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Litterfall in Pinelands of Everglades National Park



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INTRODUCTION

In December 1978, a study was initiated under the Pinelands Fire Ecology project to investigate leaf litter fall in the pinelands of Everglades National Park. The study had limited aims at this time. We hoped to demonstrate a short-term increase in litter fall caused by fire and to compare the effects of cool (with little or no scorch of needles in the overstory trees) and hot (with heavy scorch) burns.

Late in 1979, the scope of the study was expanded to include an examination of overall patterns in leaf litter fall throughout Long Pine Key. Leaf litter collection was carried out over the whole area during 1980 and the first half of 1981. Thereafter, collection was abandoned on various dates at the different sites (see below and Table 1) with the last litter collections taking place in June 1982.

Description of the Study Area

The pinelands of Everglades National Park represent the southwestern limit of the Miami Rock Ridge pinelands. They are dominated by an overstory of *Pinus elliottii* var. *densa* and a shrub layer of predominantly tropical hardwoods and palms. An herbaceous layer is also well developed in openings between the shrubs. The ground surface is very rough; eroded oolitic limestone is very commonly exposed at the ground surface in Long Pine Key. Soil is very shallow and often confined to sinkholes and cracks in the rocks. A thin layer of leaf litter (principally pine straw) covers the surface. Frequent fires remove the litter layer before an organic soil can be formed except in sinkholes and other protected sites.

General descriptions of the pinelands vegetation in southern Florida can be found in Harshberger (1914), Harper (1927), and Davis (1943). More details on the pinelands in Everglades National Park can be found in Robertson (1953), Loope et al. (1979), Taylor and Herndon (1981), and Olmsted et al. (1983).

It is important to remember that the litter collection sites are in very diverse surroundings. There is a general trend in Long Pine Key with high, well developed pineland toward the eastern end and lower-lying stunted pinelands in the west. In addition, there are numerous local variations in topography and substrate which profoundly influence the mix of pines, hardwoods, and herbaceous plants at a given site.

Materials and Methods

Each litter collection site consisted of 20 plastic trays laid out in a more-or-less regular grid pattern covering approximately 180 square meters. The grids were laid out in four rows of five trays each with approximately 3 m separation between adjacent trays and adjacent rows.

Three different tray sizes were used in setting up the collection sites. Those first obtained (used at sites I2, J1, J2, J4, and J5) were 24 by 51 cm with 6 cm high sides. This gave a collecting surface of .1224 m² per tray or 2.448 m² per collection site. All sites set out later (with the exception of E3) had trays with dimensions 33 by 46 cm with 8 cm high sides. At these sites, the collecting

surface was $.1518 \text{ m}^2$ per tray or 3.036 m^2 per site. The trays at E3 had a collecting surface of $.1935 \text{ m}^2$ per tray or 3.870 m^2 for the site. All trays had drainage holes in the bottom. The largest drainage holes were approximately 1 cm by $\frac{1}{2}$ cm in size. Of the various units which made up the leaf litter, only the seeds of Pinus elliottii and Dodonaea viscosa could pass through this size hole easily. These were a negligible component of the litter, so measurement inaccuracy from this source was of no consequence.

The grids were placed so the trays were 10 m or more distant from roads to minimize edge effect. Grids were paced off and the trays set on as nearly level an area as possible near the grid point. Owing to the very rough nature of the ground surface at some sites, it was impossible to lay out a very regular grid. With a few exceptions, the trays were left at their original locations throughout the study. The exceptions came in Block E where all trays had to be taken up to allow a prescribed burn in the block. The grids were reestablished in their original locations, but no attempt was made to ensure that trays were returned to the same positions.

Trays of the size used are adequate to measure leaf litter in the pinelands due to the nature of the vegetation. Air movement near the surface is almost eliminated by the combined effects of the pine canopy and the shrub layer. Furthermore, the major components of the leaf litter fall (Pinus elliottii, Guettarda scabra, Tetrazygia bicolor, and Myrsine florida leaves) are quite heavy and have little or no tendency to drift. The walls of the trays were considered adequate to hold material in the tray which fell in and to exclude materials which fell outside.

Four collection sites were established in Block J of Long Pine Key (see Fig. 1, sites J1, J2, J4, and J5) following a prescribed burn (backing fire with no scorch) on December 18, 1978. A "control" plot was established at the same time in Block I (Fig. 1, site I2). The pinelands at this site had last been burned two years previously (in January 1977). Soon thereafter, two additional collection sites were set up in Block N (Fig. 2) following a prescribed burn. A head fire was used in this burn which left several areas of badly scorched pines. The litter collection sites were set deliberately under badly scorched pines. Fifteen new collection sites were established in the pinelands (Fig. 1) in November and December 1979 and in January 1980 when the scope of the study was expanded. Also, a collection site was later set up in Block E (Fig. 1, site E3) for a short time. This collection site was in an area of badly scorched trees and was intended to measure the short-term effect of fire on pine needle fall. Important data associated with each collection site are given in Table 1.

Leaf litter collections continued at all sites through June 1981. Blocks A and B were burned in July of 1981 and the collection sites in those blocks were abandoned at that time. In August 1981, Tropical Storm Dennis inundated the low pinelands in the western half of Long Pine Key. Many of the litter collection sites were flooded. These sites were abandoned at that time. Collection at sites in Block N was discontinued a short time thereafter. And, finally, all remaining collection was suspended in June 1982.

In general, litter was collected every two or three weeks. Often, it was collected more frequently following a prescribed burn in order to study any effect the fire might have on leaf litter fall in more detail. The major methodological problem encountered in litter collection was deciding when to collect fronds from Sabal

palmetto, Serenoa repens, and Pteridium aquilinum. In each of the species, the old frond is not shed at a single point in time, rather, it bends slowly closer to the ground over a period of weeks or months. But, a dead frond near the ground affects fire behaviour in substantially the same manner as a dead frond on the ground, so the parts of dead fronds over a litter tray which were close enough to the ground were clipped and added to the litter sample. We had to choose an arbitrary height below which these fronds would be considered litter. A height of 30 cm was chosen as the cutoff point since dead grass clumps and draped pine needles could often be found at that height but not much above.

All material collected in the trays was taken to the lab and oven dried. Afterwards, it was separated into components and weighed to the nearest .1 gm. Initially, the litter was divided into "pine needle" and "other litter" categories, but starting in January 1980, "pine other" was separated out. The categories finally used then were "pine needle", "pine other", and "herb and hardwood".

"Herb and hardwood" litter was composed mostly of hardwood leaves with Pteridium aquilinum fronds supplying the only important herbaceous component. However, the Pteridium aquilinum fronds were a major source of litter in a few localities.

Raw litter fall values for each category were converted to litter fall per m^2 per day values which were summed to provide total litter fall values for each calendar month.

A complete set of litter fall values is available for all sites only from February 1980 on, so most of our analysis involving all sites uses litter fall values for the twelve month period February 1, 1980 - January 31, 1981 rather than a calendar year. In fact, values for the February-January period will differ little from calendar year values since litter fall is relatively low during the winter months. On occasion, we will use other periods in comparisons.

RESULTS

Pine needle fall was the major source of input to the litter layer in Long Pine Key. At our collection sites, total needle fall ranged from 100 gm/m^2 to 350 gm/m^2 for the 12 month period, February 1980-January 1981. This accounted for approximately 70 percent of the total litter fall.

In Table 2, monthly values of pine needle fall for each collection site are given. Average values of needle fall were also calculated for each block in Long Pine Key which contained collection sites. These averages are shown as bar graphs in Figures 3-5.

Pine needle fall exhibits a seasonal pattern with a broad peak occurring in the period April-November, and a period of depressed needle fall from December-March (Fig. 3-5). No one month stands out as the peak month for needle fall. Casual observations suggest that local rainstorms and their accompanying winds were important factors in determining the timing of needle fall at any given location. In fact, the general annual pattern in pine needle fall corresponds roughly to the pattern of rainfall in South Florida. However, needle fall begins to increase approximately one month before the wet season typically begins.

Using the three year record of litter fall from collection sites I2, J1, J2, J4, and J5, we can get some idea of the year-to-year variation in needle fall. Calendar year needle fall for each of these sites is given in Table 3. A large increase in needle fall for the year 1981 relative to 1979 and 1980 is immediately apparent. The increase is also striking if we look at a graph of monthly pine needle fall for site J4 for the same three years (Fig. 6). Note that the increase was spread over the whole year and not confined to any particular season.

In calculating the yearly totals for Table 3, it was necessary to estimate values for data missing in December 1979 at sites J1 and J5. This was done for site J1 by calculating a regression line between the monthly needle fall at site J2 and J1 and using the observed needle fall at J2 to estimate the missing value. The same procedure was followed to estimate the missing value for site J5. The graphs in the right half of Figure 7 show the regression lines used to make the estimates and the scatter of observed points about the regression line.

We then used the litter fall data collected at all sites during the five months, February-June 1981, to determine whether the increase in needle fall observed at the I and J sites was local. First, we constructed a graph of needle fall for the period February 1980-January 1981 versus needle fall for the period February-June 1980 (Fig. 8). From this graph, it is apparent that the needle fall in the five months (February-June) of the year is strongly related to needle fall for the entire year (February-January).

In obtaining the yearly totals for needle fall, we had to estimate needle fall at sites A1 and A2 for August 1980. This was done in the manner outlined above for sites J1 and J5 using site B2 as our standard. The regression lines used and the scatter of observed values about them are shown in the left half of Figure 7.

On calculating yearly (February-January) needle fall for all plots using a regression line derived from the graph in Figure 8, we estimate an average needle fall for 1981 of 241 gm/m^2 versus the 208 gm/m^2 measured in 1980 (Table 4). This corresponds to an average 15 percent increase in needle fall over Long Pine Key. At the I and J sites, where a direct comparison could be made, the average increase was 30 percent. This suggests the increase in needle fall was unevenly distributed with the better sites (for pines) showing more response, but we do not have enough data to investigate this possibility. The significance of the observed increase in needle fall was tested using the Wilcoxon matched-pairs signed-ranks test (Sokol and Rohlf 1969). There is less than 1 percent probability that the observed increase could be due to sampling error.

We are not sure what led to the observed increase in needle fall. Two possibilities are suggested:

1. The increase in needle fall in 1981 is a consequence of better than average growth during 1980, or,
2. The increase may have been due to shedding of younger than normal leaves as a result of drought conditions in early 1981.

Other pine litter is composed of branches, flakes of bark, and both seed and pollen cones. Overall, this component accounted for about 25 percent of the total litter fall. Table 2 contains monthly values of other pine litter at each of the collection sites.

