A Qualitative Analysis of The Southern Pine Beetle's Wildlife Impact

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School of Forestry and Wildlife Resources
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A QUALITATIVE ANALYSIS OF THE SOUTHERN PINE BEETLE'S WILDLIFE IMPACT

by

John D. Maine
William A. Leuschner
Alan R. Tipton

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AUTHORS

The authors were Graduate Research Assistant, Associate Professor of Forest Economics, and Assistant Professor of Wildlife Biometry, School of Forestry and Wildlife Resources, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

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INTRODUCTION

Wildlife's social value has long been known. Early attempts to place dollar values on wildlife were crude (Stains and Barkalow, 1951; Collins, 1959) and often incomprehensible. For example, Collins found that each deer killed by bow hunters was worth $5,280 based on hunter expenditures. However, these early researchers were aware that it is important to consider wildlife's social value in forest management decisions. These include pest management decisions generally and Southern Pine Beetle (*Dendroctonus frontalis* Zimm) (SPB) management decisions specifically.

Wildlife has three basic values in the Southeast: recreational, aesthetic, and scientific. The recreational value is realized by the more than 30 million people who spend billions of dollars each year pursuing fish and game species. These people partially support the sporting arms and ammunition, camping equipment, campground, and restaurant industries.

The aesthetic value of wildlife is realized by the millions of people who gain utility from just viewing or photographing wildlife. The broad and diverse types of people realizing this benefit and the complications of measuring aesthetic utility make the aesthetic values of wildlife difficult to quantitatively assess.

Wildlife's scientific value arises because wildlife is part of a balanced biotic community. The accidental or willful removal of one or more species could upset the ecological balance so that some species rise to unmanageable limits. In addition, any future benefits that would have been derived from the removed species are lost. Obviously, this value is also fraught with measurement problems.

Changes in these values are the SPB impacts which should be considered in management decisions. However, dollar values will not be estimated because of the measurement difficulties. Only increases or decreases in the carrying capacity for particular species will be determined. These changes will simply be stated as either positive or negative with some idea of their magnitude.

Carrying capacity is defined as a limitation on the number of game animals of any one species that can be maintained on a given area (Dasmann, 1964). Hence, the carrying capacity for one species does not consider competition for food, water, and shelter from other species. Very little is known about interspecies relationships, so species impacts are determined assuming they are the sole inhabitant of an area. Adding the various changes in species carrying capacity to obtain the total wildlife impact would be erroneous. The actual impact would be somewhat less because of the unknown interspecies competition effects.

Carrying capacity is influenced by many factors. Each species requires particular foods in particular seasons as well as different types of cover, climate, topography, and minerals. Carrying capacity is determined by the amount and distribution of these in relation to animal mobility once the necessary combination of elements needed to survive are present.

Water is rarely a limiting factor in the South, and the carrying capacity is more often determined by food and shelter. Any activity changing the amount of food and shelter may change the carrying capacity. This is where SPB enters the picture.

SPB attacks open the forest canopy in multiple spots throughout the forest stand. These openings provide sunshine for animal health and maintain perennial and annual food plants and forage growth. SPB population increases will increase the number and variety of forage plants, thus increasing the energy and nutrients available and possibly the carrying capacity. The objective of this study is to determine the nature of these changes.

METHODS AND PROCEDURES

Time and monetary constraints precluded primary data collection, field work, or experimentation. Therefore published studies were relied upon. No usable information relating SPB infestations to wildlife populations was found in the literature. Hence, the total effect of SPB on wildlife was divided into its intermediate components and information was then found in the literature relating these intermediate components to one another. These components were integrated and conclusions were drawn about SPB's overall wildlife impact.

The first and most obvious intermediate component is the forest stand. Few studies have detailed the effect of SPB on the forest stand. In general, we know that the SPB attacks are usually confined to small localized areas called "spots." Information available on these spots was gathered and formulated into the intermediate effect of SPB on the forest stand.

The second intermediate component is the understory vegetation. The spots affect the amount and kinds of understory vegetation. Numerous studies have reported on the relationships between the forest stand and understory vegetation. It was assumed that understory vegetation response is the same regardless of whether trees are removed by SPB and its associated insects and fungi or by harvesting. This assumption allowed using the many studies relating thinning, clearcuts, and other cutting operations to understory vegetation to assess SPB impacts.

Spot size was related to regeneration method using techniques similar to Leuschner et al. (1978) (Table 1). The average natural stand of loblolly pine was assumed to contain 200 trees per acre which implies that each tree takes up .005 acres. Hence, spot sizes near .005 acres or less correspond to a single tree selection. Sunda and Lowry (1975) reported that shelterwood cuttings leave about 14 trees per acre. Hence, spot sizes near .07 acres and greater than .005 acres correspond to shelterwood cuts. Spot sizes greater than .07 acres were considered small clearcuts.

Table 1. Estimated Correlation Between Spot Size and Regeneration Method

Spot Size	Regeneration Method Equivalent
Less than .005 acres	Single tree Selection cut
.005-.07 acres	Shelterwood cut
.08 acres and up	Small clearcut

The effects of understory vegetation on wildlife populations, the final component of the SPB wildlife impact system, required determining the habitat and food requirements of various wildlife species. Qualitative estimates of SPB's wildlife impact are possible if SPB's impact on understory and the understory's impact on wildlife are known.

The known direct and indirect impact streams between SPB and wildlife are summarized in a qualitative model (Figure 1). It considers only the major effects and not all possible impacts. Each box represents an intermediate component and the lines show the flow between components from SPB to wildlife. Each component is first analyzed separately and then integrated into the total SPB wildlife impact. The specific impact areas examined are numbered on the model.

SPB wildlife impact will be different for each species considered. For instance, increased edge increases rabbit and deer populations, but it does not affect small mammals. Hence, it is necessary to analyze each wildlife species or species group separately. Ten species groups are considered (Table 2). Species groups chosen were those which published information indicated would have the greatest impact. Some or most of the model may be irrelevant for some species groups. For instance, change in water temperature is only relevant for fish. SPB's overall wildlife impact will be assessed after impact has been determined for each species group.

Table 2. Wildlife species groups considered

1.	Woodpeckers	(Dendrocopus spp.)
2.	Turkey	(Meleagris gallopavo)
3.	Quail	(Colinus virginianus)
4.	Other birds	
5.	Squirrels	(Sciurus spp.)
6.	Rabbits	(Sylvilagus floridanus)
7.	Deer	(Odocoileus virginianus)
8.	Small Mammals	
9.	Fish	
10.	Other Animals	

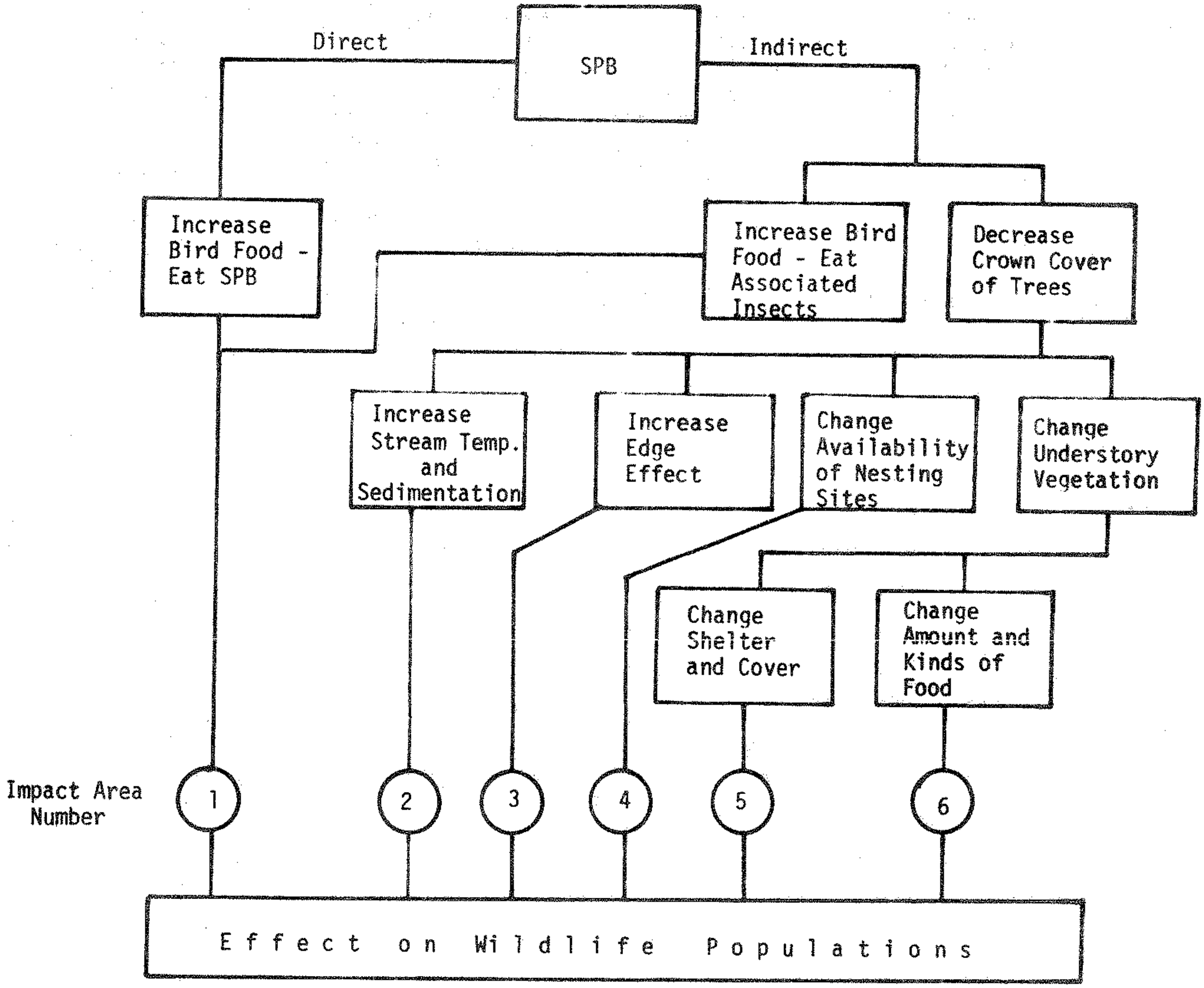

Figure 1. Qualitative model of SPB impacts on wildlife populations.

