CCC) pine plantations and pine occurring in Atlantic white-cedar *(Chamaecyparis thyoides)* swamps. Stands with the greatest risk of attack have been shown to have one or more of the following characteristics: mature to overmature, high stocking densities, stresses from past drought(s), storm damage and disease (i.e. Pitch canker, *Fusarium spp.*). Most infested stands in the Pinelands are overstocked causing intense tree competition, stress and poor growing conditions. Overstocking subjects pine to future attack and an increase in SPB populations.

III. Life Cycle

The SPB has four life stages: egg, larva, pupa, and adult and can over-winter in all. Complete metamorphosis is accomplished in approximately 1-month and there can be up to seven generations per year in the southern United States. It appears there has been one to three –(1 to 3) generations in southern New Jersey as witnessed by rate and interval of progressing heads during the first two years of infestation. Biophysical modeling of SPB development rates suggests four to four and a half –(4 to 4.5) generations may be possible in southern NJ (Ungerer *et al.* 1999). Photo 1 to the left is the adult SPB courtesy of Texas A&M, image is not to scale.

Photo 1.

The adult SPB attacks living pine trees, feed on the phloem and construct a winding, characteristic s-shaped gallery in the inner bark. Individual niches are constructed perpendicular to this s-shaped gallery where the female deposits her eggs. When multiple galleries are constructed, overlapping will occur and the eventual girdling of the tree prevents the translocation of water and nutrients. Photo 2 to the right (NJFS) shows these galleries. Additionally, SPB often introduce blue-stain fungi *(Ophiostoma spp.)* into the trees vascular system, which penetrates the xylem, prohibiting translocation of water thereby accelerating mortality. The SPB eggs hatch into white c-shaped larvae with glossy reddish-brown heads. The larvae mine the inner bark where they construct pupal chambers just below the surface of the corky outer-bark. When pupation is complete, the new broods chews exit holes through the bark and fly to infest additional green trees. SPB may fly up to 0.4 miles in the spring and fall months to infest trees and generally attack trees nearby in the summer months. SPB can also be spread by wind and the movement of infested forest products (i.e. logs and untreated bark material).

Photo 2.

IV. Types of Damage

The damage caused by SPB activity is tree mortality (Photos 3 and 4). Depending on the time of year, number of SPBs attacking, presence of blue-stain and environmental factors, mortality may become noticeable within a few weeks to four months after an attack. Newly infested trees will begin to turn yellow progressing to red. This discoloration also indicates the direction the infestation is spreading. The presence of fresh red or yellowish-white pitch tubes can also act as a guide in determining the direction of spread. Eventually the trees will turn brown, loose their needles and die. The vacated trees do not resprout or releaf. Although, during the 2003-growing season some mass attacked trees remained green and did not discolor. This may be attributed to the significant amount of available water and nutrients the trees were able to absorb during a non-drought year. It is anticipated that these trees will die during the 2004-growing season. To date, over 550,000 forest trees in New Jersey have been killed by the SPB.

The damage shown in photographs 3 and 4 is an example of what is occurring throughout the areas of infestation. During the 2003 survey, it was noted that individual infestations from the previous year merged, forming larger contiguous tracts of dead mixed pine.

Photos 3 and 4 (NJFS) show mortality of pine on two sites in southern New Jersey

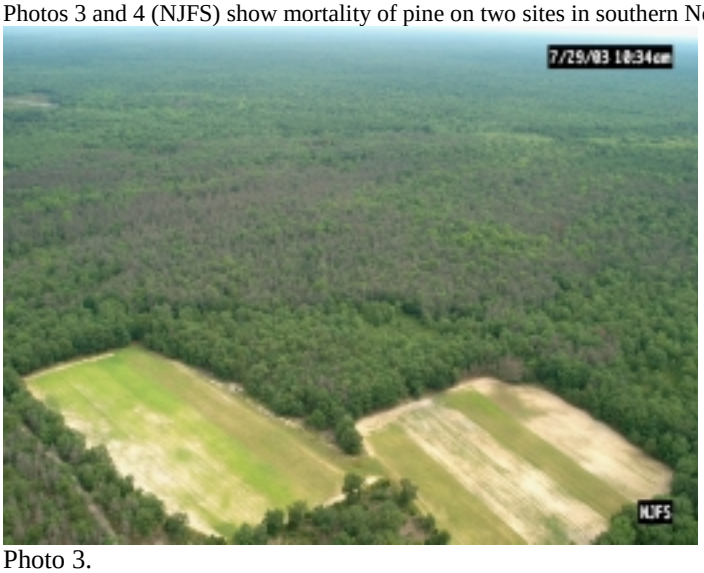

Photo 3.