This component was much more variable than pine needle fall. There was no pattern of maximum litter production in any season. In fact, the litter collection sites were too small to measure the other pine component effectively. It is clear, however, that rain storms and the associated winds tend to knock dead branches and loosely held pieces of bark off the trees.

It is worth noting that most of the pine branches collected in the litter trays had been subjected to a fair amount of weathering on the tree. They are not fresh when they reach the ground, and not all are the same age. This should be recognized when studying or modelling the decomposition of pine stems on the forest floor.

Herb and hardwood litter was composed primarily of leaves shed by the understory shrubs. However, at some sites, fronds from Pteridium aquilinum and/or Serenoa repens were very important, even dominant, parts of this component. As discussed above, fronds of these two species were collected whenever they fell within 30 cm of the ground level. See Table 2 for monthly values of this component at the collection sites.

Litter in this component is primarily dependent on the size and density of the shrubs near the collection site. The size of the shrubs is primarily dependent on the time they have had to recover from the last fire. All areas of Long Pine Key are burned frequently enough (every 3-8 years) that most hardwoods have no chance to reach any environmental limit to their growth. In Table 5 herb and hardwood litter for the 12-month period, February 1980-January 1981, is given along with the corresponding fire-free period. An increase in litter with increasing fire-free period is suggested though the relationship is evidently complex. Further, in Table 6, herb and hardwood litter for the period February-December 1980 is compared directly to herb and hardwood litter for February-December 1981 at all sites for which sufficient data were available. There is generally an increase in this component from 1980 to 1981, but it is small. Using a Wilcoxon matched-pairs signed rank test, it was found that the difference is not significant at the 5 percent level.

An especially interesting case to consider with regard to the influence of fire on herb and hardwood litter is that of the two collection sites in Block E. This block was burned in September 1980, following several months of litter collection at sites E1 and E2 within the block. As can be seen in Figure 9, at E1, which had a low herb and hardwood litter level initially, the most obvious effect of the burn is an abrupt increase in this component starting right after the burn and lasting some three months. At E2, with a high initial herb and hardwood litter level, an increase of the same duration is observed followed by an abrupt depression of this component some four months after the fire (once most of the fire-killed leaves had been shed).

DISCUSSION

One of the original motivations for collecting leaf litter was to study the effect of hot fires on pine needles. Three collection sites set in areas of heavily scorched pines (N1, N2, and E3) are available to look at this subject.

In Table 9, the pine needle fall at each site following fire is shown in detail. The needle fall for any given period post-fire was obtained by linear interpolation between collection dates. Immediately following the fire, a 10-day period is used to show maximum detail. Later, a 20-day period is used.

Note first the similarity between the pattern shown at sites N1 and N2. There is a delay between the time of the fire and the period of major needle fall. And, by the end of 30 days, some 80 percent of the needles falling within six months of the fire had fallen.

The pattern followed by needle fall at site E3 is hardly similar. Unfortunately, the first post-fire collection was made too late to see if there was any delay between the fire and the onset of heavy needle fall. We see that the heaviest needle fall occurred within 60 days of the fire, but thereafter, the needle fall at E3 remained high.

There are no clear reasons for the difference in needle fall patterns. However, it might be significant that Block N was burned in February while Block E was burned in September.

Considering the predominant influence pine needle fall has on the accumulation of leaf litter in Long Pine Key, we looked for a means of predicting needle fall based on stand characteristics of the trees surrounding the collection sites. All but the two collection sites in Block N fit into a rectangle 15 m by 20 m (300 m²). The DBH (diameter at breast height) for each tree within these rectangles was measured. Several stand characteristics were computed using these measurements and tested as predictors of pine needle fall.

Stand characteristics considered included local pine density, the average DBH of the trees around the site, the total DBH (or, equivalently, the total basal area) of the trees around the site, and the dominance factor defined as (basal area) x (density) of the local pines. Of these stand characteristics, the best predictor of pine needle fall was total basal area (or DBH). Table 7 gives the values used in these calculations. A graph of the relationship found between needle fall and the basal area of the pines is shown in Figure 10. The strength of the relationship is evident. The only point diverging seriously from the average line is that for site N1, which had much lower needle fall than would be predicted from the pine DBH. This might be due to a persistent reduction in crown needle weight traceable to the severe scorch suffered by the plants in 1979. Note however, that the graph only implies that relative needle fall in two areas will be proportional to the difference between total DBH of the pines in the areas. A change in needle fall such as was seen between 1980 and 1981 can only be detected by maintaining collecting sites.

A summary of the leaf litter fall at each collection site is given in Table 8. Perhaps the most important result to be obtained from this table is an appreciation for the variability shown by litter fall from site to site. The total litter fall and each of the components vary by a factor of three or more across Long Pine Key. This has important implications for any fire management program.

To see the implications of leaf fall variability, assume that pine litter is the only source of burnable fuel in the pinelands and further assume that a fuel density of 800 gm/m^2 is necessary to carry a fire in the pinelands under prescribed burning conditions. Then you see that the pinelands around sites I2 and J1 can potentially be burned every two years while the pinelands around site A1 require more than five years for sufficient fuel build-up to support a burn.

The model presented above is greatly oversimplified, but the general conclusion that different areas within Long Pine Key burned on different natural frequencies is clearly realistic. The current uniform treatment of the blocks under the Fire Management Plan has no biological justification.

SUMMARY AND CONCLUSIONS

Our study of the patterns of leaf litter fall in Long Pine Key has led to several important conclusions.

1. Pine needles make the largest contribution to the litter layer on the forest floor. They represent 70 percent of the total litter fall by mass.
2. It is possible to predict relative pine needle fall at a site from the total basal area of the pines around the site.
3. Litter fall is variable by a factor of about three for our collection sites.
4. Pine needle fall increased by about 15 percent in 1981 relative to 1980 when all sites were considered. The increase at the sites toward the east end of Long Pine Key was 30 percent.
5. The nonuniform distributions of pines in Long Pine Key leads to local variations in the rate of fuel accumulation which can greatly affect the potential fire frequency at any given site.
6. Any attempt to burn the different blocks in Long Pine Key according to a fixed, uniform schedule is biologically unrealistic.

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Table 1. Summary of the important characteristics of each leaf litter collection plot.

Block	Site	Date Established	Area of Collecting Surface at Site (m ²)	Period of Litter Collection
A	1	13 Dec 79	3.036	Jan 80 - Jun 81
	2	13 Dec 79	3.036	Jan 80 - Jun 81
B	1	11 Dec 79	3.036	Jan 80 - Jul 81
	2	11 Dec 79	3.036	Jan 80 - Jul 81
	3	13 Dec 79	3.036	Jan 80 - Jun 81
C	1	19 Dec 79	2.884	Jan 80 - Jul 81
E	1	11 Dec 79	3.036	Jan 80 - Jul 81
	2	11 Dec 79	3.036	Jan 80 - Jul 81
	3	23 Sep 80	3.740	Oct 80 - Jun 81
F	1	29 Nov 79	3.036	Jan 80 - Jul 81
	2	29 Nov 79	3.036	Jan 80 - Jun 81
	3	29 Nov 79	3.036	Jan 80 - Jun 81
H	1	10 Dec 79	3.036	Jan 80 - Jun 81
	2	17 Dec 79	3.036	Jan 80 - Jul 82
	3	10 Dec 79	3.036	Jan 80 - Jul 81
I	1	17 Dec 79	3.036	Jan 80 - Jul 82
	2	18 Dec 78	2.448	Jan 79 - Jul 82
J	1	18 Dec 78	2.448	Jan 79 - Jul 82
	2	18 Dec 78	2.448	Jan 79 - Jul 82
	4	18 Dec 78	2.448	Jan 79 - Jul 82
	5	18 Dec 78	2.448	Jan 79 - Jul 82
N	1	6 Feb 79	3.036	Mar 79 - Aug 81
	2	6 Feb 79	3.036	Mar 79 - Aug 81

Table 2. Monthly litterfall values at each litter collection site.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
<u>Collection Site A1</u>					
January	1980	11.93	5.41	2.15	19.49
February		5.57	2.64	5.77	13.98
March		5.72	1.68	17.20	24.60
April		8.77	1.15	13.19	23.11
May		15.47	.41	9.64	25.52
June		11.43	.56	2.12	14.11
July		17.96	2.32	2.87	23.15
August		16.85	1.37	3.15	21.37
September		19.29	1.28	3.07	23.64
October		19.15	.73	3.18	23.06
November		11.13	---	---	---
December		9.66	.34	3.15	13.15
January	1981	12.27	.09	4.54	16.90
February		10.12	2.26	7.05	19.43
March		5.66	2.85	11.01	19.52
April		10.17	.25	16.90	27.32
May		17.78	.18	13.98	31.94
June		15.43	.19	4.81	20.43
<u>Collection Site A2</u>					
January	1980	8.86	9.96	1.13	19.95
February		4.72	36.82	3.32	44.86
March		3.94	5.06	5.92	14.92
April		6.13	5.53	7.30	18.96
May		8.27	2.33	5.61	16.21
June		7.60	.63	4.53	12.76
July		13.29	2.21	6.97	22.47
August		12.32	1.92	5.75	19.99
September		19.34	2.45	2.96	24.75
October		20.14	.74	1.61	22.49
November		8.34	12.23	3.07	23.64
December		6.47	.26	1.32	8.05
January	1981	8.18	.05	1.13	9.36
February		6.05	.53	2.63	9.21
March		2.74	3.05	3.37	9.16
April		6.05	.28	5.01	11.34
May		11.76	.24	2.69	14.69
June		7.85	.25	1.14	9.24

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
<u>Collection Site B1</u>					
January	1980	14.35	---	---	37.71
February		11.28	8.15	7.78	27.21
March		11.71	3.07	18.65	33.43
April		9.08	6.41	11.76	27.25
May		17.59	3.21	9.92	30.72
June		17.36	4.50	11.89	33.75
July		20.34	5.39	8.69	34.42
August		18.73	7.18	7.81	33.72
September		18.70	3.73	4.48	26.91
October		24.28	.56	3.70	28.74
November		12.98	23.93	3.22	40.13
December		7.22	2.55	2.73	12.50
January	1981	11.69	.42	8.48	20.59
February		26.80	1.87	13.20	41.87
March		12.08	7.06	12.86	32.00
April		14.45	1.25	16.54	32.24
May		26.14	.22	16.92	43.28
June		21.29	1.98	15.52	38.79
July		19.59	1.16	4.27	25.02
<u>Collection Site B2</u>					
January	1980	16.13	2.85	3.32	22.30
February		11.36	11.03	1.48	23.87
March		8.84	4.95	1.98	15.77
April		25.77	2.13	1.29	29.19
May		19.47	33.64	.28	53.39
June		15.27	6.27	.05	21.59
July		25.81	11.89	.38	38.08
August		25.22	6.97	.20	32.39
September		36.19	17.85	.09	54.13
October		36.30	6.92	.05	43.27
November		18.15	2.53	.25	20.93
December		9.97	1.02	.34	11.33
January	1981	12.68	10.31	.63	23.62
February		11.56	4.97	.61	17.14
March		12.62	37.87	.79	51.28
April		22.56	7.15	.71	30.42
May		40.95	7.43	.32	48.70
June		32.12	3.71	2.32	38.15
July		20.56	11.04	.51	32.11