The wildlife impact will be assessed at current SPB infestation levels. This is the maximum impact which could be changed by an SPB control program. The results will be qualitative estimates with subjective rankings assigned to the impacts, except for a rudimentary estimate for number of deer. The results will indicate whether or not SPB has a large enough wildlife impact to warrant further study. They may also be used to subjectively modify the output of quantitative SPB impact models if no further study is indicated.

SPB's impact on crown cover, and the subsequent impact on understory vegetation and edge, is independent of the wildlife species being considered. However, the impact of understory vegetation and edge on wildlife is dependent on the wildlife species being considered. The independent impacts will be examined first and then extended to individual species groups.

SPB'S IMPACT ON CROWN COVER

SPB adults and larvae attack a tree by boring the inner bark and girdling the tree (Thatcher, 1970). This girdling, and associated insects and fungi, kills the tree. Complete defoliation occurs within two to three months following beetle attack (Dixon and Osgood, 1961; Doggett, 1971). In general, all pine trees within the perimeter of the spot are attacked, hence, crown cover is decreased by 100 percent in a pure pine stand. However, some spots are too small to be like clearcuts and are more like thinnings or shelterwood cuts. Leuschner et al. (1976) found 43.31 acres of SPB infestation on 85,000 acres of land in east Texas during one year. The majority of this 85,000 acres was covered with pine; thus roughly .05 percent of the total crown cover was removed. This decrease was distributed among spots ranging in size from .01 to 2.17 acres.

Surrounding trees begin to expand and close the opening following defoliation. Natural revegetation eventually closes the opening and the smaller the opening the faster it is closed. Surrounding trees expand to close the opening in about two years for the smaller spots, while it may take 12-14 years before full crown closure is restored in the larger spots (Ovington, 1957).

EFFECTS ON UNDERSTORY VEGETATION

Young, dense loblolly pine stands may transmit as little as five percent of available light into the understory (Shirley, 1945), therefore, understory vegetation is very sparse. As SPB removes sections of the pine canopy, more light, soil, nutrients, and moisture are made available to the understory and any allelopathic conditions are removed. This stimulates growth of the present understory and shade intolerant species. The percentage of species bearing fruit increases as the overstory is removed (Halls and Alcaniz, 1968). Fruits are eaten by most herbivorous wildlife species, so this impact could be nearly as important as increased understory growth.

Understory plants are divided into browse and herbage. Browse is the current year's growth of leaves and stems of woody plants. Herbage is the stems and foliage of nonwoody plants and vines. Recent studies have divided browse into succulent twigs and buds, hardened twigs and buds, dry leaves, and green leaves (Harlow and Hooper, 1971). Herbage is generally divided into grasses and sedges, forbs, ferns, and mushrooms. These plants are only measured to a height five feet above the ground for wildlife management assessments in the Southeast. The total of all herbage and browse 5 feet above the ground is termed total forage.

Herbage and browse both have an inverse curvilinear relationship to crown cover (Figure 2) (Blair, 1967; Blair and Burnett, 1976; Blair and Enghardt, 1976; Halls and Schuster, 1965; Ehrenrich and Crosby, 1960). Herbage yields may be as high as 3,000 pounds per acre where tree cover approaches zero percent (Duvall and Hilmon, 1965) and as low as 100 pounds per acre in a dense stand (Rhodes, 1952; Blair, 1967). Browse yields in forest openings where crown cover is sparse may reach 1400 pounds per acre (Stode and Chamberlain, 1959) and decline to 31 pounds per acre as crown cover increases (Patton and McGinnes, 1964).

Most wildlife food inventories measured only browse until the late 1960's because inventories were performed mainly to predict whitetail deer carrying capacity and it was thought that browse was the only component of the deer diet that affected its population numbers. However, Harlow and Hooper (1971) found that herbage also plays an important role as a wildlife food. In addition, Harlow and Whelan (1969) showed it is important to distinguish between wildlife plant food species. They suggest that the limiting value of the wildlife food is the content of available and digestable energy. Multispecies wildlife inventories must be taken because this is different for each plant species. Wildlife carrying capacity could then be determined from amounts of available energy, and the energy required by each animal species. Most of the work is very recent and there are no published studies reporting changes in individual plant species after timber harvest or energy content associated with these species. The data presented here are the best that could be found in the literature.

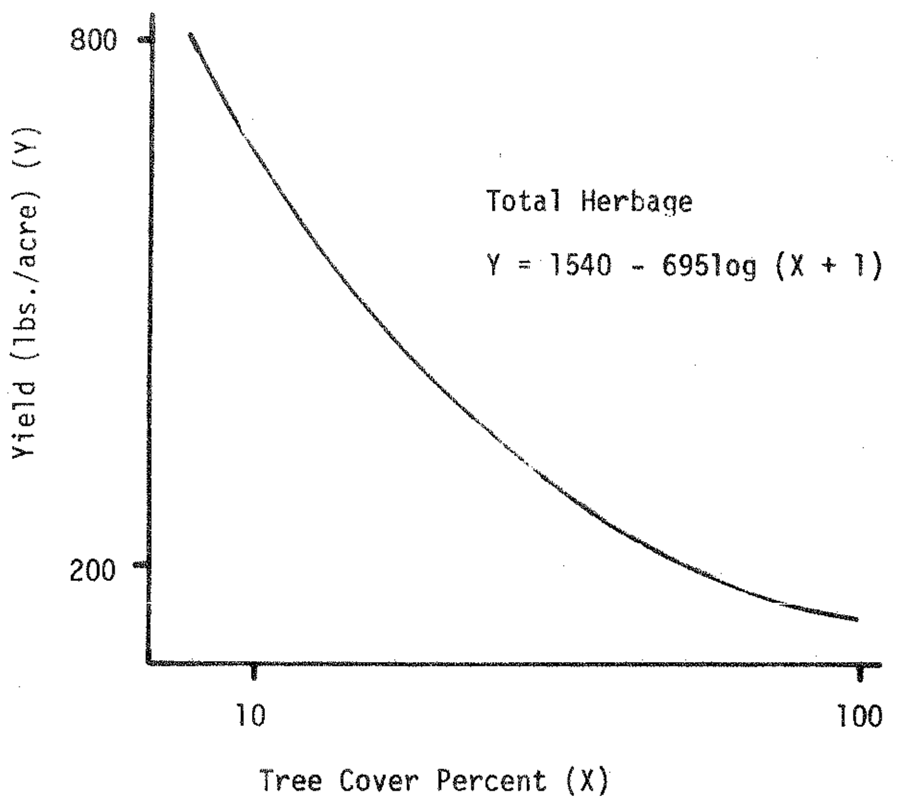

Figure 2. The relation between tree cover percent and total herbage yields. (Source: Halls and Schuster, 1965)

The data presented below were selectively drawn from many studies. Only those in the loblolly pine (Pinus taeda) range were used, and studies were discarded if the hardwoods were the main component of the overstory removal. Overstory removal will have a completely different impact on the understory in loblolly plantations than in loblolly pine-hardwood mixtures. Hence, only studies clearly specifying the overstory removal and the stand characteristics were used and the two overstory conditions are discussed separately.

Pine-Hardwood Overstories

Loblolly pine-hardwood forests usually contain more wildlife habitat components than loblolly pine plantations because mast producing hardwoods are usually present. For example, Moore (1967) found that pine plantations require 39-104 acres per deer, whereas loblolly-scrub hardwoods and loblolly pine-hardwoods require 12 to 30 acres per deer. In addition, Moore shows that bottomland hardwoods generally require 13 acres per deer, but range as low as 5 acres per deer. Hence, it appears that deer carrying capacity per acre increases as we proceed from 100 percent pine to 100 percent hardwood.

There are many studies of overstory-understory relationships in the southeast on pine-hardwood forest (Schuster, 1967; Halls and Alcaniz, 1971; Stransky and Halls, 1967; Lay, 1943; Ehrenreich and Murphy, 1962; Murphy and Ehrenreich, 1965; Blair and Brunett, 1976). Schuster (1967) and Blair and Brunett (1976) are most applicable because they specifically deal with the removal of the pine overstory in the southern loblolly pine-shortleaf pine-hardwood forest.

Schuster (1967) studied the effects of clearcuts, selection cuts, and shelterwood cuts on understory vegetation in east Texas. He presents forage data for each treatment 10 years following harvest plus data for nearby uncut stands. Forage changes are calculated by subtracting the forage on the uncut areas from that on the cut areas (Table 3). Selection cut exceeds shelterwood because a selection cut occurred only 5 years before measurement, whereas the shelterwood cut occurred ten years before measurement.

The percentage of SPB infestations which approximate shelterwood selection and clearcuts was determined using the spot-size-regeneration correlations (Table 1) and SPB spot size distribution on the Trinity District (Leuschner, et al., 1976). The results indicate that 22.3 percent of SPB spots approximate selection cuts, 72.28 percent shelterwood cuts, and 5.42 percent clearcuts. An average change in the amount of forage produced per acre is estimated by weighting Table 3 values by these percentages (Table 4). All types of forage increased except forbs. These figures are higher than other studies due to unusually dense understories; however, not all of this forage is available to wildlife populations. Much of this vegetation may be unpalatable, undigestible, or have low energy content (Stransky, 1969).

