

THE EFFECT OF THE EUROPEAN WILD BOAR
(SUS SCROFA) ON THE WOODY VEGETATION
OF GRAY BEECH FOREST IN THE
GREAT SMOKY MOUNTAINS

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ABSTRACT

The European wild boar (Sus scrofa L.) was introduced into the mountains of North Carolina in 1912 and has since spread into the Great Smoky Mountains National Park. Omnivorous feeding and rooting disturbance by this exotic species is a management problem in the park. The Gray Beech Forest is intensively used by the wild boar. Beech (Fagus grandifolia) communities occupied by wild boar displayed a reduction in total understory-reproductive plant cover. However, these disturbed areas have a slight increase in total woody plant cover. Vegetative sprouts of beech in disturbed areas were 4 to 45 times more numerous than sprouts in undisturbed areas. Beech and blackberry (Rubus canadensis) disturbed by hog rooting had high populations in the reproductive stratum.

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INTRODUCTION

The southern Appalachian highlands harbor a considerable number of endemic and disjunct plant species that date back to tertiary forests (Braun 1950). Great Smoky Mountains National Park (GRSM) is a sanctuary within this region for a richly diversified flora and fauna.

In 1912, the European wild boar (Sus scrofa L.) was introduced into the mountains of North Carolina (Stegeman 1938). The spread and history of the wild boar in North Carolina, Tennessee, and Great Smoky Mountains National Park was reviewed by Bratton (1975). Since the late 1940's, this exotic animal has been extending its range eastward across the park. In the park the hog has created complex management problems not easily resolved. The wild boar disturb wild flowers, tree roots, and seedlings; compete with other animal populations; and cause soil erosion in hog rooted and wallowed habitats (Bratton 1974b). The research presented here investigates one of the management problems created by this exotic species, the wild boar's effect on the reproduction and distribution of woody species in Gray Beech Forest.

Feeding and Rooting Activity of the European Wild Boar in Beech Forest

European wild boar are omnivorous and are habitat generalists. Relatively little is known about the food habits of this invading species in the southern Appalachians. Henry and Conley (1972) studied their food habits in an oak-hickory woodland in Tennessee. A fall mast crop comprised a majority of the food consumed, with 89.4 percent and 6.4 percent representing volume of plant matter and animal food respectively. Forest dominated by sugar maple, beech, and yellow birch represented only 3.5 percent of their study area.

The availability of mast in the Gray Beech Forest of the Great Smoky Mountains National Park is unknown. Beechnuts ripen between September and November, however, the beech forest habitat was usually occupied by large boar populations during the spring and summer months. Beechnuts are probably not an important potential food source. Neither Russell (1953) nor I in the present study found a single seedling of beech in the high-elevation forests. Root suckers are the major form of reproduction. Russell found that seeds were produced in the gaps by large trees in 1948. The viability of reproduction by gray beechnuts of Great Smoky Mountains National Park has never been investigated.

The large starchy fruit of yellow buckeye ripens in September and germinates in the early spring after the seeds have wintered

on the ground (Fowells 1965). Fowells also stated that no further information is available on the number of seeds produced by individual trees, the conditions favoring seed production, and the frequency of seed years. Yellow buckeye represents a potential food source for hogs but effects of the poisonous glucoside, aesculin, in the fruit have not been investigated. Conley et al., (1972) have observed the food utilized by the hogs in the Tellico management area of Tennessee. Bratton (1974a) composed a general and species list of Eurasian plants eaten by the wild boars that are also common to the Great Smoky Mountains National Park. Both researchers have indicated that many woody species are potential foods for the wild boar.

During spring and summer the beech forests have a large quantity and diversity of herbaceous flora from which the hogs can feed continuously in small areas. As the summer wanes, the amount of food becomes scarce and the hogs continue to root the same areas, resulting in the tilled garden appearance of the soils in parts of the Gray Beech Forest.

Study Area

Gray Beech Forest located on higher elevation ridges of the Great Smoky Mountains National Park was chosen as the sampling area for determining effects of the wild boar's invasion into the park. The gray beech community, dominated by Fagus grandifolia, has been well described by various authors (Cain 1931; Russell 1953; Whittaker 1956; Crandell 1958), but the structure of the plant community has been rapidly changing since the boar's invasion (Bratton 1974a, 1975). These mesic beech forests are one of the most intensely hog-rooted habitats in Great Smoky Mountains National Park. Bratton (1974) reported that herbaceous cover is drastically reduced in hog-disturbed sites when compared to undisturbed sites.

In the summer of 1976, 10-meter by 10-meter plots were located in both undisturbed and hog-rooted beech forests. These sites were in areas similar to those sampled by Bratton (1975) in the summer of 1973. A total of 115 plots were established, of which 63 were in hog-rooted areas while the remaining 52 were in undisturbed stands (Fig. 1). The first 63 plots were grouped into five major locales: Jenkins Knob to the Narrows (including Double Springs), Silers Bald, Derrick Knob, Cold Spring Knob and Hemlock Knob, and Spence Field to Little Bald. The undisturbed plots were in four major locales: Newfound Gap, Indian Gap, Mesa Knob, and Pauls Gap/Beech Gap (Table 1).