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
<u>Collection Site B3</u>					
January	1980	5.75	5.08	1.75	12.58
February		4.21	10.79	6.66	21.66
March		2.42	3.73	8.75	14.90
April		10.22	2.37	4.17	16.76
May		10.23	2.76	3.19	16.18
June		8.83	.81	2.41	12.05
July		15.90	1.60	2.90	20.40
August		20.75	7.58	3.45	31.78
September		18.64	4.48	1.50	24.62
October		18.57	.50	1.34	20.41
November		10.03	1.08	1.01	12.12
December		5.35	.28	1.08	6.71
January	1981	4.46	.28	5.64	10.38
February		4.03	1.46	7.96	13.45
March		3.46	2.17	2.20	7.83
April		9.62	.31	2.78	12.71
May		13.36	.79	2.56	16.71
June		8.58	1.70	1.73	12.01
<u>Collection Site C1</u>					
January	1980	11.50	---	---	20.89
February		3.13	5.34	.88	9.35
March		5.30	3.70	.99	9.99
April		8.87	2.07	.95	11.89
May		10.25	6.20	1.16	17.61
June		12.57	37.16	1.59	51.32
July		19.96	19.63	.92	40.51
August		22.05	13.32	1.43	36.80
September		26.46	4.93	.13	31.52
October		36.82	2.44	.53	39.79
November		11.80	2.52	.38	14.70
December		5.98	8.73	.79	15.50
January	1981	7.49	.32	1.14	8.95
February		4.70	3.34	1.03	9.07
March		7.58	15.14	.88	23.60
April		17.02	.19	1.38	18.59
May		19.41	.33	2.27	22.01
June		19.59	2.96	.58	23.13
July		14.27	13.98	.47	28.72

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
<u>Collection Site E1</u>					
January	1980	6.94	5.67	.11	12.72
February		6.21	4.81	.51	11.53
March		4.47	.99	1.26	6.72
April		7.55	1.05	1.48	10.08
May		9.39	3.33	.32	13.04
June		8.14	1.01	.15	9.30
July		15.69	4.42	.61	20.72
August		19.22	2.93	.57	22.72
September		22.95	1.27	2.01	26.23
October		26.42	.34	2.35	29.11
November		7.73	.20	1.29	9.22
December		5.47	.14	.49	6.10
January	1981	4.89	.60	.18	5.67
February		3.69	1.43	.48	5.60
March		4.78	3.46	1.22	9.46
April		6.23	.12	.20	6.55
May		12.36	.08	.18	12.62
June		10.05	1.11	.03	11.19
July		11.39	.67	.06	12.12
<u>Collection Site E2</u>					
January	1980	15.37	3.77	6.73	25.87
February		12.32	4.46	6.55	23.33
March		9.55	7.20	5.69	22.44
April		30.89	5.57	1.54	38.00
May		24.27	3.56	2.83	30.66
June		11.65	3.59	.72	15.96
July		22.20	11.73	2.75	36.68
August		22.47	6.55	1.54	30.56
September		23.22	1.57	2.46	27.25
October		33.84	.57	3.58	37.99
November		15.23	.41	2.28	17.92
December		4.72	1.10	.26	6.08
January	1981	5.40	6.55	.64	12.59
February		5.74	17.77	.18	23.69
March		9.06	8.67	.58	18.31
April		17.12	.24	.68	18.04
May		23.89	1.84	.31	26.04
June		13.78	18.31	.37	32.46
July		16.20	1.20	1.35	18.75

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
<u>Collection Site E3</u>					
October	1980	53.77	.55	.19	54.51
November		47.31	2.25	.13	49.69
December		26.10	4.93	.00	31.03
January	1981	12.75	.10	.24	13.09
February		25.65	.35	.43	26.43
March		25.87	4.37	.78	31.02
April		12.76	5.32	.20	18.28
May		4.03	1.83	.15	6.01
June		7.00	4.17	.22	11.39
<u>Collection Site F1</u>					
January	1980	23.60	---	---	33.71
February		8.54	1.65	4.73	14.92
March		7.42	2.34	2.11	11.87
April		18.46	3.98	1.64	24.08
May		22.48	16.11	1.53	40.12
June		18.09	.35	2.42	20.86
July		30.14	12.95	.38	43.47
August		25.59	.87	.41	26.87
September		19.34	.84	.30	20.48
October		21.82	.84	.10	22.76
November		22.83	8.45	.25	31.53
December		10.08	8.87	.50	19.45
January	1981	12.83	12.39	.49	25.71
February		13.47	5.43	1.03	19.93
March		19.66	8.98	1.08	29.72
April		40.24	1.97	.91	43.12
May		44.46	.22	1.36	46.04
June		32.08	.23	.92	33.23
July		26.43	1.08	2.81	30.32
<u>Collection Site F2</u>					
January	1980	---	---	---	---
February		3.16	4.74	.72	8.62
March		3.22	.47	1.43	5.12
April		12.14	6.41	4.71	23.26
May		19.23	.98	.71	20.92
June		16.16	.44	.13	16.73
July		20.13	.68	.57	21.38

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
August	1981	8.41	.37	.02	8.80
September		9.99	1.44	.43	11.86
October		27.74	2.65	.23	30.62
November		14.23	1.84	.32	16.39
December		9.81	.30	.27	10.38
January		12.55	.96	.07	13.58
February		9.17	2.60	.26	12.03
March		6.35	4.20	.95	11.50
April		16.23	3.22	.53	19.98
May		40.69	.62	.45	41.76
June		19.50	.13	.25	19.88

Collection Site F3

January	1980	---	---	---	---
February		1.49	12.58	.42	14.49
March		6.88	10.94	.95	18.77
April		5.18	3.72	1.57	10.47
May		11.74	8.19	.48	20.41
June		11.25	.88	.25	12.38
July		14.32	3.29	.87	18.48
August		16.20	2.67	.55	19.42
September		24.17	4.68	.25	29.10
October		32.42	1.90	.47	34.79
November		10.02	.64	1.34	12.00
December		3.80	.71	.64	5.15
January	1981	4.74	.77	1.59	7.10
February		7.74	6.63	2.28	16.65
March		3.18	16.79	1.87	21.84
April		7.45	5.83	.24	13.52
May		11.91	.27	.31	12.49
June		13.61	6.47	.35	20.43

Collection Site H1

January	1980	---	---	---	---
February		7.65	2.55	4.75	14.95
March		9.67	12.56	7.80	30.03
April		14.48	1.99	5.20	21.67
May		23.46	6.38	4.60	34.44
June		15.12	.57	2.16	17.85
July		27.38	6.23	1.95	35.56
August		30.09	2.29	1.58	33.96
September		25.89	3.28	1.91	31.08

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
October	1981	43.48	1.35	1.95	46.78
November		9.81	1.79	2.13	13.73
December		9.69	1.33	2.15	13.17
January		12.25	.65	8.48	21.38
February		13.33	1.18	7.23	21.74
March		10.05	13.07	6.26	29.38
April		20.53	.78	6.81	28.12
May		31.96	.30	5.99	38.25
June		24.70	.41	4.57	29.68

Collection Site H2

January	1980	18.25	4.47	.45	23.17
February		15.50	10.65	1.76	27.91
March		17.36	3.92	1.74	23.02
April		43.94	43.38	6.71	94.03
May		45.44	1.22	2.73	49.39
June		22.08	1.03	.46	23.57
July		23.22	4.65	.63	28.50
August		28.81	5.84	5.68	40.33
September		21.29	3.53	1.54	26.36
October		25.73	2.61	1.12	29.46
November		25.25	7.05	.93	33.23
December		12.20	.47	.83	13.50
January	1981	9.31	.45	1.59	11.35
February		11.61	3.01	1.49	20.61
March		12.65	6.01	1.64	20.30
April		22.60	.45	2.20	25.25
May		40.99	.20	7.29	48.48
June		27.68	.17	2.76	30.61
July		20.89	41.05	1.00	62.94
August		25.50	2.95	1.37	29.82
September		37.02	.63	1.15	38.80
October		30.67	3.27	2.48	36.42
November		17.86	2.29	1.91	22.06
December		20.54	.26	2.37	23.17

Collection Site H3

January	1980	---	---	---	---
February		3.39	18.31	8.08	29.78
March		2.53	4.90	18.71	26.14
April		4.67	3.72	12.49	20.88

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
May	1981	8.75	4.74	42.86	56.35
June		6.07	.60	6.30	12.97
July		16.64	3.49	1.42	21.55
August		32.39	5.80	1.79	39.98
September		6.99	3.72	7.40	18.11
October		16.07	7.55	4.98	28.60
November		5.99	6.46	5.21	17.66
December		3.78	1.14	5.18	10.10
January		3.11	5.22	14.58	22.91
February		3.78	3.01	16.90	23.69
March		4.87	13.57	16.70	35.14
April		5.99	.48	16.20	22.67
May		9.87	.89	12.30	23.06
June		9.93	.72	8.54	19.19
July		7.12	3.11	5.54	15.77

Collection Site II

January	1980	10.35	5.19	.76	16.30
February		6.71	7.80	2.54	16.96
March		6.97	6.57	6.39	19.93
April		17.36	1.62	6.28	25.26
May		26.81	3.49	4.52	34.82
June		15.33	1.89	1.79	19.01
July		24.42	2.71	1.50	28.63
August		40.73	4.58	2.34	47.65
September		17.01	1.50	1.54	20.05
October		14.46	.74	1.70	16.90
November		12.65	1.47	1.44	15.56
December		5.42	10.00	1.12	16.54
January	1981	5.22	.29	2.21	7.72
February		6.92	5.08	2.25	14.25
March		9.76	11.58	3.55	24.89
April		14.87	1.10	4.30	20.27
May		29.61	2.56	5.21	37.38
June		29.08	.83	3.93	33.84
July		17.70	3.49	3.03	24.22
August		13.83	15.50	6.31	35.64
September		25.19	---	---	27.58
October		22.27	---	---	25.69
November		14.50	---	---	18.62
December		9.89	---	---	12.82