Palatability and energy content vary by plant species, and different plant species are used as food by different animals; hence, data on the quantities of each plant species are needed. These data are scarce and Schuster's

Table 3. Change in amounts of oven-dry forage production by plant groups and cutting treatments ten years following timber harvest in a loblolly pine-hardwood forest.[a]

Forage Group	Treatment		
	Selection cut[b] lbs/acre	Shelterwood cut[c] lbs/acre	Clearcut lbs/acre
Grass and Grass-like	118.6	98.2	475.4
Forbs	5.8	- 6.6	55.1
Legumes	24.5	16.0	29.2
Total Herbage	149.0	107.6	559.7
Total Browse	277.9	193.9	403.4
Total Forage	426.9	301.6	963.2

[a] Derived from Schuster (1967) by subtracting amounts produced on uncut areas from the amounts produced on selection cut, shelterwood cut, and clearcut areas.

[b] Measured 5 years after harvest.

[c] Measured 10 years after harvest.

Table 4. Estimated average change in forage per acre of SPB infestation in a loblolly pine-hardwood forest.

Forage group	Change in forage lbs/acre
Grass and Grass-like	123
Forbs	0
Legumes	19
Total Herbage	142
Total Browse	224
Total Forage	366

(1967) are the best data even though he only presents the percentage frequency of occurrence, not weight (Appendix I).

An average SPB attack was simulated using these and the Trinity District data (Footnote b, Appendix I). Most browse species increased and those increasing the most were: blackberry (Rubus spp.), carolina jassamine (Gelsemium sempervirens), short-leaf pine (Pinus echinada), sweet gum (Liquidambar styraciflua), post oak (Quercus stellata), and poison ivy (Rhus radicans). Those that decreased were: flowering dogwood (Cornus florida), Virginia creeper (Parthenocissus quinquefolia), and blackhaw (Viburnum rufidulum). In general, the species increases and decreases correlated quite well with their shade tolerance.

Nearly all of the forbs and legumes increased, and only partridge berry (Mitchella repens) decreased. This is logical since partridge berry is a shade tolerant species known to be found in dense woods and not in forest openings. The species which increased the most were: butterfly pea (Centrosema virginianum), tick clover (Desmodium spp.), hairy elephant's foot (Elephantopus tomentosus), and shapely milkpea (Galactia regularis). All are legumes except hairy elephant's foot which is a forb. Forb species decreased most. This helps explain that total forb production did not vary between unaffected and infested stands.

None of the grasses and grasslikes decreased. Broomsage bluestem (Ardropogon virginicus), three awn (Aristida purpurascens), sedge (Carex spp.), and the panic grasses (Panicum spp.) increased radically.

Schuster (1967) also calculated a correlation matrix between oven-dry pounds per acre of browse, legumes, forbs, grasses, total herbage, and 13 independent variables. SPB would probably have a major effect on basal area, dominant overstory cover, and mid + dominant overstory cover (Appendix II, Table 1). All significant variables were negatively correlated with all types of forage production. Hence, the intensity of SPB attack is likely to be positively correlated with the amount of forage produced.

Schuster also calculated multiple regressions to show the relations between habitat factors and forage yields (Appendix II, Table 2). Only statistically significant variables were included. These equations could be used to simulate SPB's effect on forage yields if data were available for SPB's effect on the independent variables.

Schuster's work was one of the finest and most conclusive studies found. However, there are several drawbacks. First, it was for one point in time, ten years following timber harvest. There is no indication of forage yields from 0-9 or 11-∞ years after harvest. Second, although the data are quite consistent, they are high relative to most other studies performed in the same area. These high figures are attributed to the unusually dense understory found on his study area.

Blair and Brunett (1976), however, studied the effects of selective logging over time on several types of forage in a pine-hardwood forest in central

Louisiana. Data were presented periodically for 11 years following timber harvest (Table 5). Maximum understory vegetation production usually occurs approximately two years following timber harvest. This means Schuster's study was performed eight years following the peak of understory vegetation production, hence, impacts calculated from it would be low. Unfortunately, undisturbed stand data are not presented hence the study cannot be used to estimate SPB impact.

Blair and Brunett's (1976) data for amount of understory vegetation is much lower than Schuster's (1967) and compares quite well with other studies. Hence, Blair and Brunett's study has shown that Schuster's data may be too low because it was taken 10 years following timber harvest, and too high because of unusually dense understories.

Pine Overstories

Pine plantations yield high amounts of browse during their first few years before the canopy closes. However, little or no browse is produced after canopy closure (Stransky and Halls, 1967) and total forage yields are very low. The absolute changes in the Schuster study were high, but the percentage increase in total forage was only 86 percent. The percentage increase in forage under a pure pine stand is likely to be more than 86 percent because of the relative lack of forage to begin with. In addition, SPB attacks in pure pine stands remove 100 percent of the overstory, whereas the hardwood component is left in mixed stands. Hence, the change in understory vegetation in pure pine stands is likely to be greater than in mixed stands. We would again expect that this increase is dominated by browse and grasses as in pine-hardwood forest because most of the shade intolerant species are in these groups.

Understory Impact Conclusions

Conclusions drawn from these sections are rough generalizations because of data limitations. Accuracy is lost in generalizing, and the data are drawn from different sources at different times; hence, quantitative conclusions could be misleading. However, the following conclusions are still possible:

1. A decrease in the crown cover caused by SPB allows more light and water to reach the understory, which causes an increase in the total forage produced.

2. The amount of forage produced in an acre of SPB spots is usually more than twice the amount of forage produced on an undisturbed acre of forest.

3. The impact of SPB on forage production in pure pine stands is likely to be larger than the impact in natural loblolly-hardwood forest.

4. The increase in forage on SPB spots is likely to be dominated by browse.

Table 5. Vegetation response to selection harvest in 1959 (lbs/acre).

	Year						
Vegetation Class	1960	1961	1962	1964	1966	1968	1970
Grasses	63.5	78.0	59.6	29.2	19.0	15.7	11.8
Sedges and Rushes	8.3	10.6	6.2	3.6	1.9	2.9	2.4
FORBS:	13.8	11.3	12.5	3.9	2.3	6.4	4.6
Composites	4.6	2.6	2.2	.8	.3	.4	.2
Legumes	.4	.4	.1	.2	.2	.4	.1
Other species	8.8	8.3	10.2	2.9	1.8	5.6	4.3
TOTAL HERBACEOUS	85.6	99.9	78.3	36.7	23.2	25.0	18.8
Vines	54.1	59.6	46.5	31.7	24.0	24.0	15.6
Shrubs and Trees	229.0	232.6	226.8	176.8	132.7	119.3	88.4
TOTAL BROWSE	283.1	292.2	273.3	208.5	161.7	143.3	104.0
TOTAL FORAGE	368.7	392.1	351.6	245.2	184.9	168.3	122.8

SOURCE: Blair and Brunett, 1976.

5. SPB increases the percentage of plants bearing fruit, in addition to forage.

6. There is little impact on the number of forage species. Some shade tolerants will disappear while other shade intolerants will appear.

7. The increase in browse will be dominated by: carolina jasmine, poison ivy, blackberry, shortleaf pine, sweet gum, blackhaw, and post oak.

8. The increase in grass production will be dominated by: broomsage bluestem, panic grass, longleaf uniola, three awn, and sedge.

9. The increase in forb and legume production will be dominated by: butterfly pea, tick clover, hairy elephant's foot, and shapely milkpea.

IMPACT ON EDGE

Different wildlife species often require different understory plant species to maintain population health. Wildlife also occupies an area in which an individual animal spends all or most of its time called its home range (Burt, 1943). For many species, this home range is small. For example, a deer's is usually less than a square mile and often only a quarter mile in diameter (Dasmann and Taber, 1956; Leopold et al., 1951; Marchinton and Jeter, 1967). The home range of ruffed grouse is usually about a mile in diameter (Wing, 1951). Maximum wildlife populations can only be maintained if the needed understory species and other habitat components are available within its home range. This quality is known as interspersion. Interspersion is loosely defined by Wing (1951) as the mixing of plant species. Loblolly pine monocultures are classical examples of areas with little interspersion. This even-aged forest supports far fewer animals than a mixed species selection forest.

SPB attacks increase interspersion because spots contain different plant species and other habitat components than the surrounding undisturbed forest. This effect is greater in loblolly plantations where interspersion is extremely limited.

Edge is often used as a measure of interspersion. Murray (1957) defines edge as an interface between types of vegetation which takes on special characteristics by virtue of this position. Giles (1960) defines edge as the area where two ecotones meet. Edge effect is the impact of edge on wildlife populations. Giles (1960) defines edge effect as the attraction which edges have for wildlife and their ability to support larger and more varied wildlife populations than either adjoining community. Hence, an area between an SPB spot and the surrounding forest would be termed edge, and the impact of this area on wildlife populations is SPB's edge effect.

Several edge effect studies have been performed. Bump et al. (1947) found that ruffed grouse population size was correlated with amount of edge. Odum (1959) found that edges contain organisms which inhabit each of the overlapping ecotones plus some organisms that inhabit neither alone. Leopold (1933) stated that the amount of game in a forest is proportional to the distances around the types of vegetation. In general, we know that:

1. The number and variety of plant species is higher in the edge than in either of the adjoining types (Barrick, 1945).

2. Edge has depth and consists of more than just a line between two forest types (Giles, 1960).

3. The average edge width is narrow enough to be transversed by most animal species (Barrick, 1945).

4. The edges between forest types have the greatest potentialities for forest habitat improvement because of the increased cover and variety and abundance of food caused by edge (Barrick, 1945).