Russell (1953) has described the beech gaps as small stands or deciduous "islands" in the forest. All the undisturbed plots from this study were from gaps having this characteristic "island" appearance. All hog-disturbed plots were located in the continuous expanse of crestline beech forest west of Double Springs (Jenkins Knob). It is impossible to verify that the disturbed and undisturbed areas were identical in vegetative character prior to hog invasion. The vegetative composition of each sample location is a unique occurrence. However, prior to major invasion these two areas were largely similar (Russell 1953; Whittaker 1956) and minor inherent differences in the stands did not obscure the changes caused by hogs.

The low elevation beech forests of Cold Spring Knob and Hemlock Knob, Derrick Knob, and Spence Field to Little Bald were comparatively similar to Newfound Gap, Pauls Gap, and Beech Gap (Tables 1-4). The high elevation beech forests near Silers Bald and Jenkins Knob to the Narrows were similar to Indian Gap and Mesa Knob.

Mesa Knob was the most unusual stand due to its high elevation and the intergradation with the spruce-fir forest. As one moves eastward, Mesa Knob is the last of the crestline beech forests (Fig. 1) until the far eastern boundaries of the park are encountered. Pauls Gap and Beech Gap in the northeast section of the park were

the only plots not on the crest of the Great Smoky Mountains. Nevertheless, they are rich mesic beech gaps under the influence of the Upper Cove Forest.

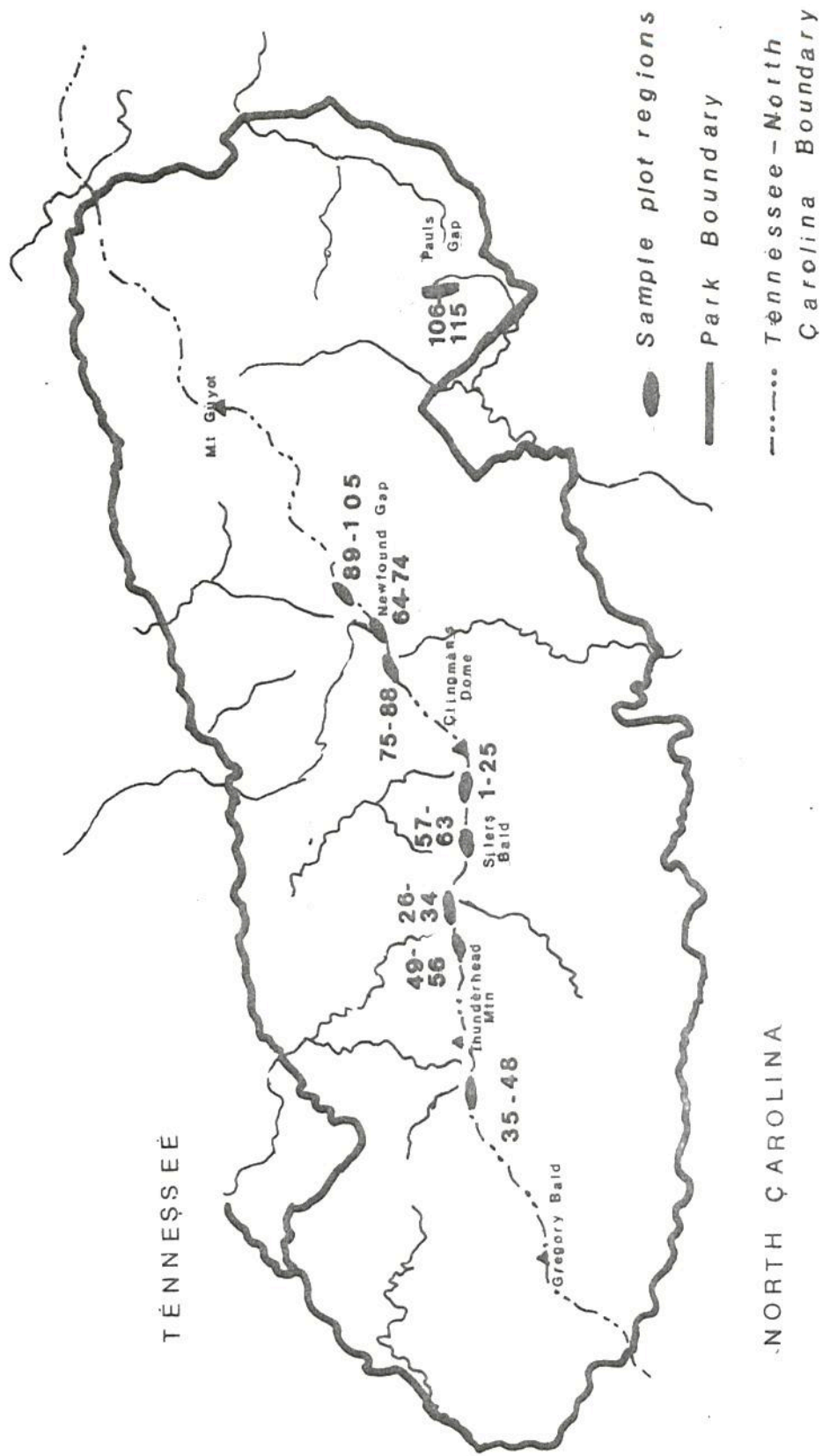
Methods

Disturbed and undisturbed sites were subjectively chosen. Each individual plot within a site was located using random distances of 10 to 40 meters and random compass directions. In some locations where random plots may have caused excessive overlap, the first plot was chosen at random, and random non-overlapping adjacent plots were sampled. The plots were free from recent fires, logging, or other major disturbances and at least 8 meters away from any trail. Each plot was 100 square meters, with a nested 25-square meter sub-plot in the northeast corner. The diameter at breast height (dbh) of all species greater than 2.5 centimeters were measured in the entire plot. The 25-square meter plot was used to evaluate all woody species with a dbh less than 2.54 centimeters. These individuals were separated into two size classes. Individuals that were greater than 40 centimeters in height were evaluated in four 6.25-square meter plots (understory (U) plots). Individuals less than or equal to 40 centimeters in height were evaluated from 25-square meter plots (reproductive (R) plots). Each individual within its respective species was tallied. (Multiple stems originating from one apical region were observed as one stem.) The number of stems per plot for each U and R plot

Figure 1. The location of beech forest plots 1 to 115 in the Great Smoky Mountains National Park.