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
<u>Collection Site I2</u>					
January	1979	22.88	---	---	37.78
February		18.73	---	---	23.00
March		13.78	---	---	30.39
April		32.24	---	---	44.10
May		24.17	---	---	35.65
June		39.50	---	---	42.92
July		45.31	---	---	51.38
August		45.75	---	---	59.20
September		44.89	---	---	81.06
October		30.66	---	---	33.28
November		30.12	---	---	33.85
December		15.38	---	---	17.50
January	1980	16.17	---	---	20.93
February		13.49	11.37	1.86	26.72
March		14.68	5.54	4.47	24.69
April		34.71	18.83	2.67	56.21
May		56.19	19.16	4.87	80.22
June		37.64	3.17	2.21	43.02
July		19.18	1.39	1.52	22.09
August		15.63	.96	1.31	17.90
September		34.08	3.44	1.72	39.24
October		28.13	1.88	.99	31.00
November		35.10	8.19	4.00	47.29
December		18.00	4.83	2.32	25.15
January	1981	19.90	.45	1.67	22.02
February		27.00	5.90	2.24	35.14
March		24.02	17.52	3.69	45.23
April		31.51	3.47	5.07	40.05
May		41.03	2.83	7.08	50.94
June		41.81	1.39	2.10	45.30
July		46.20	44.87	2.41	93.48
August		42.75	12.79	2.11	57.65
September		40.73	16.29	1.90	58.92
October		48.65	17.35	2.25	68.25
November		31.61	2.45	2.26	36.32
December		29.35	1.02	2.51	32.88
<u>Collection Site J1</u>					
January	1979	23.33	---	---	33.24
February		16.62	---	---	18.20
March		11.15	---	---	24.86

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
April	1980	16.96	---	---	24.08
May		17.08	---	---	22.03
June		35.09	---	---	36.21
July		44.99	---	---	47.70
August		46.78	---	---	148.77
September		37.07	---	---	41.75
October		26.56	---	---	27.78
November		25.63	---	---	26.67
December		18.82	---	---	20.66
January		15.58	---	---	19.16
February		23.12	20.53	.55	44.20
March		22.34	8.69	1.23	32.26
April	1981	50.03	17.91	1.50	69.44
May		62.46	26.87	1.86	91.19
June		27.60	1.30	.79	29.69
July		18.50	8.76	.56	27.82
August		25.96	8.53	2.11	36.60
September		24.75	4.55	2.91	32.21
October		28.64	1.15	2.76	32.55
November		32.45	63.48	.35	96.28
December		14.80	43.76	.91	59.47
January		17.05	6.73	3.57	27.35
February		27.79	20.84	.89	49.52
March		27.29	33.93	3.07	64.29
April	1981	25.66	1.68	1.73	29.07
May		53.31	1.15	3.17	57.63
June		52.80	1.51	1.57	55.88
July		54.20	5.05	2.15	61.40
August		48.83	4.85	5.17	58.85
September		51.75	3.57	1.99	57.31
October		55.42	4.20	1.29	60.91
November		29.13	1.47	2.20	32.80
December		21.46	2.03	1.52	25.01

Collection Site J2

January	1979	15.39	---	---	24.70
February		11.50	---	---	15.76
March		7.89	---	---	17.06
April		15.11	---	---	21.31
May		14.50	---	---	16.41
June		19.26	---	---	23.40
July		31.14	---	---	50.22

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
August	1980	29.09	---	---	30.04
September		29.02	---	---	33.04
October		24.97	---	---	28.87
November		17.58	---	---	21.26
December		14.47	---	---	16.30
January		10.56	---	---	12.62
February		9.02	6.67	.42	16.11
March		8.76	9.79	1.48	20.03
April		31.96	5.20	1.75	38.91
May		52.18	3.57	4.25	60.00
June		24.44	5.28	3.53	33.25
July		30.43	29.33	.81	60.57
August	1981	28.07	6.36	.42	34.85
September		24.39	2.93	.27	27.59
October		32.63	1.95	1.82	36.40
November		22.39	1.45	2.97	26.81
December		11.73	.33	1.27	13.33
January		10.46	1.19	1.67	13.32
February		13.87	4.10	1.29	19.26
March		17.56	32.86	2.59	53.01
April		38.53	16.19	2.24	56.96
May		65.39	2.43	3.45	71.27
June		47.75	5.33	6.03	59.11
July		42.46	13.54	1.69	57.69
August		31.28	6.04	.86	38.18
September		26.52	2.52	1.24	30.28
October		32.89	6.87	1.49	41.25
November		18.79	13.05	1.80	33.64
December		22.44	10.59	3.57	36.60

Collection Site J4

January	1979	19.78	---	---	27.73
February		11.90	---	---	13.13
March		9.43	---	---	18.09
April		17.25	---	---	26.79
May		13.59	---	---	16.42
June		28.93	---	---	33.94
July		42.28	---	---	44.40
August		35.59	---	---	39.32
September		32.65	---	---	37.34
October		24.75	---	---	25.91
November		20.61	---	---	23.25
December		13.96	---	---	18.24
January	1980	12.61	---	---	20.34

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
February		9.19	6.78	4.16	20.13
March		12.42	3.51	1.30	17.23
April		47.64	17.44	1.12	66.20
May		51.76	4.89	1.44	58.09
June		30.18	1.64	.94	32.76
July		34.94	2.92	.01	37.87
August		32.31	2.46	.74	35.51
September		21.76	4.59	.64	26.99
October		27.15	1.73	1.04	29.92
November		30.27	1.45	.13	31.85
December		14.44	.96	1.42	16.82
January	1981	11.98	1.57	1.39	14.94
February		19.60	4.59	.66	24.85
March		18.41	29.50	1.25	49.16
April		29.27	.85	1.17	31.29
May		66.41	2.98	.95	70.34
June		60.07	2.04	.44	62.55
July		52.77	5.71	.33	58.81
August		41.08	155.29	.00	196.37
September		28.30	2.74	.18	31.22
October		35.96	5.37	.48	41.81
November		24.37	2.59	.82	27.78
December		27.00	1.52	1.81	30.33

Collection Site J5

January	1979	13.42	---	---	21.17
February		11.37	---	---	13.37
March		8.96	---	---	22.03
April		15.99	---	---	19.23
May		12.62	---	---	14.61
June		15.49	---	---	22.08
July		23.59	---	---	23.99
August		25.60	---	---	32.11
September		26.08	---	---	30.38
October		20.76	---	---	24.42
November		18.02	---	---	19.52
December		13.73	---	---	12.89
January	1980	10.99	---	---	17.75
February		7.22	8.74	.26	16.22
March		9.38	5.14	.53	15.05
April		27.11	6.49	3.22	36.82
May		34.25	2.85	3.69	40.79

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
June		19.18	.90	1.52	21.60
July		22.89	4.99	.67	28.55
August		25.25	3.53	1.10	29.88
September		14.68	2.86	3.08	20.62
October		18.11	.80	.51	19.42
November		19.37	3.99	.64	24.00
December		9.58	15.07	.56	25.21
January	1981	14.30	8.92	.99	24.21
February		18.37	12.02	1.18	31.57
March		15.02	15.94	2.54	33.50
April		23.53	.73	4.09	28.35
May		45.02	.89	2.58	48.49
June		36.17	3.03	1.26	40.46
July		34.73	5.22	.98	40.93
August		31.84	2.71	1.53	36.08
September		37.76	1.67	.87	40.30
October		36.77	22.21	1.57	60.55
November		19.40	6.66	1.53	27.59
December		20.48	1.02	2.45	23.95

Collection Site N1

March	1979	45.90	---	---	51.46
April		11.32	---	---	17.81
May		9.72	---	---	60.04
June		9.52	---	---	16.63
July		10.52	---	---	16.51
August		11.18	---	---	30.01
September		8.89	---	---	44.48
October		7.77	---	---	26.11
November		5.37	---	---	9.52
December		3.29	---	---	7.79
January	1980	3.61	---	---	12.78
February		3.93	---	---	11.35
March		6.93	---	---	11.42
April		5.74	---	---	8.90
May		12.61	---	---	33.24
June		14.53	---	---	21.60
July		24.65	---	---	40.06
August		21.61	---	---	32.54
September		18.89	---	---	21.56
October		22.36	---	---	27.45
November		20.48	---	---	25.26

Table 2 continued.

Month	Year	Pine Needle Litter	Other Pine Litter	Herb and Hardwood Litter	Total Litter
December	1981	13.29	---	---	17.28
January		7.32	---	---	12.21
February		7.67	---	---	86.22
March		11.62	---	---	43.01
April		18.76	---	---	27.04
May		30.26	---	---	36.55
June		24.63	---	---	29.93
July		23.64	---	---	35.02
August		23.60	---	---	82.06
<u>Collection Site N2</u>					
March	1979	33.32	---	---	36.92
April		11.72	---	---	35.91
May		11.41	---	---	48.11
June		14.71	---	---	31.35
July		11.91	---	---	19.56
August		11.06	---	---	17.62
September		14.02	---	---	27.12
October		11.28	---	---	22.48
November	1980	6.71	---	---	20.35
December		5.81	---	---	11.93
January		5.14	---	---	21.56
February		4.58	---	---	14.57
March		6.63	---	---	10.55
April		10.31	---	---	25.71
May		20.31	---	---	46.13
June		13.50	---	---	18.55
July	1981	20.27	---	---	28.13
August		22.46	---	---	36.05
September		18.09	---	---	19.46
October		18.05	---	---	20.40
November		19.65	---	---	22.92
December		15.60	---	---	18.84
January		11.78	---	---	13.93
February		11.59	---	---	15.76
March	1981	15.22	---	---	28.14
April		17.35	---	---	23.76
May		23.14	---	---	34.29
June		25.71	---	---	29.13
July		29.67	---	---	37.16
August		24.04	---	---	40.89

Table 3. Needle fall (gm/m^2) in Blocks I and J for calendar years 1979, 1980, and 1981.

Block	Site	1979	1980	1981
I	2	363.41	323.00	424.56
J	1	320.08*	346.23	464.69
	2	229.92	286.56	367.94
	4	270.72	324.67	415.22
	5	205.63*	218.01	333.39

* Data missing for December 1979, value estimated as described in text.

Table 4. Calculation of pine needle fall values for 1981 using measured values from the first five months.