5. Edge areas are more favorable as wildlife habitat than either type considered alone (Dasmann, 1964).

6. In general, edges contain a higher number of species of animals than either type alone.

Therefore, edge introduces a high degree of interspersion into forest stands, and edge effect is merely an expression of the interspersion produced by edges. Further, a measure of the amount of edge in a forest stand could be used as a relative measure of the interspersion. Edge is not the sole cause of interspersion, but is a sufficient measure of the difference in interspersion between an unattacked and SPB attacked stand. Odum (1959) states that the population densities are proportional to the number of feet of linear edge per unit area of community. McCaffery and Creed (1969) found a correlation coefficient of .65 for this relationship. Hence, we conclude that linear edge per acre is the best quantitative measure of interspersion that we can use.

The amount of linear edge per acre caused by SPB infestations can be estimated using the Trinity District data for spot size distributions (Leuschner et al., 1976) and varying assumptions about spot configuration. These assumptions are:

1. SPB spots sizes are distributed as in the Trinity District data at current levels of control.

2. Edge effect does not occur due to shading from nearby trees if the spot area is less than .028 acres (20 ft. radius for circular spots).

The amount of edge caused by SPB was determined by calculating the perimeter of the spot in the spot size class, dividing by spot size (in acres) to get an average edge per acre, multiplying by the number of acres (out of 44.31 total) to get the total amount of edge in that spot size class, summing over all spot sizes to get the total amount of edge, and dividing by 44.31 to get the average edge per acre of SPB infestation. One acre of SPB spots would add 1755 linear feet of edge to a forest stand if spots are circular, 2,100 feet if rectangular with length two times width, and 2,266 feet if triangular with base equal height (Table 6). Most SPB spot configurations would probably fall within these bounds hence, each acre of SPB spot will add approximately 2,000 feet of linear edge to a forest stand if the size distribution is the same as on the Trinity District.

Many wildlife biologists believe that rectangular one acre strips, where the width is twice the height of the surrounding trees is an ideal size for wildlife clearings intended to provide interspersion (Giles 1960). The strip is sufficiently long to provide a lot of edge and sufficiently wide to maintain the depth quality of edge. Each one acre strip will add approximately 1,000 feet of linear edge to a stand (Giles, 1958) as compared to 2,000 feet per acre of SPB spot. Hence, SPB adds a great amount of interspersion on a per acre basis. However, SPB adds only about 640 feet of linear edge per square mile of forest assuming the same spot density as on the Trinity District. Hence, SPB spots greatly increase interspersion per acre of spot but only provide limited amounts of interspersion to an entire forest because of the low acreage affected by SPB.

Table 6. Calculations to determine average linear edge per acre with varying SPB spot configuration assumptions.

Spot size class	Acreage in spot size class [b]	Circular spots			Triangular spots (Base=height)			Rectangular spots (length=2 x width)		
		Edge/spot	Edge/acre	Total edge	Edge/spot	Edge/acre	Total edge	Edge/spot	Edge/acre	Total edge
.01	.92	0	0	0	0	0	0	0	0	0
.02	2.01	0	0	0	0	0	0	0	0	0
.03	2.50	128.2	4,271.7	10,679	165.4	5,514.6	13,787	153.4	5,112.3	12,781
.04	1.44	148.0	3,699.3	5,327	191.0	4,775.8	6,877	177.1	4,427.5	6,376
.05	1.77	165.4	3,308.8	5,857	213.6	4,271.6	7,561	198.0	3,960.0	7,009
.06	1.53	181.8	3,020.5	4,621	234.0	3,899.4	5,966	216.9	3,615.0	5,531
.07	2.50	195.8	2,796.4	6,991	252.7	3,610.2	9,025	234.3	3,346.9	8,367
.08	1.14	209.3	2,615.8	2,982	270.2	3,377.0	3,850	250.5	3,130.6	3,569
.09	1.82	222.0	2,466.2	4,489	286.5	3,183.9	5,795	265.6	2,951.6	5,372
.10	1.53	234.0	2,339.6	3,580	302.0	3,020.5	4,621	280.9	2,800.1	4,284
.11	1.10	245.4	2,230.7	2,454	316.8	2,879.9	3,168	293.7	2,669.8	2,937
.12-.14	2.98	266.8	2,052.0	6,115	344.4	2,649.1	7,894	319.3	2,455.9	7,319
.15-.19	2.93	305.1	1,794.4	5,258	393.8	2,316.6	6,788	365.1	2,147.6	6,292
.20-.24	2.59	347.0	1,577.4	4,085	448.0	2,036.4	5,274	415.3	1,887.9	4,890
.25-.29	1.31	384.4	1,423.9	1,865	496.3	1,838.2	2,408	460.1	1,704.1	2,232
.30-.39	3.78	434.6	1,259.6	4,761	561.0	1,626.2	6,147	520.1	1,507.5	5,699
.40-.49	.45	493.6	1,109.1	499	637.2	1,431.8	644	590.7	1,327.4	597
.50-.74	0	582.6	939.6	0	752.1	1,213.1	0	697.2	1,124.6	0
.75-.99	4.68	690.1	793.2	3,712	890.9	1,024.0	4,793	825.9	949.3	4,443
1.00	7.53	-----	-------	4,484[a]	-----	-------	5,789[a]	-----	-------	5,366[a]
TOTAL	44.31	-----	-------	77,759	-----	-------	100,386	-----	-------	93,064
Average edge per acre				1,755			2,266			2,100

[a] Only 5 spots were > 1 acre. Their sizes were 1.01, 1.05, 1.34, 1.96, and 2.17 acres.

[b] Source: Leuschner, et. al. 1976.

IMPACT ON SPECIES GROUPS

SPB's impact on crown cover, the impact of decreased crown cover on understory vegetation, and the impact on edge have been analyzed in the three previous sections. The following sections contain analyses of SPB's impact on wildlife species groups using information from these sections. This section will only discuss the portions of Figure 1 relevant to the particular species (Table 2).

Woodpeckers

Woodpeckers feed on SPB and its associated insects. The downy woodpecker (*Denrocopus pubescens*), pileated woodpecker (*Dryocopus peleatus*), and the red-bellied woodpecker (*Centurus carolinus*) are the major avian SPB predators in the Gulf South (Coulson et al, 1972). Overgaard (1970) found that SPB brood density could be reduced as much as 24.4 percent by these woodpeckers and that they feed mainly on the immature SPB stages in the winter. Food supply is most likely the limiting factor in woodpecker populations in winter, hence, increased SPB could increase populations. No information is available on the size of this increase or the value of these woodpeckers to society.

In related studies, researchers determined the relationship between woodpecker densities and the spruce bark beetle (*Dendroctonus rufipennis*). During the breeding season, woodpecker populations were found to be as low as 1 per 41 hectares in areas of low beetle populations (Baldwin, 1968), and as high as 22 per hectare in areas with vast beetle outbreaks (Yeager, 1955). The upper limit during the breeding season is usually low because of territoriality and antagonistic behavior (Schmid and Frye, 1977).

The American ivory-billed woodpecker (*Cauperphilus principalis*) feeds on wood-boring beetle larvae. It is presently endangered and very close to extinction because of scarce habitat in its range of Florida, Texas, Louisiana, and South Carolina. The Committee on Rare and Endangered Wildlife Species states reduced forests with dead and dying trees containing wood boring beetle larvae as the cause of the woodpecker's decline (USDI, 1973). Therefore, reduced SPB infestations could contribute to this woodpecker's extinction. Again the magnitude of this relationship and the value of this bird to society are unknown.

SPB spots can cause increased nesting sites by creating hollow trees. Further, with modern intensive forest management, hollow nesting trees may become the limiting population factor. However, Leuschner et al. (1976) indicate only a .05 percent of the forest area may be attacked in a year thus less than .05 percent of the area will have SPB killed snags, which if large enough, could make suitable nesting sites. This effect is decreased further because large killed trees are most likely to be salvaged.

The rest of the model will have little impact on woodpecker populations. Edge effect is assumed to be minor because woodpeckers do not benefit to a great extent from the changes in interspersion other than the interspersion of hollow nesting trees included in impact 4 of Figure 1. In addition, increased understory vegetation has little impact since woodpeckers feed mainly on insects. Hence, impacts 1 and 4 in Figure 1 are the major SPB impacts on woodpecker populations. Impact 1 is fairly significant and impact 4 is fairly insignificant relative to SPB's other impacts.

Turkey

The wild turkey (Meleagris gallopavo) lives principally in mature open hardwood types but can live in a variety of habitats including the pine and mixed pine-hardwood types (Wing, 1951). Mature, virgin pine stands are the only pure pine stands that turkeys use for food or cover. Turkeys are rarely found in loblolly pine plantations due to lack of large mature hardwoods which provide roosting sites and mast.

Turkeys eat a variety of foods including nuts, fruits, seeds, berries, and insects. In general, animal food is only 3-30 percent of the turkey's diet depending on the time of year (Rivers, 1940). Animal food is highest in the summer when insects are abundant, and coleoptera parts were the most frequent animal parts found in turkey droppings (Dalke et al., 1942).

Plant food was 70-97 percent of the turkey's diet and fruits and seeds were more than three quarters of the total (Martin, May and Clarke; 1939). Flowering dogwood (Cornus florida) is the major fleshy fruit eaten by turkeys and acorns are the most important nonfleshy fruit. In addition, turkeys eat the fruits and seeds of grapes, greenbriar, blackgum, blueberry, beech, blackberry, strawberry, lespedesa, desmodiums, and persimmon. Grasses and grasslike plants generally make up less than 20 percent of the turkey's diet.