1 - 25	Jenkins Knob to the Narrows (Double Springs)
26 - 34	Cold Spring Knob and Hemlock Knob
35 - 48	Spence Field to Little Bald
49 - 56	Derrick Knob
57 - 63	Silers Bald
64 - 74	Newfound Gap
75 - 88	Indian Gap
89 - 105	Mesa Knob
106 - 115	Pauls Gap and Beech Gap

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was a composite value originating from the total of all stems within each 25-square meter plot (i.e., 8 stems per U plot or 8 stems per 25 square meters for a U plot). Each size class plot (1 square meter or 6.25 square meters) was given a percentage cover value for the woody species in the plot. A total of 252 disturbed and 208 undisturbed plots were measured to evaluate the young understory, while 1,575 disturbed and 1,300 undisturbed plots measured the reproductive cover.

The taxonomic and nomenclature employed in this paper are after Radford et al. (1968). All plots were located on USGS 7.5-minute topographic maps. Elevation, aspect, and field notes (i. e., grazing or other disturbances) were recorded for each plot.

Basal area and relative dominance was computed on a Monroe programmable calculator. A digital computer was employed for linear regression of beech plots. The G-statistical method (numerically similar to chi-square) illustrated the 2 x 2 test of independence in beech reproduction. The only fixed variable was the sample size. Since $\int \ln \int$ tables were available, this statistical test was computationally simpler than chi-square. The sample size was less than 200, so Yates' correction was used to adjust the observed frequencies by 0.5 (Sokal and Rohlf 1969).

Table 1. The elevation range and number of plots by location on
boar-disturbed and undisturbed sites in Great Smoky
Mountains National Park

Location	Abbrev- iation	Elevation Range (m)	Disturbed (D) or Undisturbed (UD)	No. of plots
Cold Spring Knob and Hemlock Knob	CKHK	1450-1560	D	9
Derrick Knob	DK	1460-1490	D	8
Spence Field to Little Bald	SFLB	1490-1530	D	14
Silers Bald	SB	1615-1645	D	7
Jenkins Knob to the Narrows	JKN	1660-1685	D	25
Newfound Gap	NG	1510-1585	UD	11
Pauls Gap and Beech Gap	PGBG	1545-1560	UD	10
Indian Gap	IG	1640-1660	UD	14
Mesa Knob	MK	1680-1725	UD	17

RESULTS

Overstory Vegetation

The high-elevation Gray Beech Forest is dominated by American beech (Fagus grandifolia). Bratton (1975) indicated that yellow buckeye (Aesculus octandra) was the second most frequent tree, while yellow birch (Betula lutea) was third most frequent. In this study a total of 22 aborescent species were recorded; 17 ~~were~~ found in the overstory. In all locations, beech was the most important tree species (Tables 1, 2, 5, and 6 in the Appendix). The relative dominance of beech in disturbed areas varied from 31.1 percent at Cold Spring Knob to 81.6 percent at Silers Bald. The relative dominance of beech in undisturbed gap plots remains close to 65 percent.

Yellow birch frequently occurred on north-facing slopes and in the regions between spruce-fir forests. Many undisturbed sites are "island" beech gaps located among extensive spruce-fir. In this topographic position the proportion of yellow birch was infrequent at the lower elevations and common in the high-elevation plots of Indian Gap and Mesa Knob. Yellow birch was an unimportant species in high-elevation beech forests west of Clingmans Dome (Figure 1). The crestline plots at lower elevations, such as Spence Field to Little Bald and Derrick Knob, indicated that yellow birch was a major community associate.

Bratton (1975) describes yellow buckeye as a common associate when Gray Beech Forest grades into Upper Cove Forest. Yellow buckeye was an important component for all plots west of Clingmans Dome and occupied 12 percent to 22 percent relative basal area for all disturbed plots sampled (Table 2). In the high-elevation gaps, yellow buckeye populations disappeared, with the exception of a few individuals on the south slopes of Newfound Gap and Indian Gap. Yellow buckeye increased its dominance at the edge of the moist Upper Cove Forest at Pauls Gap and Beech Gap. Sugar maple (Acer saccharum) was a common species in the moist low-elevation beech forests. Derrick Knob, Cold Spring Knob, and Hemlock Knob were strongly influenced by this Upper Cove Forest species, yet it was almost absent from Spence Field to Little Bald. Red spruce (Picea rubens) and Fraser fir (Abies fraseri) were most common in the beech forests when the forests were surrounded by spruce-fir at high elevations.

The average total basal area for all species per plot was lowest at higher elevations while the lower mesic forests of Newfound Gap displayed the largest basal area per plot (Table 2). A trend in all sites sampled except Silers Bald indicated that the average total basal area per plot decreased as the elevation of the sample plots

Table 2. The relative proportion (percent) of basal area for woody species greater than 2.5 centimeters diameter at breast height in boar-disturbed and undisturbed areas.