Photo 4.

V. Methodology of SPB Mapping

The NJFS State and Private Forestry and Forest Health Programs (FHP) used Digital Aerial Sketchmapping (D-ASM) in 2003 to increase accuracy in Damage Causing Agent (DCA) delineation. D-ASM includes using an aerial observer(s); laptop computers loaded with in-house customized Geographical Information Systems (GIS) software, integrated Global Positioning Systems (GPS) and touchscreen monitors for drawing polygons over scrolling Color Infrared (CIR) Imagery. All areas within the NJ Pinelands where surveyed. Flight lines were flown east-west and west-east at two-mile intervals in the southern portion and four miles in the northern portion of the pinelands. This provided one and two mile coverage on each side of the aircraft, respectively. The difference in flight line width was due to aerial and on-ground reconnaissance and previously mapped 2002 infestation concentrations. It was determined that the southern portion of the pinelands would have a tighter swath of observation because nearly all infestations occur in the southern counties. The headwater of the Mullica River was the transition between two –(2) and four –(4) mile flight lines. The previous years SPB coverage was used as a reference for expansion of infestations and all areas of infested pine detectable were sketched.

The NJFS also acquired a grant from the US Department of Agriculture Forest Service (USFS) toward a photographic mission covering the concentrated infestation areas. The mission was flown by the USFS Region 8 based out of Atlanta, GA using CIR film, flying north to south producing nine by nine (9”x9”) photos at a scale of 1:1,000. An overlapping image set was acquired for stereoscopic coverage. These photos were used to increase accuracy in delineating SPB infestations and provided another tool for detection.

VI. Suppression Priorities

While the Suppression Project Criteria drafted during the first year of infestation is still relevant, refinement of priority areas has been established. Priority areas for suppression have been grouped into forest resource and recreational categories.

- Forest Resource Priorities

  CCC Plantations, experimental plantings, seed orchards and/or representative communities (coniferous and deciduous), strategic fuelbreaks, successful regenerating stands following previous DCA suppression or salvage, past harvest areas in need of thinning, and proximity to private property.

➢ Recreational Resource Priorities

Campgrounds, picnic areas, administration areas, priority trails, and forested areas adjacent recreational facilities The above priorities apply to state lands. However, private lands whether commercial, residential, rural or urban will have priorities pertaining to the landowners ability to implement suppression, salvage and restoration practices.

VII. Results and Discussion

Eighteen -(18) pheromone traps were deployed encompassing six -(6) counties throughout the NJ pinelands region on April 2, 2003. Atlantic, Burlington, Cape May, Cumberland, Ocean and Salem counties were surveyed. The survey was designed to monitor three -(3) traps per county, providing a better account for trap content variations. This is an increase from six -(6) traps deployed in spring 2002. It was anticipated that by deploying more traps per county a better projection of SPB could be estimated for 2003 as opposed to 2002. Traps were placed in areas where pine was not a dominant component so as not to draw the SPB into non-infested stands. The trap samples were then collected weekly and analyzed in order to determine the populations of SPB versus the predatory checkered beetle (*Thanasimus dubius* Fabricius). The results were included in the state cooperative, South wide SPB Prediction System. Initial results of trapping and corresponding SPB/checkered beetle ratio calculations predicted a static/moderate or declining/low SPB population for NJ. Of the remaining fifteen –(15) southeastern states (AL, AR, DE, FL, GA, KY, LA, MD, NC, OK, SC, TN, TX, and VA) cooperating in the survey, only two states, Mississippi and Louisiana, predicted increasing levels of SPB in 2003. Maryland and Delaware results indicated static/low levels of SPB (Upton and Billings, 2003). Weekly temperatures were also recorded to determine a correlation between temperature and SPB movement (see **Figure 1.** and **2.**).