The limiting factor in turkey populations in pine plantations is probably mast producing trees. SPB spots would have little effect on mast, thus SPB infestations in pine plantations have little impact on turkey populations.

Wild turkey might benefit from the increased food on the SPB spots such as grasses and the fruits and seeds of miscellaneous forbs. In addition, the percentage of plants bearing fruit in SPB spots is increased (see earlier results). However, the major turkey foods of dogwood fruit and hardwood mast are nonexistent, hence, we conclude that this impact is only slight. The areas of possible impact are 1, 3, and 6 (Table 11), but all are negligible in pine plantations.

Hardwoods in mixed pine-hardwood forests can provide mast and roosting sites because the decreased competition on residual hardwoods will allow them to expand and produce more mast. These limiting factors might then be affected a small amount by SPB spots. SPB spots in pine-hardwood forest did not affect forb production (Table 4), but legume production is increased significantly, including butterfly pea, shapely milkpea, and tick clover. In addition, grasses and grasslikes increased significantly, including panicums, broomsage bluestem, three awn, sedge, and longleaf uniola. The frequency of occurrence of dogwood decreased significantly.

Increased grasses and animal food are of minor importance in the diet, but increased legumes are important because of their seeds. However, this may be offset by a large decrease in dogwoods and hence, dogwood fruit.

Little is known about the impact of edge on turkeys, and it is assumed minor. Hence, SPB has possible impact on 1, 3, and 6 in pine-hardwood forest. Impact 1 is concluded to be only slightly positive, impact 3 is near 0, and impact 6 has both positive and negative aspects which are assumed to cancel out. Therefore, the overall impact of SPB on wild turkey populations in pine-hardwood forest is again relatively insignificant (Table 11).

Quail

The bobwhite quail (Colinus virginianus) is a broad ranging species found throughout eastern and southern North America. The vast number of food and habitat studies done on this species are too numerous to summarize. Attention will, therefore, be focused on the most applicable major studies in the eastern and particularly the southeastern United States.

Bobwhite quail are found in specific habitats. They are an "edge" species most commonly found in fence rows, field edges, swales, and brush lands (Wing, 1951), and are seldom found in the center of large fields or dense woodlands. Webb and Barkalow (1940) found 24 percent of quail coveys observed in woodlands, 63 percent in fields, and 13 percent in mixtures or swamps. All but two of those found in the woodlands (22 of 91 coveys observed) were within 100 yards of cover. Webb and Barkalow concluded that fields provide the food needed by bobwhite while forest and brush provide cover, hence, adequate interspersion of these factors is necessary to support high quail populations.

Quail require five types of cover according to Wing (1951): travel, resting, roosting, feeding, and nesting cover. An area must contain vegetation that adequately provides these five cover types, as well as food, with both sufficiently interspersed to be within the quail's limited range.

Several food studies have determined quail diet by inspection of crops or droppings (Larimer, 1960; Korschegan, 1948; Reeves, 1954; Barbour, 1951; Cady, 1944; Gray, 1940). These studies reflect the local availability of plant and animal species but dc not indicate all diet possibilities.

Some food studies synthesize and qualitatively generalize from other studies (Davison, 1958). SPB's impact on quail is best analyzed either by general studies such as Davison's or studies done in localities in which most of the vegetation types found on SPB spots are present so that local species availability does not affect results.

Davison (1958) classified bobwhite foods as choice, inferior, or unimportant (Table 7). He states that a choice food is always worthy of consideration in management, inferior foods have lesser importance, and unimportant foods should never be considered.

Table 7. Classification of Bobwhite Plant Foods

Choice Foods		Inferior Foods	
Bean	Pecan	Amaranth	Mentzellia
Blackberry	Pine	Ash	Oat
Millet	Ragweed	Bayberry	Osageorange
Clover	Rape	Beech	Palmetto
Corn	Razorsedge	Blackgum	Persea
Cowpea	Rice	Bladderwort	Prairieclover
Croton	Rye	Blueberry	Potato bean
Dogwood	Seasame	Buckwheat	Puffball
Four o'clock	Sorghum	Bumelia	Raspberry
Lespedeza	Strawberry	Butterfly pea	Phynchosia
Milkpea	Sunflower	Carpetgrass	Rushfoil
Oak acorns	Sweetgun	Clusterpea	Sassafras
Panicum	Swithgrass	Hog peanut	Sesbania
Partridge pea	Tick clover	Goldstargrass	Skunk cabbage
Paspalum	Vetch	Gorpherapple	Snapweed
Peanut	Wild Bean	Inkberry	Stillingia
Pearlmillet		Johnsongrass	Sundagrass
		Locust	Tread softly
		Lovevine	Wax myrtle

Source: Davison, 1958.

Several bobwhite quail food studies were performed in the loblolly region (Allen and Pearson, 1945; Baldwin and Handley, 1946; Brunswig and Johnson, 1972; Gray, 1940; Johnson and Pearson, 1948) (Table 8). The local species availability for these studies would probably be similar to that on SPB spots. Any species compromising one percent or more of the bobwhite's diet will probably be eaten if available in sufficient amounts, and if food is limiting.

Table 7 and 8 indicate that the bobwhite's most important foods are forbs, fruits, acorns, and farm crops. In contrast, SPB spots have the greatest impact on browse and grasses, hence, SPB is expected to have a slight impact on bobwhite foods in pine plantations.

SPB will cause an edge effect on bobwhite through increased interspersion. SPB spots will break up continuous plantations and provide small areas of interspersed habitat that quail are known to need. In addition, SPB spots will provide more understory cover than a dense pine plantation. Therefore, in pine plantations, the major SPB impacts are on edge and cover, and food impacts are positive but minor (Impacts 3, 5, and 6; Table 11).

Understory species which increased the most in mixed pine-hardwood forests were butterfly pea, tick clover, hairy elephants foot, and shapely milkpea

Table 8. Summary of bobwhite quail foods in percentage weight of quail diet.

Plant species	Virginia	Alabama			Georgia
	Baldwin & H.	Allen	Johnson & P.	Gray	Brunswig & J.
Ragweed	20.6	-	8.9	1.8	6.8
Soybeans	3.2	2.1	4.4	-	-
Lespedeza spp.	17.6	1.5	20.6	28.0	21.8
Partridge pea	4.2	-	-	-	8.4
Cowpeak	6.9	8.9	11.9	3.0	-
Wheat	2.1	-	-	-	-
Corn	+	3.2	2.3	+	-
Beggerweeds	5.0	3.8	5.4	10.0	5.1
Oaks (acorns)	3.5	23.7	11.7	2.5	7.9
Ash (samara)	1.6	-	-	-	+
Jewelweed	1.9	-	-	-	+
Rye	2.5	-	-	-	-
Sweetfern	2.3	-	-	-	+
Pines	1.8	-	-	-	+
Hog peanut	1.7	-	-	-	+
Vetch	2.2	-	-	-	-
Bush clovers	1.9	-	-	-	4.2
Milk peas	1.6	-	-	-	4.2
Dogwood	1.5	-	-	-	1.5
Grasshopper	1.3	1.7	1.9	1.7	5.5
Wild bean	1.2	-	-	-	+
Pokeweed	-	-	-	-	18.2
Rhus	-	-	-	-	2.9
Nightshade	-	-	-	-	2.4
Crabgrass	-	-	-	-	1.7
Plume grass	-	-	-	-	1.2
Butterfly pea	-	-	-	-	1.1
Persimmon	1.1	-	-	-	-
Other	15.4	55.1	32.9	53.0	7.1

- = not reported.
+ = less than 1 percent by volume.

(Appendix I), all of which are important bobwhite foods and compromise over 40 percent of the quail's diet. However, Table 4 indicates that only 5.2 percent of the increase in total forage was legumes; hence, SPB's impact on quail foods in pine-hardwood forest is still small but positive.

The increased edge will also have an impact on Bobwhite, but not so pronounced as in pine plantations. In addition, SPB spots in pine-hardwood forest will also increase cover because of the dead timber and young bush growth. Hence, in pine-hardwood forests, there are modest positive impacts on edge and cover, and minor impacts on food (Impacts 3, 5, and 6; Table 11).

Other Birds

This is a catch-all group for the vast number of birds we know little about, expect little impact upon, or have little time to investigate individually. It includes doves (*Zenaidura macroura*), hawks (*Buteonidae* and *Accipitrinae*), owls (*Tytonidae* and *Strigidae*), woodcocks (*Philohela minor*), blackbirds (*Molothrus ater*), robins (*Turdus migratorius*), various songbirds, and other game and nongame birds. It does not include birds whose ranges differ from loblolly and shortleaf pine such as grouse (*Bonasa umbellus*), waterfowl, or mountain quail (*Oreortyx picta*). The impact on these latter birds will be zero.

The birds in this group (except hawks and owls) also feed on a variety of seeds, fruits, berries, insects, and herbaceous plants. Hawks and owls are predatory and feed on a variety of small mammals, insects, and birds. In general, we know that the amount of seeds, fruit, and berries on SPB spots is greater than on undisturbed forest acres. Hence, if a food impact exists, it would be at least slightly positive. It is also probable that the edge effect is slightly positive because this group of birds generally requires interspersion (Johnston and Odum, 1956).

Recent work has shown that nongame bird population richness and density is high in the early stages of loblolly-shortleaf pine succession (Meyers and Johnson, 1978). In addition, Meyers and Johnson show that species richness continually decreases after canopy closure until age 35. Hence, SPB attacks in middle aged dense loblolly-shortleaf pine stands will have a positive impact on nongame bird populations.

The impact on owls and hawks depends on the impact on small mammals. Edwards (1978) reports that a newly cut timber stand is rich in passerines and small mammals. He also reports that pure pine stands provide very little habitat for raptors. Hence, we would anticipate a slight positive impact on hawks and owls. This may be offset by increased ground cover which provides more escape cover for their prey. However, the increased ground cover is used for nesting sites and shelter by many other birds.