Block	Site	Needle Fall 2/80-6/80 (gm/m ²)	Needle Fall 2/80-1/81 (gm/m ²)	Needle Fall 2/81-6/81 (gm/m ²)	Calculated Needle Fall 2/81-1/82 (gm/m ²)
A	1	46.96	153.27*	59.16	178.18
	2	30.66	118.74*	34.45	141.54
B	1	67.02	180.96	100.76	239.87
	2	80.71	245.03	119.81	268.12
	3	35.91	129.61	39.05	148.36
C	1	40.12	170.68	68.30	191.74
E	1	35.76	138.13	37.11	145.49
	2	88.68	215.76	69.59	193.65
F	1	77.02	219.65	149.91	312.76
	2	53.91	156.77	91.94	226.79
	3	36.54	142.21	43.89	155.54
H	1	70.38	228.97	100.57	239.59
	2	144.32	290.13	120.03	268.45
	3	25.41	110.38	34.44	141.53
I	1	73.18	193.09	90.24	224.27
	2	156.71	326.73	165.37	335.68
J	1	185.55	347.70	186.85	367.53
	2	126.36	286.46	183.10	361.97
	4	151.19	324.04	193.76	377.78
	5	97.14	221.32	138.11	295.26

Needle Fall (2/80-1/81) = 1.4829* Needle Fall (2/80-6/80) + 90.46 gm/m².

$r^2 = .9479$

* data missing for November 1980, value estimated as explained in text.

Table 5. Herb and hardwood litter collected in each block for the period February 1980 - January 1981 with the fire-free period at the start of collection.

Block	Number Of sites	Total Herb and Hardwood Litter 2/80-1/81 (gm/m ²)	Mean Herb and Hardwood Litter 2/80-1/81 (gm/m ²)	Months since Last Fire as of January 1980
A	2	109.03	54.52	58
B	3	148.23	49.41	36-51
C	1	10.89	10.89	1
E	2	42.06	21.03	**
F	3	34.95	11.67	2
H	3	199.38	66.46	36-70
I	2	62.98	31.49	36
J	4	66.26	16.56	13

** earlier records not clear, but at least 60 months.

Table 6. A direct comparison of herb and hardwood litter for two consecutive years. There is an increase in this component of litter with fire-free period.

Block	Site	Herb and Hardwood Litter 2/80-12/80 (gm/m ²)	Herb and Hardwood Litter 2/81-12/81 (gm/m ²)
H	2	24.13	25.66
I	1	31.16	36.79
	2	27.94	33.62
J	1	15.53	24.75
	2	18.99	26.25
	4	12.94	7.69
	5	15.78	20.58

Table 7. Total basal area of pine trees in 300 m² plot overlaying collection sites and pine needle fall at site.

Block	Site	Basal Area (m ² /ha)	Density (Trees Per 300 m ² plot)	Pine Needle Fall, 2/80-1/81 (gm/m ²)	Pine Needle Fall, 2/81-6/81 (gm/m ²)
A	1	11.45	16	153.27	59.16
	2	11.63	33	118.74	34.45
B	1	9.44	23	180.96	100.76
	2	15.74	17	245.03	119.81
	3	8.01	29	129.61	39.05
C	1	13.47	24	170.68	68.30
E	1	8.91	25	138.13	37.11
	2	9.71	24	215.76	69.59
F	1	14.48	33	219.65	149.91
	2	10.28	39	156.77	91.94
	3	9.99	10	142.21	43.89
H	1	13.92	22	228.97	100.57
	2	16.63	19	290.13	120.03
	3	11.00	15	110.38	34.44
I	1	12.80	9	192.09	90.24
	2	22.52	19	326.73	165.37
J	1	19.89	8	347.70	186.85
	2	20.67	8	286.46	183.10
	4	21.10	17	324.04	194.39
	5	16.37	12	221.32	138.11
N	1	12.58	27	172.34	92.94
	2	22.01	39	181.23	93.01

Table 8. Summary of litterfall at individual collection sites for the period February 1980 - February 1981.

Block	Site	Pine Needle (gm/m ²)	Pine Other (gm/m ²)	Pine Total (gm/m ²)	Herb and Hardwood (gm/m ²)	Total Litter (gm/m ²)
A	1	153.27	1.44	154.71	67.88	222.59
A	2	118.74	54.92	173.67	41.15	214.82
B	1	180.96	69.30	250.26	99.11	349.37
B	2	245.03	115.51	360.54	7.02	367.56
B	3	129.61	36.26	165.87	42.10	207.97
C	1	170.68	106.26	277.04	10.89	287.93
E	1	138.13	21.09	159.22	11.22	170.44
E	2	215.76	52.86	268.62	30.84	299.46
F	1	219.65	67.15	286.80	15.96	302.76
F	2	156.77	21.28	178.01	9.61	187.66
F	3	142.21	50.97	193.18	9.38	202.56
H	1	228.97	40.97	269.94	44.66	314.60
H	2	290.13	84.80	374.93	25.72	400.65
H	3	110.38	65.65	176.03	129.00	305.03
I	1	193.09	42.57	235.66	33.37	269.03
I	2	326.73	79.21	405.94	29.61	435.55
J	1	347.70	212.16	559.86	19.10	579.06
J	2	286.46	75.65	362.11	19.06	381.17
J	4	324.04	49.94	373.98	14.33	388.31
J	5	221.32	67.28	288.60	13.77	302.37

Table 9. Pine needle fall (gm/m^2) in sites under badly scorched pines.

Days Post Fire	Collecting Site		
	N1	N2	E3
1 - 10	12	10	--
11 - 20	748	570	--
21 - 30	95	69	30 (first collection)
31 - 40	31	26	37
41 - 60	42	35	143
61 - 80	19	16	65
81 - 100	17	19	60
101 - 120	18	21	26
121 - 140	16	24	63
141 - 160	14	18	57
141 - 180	14	14	66

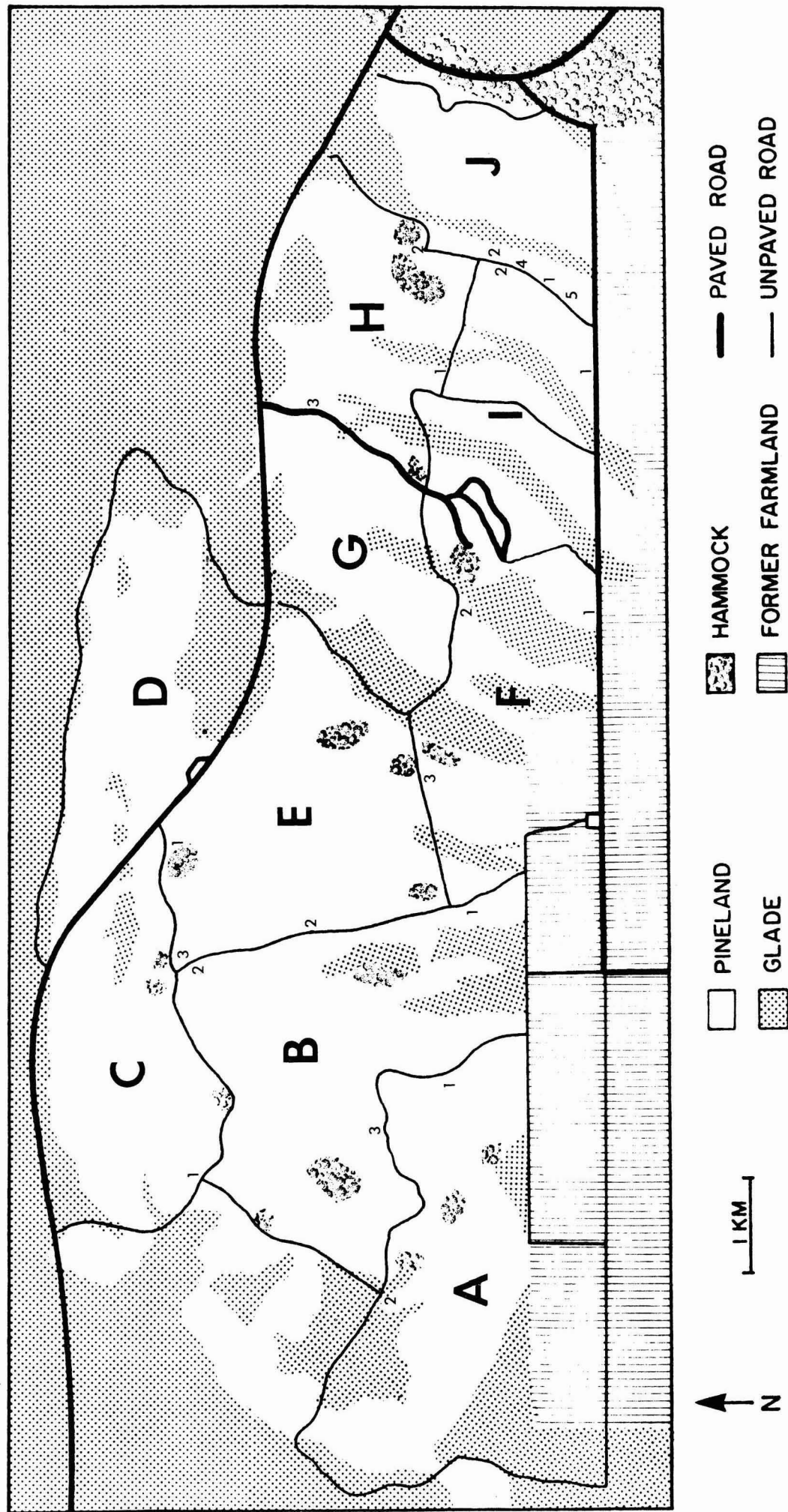


Figure 1. Base map of Long Pine Key showing management blocks (A, B, C, etc.) and litter collection sites (1, 2, 3, etc.).