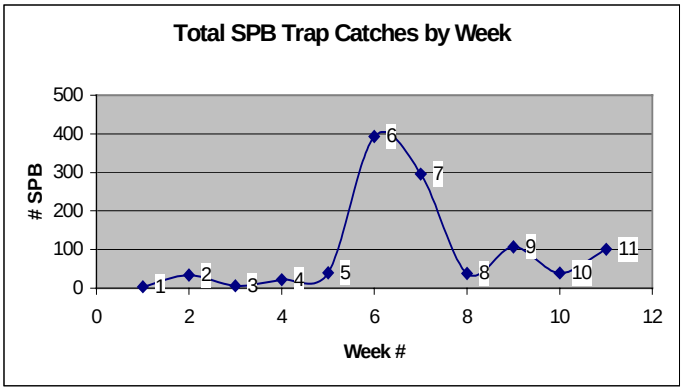

Figure 1. SPB catch trend over 11 weeks (4-9-03 to 6-19-03). The trap population spike characterized in week 6 may have marked the first mass emergence (generation 1) of adult southern pine beetle in 2003.

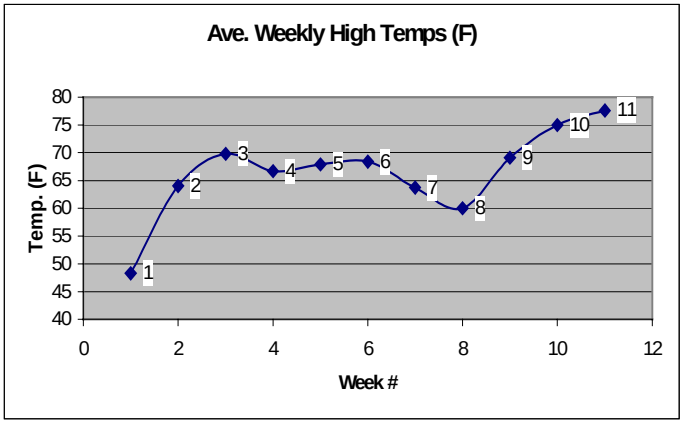

Figure 2. Traps were collected weekly starting April 9 and ending June19, 2003.

Annual predictions of infestation trends have proven to be 75-85% accurate (Upton and Billings, 2003). Nonetheless, 2002 SPB infestations reached epidemic levels in NJ while prior SPB predictions indicated low/declining for that summer. Further analysis of SPB trapping surveys may be required to predict SPB populations in NJ. However, spring trapping surveys in 2002 and 2003 fell upon abnormal spring climate conditions. The spring of 2002 was unusually

warm with record heat in early April but cooler than average later in that month. The spring of 2003 was cool and wet. Archived and future trapping data will be further analyzed and development or refinement of prediction trends suitable to NJ will be explored, if needed.

Aerial and ground truth surveys and the photographic mission indicated that 145 *new* SPB infestations developed in pinelands region from fall 2002 to fall 2003. Although the number of new and total infestations has decreased from 2002 to 2003, the average size has doubled. This is a result of individual infestations expanding as well as merging with other infestations (**Table 1**.).

Table 1. A comparison of SPB surveys - 2002 (yr. 1) vs. 2003 (yr. 2)

Survey Results					
Year	**Acres Infested**	**Total Number of SPB Spots**	**Average Size**	**Methodology**	**% change**
2002	1,412	265	5.3 acres	D-ASM[1]	N/A
2003	2,508	241	10.5 acres	D-ASM[2]	+ 56.3

[1] = Topographic map scrolling on a laptop computer with SPB points entered by touchpad
[2] = False Color Infrared imagery scrolling on touchscreen monitor with SPB polygons (infestations) traced and entered via. stylus into laptop computer

There may be more infestations occurring in the forest that have not been recorded. This is because additional trees could be under attack but their needles have not faded to the point of detection. In addition, it is likely that many spots less than one acre –(<1 acre) in size were not yet detectable by the 2003 aerial survey. These and any other infestations, if any, will be recorded during the 2004 survey. Infestations for 2002 and 2003 can be seen on **Map 1**.

Presently, uninfested pine stands in southern NJ are at risk for SPB attack. In order to expedite the approval process for suppressing SPB, the NJDEP Forest Service entered a Memorandum of Agreement (MOA) with the NJ Pinelands Commission. The MOA provided for eleven –(11) sites to serve as an example in SPB control. Nine –(9) sites are located in Belleplain State Forest and two –(2) in Peaslee Wildlife Management Area (WMA).

The NJFS selected Alternative 2 (Section IX.) in suppressing eight –(8) sites and Alt. 3 for one –(1) site. All infested trees were harvested and treated (chipped) for Alt. 2. This was performed by using the whole tree harvest method. Due to the location and size of the ninth site, Alt. 3 was implemented. These suppression sites were used as a comparison to other nearby non-treated sites for expansion or continued SPB activity. The suppression activity (**Map 2**) appears to have stopped and/or significantly slowed the spread of SPB in the immediate forested areas containing a pine component. However, due to the timing of completion (October) of suppression activities and the approach of SPB dormancy, a more conclusive evaluation may be necessary in spring/summer –2004. Conversely, SPB activity in the untreated areas used for a comparison indicated a significant increase in size (**Map 3**) during the period between surveys.