Species	DISTURBED				LOCATION*				UNDISTURBED			
	CKHK %	DK %	SFLB %	SB %	JKN %	NG %	PGBG %	IG %	MK %			
<i>Abies fraseri</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	4.4			
<i>Acer pensylvanicum</i>	0.03	1.8	0.0	0.0	0.0	1.3	0.2	0.1	0.0			
<i>Acer saccharum</i>	31.2	16.4	0.5	1.6	0.5	4.5	7.1	0.0	0.0			
<i>Acer spicatum</i>	0.0	0.0	0.2	0.3	0.0	0.4	0.0	1.3	0.6			
<i>Aesculus octandra</i>	17.8	22.4	14.1	11.9	20.7	5.1	20.8	9.0	0.0			
<i>Amelanchier aborea</i> var. <i>laevis</i>	0.0	0.3	0.02	0.0	0.1	0.8	0.0	0.0	0.0			
<i>Betula lenta</i>	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0			
<i>Betula lutea</i>	10.3	15.9	23.7	0.0	1.3	12.1	3.3	21.9	32.9			
<i>Cornus alternifolia</i>	0.1	0.0	0.1	0.0	0.0	0.0	0.03	0.0	0.1			
<i>Crataegus</i> sp.	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0			
<i>Fagus grandifolia</i>	36.1	43.4	55.1	81.6	71.7	63.0	65.4	63.9	45.9			
<i>Halesia carolina</i>	4.3	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0			
<i>Picea rubrens</i>	0.0	0.0	0.0	4.7	3.7	6.6	0.0	3.6	13.1			
<i>Prunus pensylvanica</i>	0.0	0.0	0.0	0.0	0.1	0.0	2.9	0.0	0.9			
<i>Prunus serotina</i>	0.0	0.0	1.7	0.0	1.8	0.0	0.0	0.0	0.0			
<i>Quercus rubra</i>	0.04	0.0	4.3	0.0	0.0	0.0	0.2	0.0	0.0			
<i>Sorbus americana</i>	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	2.2			
<i>Viburnum alnifolium</i>	0.0	0.0	0.0	0.0	0.0	0.02	0.0	0.03	0.0			

*See Table 1

increased. Field sampling at Silers Bald had to be terminated after seven plots due to continuous encounters with black bears. It is probable that the large basal area difference for the Silers Bald area was due to inadequate sample size for estimating the overstory vegetation.

Understory Vegetation

Composition

Beech and blackberry were dominant in the understory of undamaged areas. Beech comprised 40 percent of the stems at Pauls Gap and Beech Gap but blackberry dominated the areas at higher elevations, accounting for 50 percent or more of the woody stems. Hobble-bush (Virburnum alnifolium) occurred sporadically, with large populations at Newfound Gap and Indian Gap (Table 3).

The hog-disturbed understory plots were also dominated by beech and blackberry, but the distribution patterns were different from those in the undisturbed areas. Beech represented a majority of the understory stems in the higher elevation plots at Silers Bald and the area from Jenkins Knob to the Narrows. Beech was less abundant at lower elevations. The distribution of blackberry was irregular. Blackberry was most common from Spence Field and Little Bald, but did not occur at Silers Bald or Derrick Knob. Sugar maple was a significant understory component at Derrick Knob, Cold Spring Knob,

Table 3. The proportion (percent) of woody species in the understory (U-plots) in board-disturbed and undisturbed areas.

Species	LOCATION*									
	DISTURBED					UNDISTURBED				
	CHKH %	DK %	SFLB %	SB %	JKN %	NG %	PGBG %	IG %	MK %	
<i>Abies fraseri</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.9	
<i>Acer pensylvanicum</i>	0.0	1.3	0.0	0.0	0.0	0.8	0.0	0.6	0.0	
<i>Acer saccharum</i>	22.1	28.9	0.0	0.0	0.0	0.0	17.6	0.0	0.0	
<i>Acer spicatum</i>	0.0	0.0	0.0	5.6	0.0	4.2	0.0	1.9	1.7	
<i>Aesculus octandra</i>	1.6	13.2	2.1	7.4	4.8	1.1	3.6	0.0	0.0	
<i>Amelanchier aborea</i> var. <i>laevis</i>	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
<i>Betula lutea</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	0.0	
<i>Cornus alternifolia</i>	0.5	0.0	0.8	0.0	0.0	0.0	2.4	0.0	0.9	
<i>Crataegus</i> sp.	0.5	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	
<i>Fagus grandifolia</i>	17.9	55.3	32.9	81.5	83.8	22.3	39.9	10.9	26.0	
<i>Halesia carolina</i>	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	
<i>Picea rubrens</i>	0.0	0.0	0.0	0.0	1.0	0.3	0.0	1.3	0.0	
<i>Prunus pensylvanica</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	
<i>Quercus rubra</i>	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
<i>Rubus canadensis</i>	57.4	0.0	62.9	0.0	10.5	24.3	31.5	49.4	62.1	
<i>Sorbus americana</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.4	
<i>Vaccinium constablaei</i>	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.4	
<i>Vaccinium erythrocarpum</i>	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	4.6	
<i>Virburnum alnifolium</i>	0.0	0.0	0.0	5.6	0.0	40.6	1.8	33.4	3.0	
<i>Virburnum cassinoides</i>	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	

*See Table 1

and Hemlock Knob. Yellow buckeye was distributed throughout the hog-disturbed areas, but represented less than 10 percent of the stems at the sites sampled.