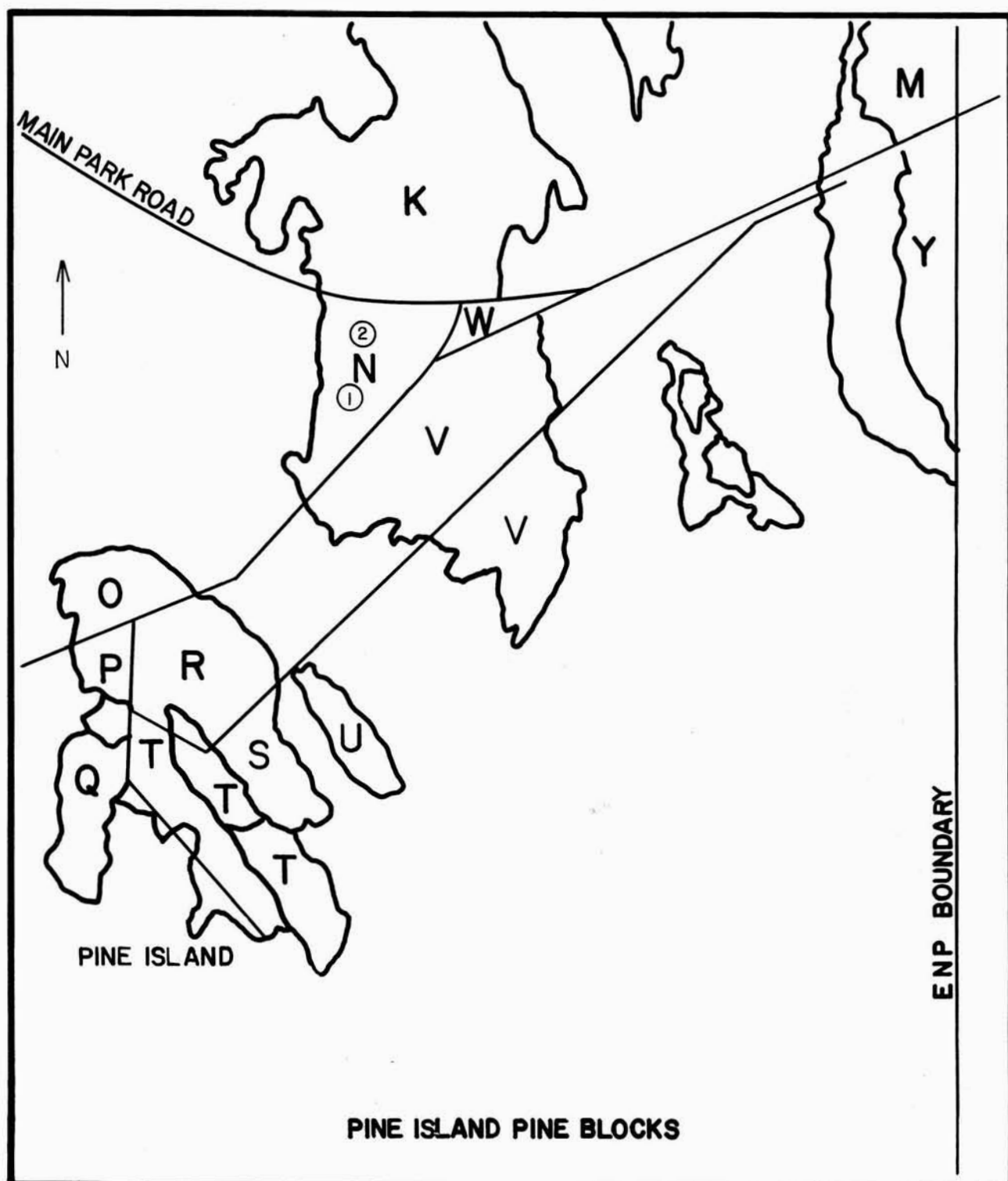


Figure 2. Base map of Pine Island showing management blocks (M, N, O, etc.) and litter collection sites (1, 2).

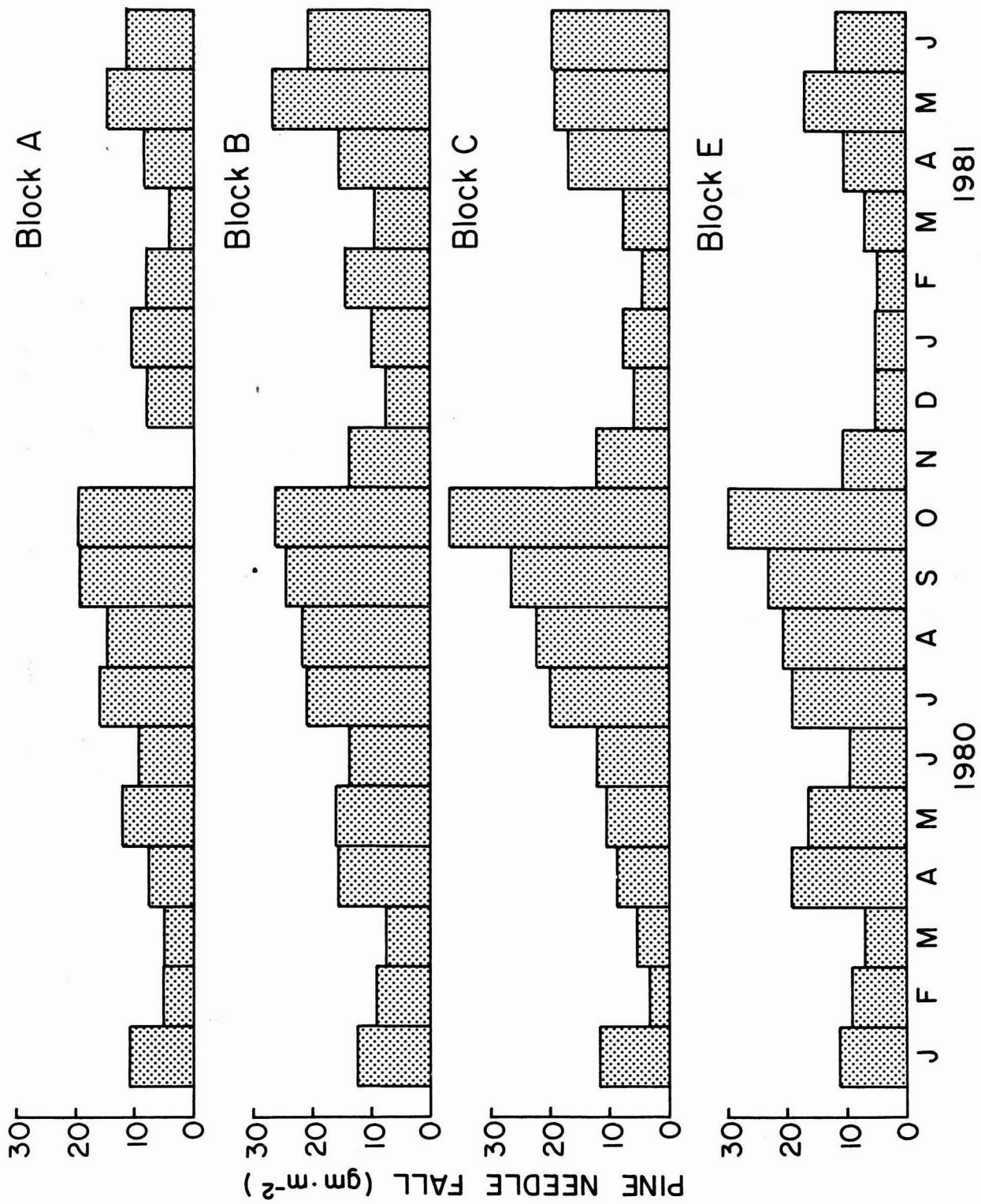


Figure 3. Average monthly pine needle litter collected in management blocks A, B, C, and E, Long Pine Key.

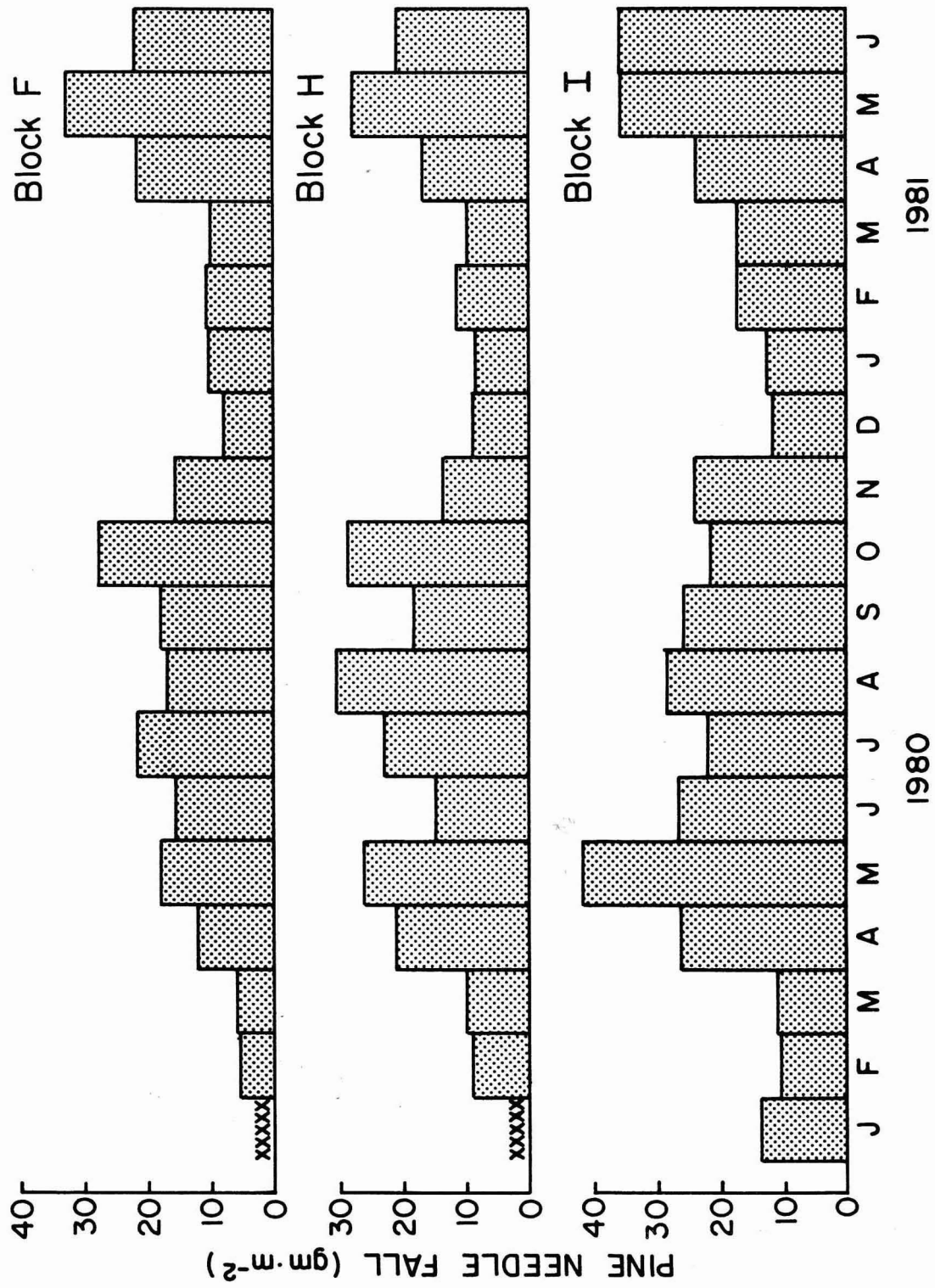


Figure 4. Average monthly pine needle litter collected in management blocks F, H, and I, Long Pine Key. Missing data indicated by xxxxx.