Photo 4.

The need to continue development of a SPB suppression and salvage operation are based on projected pine component losses, fire hazard, accessibility, logistics, wildlife habitat changes, and economics. Photo 4 shows SPB is not only a contiguous forest resource problem. Dead trees (blue arrow) present a danger to residential dwellings. The fire hazard is of particular concern due to wildfire history in the Pinelands region. As the trees brown, they drop their needles onto understory vegetation creating a fuel

ladder that can cause a ground fire to quickly climb into the tree crowns. A crown fire can spread fast, be difficult to control, and contribute to spot fires hundreds of feet away where this process could be repeated. Direct suppression by cutting and removing, at minimum, the heads of infestations is a prudent preventative measure. Not only is controlling the insect spread important, but direct suppression also secures the creation of firebreaks between beetle killed areas and surrounding forest regions.

The Division of Parks and Forestry continue to select target areas for suppression, salvage and restoration. Areas selected for prescribed burning (RxB) will consider erratic burning conditions created by SPB. The current SPB infestations impose serious negative effects to forest management objectives to Belleplain State Forest. These management objectives include but are not limited to forest health, timber production, watershed protection and improvement, forest fire management, wildlife management, and recreational values. The SPB has the potential to continue in drastically effecting all of these objectives.

Due to the cold temperatures NJ is experiencing for the 2nd consecutive winter, spring 2004 trap data will be particularly interesting in projecting SPB populations. Apparently, the severity of winter 2002-03 was not enough to halt the SPB population and prevent significant outbreaks in 2003. It is likely; however, that lower temperature thresholds experienced in winter 2002-3 and to date in 2003-4 did effect SPB populations in NJ. SPB is susceptible to extreme cold but is capable of withstanding temperatures well below 0° C (32°F). Supercooling (cooling the SPB to a point in which ice crystallization occurs within the body) has been documented to kill SPB (Louisiana origin) in all life stages by lowering body temperature to –12.8° C (9° F) (Lombardero *et. al* 2000). However, supercooling may not account for additional climate variables. Examining more practical and comparative measurements such lower lethal temperatures (cooling the air temperature around the SPB overwintering host trees) may lend better insight into temperature caused mortality. Lower lethal air temperatures of -16 °C (3.2 °F) have been found to kill more than 90% of the SPB influenced (Ungerer *et al* 1999).

Table. 2 Number of Days Low Temperatures Exceeded Supercooling or Lower Lethal Thresholds for SPB

	December	January	February	Total
2002 Supercooling[1]	0	5	4	9
2003 Supercooling[2]	0	5	0	5
2002 Lower lethal[3]	0	0	1	1
2003 Lower lethal[4]	0	0	1	1

1 = January supercooling temperatures (-12.8° C = 8.9° F) for adult SPB (Lombardero *et al.* 2000).
2 = January supercooling temperatures (-12.8° C = 8.9° F) for adult SPB (Lombardero *et al.* 2000) as of Feb. 9, 2004.
3 = Daily minimum temperatures below lethal threshold (~-16° C = 3.2° F) (Ungerer *et al.* 1999).
4 = Daily minimum temperatures below lethal threshold (~-16° C = 3.2° F) (Ungerer *et al.* 1999) as of Feb. 9, 2004.

Many of the daily low temperatures expressed in **Table. 2** above occurred one after the other, but for no more than two – (2) consecutive days. It then remains unclear why a significant population of SPB survived the winter of 2002-3. The SPB itself is not known to produce anti-freezing agents and over-wintering in the bark of host trees provides modest microhabitat buffering, ranging from 0 to 2 °C (Bolstad *et al*. 1997). However, temperatures used for comparison are twenty-four hour – (24hr.) minimums and the duration at that minimum is unknown. Additionally, weather data from weather stations provide a reasonable approximation of conditions in nearby forests but a forest is generally 1-3° C warmer at night than an open field (Geiger 1957). It is possible that micro-inversions or localized temperatures created by the maritime influence of the Atlantic Ocean and Delaware Bay contributed to geographic variability. Furthermore, beetle populations at the ecosystem level are a result of complex interactions among variables. Weather type variables may be too simple to capture the complex relationships between the SPB and its environment (Coulson 1980). It is unclear at this time if winter temperatures at the northern range of the SPB have exerted selection for behavioral and physiological attributes that advocate overwinter survival.