Hence, for other birds we would expect impacts on edge, nesting sites, and food to be slightly positive, and a cancellation between predator and nonpredator birds on cover (Impacts 3, 4, 5, and 6; Table 11).

Rabbits

The cottontail rabbit (Sylvilagus floridanus) is found everywhere that loblolly pine is and in populations as high as 2 per acre (Wing, 1951). They typically inhabit brush lands, open woodlands, fence rows, overgrown fields, and thickets.

Rabbits are hunted by nearly every carnivorous bird and animal (Madison, 1959), so escape cover is extremely important. This element alone can often be the main regulatory tool for rabbit management. Downed trees, high grass, or dense understory vegetation can supply sufficient rabbit cover. These are usually plentiful in the summer but can become critical in winter.

The rabbit's home range varies from 1 to 10 acres, averaging about 6 (Wing, 1951). Interspersion is very important due to this small home range, so the amount of linear edge in a forest can have pronounced impact on rabbit populations.

Rabbits eat a variety of foods, some claim almost anything available (Wing, 1951). Their major foods are the seeds, leaves, stems, or fruit of crataegus, blackberries, raspberries, sumac, lespedeza, clover, goldenrod, timothy, grass, vetch, cultivated crops, and other herbaceous and woody species (Dusi, 1952; Lantz, 1929; Madson, 1959). Rabbits prefer the more succulent species.

SPB impact will be through edge, cover, and food. SPB adds about 2,000 feet of linear edge to a forest per acre of infestation (Table 6), and causes considerable amounts of downed timber and new, young vegetation for cover; hence, these two features of SPB spots will have a relatively large impact. However, the total impact may still be small due to the small acreage affected. The impact of increased food should be less than either cover or edge, since food is not a likely limiting factor. Therefore, we would expect a relatively large impact on cover and edge, and a smaller impact on food (Impacts 3, 5, and 6; Table 11).

Squirrels

The gray and fox squirrels (Sciurus carolinensis, Sciurus niger) are the two major southeastern squirrel species. These two species are very similar in their food and habitat requirements, and the differences are small enough to ignore in this report.

The gray and fox squirrel's range is practically the same as the oak-hickory forest's. They inhabit forests having sufficient mast, other foods, and den trees. They rarely inhabit pine monocultures, or brush and cutover lands. Den trees are very important because they provide shelter and nesting sites. Every squirrel usually has at least one leaf nest and one den-tree nest.

Squirrel food is rather special, mainly fleshy fruits, mast, and seeds. A partial list of foods eaten by squirrels has been compiled by Wing (1951) (Table 9). Dudderar (1967) has compiled a much larger and specific list for further reference.

Table 9. Foods Regularly Eaten by Gray and Fox Squirrels

Mast	Fleshy Fruits	Seeds	Vegetation
Hickory nuts	Grapes	Maple	Fungi
Acorns	Blackberries	Elm	Maple buds
Chestnuts	Raspberries	Box elder	Elm buds
Beechnuts	Cherries	Corn	Aspen buds
Walnuts	Plums	Euonymus	Willow buds
Butternuts	Mulberries	Basswood	Sprouts
Buckeyes	Dogwood	Bittersweet	
Hazelnuts	Sour gum		
	Huckelberries		
	Blueberries		

Source: Wing, 1951.

Squirrels rarely inhabit pine plantations, and their cruising radius is very small. Hence, few ever wander very far into pine plantations, and any change in the vegetation in pine plantations caused by SPB will have little, if any, impact on squirrels.

The situation is somewhat different in mixed pine-hardwood forests. SPB will remove some pine and possibly relax competition on mast producing trees. This impact is probably very small. SPB could have a small negative impact by destroying older pines sometimes used for leaf nests. Change in foods is also likely to be minor. Very little of the new vegetation in SPB spots is old enough to produce mast.

Hence, it is probable that the overall impact of SPB on squirrel populations will be very slight. The impact in pine plantations will be 0, and the impact in mixed pine-hardwood forests will be slightly negative on nesting sites and cover, and slightly positive on food (Impacts 4, 5, and 6; Table 11).

White-Tailed Deer

White-tailed deer (*Odocoileus virginianus*) is perhaps one of the most frequently studied wildlife species in North America. Information on their habitat and food requirements is abundant (May, 1956; Chamrad and Box, 1968; Korschgen, 1962; Short, 1972). New, elaborate methods for determining deer carrying capacity have been developed (Harlow and Whelan, 1969) but they often exceed data limits, or are too complex for such a small portion of this report. They could provide quantitative impacts of SPB on deer carrying capacities in later studies. In this report, older, less rigorous methods will be used. These methods are not the best available, but are sufficient for this report considering time and data limitations.

The white-tailed deer is found throughout the wooded areas of North America from Florida to southern Canada and the northern Rockies. It inhabits almost any area providing dense, wooded areas, or thick brush for shelter from predators (including man) during the day when they sleep.

Pine plantations and pine-hardwood forest usually provide sufficient shelter, and the limiting factor in these areas is usually either winter food supply or hunting. Therefore, the impact of SPB on quality and quantity of available forage and its interspersion will cause the major impact on deer carrying capacity.

Several studies show that in the Southeastern Coastal plain honeysuckle leaves, oak acorns, and grasses account for 70 percent of the diet (Table 10), for example, Harlow and Hooper (1971). SPB attacks in loblolly pine plantations are likely to have little impact on acorns; however, they can increase browse and grasses. Species in both of these categories are consumed readily by deer, hence, SPB spots in pine plantations are likely to increase deer populations when SPB spots are abundant.

The situation is very similar in pine-hardwood forests. Honeysuckle would not increase as much as on pine plantations, however, this is partially offset by increased mast from surrounding hardwood trees. Hence, we would expect SPB spots in pine-hardwood forest would also increase populations where SPB spots are abundant. However, it should be kept in mind that Leuschner et al. (1976) show that SPB spots on the Trinity District only covered .05 percent of the land area so the total impact may be small.

Increased carrying capacity caused by increased food could be determined using the following modern complex method:

1. Obtain data on amounts of preferred deer foods eaten by season (Available from Harlow and Hooper, 1971).

2. Rank foods by percentage of total dry matter volume.

3. Obtain a digestion coefficient for each major food species.

4. Calculate Kg/Ha increase of preferred deer foods by species on SPB spots in the winter, the limiting season.

5. Multiply (3) x (4) in order to obtain the Kg/Ha increase of digestible deer foods on SPB spots.

6. Obtain the gross energy values for each preferred species.

7. Multiply (5) x (6) to obtain the gross increase in digestible food energy on SPB spots.

8. Obtain the amount of digestible energy required per deer per day for normal maintenance functions (about 3,300-9,900 kcal/day) (French et al, 1956).

Table 10. Winter foods of the white-tailed deer in percentage volume for the coastal plain states.

Plant Species	Plant Part: Leaves	Twigs & buds	Fruit	Total
Trees, shrubs & vines				
Honeysuckle	37.9	.1	0	38.0
Oak	1.0	0	20.6	21.6
Bullberry	1.8	0	.3	2.1
Black titi	1.1	0	0	1.1
Greenbrier	1.0	0	0	1.0
Sumac	0	0	.7	.7
Sweet bay	.7	0	0	.7
Cactus	.6	0	0	.6
Willow	.4	0	0	.4
Blackberry	.3	0	0	.3
Blueberry	.2	0	.1	.3
Pine	0	0	.2	.2
Saw palmettow	0	0	.2	.2
Sassafras	0	0	.1	1
Unknown	7.8	4.7	0	12.5
Forbs				
Deer's tongue	3.6	0	0	3.6
Composite	1.3	0	0	1.3
Unknown	0	1.6	0	1.6
Grasses & sedges				
Fungi	-	-	-	3.2
Total forage	68.2	6.4	22.2	100.0

SOURCE: Harlow & Hooper, 1971.

9. Divide (7) by (8) to obtain the number of deer days increase in carrying capacity per ha. of SPB spots. (Source: James B. Whelan, Adjunct Professor of Wildlife; Assistant Unit Leader, Virginia Cooperative Wildlife Research Unit, Virginia Polytechnic Institute and State University; personal conversation).

We lack data to estimate steps 3, 4, and 6, and these complex methods are beyond the scope of this report. Therefore, a simpler, less accurate, but sufficient method will be followed:

1. Obtain the total increase in browse on SPB spots--about 224 lbs/acre on mixed pine-hardwood forests (Table 4), and somewhat larger on pine plantations.

2. Obtain the percentage of browse which is palatable and utilized by deer--about 65 percent (Blair, 1960).

3. Obtain a percent digestibility factor for winter browse--about 40 percent (Blair, 1960).

4. Multiply (1), (2), and (3) to obtain the total increase in palatable, digestible, browse on SPB spots--about 58 lbs/acre on mixed pine-hardwood forests, and somewhat larger on pine plantations.

5. Obtain the amount of deer browse consumed per day per deer--between 3 and 4.7 lbs/day (French et al., 1956; Nichol, 1938; Gerstell, 1938; Hosley, 1956).

6. Divide (4) by (5) to obtain the number of deer days increase in browse per acre on SPB spots--approximately 14.5 in mixed pine hardwood forests, somewhat more in pine plantations. Hence, each acre of SPB spots in mixed pine-hardwood forests will increase the white-tailed deer carrying capacity by about 14.5 deer days which equals one deer a year increase for every 25 acres of SPB spots in mixed pine hardwood forests, and a little less in pine plantations.