In the woody reproductive (seedling, small sapling) size class, blackberry was a major component in undamaged gaps (Table 4). Beech stems varied from 7 to 11 percent of the stems and were widely scattered among the thick herbs. At the disturbed sites, reproductive class beech was far more important, accounting for 80 percent to 90 percent of the stems at some locations such as Derrick Knob and Silers Bald. Blackberry was patchy in its occurrence, with none at Derrick Knob and large populations at Cold Spring Knob and Hemlock Knob. Beech and blackberry were equally common from Spence Field to Little Bald. The seedling populations of sugar maple and buckeye were insignificant at the hog-disturbed sites.

Total estimates of plant ground cover were made for determining trends in both disturbed and undisturbed areas. The plant cover in the undisturbed areas ranged from 60 percent at Pauls Gap and Beech Gap to almost 100 percent at Mesa Knob. The percent cover for the disturbed areas ranged from 10 percent at Jenkins Knob, and up to 40 percent at Hemlock Knob, the latter a relatively lightly rooted site. At the time of this study, Indian Gap had an understory cover above 80 percent but had suffered hog rooting for the first

Table 4. The proportion (percent) of woody species reproduction (R-plots) in boar-disturbed and undisturbed areas.

Species	LOCATION*									
	DISTURBED					UNDISTURBED				
	CKHK %	DK %	SPLB %	SB %	JKN %	NG %	PGBG %	IG %	MK %	
<i>Abies fraseri</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	18.4	
<i>Acer pensylvanicum</i>	0.0	0.0	0.0	0.0	0.0	0.5	0.0	1.7	0.0	
<i>Acer saccharum</i>	2.2	2.7	0.2	0.0	0.0	1.5	28.3	0.0	0.0	
<i>Acer spicatum</i>	0.0	0.0	0.0	0.4	0.0	3.6	0.0	0.4	0.0	
<i>Aesculus octandra</i>	1.4	5.4	1.1	1.2	0.3	1.0	4.1	0.0	0.0	
<i>Amelanchier aborea</i> var. <i>laevis</i>	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	
<i>Cornus alternifolia</i>	0.0	0.0	0.4	0.0	0.0	0.0	0.7	0.8	0.0	
<i>Crataegus</i> sp.	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	
<i>Fagus grandifolia</i>	18.8	91.8	48.8	91.2	82.0	8.2	11.0	8.5	7.1	
<i>Picea rubrens</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	
<i>Prunus pensylvanica</i>	0.0	0.0	0.4	0.0	0.0	1.0	2.1	0.4	0.0	
<i>Prunus serotina</i>	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	
<i>Quercus rubra</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	
<i>Rubus canadensis</i>	76.1	0.0	49.0	6.0	16.2	32.3	46.9	43.6	66.3	
<i>Sorbis americana</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	
<i>Vaccinium constablaei</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	
<i>Vaccinium erythrocarpum</i>	0.0	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	
<i>Viburnum alnifolium</i>	1.1	0.0	0.0	1.2	0.0	45.6	4.8	43.6	5.1	
<i>Viburnum cassinoides</i>	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	

*See Table 1

time during that growing season. Rooting of this area was still of minor importance.

Russell (1953) and Schofield (1960) found the plant cover in the Double Springs-Jenkins Knob area to be similar to that of other gaps. Wolfe (1967) described the herbaceous cover as almost 100 percent. Bratton (1975) reported the herbaceous cover in 1973 had declined to 8 percent to 10 percent after the hog invasion. Samples collected for this study in 1976 indicate that the cover is remaining at approximately the 10 percent level. A majority of the lower strata cover is beech and blackberry.

Ferns were an important plant cover component of undisturbed sites but were scarce in the disturbed areas. Bratton (1974a) lists two ferns as being eaten by wild boar in Eurasia but notes that ferns in the hog-rooted beech gaps appear to be killed incidentally, uprooted, and desiccated rather than being eaten. Observations made in the recently invaded Indian Gap area indicate that Lady fern (Athyrium felix-femina) was rarely chosen as a primary food and neither leaves nor roots were consumed. The utilization of various fern species as food items is probably related to the amount of starch in the rhizome and the availability of other food sources.

Table 5. The average percent cover and average number of stems per plot of woody species in understory (U) plots and reproduction (R) plots on hog-disturbed and undisturbed areas.