The NJFS referenced temperature data for the past six –(6) years to provide insight on climatic factors influencing SPB migration to southern NJ. **Figure 3** represents how far temperatures have departed from the norm. The line between 1 and –1 represents the normal temperature for that month.

The following monthly normal temperatures are: October: 54.9° F, November: 45.8° F, December: 35.8° F, January: 30.9° F, February: 33.0° F, and March: 41.5° F.

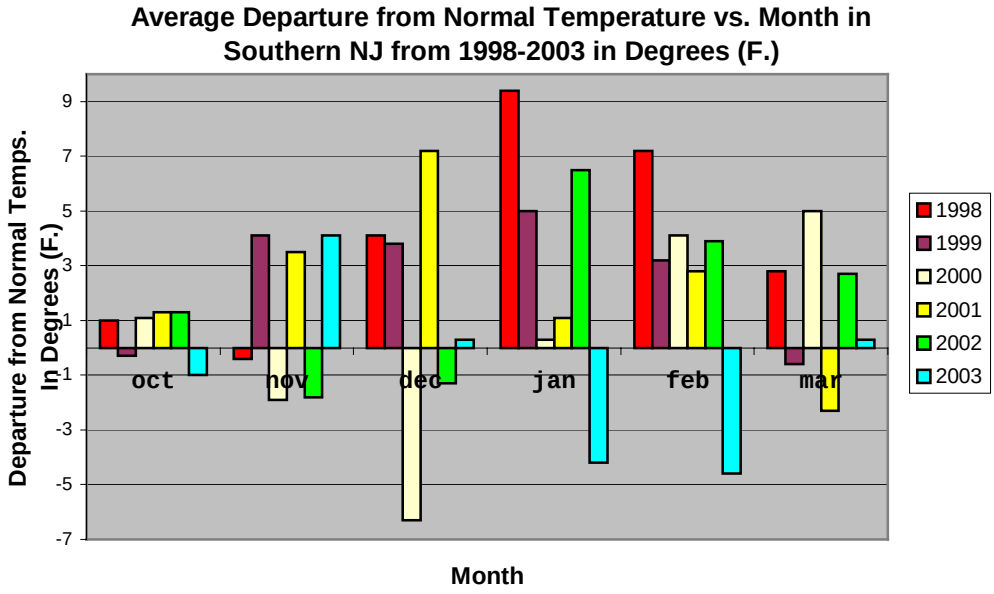

Figure 3. Note December 2000. Although much cooler than average, December temperatures never reached thresholds cold enough to kill the SPB.

Source: National Oceanic and Atmospheric Administration (NOAA) – National Weather Service (NWS)

Wildlife Considerations

Some areas infested by SPB are known to contain populations of the Barred owl *(Strix varia)*. Although the barred owl is secure in its natural range, it is listed as threatened in New Jersey. SPB may have a negative impact on existing and future barred owl populations. Preferred barred owl habitat in southern New Jersey has been primarily associated with three habitat types; Atlantic white-cedar swamps, pitch pine lowland habitat and hardwood swamps (Sutton and Sutton 1985, Laidig and Dobkin 1995). SPB induced mortality in southern NJ occur primarily in pitch pine lowland stands, stands of mixed pine and hardwood, and on pine occurring in Atlantic white-cedar swamps and has altered existing habitat. Great horned owl *(Bubo virginianus)*, a predator of barred owl and competitor of considerable prey overlap (Bosakowski and Smith 1992) may benefit from forest fragmentation attributed to SPB caused mortality. Continued mortality will open the crown canopy, possibly creating favorable conditions for the great horned owl while adversely affecting existing barred owl populations.

Local woodpecker populations have assisted in control of SPB populations by foraging and scraping of bark from infested trees. Inversely, SPB has provided an additional food source for woodpecker activity following the infestation heads. The checkered beetle has also assisted in the control and can be observed preying upon SPB on the bark of newly infested trees. However, these short-term benefits will be exhausted once the overstory fragments as mentioned above.

VIII. Recommendations

The NJFS recommends the continuation of SPB monitoring. On-site activities will include suppression in 2004 where and when applicable. Determination and recommendation of additional control sites will be provided in summer 2004. The most effective alternative of control is cut-and-remove. This alternative removes the infested trees and destroys all life stages of the SPB on-site, preventing future generations. Where and when cut-and-remove is not logistically feasible, other alternatives can be applied. Due to the SPB activity over two –(2) years, efforts in forest restoration / rehabilitation have become as significant as SPB suppression. This is a result of thousands of acres

containing various concentrations of dead, mixed-pine. Silvicultural prescriptions to restore / rehab these areas will include salvage harvests followed by site preparation and planting.