The value of the deer impact is likely to be relatively high because of the high value placed on white-tailed deer. However, 50,000 acres of loblolly-shortleaf pine-hardwood forest would be required for 25 acres of SPB spots, assuming the Trinity District spot severity rate. Hence, at most we would expect the carrying capacity on 50,000 acres of loblolly-shortleaf pine-hardwood forest to increase by only one deer. This may put the size of the impact in perspective.

The preceding is probably an over estimate because the home range of one deer is less than 50,000 acres. Further, Schuster's study may slightly overestimate SPB's impact on understory vegetation. Our estimate is rough and may contain a wide margin of error, particularly for the individual sites due to the system's variability. However, it gives an approximate idea of SPB's impact.

White-tailed deer are also affected by the increased interspersion caused by SPB spots. Deer normally browse in open areas at night and retreat to dense thickets during the day for protection. The interspersion of these two elements is important but not so important as for rabbits because the deer are much more mobile. Therefore, SPB's major impact on deer is increased food, but secondary impacts also occur on edge. These impacts are expected to be somewhat larger in pine plantations than mixed pine-hardwood forests (Impact 3 and 6; Table 11).

Small Mammals

Small mammals include mice, shrews, moles, voles, rats and other small members of the Insectivora and Rodentia orders. Very little information is available on the habitat and food requirements. That available indicates group members feed on insects, deer antlers, and low plants and leaves. The major SPB impact on this group would be in bringing vegetation closer to the ground causing increased food availability and shelter. According to Murray (1957), the edge effect is unimportant for small mammals. The estimated effects of SPB on small mammals is expected to be very slight (Table 11).

Fish

SPB spots will have an impact on fish only when the spots cause enough increased sedimentation or stream temperature to affect fish populations. The only case in which this is possible is if the SPB spots are located directly on the stream. Even then, the change in stream temperature and sedimentation is likely to be very slight (Shore, 1978). Hence, SPB's impact on fish populations is expected to be insignificant (Table 11).

Other Animals

This group includes opossums (*Didelphis virginiana*), foxes (*Urocyon* spp., *Vulpes* spp.), skunks (*Mephitis mephitis*), other furbearers and other animals. Literature on their food and habitat requirements is very scarce.

The one distinguishable impact is on beaver (*Castor canadensis*). Beaver are known to relish young loblolly pine plantations and inflict extensive tree damage when located near streams or rivers (Chabreck, 1958). However, removal of the pine on an SPB spot would probably not affect beaver populations because nearby trees would probably be substituted. In addition, SPB usually do not attack young plantations.

Most of the furbearers spend most of their time in and around bodies of water and would be unaffected by edge, food, or cover changes in SPB spots. Many other furbearers such as foxes, weasels, and bobcats are carnivorous and would be affected very little by SPB spots. Therefore, the impact of SPB on other animals is expected to be insignificant (Table 11).

SUMMARY OF SPB's WILDLIFE IMPACT

The purpose of this paper has been to systematically examine SPB's wildlife impact and to determine if the impact is large enough to warrant further investigation and incorporation into SPB control decisions. No primary data were available on wildlife populations before and after SPB attack, hence a surrogate means of assessing SPB's wildlife impact was necessary.

The method used equated SPB spots to various cutting operations. Small SPB spots were equated to selection cuts, medium SPB spots to shelterwood cuts, and large SPB spots were considered clearcuts. Published data on forage production before and after these cutting operations were then used to estimate the average change in forage production per acre of SPB spot assuming the same spot size distribution as in Leuschner et al. (1976). The change in forage production on pine-hardwood forest was estimated to be 366 pounds per acre of SPB spot. Similar data for pine plantations were unavailable, but studies have shown that dense plantations provide very little forage, hence overstory removal is likely to have a larger impact than in pine-hardwood forest.

SPB also has other wildlife habitat impacts. SPB was estimated to increase the linear edge in a stand by 2,000 feet per acre of SPB spot. Edge depth is likely to be small because of the small spot size. Spots also provide snags for cavity nesting birds, and the insects are a direct source of food for some of these birds.

SPB impacts on wildlife species groups must be expressed as qualitative generalities due to the surrogate methods used. These impacts are summarized in Table 11. Only the general direction of the impacts

SPB has a positive impact on woodpeckers, quail, rabbits, deer, small mammals, and other birds. Increases in edge and food cause most of these impacts.

The impacts' magnitude is very hard to determine. A rudimentary attempt indicated that more than 25 acres of SPB spots are needed to increase carrying capacity by one deer. The small size and low incidence of SPB spots greatly diminish SPB's wildlife impact in any area.

The preceding analysis argues against further wildlife impact research. SPB has a positive impact but the magnitude is so small that further expenditures to quantify general impacts are unwarranted. However, these conclusions are themselves very general and further investigation of impacts on individual species might be warranted in special cases. Further, this analysis was based on the severity and spot size distribution found on the Trinity District. A more intense, severe outbreak could change the conclusions.

SPB's positive impact is a cost of control. The quantity of decreased populations, although expected to be small, is unknown; thus, these guidelines are partial. However, SPB control decisions should weigh all the known benefits and costs, not only those which are readily quantifiable. In most cases the wildlife impact should be negligible but special cases may exist where it will be large enough to affect the decision. Alternatively, the net benefits of a control program may be quite small and the negative effect on wildlife populations may be enough to make the pest manager decide against the program. In any event, we urge explicit consideration of wildlife impacts even if the conclusion is likely to be that they are negligible.

Table 11. Summary of qualitative impacts of SPB on wildlife.

Wildlife species	Loblolly pine plantation: Areas of impact (Fig. 1)						Loblolly pine-hardwood: Areas of impact (Fig. 1)						Total Impact
	1 SPB as Food	2 Stream Temp.	3 Edge	4 Nest Sites	5 Cover	6 Food	1 SPB as Food	2 Steam Temp.	3 Edge	4 Nest Sites	5 Cover	6 Food	
Woodpeckers	+	0	0	+	-	-	+	-	-	+	-	-	+
Turkey	0	0	0	0	0	0	0	0	0	0	0	0	0
Quail	0	0	+	0	+	+	0	0	+	0	+	+	+
Other birds	0	0	+	+	0	+	0	0	+	+	0	+	+
Rabbits	0	0	+	0	+	+	0	0	+	0	+	+	+
Squirrel	0	0	0	0	0	0	0	0	0	-	-	+	0
Deer	0	0	+	0	0	+	0	0	+	0	0	+	+
Small mammals	0	0	0	0	+	+	0	0	0	0	+	+	+
Fish	0	0	0	0	0	0	0	0	0	0	0	0	0
Other animals	0	0	0	0	0	0	0	0	0	0	0	0	0

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APPENDIX I

Understory Species Occurrence and Change on SPB Spots

Table I-1. Percentage frequency of occurrence of plant species by cutting treatment and estimated change in percentage frequency of occurrence of plant species on SPB spots.[a/] [b/]

Species	Cutting Treatment Clear-cut (1)	Shelter-wood (2)	Selection (3)	Uncut (4)	Change in % freq. occ. on SPB spots (5)
Browse:					
Ampelopsis arborea	5.2	22.9	5.2	10.4	7.7
Berchemia scandens	4.2	5.2	5.2	3.1	2.1
Callicarpa americana	20.8	28.1	23.9	28.1	- 1.3
Chinonanthus virginicus	7.3	7.3	14.6	12.5	- 3.6
Cornus florida	11.5	11.5	27.1	33.3	-18.4
Crataegus spp.	20.8	9.4	14.6	4.2	7.0
Gelsemium sempervirens	38.5	48.9	41.7	28.1	18.7
Hypericum hypercoides	18.8	4.2	13.5	3.1	4.0
Hypericum stans	1.0	.0	.0	.0	.1
Morus rubra	1.0	1.0	2.1	1.0	.3
Nyssa sylvatica	6.3	6.3	10.4	4.2	3.0
Quercus alba	3.1	1.0	.0	1.0	- .1
Quercus nigra	6.3	7.3	8.3	8.3	- .8
Rhus radicans	15.6	25.0	21.9	13.5	10.4
Rubus spp.	36.5	45.8	37.5	16.7	26.9
Sassafras albidum	6.3	10.4	13.5	7.3	3.6
Schrankia uncinata	1.0	.0	.0	.0	.1
Smilax bona-nox	.0	2.1	.0	3.1	- 1.6
Smilax glauca	7.3	15.6	12.5	13.5	1.0
Smilax laurifolia	.0	1.0	4.2	3.1	- 1.5

Table I-1.Continued.