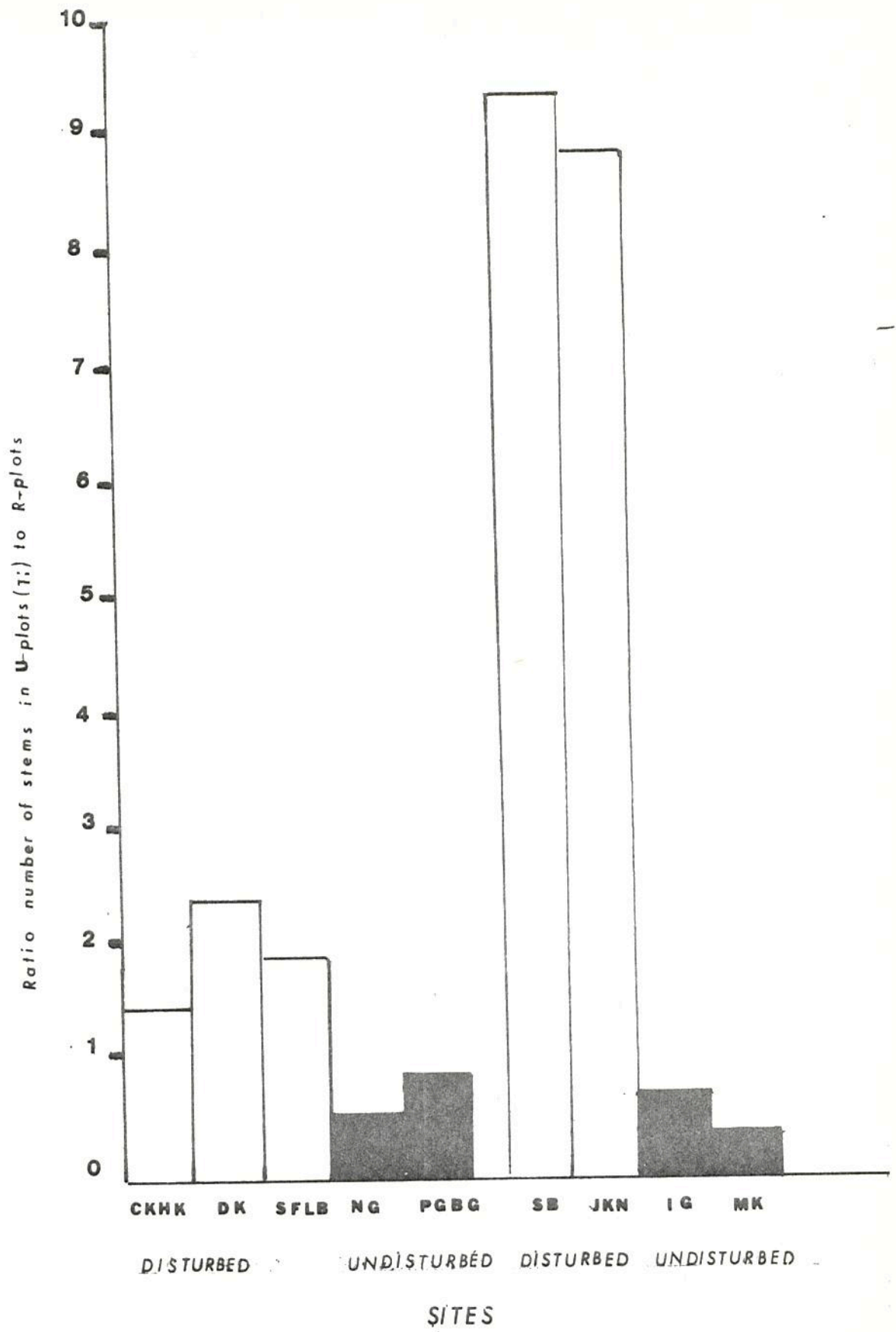
Location*	U-Plots				R-Plots			
	Avg. % cover	Avg. No. stems/plot	% Rel. dom. stems Fagr	% Rel. dom. stems Ruca	Avg. % cover	Avg. No. stems/plot	% Rel. dom. stems Fagr	% Rel. dom. stems Ruca
<u>Disturbed</u>								
Cold Spring Knob and Hemlock Knob	22.8	21.1	17.9	57.4	7.0	30.6	18.8	76.1
Derrick Knob	11.0	9.5	55.3	0.0	4.3	23.0	91.8	0.0
Spence Field to Little Bald	17.7	17.1	32.9	62.9	7.9	33.6	48.4	49.0
Silers Bald	21.7	7.7	81.5	0.0	8.1	35.9	91.2	6.0
Jenkins Knob to the Narrows	11.2	4.2	83.8	10.5	5.1	37.1	82.0	16.2
<u>Undisturbed</u>								
Newfound Gap	37.4	32.4	22.1	24.3	4.2	17.7	8.2	32.3
Pauls Gap and Beech Gap	25.6	16.8	39.9	31.5	4.0	14.5	11.0	46.9
Indian Gap	25.8	22.2	10.9	49.8	4.5	16.9	8.5	43.6
Mesa Knob	11.7	13.8	26.0	62.1	1.8	5.8	7.1	66.3

*See Figure 1 and Table 1.

Figure 2. The ratio of the total number of woody stems in understory plots to reproduction (R) plots for boar-disturbed and undisturbed areas.

NOTE: For location, see Table 1.

Figure 2



Size Class Composition

The disturbed plots had a much larger ratio of reproductive size stems to understory size stems of all species than the undisturbed plots (Fig. 2). This phenomenon was related to several factors. The average number of understory size stems was far less in disturbed plots than in undisturbed ones, while the average number of stems in the reproductive size class was substantially greater in the disturbed plots. The reproductive stems were present in large numbers in the disturbed plots, but most have failed to grow beyond 40 centimeters in height.

Beech root sprouts were primarily responsible for the increase in the reproductive size class in disturbed areas. Although the average beech stem density for undisturbed understory plots was 4.6 stems per plot and 4.5 stems per plot for disturbed plots, the number of reproductive size stems was four to 45 times greater in the disturbed sites (Table 6). This difference is probably not due to canopy composition, since the average basal of beech in the disturbed plots was 21.5 square meters per hectare while that of the undisturbed plots was 21.8 square meters per hectare.