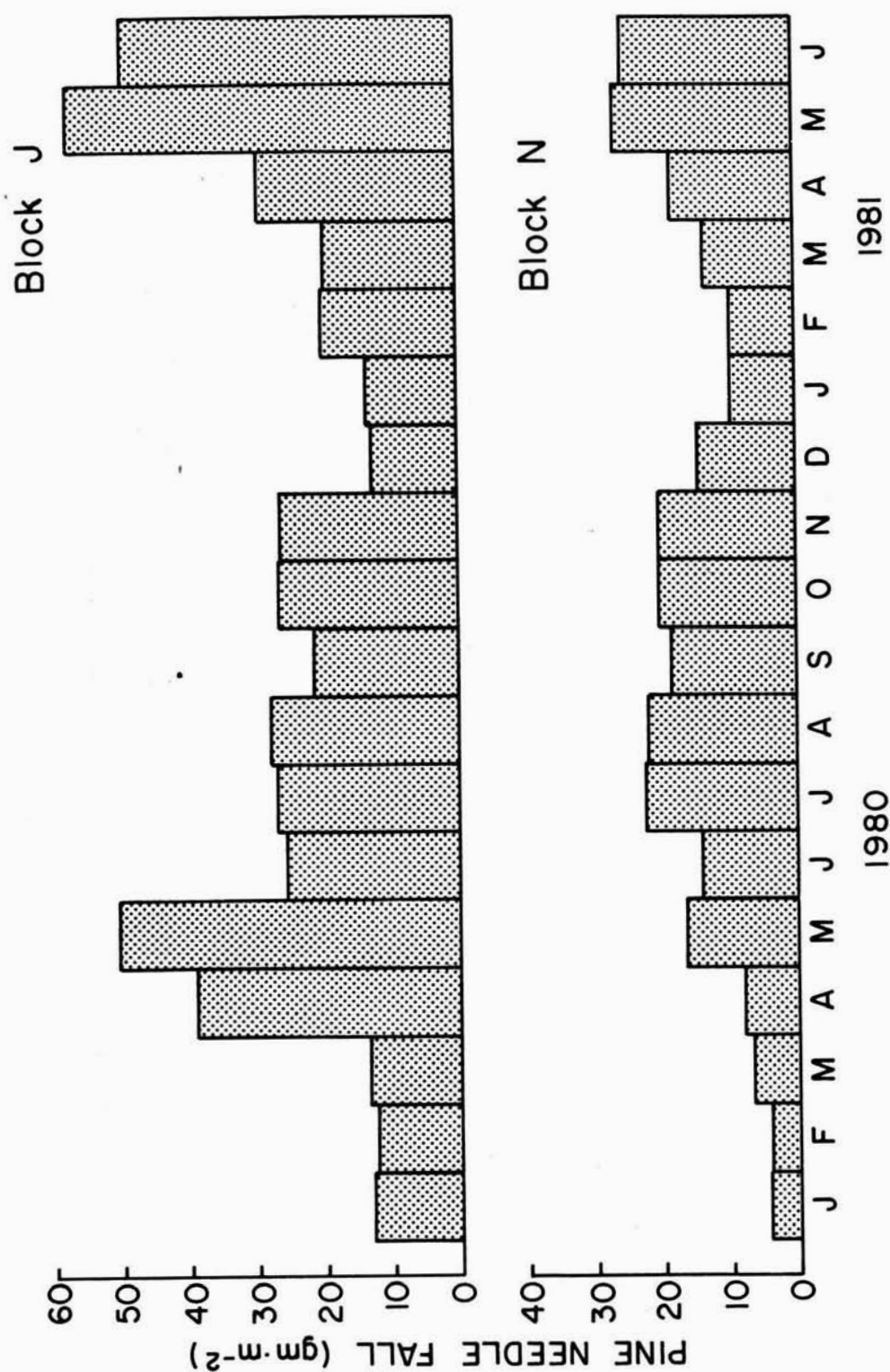


Figure 5. Average monthly pine needle litter collected in management blocks J (Long Pine Key) and N (Pine Island).

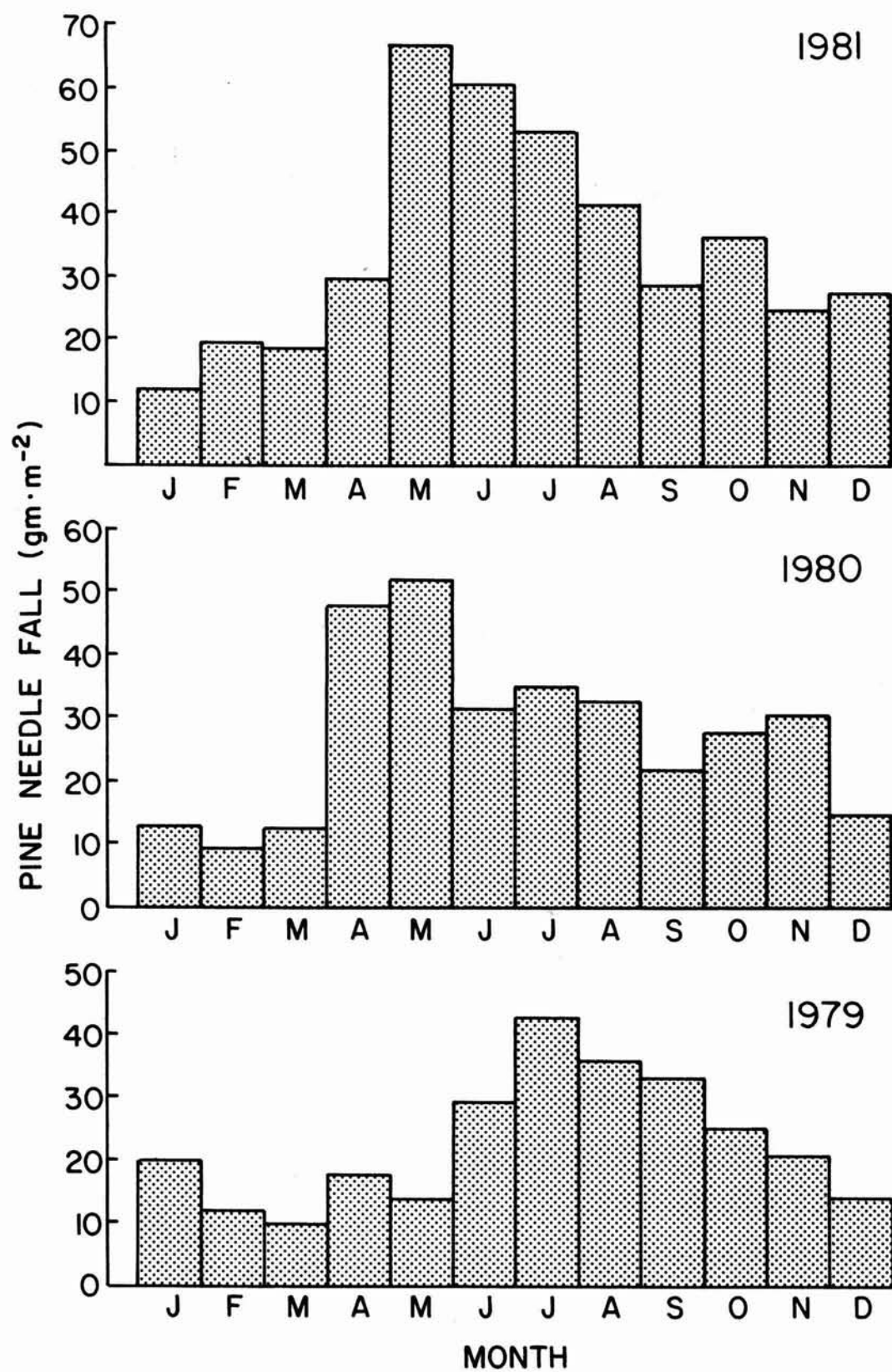


Figure 6. Total monthly pine needle litter collected at site J4 during 1979, 1980, and 1981.

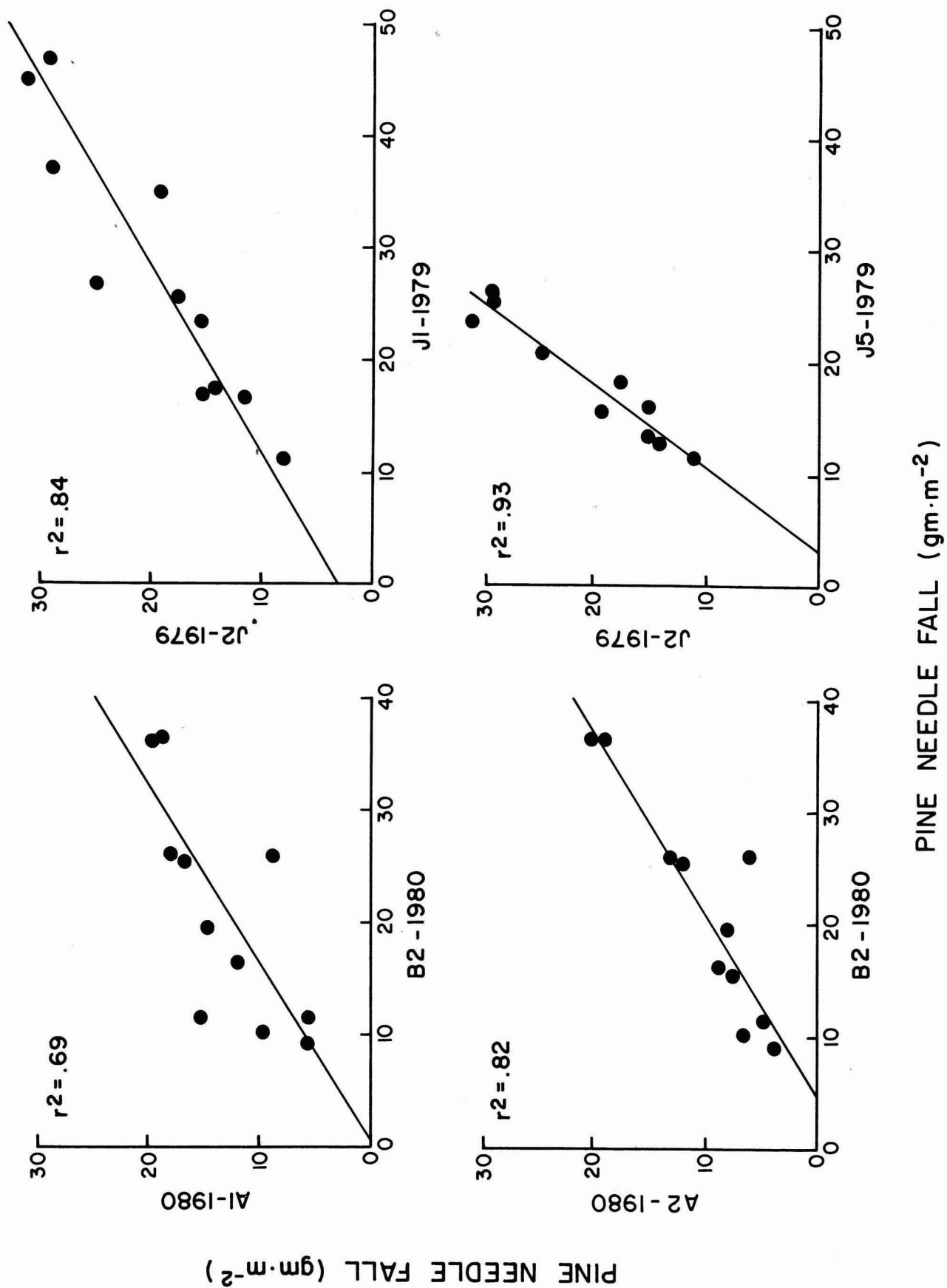


Figure 7. Regression lines used to estimate monthly pine needle fall values at collection sites A1 and A2 for November 1980 and at sites J1 and J5 for December 1979.