The NJFS is researching the use of anti-aggregation pheromones such as Verbonone pouches. When used in high doses verbonone repels the SPB. These pouches can be deployed in areas of high priority such as seed orchards, campgrounds, visitor centers, or research plots where cutting is not preferred. Verbonone, at this time is not registered for use/deployment in New Jersey. Efforts are continuing to have this anti-aggregate registered.

Restoration proposals for the eight –(8) sites in Belleplain State Forest were submitted (December 2003) to the NJ Pinelands Commission. Silvicultural prescriptions include site preparation using a drum chopper and forestry mower, tree planting, herbicide application, and fencing. Tree species to be planted include pitch pine *(Pinus rigida)* and shortleaf pine (*Pinus echinata)* and mixed hardwoods. These efforts will provide a future and contiguous canopy closure and reduces the chance of invasive species colonization. Areas restored will be monitored for seedling survival, replanted if necessary, and if any invasive species present themselves, they will be eradicated.

In order to assure the best opportunity for SPB suppression success it is critical that we work to improve the site review and approval process timeframe. Accordingly, efficient interagency cooperation and coordination is essential to achieve that goal. In addition, considering the exponential growth potential of SPB infestations the NJFS is recommending that we explore amending the existing MOA with the NJ Pinelands Commission to provide greater priority in reducing review and approval timeframe for sites recommended for SPB suppression activities.

Expedited suppression has proved effective in the southern US, moving several states to provide cost-share for control practices and mandating immediate spot control on private land. Additionally, it is recommended that the approval process be expanded to include salvage and restoration proposals as well. Of the thousands of acres of dead pine, hundreds of acres should be salvaged before the economic option is lost. Rapid deterioration of standing dead trees requires that if salvage is to be attempted, it should be conducted as soon as possible after the trees have died. However, in some priority areas deterioration makes salvage and restoration efforts extremely difficult, hazardous and improbable. A no-cost operation can change to a costly operation, therefore may not be performed at all. This can be accepted in non-priority areas (i.e. those not listed in Section VI).

IX. Suppression Alternatives for SPB Control

Below are four alternatives that represent current control strategies used for SPB in the southern US. Due to the SPB expanding its northern range, the effectiveness of any method(s) selected for use in NJ will be determined over time. At this date, NJFS has one season in the implementation of alternatives. The combining of alternatives is possible in controlling SPB infestations. Individual or a combination of alternatives (1-4) will also be based on a site-by-site basis.

Alternative 1 – No Action

Alternative 2 – Cut-and-Remove

Removal of infested trees should begin immediately. Where needed, a 50 to 100 foot buffer strip should be marked, cut-and-removed directly adjacent to and ahead of the most recently infested trees. A percentage of trees on-site that have been vacated entirely by SPB could be left standing if they do not pose a fire or other public health hazard. This may help populations of checkered beetles to increase and prey on SPB. The priority of removing infested trees is as follows:

Spring – Fall

1. Remove trees in the buffer zone. A 50 - 100 foot buffer strip of uninfested green trees around the spot head should be removed to minimize reinfestation and to disperse the beetles. The buffer zone should be equal to the height of the trees in the stand being treated.
2. Infested green trees. This will remove SPB pheromone source and potential broods.
3. Fading trees. This removes the potential brood.

4. Red-topped trees. It may not be necessary to remove these trees if the SPB have exited. These could be left standing for the development of predators to the SPB.

Fall to Spring

1. Red-topped, fading and green infested trees. These trees may still contain living brood during the fall and winter.
2. Trees with fresh attacks.
3. Trees in the buffer zone.

Alternative 3 – Cut-and-Leave

Cut-and-leave is designed to disrupt spot growth and reduces mass attacks by dispersing the SPB.

1. Identify all active trees within the spot
2. Fell all active trees toward the center of the spot
3. Fell a horseshoe shaped buffer around green, uninfested trees with fresh attacks toward the center of the spot. In small spots, the buffer can encircle the spot. The buffer width should not be greater than the height of the trees being treated.
4. Dead trees where the SPB have emerged do not have to be felled unless there is a fire or other public health hazard.

Alternative 4 – Pile-and-Burn

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