It should be noted that the amount of root sprouting was variable among disturbed plots. The area from Spence Field to Little Bald,

with the longest history of disturbance by wild boar of the study sites, had a high average number of reproductive size stems per plot. The greatest number of root sprouts, however, was found in the more recently invaded higher elevation stands near Silers Bald. This increase in the number of root sprouts is consistent with an increase in the basal area of beech.

Linear regressions show the relationship between the basal area of beech per plot (independent variable) and the number of beech stems per plot (dependent variable) for both the reproductive size stems from disturbed plots and the understory size stems from undisturbed plots (Tables 6, 7, and 8). As basal area of beech increases, so does the root-sprouting response to hog-rooting activities. The number of reproductive size stems in undisturbed plots, however, did not increase with basal area. The opposite seems to be true for the understory size class where only the undisturbed plots provided a significant regression. These statistical relationships indicate that hog rooting is a significant regression. These statistical relationships indicate that hog rooting is a significant disturbance to the reproduction of beech and causes serious alterations within the understory.

The presence or absence of beech in different size classes for disturbed and undisturbed plots is summarized in Tables 9 and 10. The observed G-statistic for beech in the reproductive size plots was

Table 7. Regression statistics of basal area per plot versus stems per plot of Fagus grandifolia for understory (U) and reproduction (R) plots in disturbed and undisturbed areas.

<u>U-plots in disturbed region</u>				
<u>Source of variation</u>	<u>df</u>	<u>SS</u>	<u>F</u>	<u>Prob. F > .05</u>
Explained model	1	39.77	2.45	Not significant
Total	56	931.93		
<u>R-plots in disturbed region</u>				
<u>Source of variation</u>	<u>df</u>	<u>SS</u>	<u>F</u>	<u>Prob. F > .05</u>
Explained model	1	4,125.15	8.36	0.005
Total	58	32,239.56		
<u>U-plots in undisturbed region</u>				
<u>Source of variation</u>	<u>df</u>	<u>SS</u>	<u>F</u>	<u>Prob. F > .05</u>
Explained model	1	85.89	4.81	0.034
Total	42	818.65		
<u>R-plots in undisturbed region</u>				
<u>Source of variation</u>	<u>df</u>	<u>SS</u>	<u>F</u>	<u>Prob. F > .05</u>
Explained model	1	2.59	0.95	Not significant
Total	22	59.65		

Table 8. Summary of regression significance (+) of basal area per plot versus stems per plot of Fagus grandifolia for total U- and R-plots in disturbed and undisturbed regions.

<u>U-plots</u>	<u>R-plots</u>
+	-
-	+

Table 9. 2 x 2 Test of independence of Fagus grandifolia in reproductive (R) plots using the G-statistic¹

<u>Stem class</u>	<u>Disturbed</u>	<u>Undisturbed</u>	<u>Total</u>
With stems	58.5	23.5	82
Without stems	4.5	27.5	31
Totals	63	51	114
Computed G-statistic		Chi-square	
$G_{adj} = .32.536$		$\chi^2 .05 [1] = 3.841$	

Table 10. 2 x 2 Test of independence of Fagus grandifolia in understory (U) plots using the G-statistic¹

<u>Stem class</u>	<u>Disturbed</u>	<u>Undisturbed</u>	<u>Total</u>
With stems	56.5	45.5	102
Without stems	6.5	5.5	12
Totals	63	51	114
Computed G-statistic		Chi-square	
$G_{adj} = .005$		$\chi^2 .05 [1] = 3.841$	

¹Yates correction for sample sizes less than 200 was observed (Sokal and Rohlf 1969).

much greater than the chi-square value for one degree of freedom. The null hypothesis that the presence or absence of beech reproduction was independent of hog rooting was therefore rejected. In the case of the understory size class, however, the null hypothesis was accepted.

The occurrence of yellow buckeye was too infrequent for statistical tests, but these data can be compared to those of Russell (1953). Russell, sampling over a shorter vertical interval at Jenkins Knob, found 7 stems per 5 square meters, while the 1976 plots from the same area had 5 stems per 5 square meters. This difference is not great enough to be of significance.

Sugar maple was also too uncommon to apply statistical tests but the disturbed vegetation of Derrick Knob, Cold Spring Knob, and Hemlock Knob can be compared to undisturbed populations of Pauls Gap and Beech Gap. The density of sugar maple in the reproductive size class was 4.5 to 6.5 times greater in undisturbed plots than in the disturbed plots. Note, however, that the undisturbed plots had 1.2 times more reproductive stems than understory stems per plot.

The total average density of undisturbed understory size stems of blackberry was 8.3 stems per plot. This was 1.9 times greater than

disturbed average of 4.4 stems per plot. There was a definite reduction in the tall (.5 to 1 meter) arching branches of blackberry, which is characteristic of mature plants. In the case of reproductive size stems, however, there were 1.7 times more in the hog-disturbed areas (9.9 stems per plot) than encountered in the undisturbed plots (5.8 stems per plot). The total number of stems per plot thus was almost the same for the two types of areas (14.3 stems per plot for disturbed sites and 14.1 stems per plot for undisturbed) but the size distribution of the stems was quite different.

DISCUSSION

Bratton (1974a, 1975) documents a reduction in herbaceous cover, reductions in the populations of individual herb species, and changes in herb community structure, due to the invasion of wild boar into Gray Beech Forest. Even though the diversity of arborescent species is relatively low in Gray Beech Forest, this study shows that hog-rooting activity is responsible for an increase in the number of reproductive stems of beech, a slight increase in total reproductive cover, and an increase in total reproductive stems.