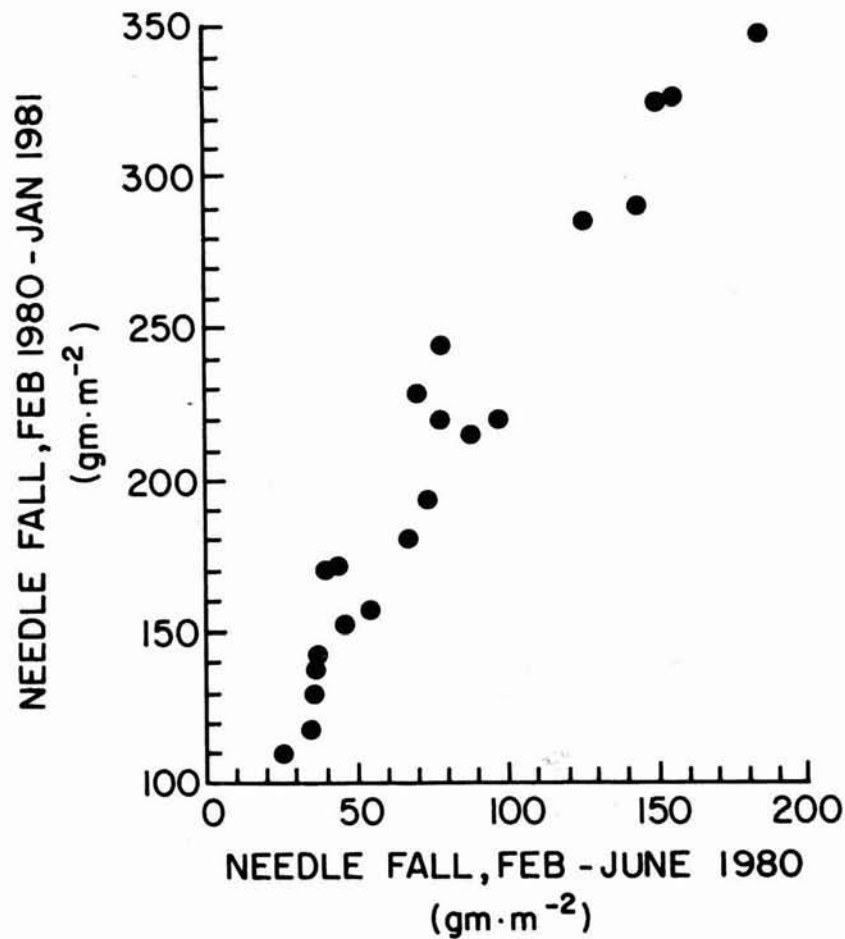


Figure 8. Relation between pine needle litter for the 'year' (February-January) and the litter collected during the first five months of the 'year' (February-June).

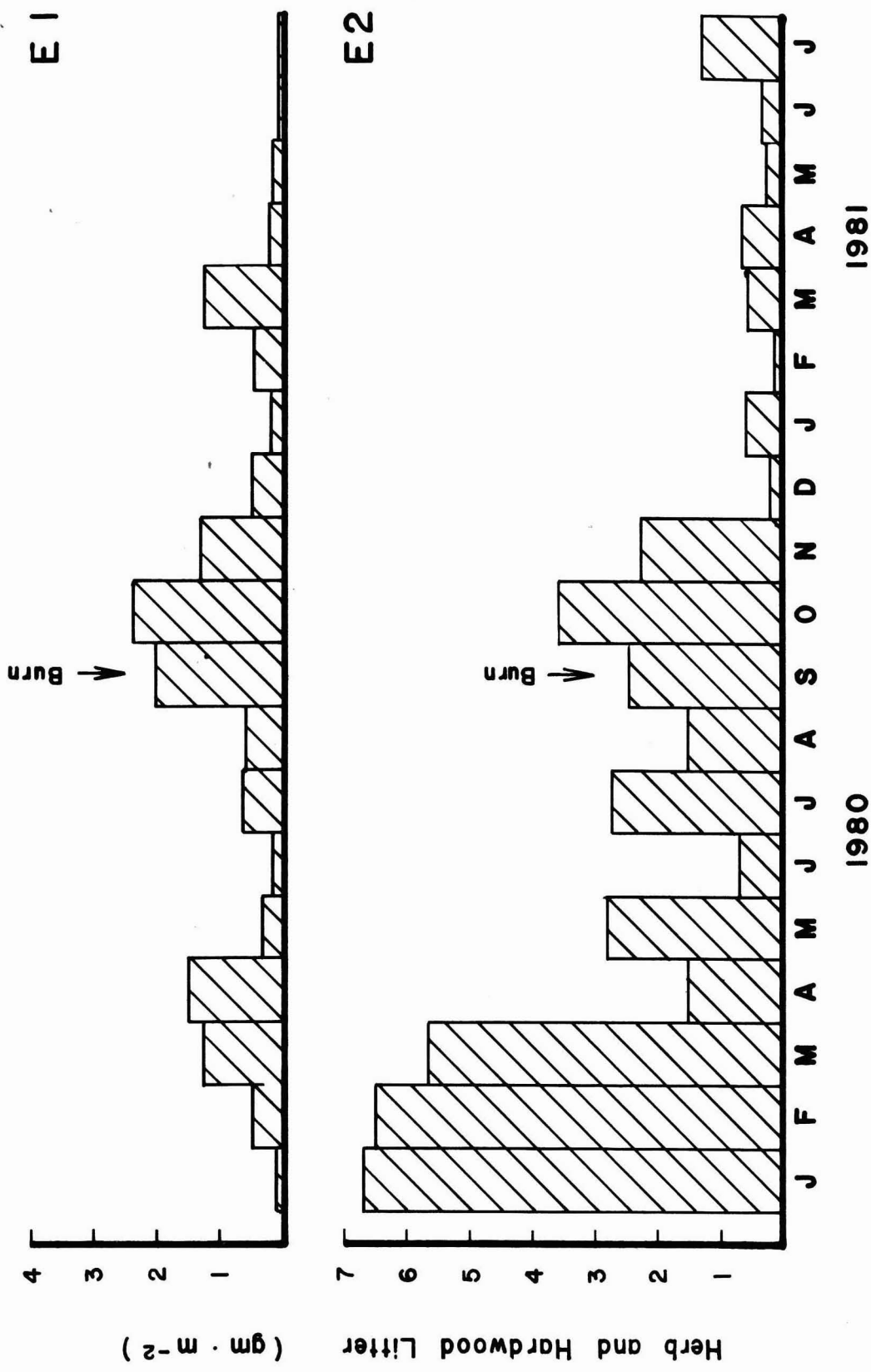


Figure 9. Monthly herb and hardwood litter collected at sites E1 and E2. Note the increase in this component immediately following a prescribed burn of Block E in September 1980.

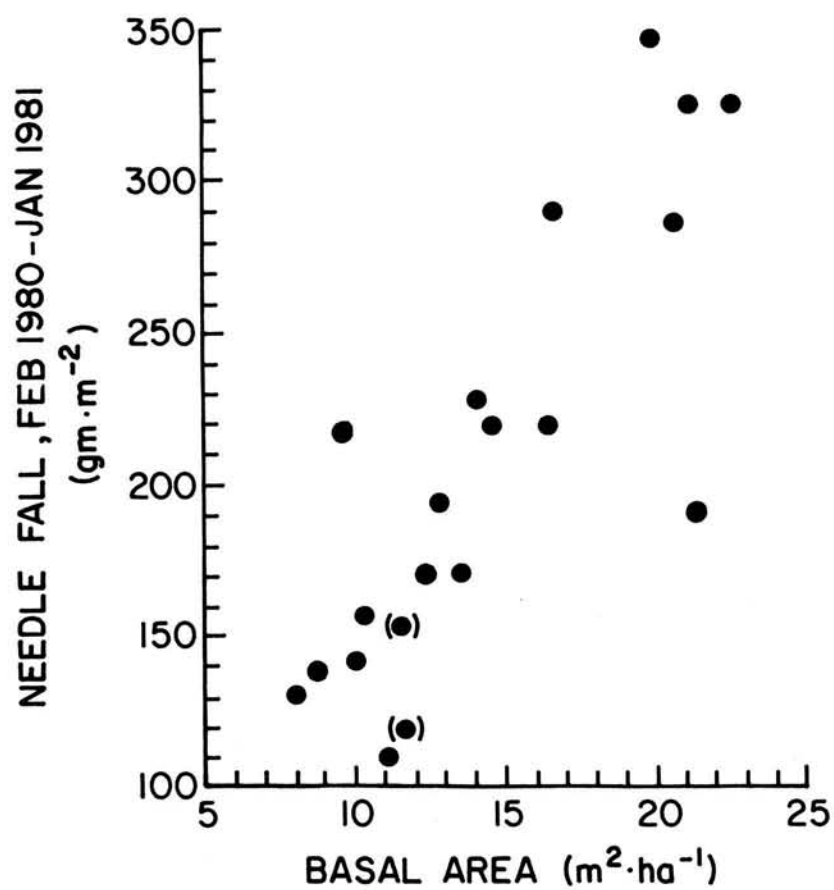


Figure 10. Relation between pine needle litter for the 'year' (February-January) and the total basal area of pine trees in the immediate vicinity.