Species	Cutting Treatment Clear-cut (1)	Shelter-wood (2)	Selection (3)	Uncut (4)	Change in % freq. occ. on SPB spots (5)
Similax rotunda folia	1.0	2.1	1.0	2.1	.2
Ulmus alata	3.1	5.2	1.0	.0	4.2
Vitis aestivalis	4.2	6.3	7.3	5.2	1.2
Viburnum nudum	.0	3.1	.0	.0	2.3
Vitis rotunda folia	9.4	8.3	18.8	10.4	.3
Viburnum rufidulum	29.2	17.7	23.9	30.2	-10.6
Acer rubrum	15.6	11.5	10.4	12.5	- 1.0
Aralia spinosa	3.1	1.0	1.0	1.0	.1
Asimia parviflora	.0	.0	2.1	1.0	- .6
Carya spp.	6.3	3.1	3.1	6.3	- 3.0
Ceanothus americanus	.0	3.1	6.3	6.3	- 2.7
Celtis laevigata	1.0	.0	1.0	1.0	- .7
Ilex opaca	.0	.0	1.0	.0	.2
Juniperus virginiana	.0	.0	.0	1.0	- 1.0
Liquidambar styraciflua	27.1	20.8	26.0	11.5	10.9
Magnolia virginiana	.0	2.1	1.0	.0	1.8
Myrica cerifera	8.3	12.5	7.3	4.2	7.0
Parthenocissus quinquefolia	7.3	6.3	13.5	18.8	-10.9
Pinus echinata	54.2	26.0	26.0	6.3	21.3
Pinus taeda	12.5	12.5	20.8	9.4	5.0
Prunus mexicana	1.0	.0	.0	.0	.1
Prunus serotina	.0	2.1	.0	1.0	.5
Prunus umbellata	2.5	6.3	20.8	4.2	5.7
Quercus falcata	15.6	13.5	12.5	10.4	3.0
Quercus marilanica	8.3	2.1	5.2	9.4	- 6.3
Quercus stellata	35.4	44.8	33.3	28.1	13.7

Table I-1. Continued

Species	Cutting Treatment: Clear-cut (1)	Shelter-wood (2)	Selection (3)	Uncut (4)	Change in % freq. occ. on SPB spots (5)
Rhus copallina	13.5	6.3	5.2	2.1	4.4
Rhus glabra	2.1	4.2	6.3	.0	4.6
Vaccinium arboreum	7.3	3.1	5.2	1.0	2.8
Vaccinium stamenium	6.3	10.4	11.5	10.4	.0
Zanthoxylum clava-herculis	.0	1.0	1.0	.0	1.0
Herbage: Forbs and Legumes					
Ambrosia psilostachya	9.4	4.2	6.3	2.1	2.9
Antennaria plantaginifolia	8.3	.0	1.0	2.1	- 1.4
Aster spp.	5.2	5.2	4.2	3.1	1.9
Berlandiera texana	1.0	2.1	1.0	.0	1.8
Cassial fasiculata	7.3	6.3	6.3	.0	6.4
Centrasema virginianum	15.6	17.7	22.9	5.2	13.6
Chrysupsis graminifolia	7.3	3.1	7.3	.0	4.3
Compositae supp.	1.0	3.1	3.1	5.2	- 2.2
Croton glandulosus	14.5	8.3	14.5	6.3	3.7
Crotolaria sagittalis	7.3	1.0	6.3	1.0	1.5
Desmodium ciliare	5.2	1.0	1.0	.0	1.2
Desmodium spp.	10.4	15.6	14.6	2.1	13.1
Diodia teres	10.4	1.0	10.4	1.0	2.6
Elephantopus tomentosus	8.3	18.7	4.2	4.2	10.8
Galactia spp.	17.7	13.5	9.4	6.3	6.6
Galactia mollis	9.4	6.3	4.2	9.4	- 3.4
Galactia regularis	19.8	28.1	43.7	13.5	17.7
Galium pilosum	12.5	7.3	11.4	3.1	5.4
Helianthus hirsutus	21.9	9.4	9.4	2.1	8.0
Heterotheca pilosa	1.0	1.0	1.0	.0	1.0
Houstonia nigricans	6.3	1.0	1.0	.0	1.3

Table I-1.Continued.

Species	Cutting Treatment				Change in % freq. occ. on SPB spots (5)
	Clear-cut (1)	Shelter-wood (2)	Selection (3)	Uncut (4)	
Lespedeza capitata	3.1	2.1	5.2	1.0	1.9
Lespedeza spp.	12.5	6.3	9.4	2.1	5.3
Liatris elegans	5.2	8.3	12.5	.0	9.1
Liatris squarrosa	6.3	.0	1.0	.0	.6
Ludwigia alternifolia	1.0	3.1	2.1	1.0	1.8
Mitchella repens	8.3	14.5	12.5	29.2	-13.6
Oxalis spp.	3.1	.0	1.0	.0	.4
Phlox spp.	2.1	2.1	3.1	.0	2.3
Pteridium aquilinum	12.5	17.7	17.7	13.5	3.9
Pycnanthemum albescens	2.1	2.1	2.1	1.0	1.1
Rhynchosia latifolia	3.1	4.2	3.1	3.1	.8
Rhynchosia spp.	5.2	15.6	5.2	3.1	9.7
Ruellia caroliniensis	6.3	1.0	8.3	1.0	1.9
Rudbeckia hirta	5.2	1.0	1.0	.0	1.2
Sanicula canadensis	5.2	5.2	9.4	7.3	- 1.2
Scutellaria cardiophylla	2.1	2.1	2.1	1.0	1.1
Sulidago nemoralis	24.0	10.4	20.8	10.4	1.1
Sulidago odora	3.1	7.3	3.1	1.0	5.2
Sulidago radula	3.1	3.1	.0	1.0	1.4
Stylosanthes biflora	16.7	9.4	12.5	1.0	9.5
Tragia articifolia	10.4	13.5	15.6	10.4	3.4
Vernonia texana	17.7	14.6	29.2	22.9	- 4.9
Viola spp.	4.2	4.2	2.1	5.2	- 1.5
<u>Grasses and Grass-likes:</u>					
Andropogon divergens	56.2	18.8	37.5	16.7	8.3
Andropogon ternarius	9.4	1.0	7.3	.0	2.9
Andropogon virginicus	45.8	18.7	26.0	5.2	16.7

Table I-1. Continued.

Species	Cutting Treatment				Change in % freq. occ. on SPB spots (5)
	Clear-cut (1)	Shelter-wood (2)	Selection (3)	Uncut (4)	
Aristida lanosa	1.0	1.0	7.3	.0	2.4
Aristida purpurascens	46.9	25.0	31.3	2.1	25.6
Carex spp.	18.8	16.7	19.8	7.3	10.3
Eragrostis spectabilis	2.1	1.0	1.0	.0	1.1
Gymropogon ambiguus	13.5	6.3	15.6	1.0	7.8
Manisuris cylindrica	.0	.0	2.1	.0	.5
Panicum ancepts	11.4	15.6	5.2	2.1	11.0
Panicum spp.	67.7	56.3	66.7	35.4	24.0
Panicum sphaerocarpon	20.8	7.3	12.5	1.0	8.2
Paspalum bifidum	3.1	.0	1.0	.0	.4
Scleria triglomerata	19.8	13.5	30.2	12.5	5.1
Surghastrum elliottii	5.2	2.1	.0	.0	1.8
Sporobolus junceus	3.1	2.1	9.4	2.1	1.7
Triden falvus	1.0	2.1	5.2	1.0	1.7
Chasman thium sessiliflora	25.0	47.9	26.0	19.8	22.1
Unknown	4.2	1.0	.0	.0	1.0

[a]Columns 1-4 are obtained from Schuster (1967). Column 5 is estimated using the formula: .0542 ((1)-(4)) + .7228 ((2) - (4)) + .223 ((3) - (4)).

[b]The first four come from Schuster (1967). The uncut column was subtracted from each of the other three columns to estimate the change in frequency of occurrence by timber harvest. These changes were then weighted by the estimated percentage of SPB spots approximating the three harvest methods to obtain the change in frequency of occurrence following SPB attack (last column).

APPENDIX II

Correlations and Regressions Between Forage Yields and Habitat Variables

Table II-1. Simple correlation analysis between habitat variables and forage yields.

Habitat factors	Forage production correlation coefficients				
	Browse	Legumes	Forbs	Grasses	Herbage
Mid-story cover (%)	-.547	-.368	-.237	-.594	-.617
Dominant overstory cover (%)	-.219	-.227	NS	-.491	-.479
Mid + dominant overstory cover (%)	-.540	-.409	-.284	-.743	-.752
Tree basal area (sq. ft./acre)	-.399	-.274	-.228	-.650	-.637

SOURCE: Schuster, 1967

NS = Nonsignificant (.05 level).

Table II-2. Multiple regression analysis showing relations between forage yields and habitat variables.

Forage Yields	Multiple regression equation	Multiple R^2
Browse	$791 - 3.56\ X_8 + 10.57\ X_9 + 3.11\ X_{11} - 6.04\ X_{12}$	.704
Legume	$36.7 + 1.26\ X_4 - 0.55\ X_{12}$	.558
Other Forb	$223.3 - 2.83\ X_6 - 0.89\ X_{12}$	.335
Grass	$503.9 + 2.30\ X_8 - 4.83\ X_{10} - 3.88\ X_{11} - 1.62\ X_{13}$	.772
Total Herbaceous	$831.9 - 5.75\ X_{12} - 1.61\ X_{13}$	.763

SOURCE: Schuster, 1967.

Habitat factors: X_4 = depth to B Horizon; X_6 = % silt + clay in A horizon; X_8 = % silt + clay in B horizon; X_9 = % browse cover; X_{10} = % mid-story cover; X_{11} = % dominant story cover; X_{12} = mid + dominant story cover; X_{13} = tree basal area.

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3. Yields of Old-field Loblolly Pine Plantations. H. E. Burkhart, R. C. Parker, M. R. Strub and R. G. Oderwald, FWS-3-72, 1972.

4. Cost of Establishing Loblolly Pine Plantations in Virginia: Methodology and Estimates. E. F. Thompson, M. E. Shores and A. D. Sullivan, FWS-1-73, 1973.

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9. The Economics of Producing and Marketing Christmas Trees. W. A. Leuschner and W. A. Sellers, FWS-1-75, 1975 (out of print).

10. Site and Yield Information Applicable to Virginia's Hardwoods: A Review. T. F. Evans, H. E. Burkhart, and R. C. Parker, FWS-2-75, 1975 (out of print).

11. Computer-Implemented Simulation as a Planning Aid for State Fisheries Management Agencies. R. D. Clark, Jr. and R. T. Lackey, FWS-3-75, 1975.

12. Recreational Fisheries Management and Ecosystem Modeling. R. T. Lackey, FWS-4-75, 1975.

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17. Proceedings of the Forest Taxation Symposium. Edited by H. L. Haney and J. E. Gunter, FWS-2-78, 1978.

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School of Forestry and Wildlife Resources
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061