Since only the hog-disturbed areas contained large numbers of root sprouts, it was evident that the feeding behavior of the wild boar was responsible for these changes. The actual stimulus for the production of the sprouts is unknown, however. Present theory states that the vegetative reproductive response is often provoked by injury to the tree, but beech suckers also occur in undisturbed areas. Either the exposure or injury of the roots by hogs or the tilling of the soil may stimulate this increase in reproductive beech stems. Destruction of the dense herbaceous cover and increased solar radiation to the mineral soil may also be important.

The amount of reproduction seems to be related to elevation and the basal area of canopy-sized beech (these two variables are not

independent). The lowest elevation disturbed plots showed a ninefold increase in reproductive size beech stems over the most similar disturbed areas, while the high elevation disturbed plots, like those of Silers Bald, showed a forty-fivefold increase over the most undisturbed areas, such as Indian Gap.

When Russell (1953) sampled the vegetation near Double Springs Gap, he placed all aborescent species into one-inch dbh (diameter at breast height) classes. All species less than one inch dbh and greater than 6 feet in height were put in one class, in which 96 stems per 500 square meters at Double Springs were counted. The understory plots for this study measured all stems greater than 40 centimeters in height and less than 1 inch dbh. Although this study used a size class that contained 1.4 meters more vertical distance in the stratum and, therefore, should have included more individuals than Russell's, the 1976 plots had 70 stems per 500 square meters--26 stems per 500 square meters fewer than the figure cited by Russell. This indicates a decrease in understory size stems, which implies that over a long time period the hogs may disturb the natural size distribution of overstory species. Hog invasion is too recent for verification of long-term successional trends, since edaphic and climatic factors may also be involved, but the potential for alteration exists.

A long-term permanent plot is necessary to answer important questions such as:

1. How well will the reproductive size beech stem survive?
2. What will be the hogs' long-term effects on canopy composition?
3. If wild boar populations are reduced through control efforts or natural events, how will the small beech stems interact with a recovering herbaceous community?

The data have indicated that the continual disturbance by hogs is holding blackberry (Rubus canadensis) in the lower vertical stratum near the ground. The leaves, roots, and fruits have been cited as boar food in Eurasian studies (Bratton 1974a). The evidence for this in the Great Smoky Mountains National Park has been sporadic. Although the tender new shoots of R. canadensis have occasionally been grazed in sample plots, remnant abundance of R. canadensis indicated that it is not preferred food for the wild boar. Mark Harmon, a park technician studying hog food habits, has observed wild boar feeding directly on the leaves and stems of Rubus canadensis in the Great Smoky Mountains National Park.

This species of blackberry does not fruit under an overstory canopy; therefore reproduction in a forested situation is vegetative. R. canadensis did flower along trails and fringes of grassy balds where there was sufficient radiant energy to stimulate sexual reproductive structures. The fruits are eaten by black bears and

apparently by wild boar. These species are a potential source for immigration of seeds by fecal excretions. The actual rooting of blackberry populations was highly variable. Shaffer (1977) indicated that both woodland and field patches of blackberry at the Spence Field area were rooted to varying degrees. It is difficult to make definite conclusions concerning the future populations of R. canadensis in areas rooted by the European wild boar. The actual frequency/site showed that blackberry occurred irregularly within sample plots. Apparently, this clumped distribution was a result of reproduction from root meristem in the surface horizon. Other variables such as intensity of rooting, the vegetative response to disturbances, the immigration and success of seeds, and the light conditions defining the reproduction of this species are needed to further investigate the relationships between the wild boar and R. canadensis populations.

The fate of the less common species, such as alternate-leaved dogwood (Cornus alternifolia), is difficult to evaluate. Although there is evidence that yellow buckeye, sugar maple, and shrubs are being disturbed, an assessment of the eventual impact of the wild boar on their distributions and on their gene pools will require careful work with permanent plots.

SUMMARY AND CONCLUSION

The hog invasion into the Gray Beech Forest has significantly altered the structure and composition of arborescent species in the Great Smoky Mountains National Park. The effects of the boar as observed in disturbed and undisturbed locations were:

1. The disturbed areas had a substantial reduction in total plant cover, including both herbaceous and woody species.
2. The disturbed plots had a 3 to 26 percent reduction in woody understory cover in lower elevation areas.
3. The undisturbed plots had a slight increase in total woody cover.
4. Hog rooting stimulated a vegetative reproductive response in F. grandifolia. Root suckers accounted for the tremendous increase in beech reproductive cover, which was 4 to 44 times greater than in undisturbed plots.
5. The increased amount of beech reproduction remained in the ground cover. The reproductive density of beech in disturbed areas was greater than understory density at the same locations.
6. When comparing understory density to previous research (Russell 1953), Double Springs Gap showed a decrease in beech

understory density. Evidence indicates that hog rooting may be disturbing the natural size distribution of arborescent species in the lower strata.

7. Regressions of basal area per plot versus the number of beech stems per plot indicate that boar rooting was significantly disturbing the understory and reproduction of F. grandifolia.

8. The feeding activity of the boar may indirectly represent a potential threat to the reproduction of sugar maple.

9. The foliar height of blackberry (Rubus canadensis) was suppressed by hog rooting. There was a significant decrease in the mature arching Rubus stems in the disturbed areas. The reproductive stems had the opposite response, with an increased density of shorter stems.

10. A negative or positive effect on rare arborescent species could not be detected in this study.

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