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ANNUAL PROGRESS REPORT

of the

RESEARCH PROJECT

entitled

THE FLORA AND VEGETATIONAL ECOLOGY

OF ISLE ROYALE NATIONAL PARK

by

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## OBJECTIVES

Following fire, boreal - type forests of Isle Royale are, for the most part, invaded by white birch (Betula papyrifera), quaking aspen (Populus tremuloides), jack pine (Pinus banksiana), or mixtures of these species. Of these, the birch is by far the most prevalent while aspen ranks second. Both are well distributed about the park. Occurrence of jack pine is much more localized, however. Only on the large peninsula between Morkey Basin and the southeast outer shore of the island does it occur in significant quantities.

The main objective of this year's research was to study post-fire forest stands dominated by white birch, by quaking aspen or by jack pine. We were interested, firstly, in determining what causative factors result in the establishment in one or another of these pioneer forest types. Secondly, we aimed at characterizing each forest type and, in particular, at comparing the three types with regard to the attributes which result from their establishment.

Another objective for this year's research was to continue the flora project (project 1 of our proposal) which will eventually result in a complete annotated list of the vascular plants of Isle Royale. Still another objective was to continue our observation of the effects

of moose and beaver on the vegetation (project 8).

## METHODS

Post-fire stand-type study. This study was conducted in areas which, by previous reconnaissance, were found to contain an abundance of young stands dominated by white birch, quaking aspen, or jack pine. Within these areas equally spaced transects were followed perpendicular to the major topographic features of the main island. Any stand encountered along the transects in which the relative basal area of white birch, quaking aspen or jack pine was at least 70% was selected for possible study. In addition, to minimize differences due to successional stages, only stands which were estimated to be in the age range of 100 years were considered. Thirty stands of each of the three types were selected for the comparison study.

For sampling of the tree stratum a 30 X 12 m plot was randomly positioned within each stand with the 30 m side perpendicular to the transect line. The diameter at breast height (D.B.H.) and species were recorded for all trees (D.B.H. > 5 cm) within the plot. Also the number of windfall trees with their base within the plot was recorded. The height and species of all saplings (height > 1 m, D.B.H. < 5 cm) within a 1 m wide strip on one side of the 30 cm long center-line of the tree plot were re-

corded. The percent cover of species within the tall shrub stratum (height > 1 m) was determined by the line-intercept method using 3 randomly located lines perpendicular to and extending 6 m on either side of the above mentioned tree plot center-line. Percent cover of low vascular plants (height < 1 m) was estimated in each of 10 randomly placed 40 X 50 cm rectangular plots each demarcated by a 40 X 50 cm metal frame. A commonly used 7 point scale of cover abundance was used, namely:

|   |   |         |
|---|---|---------|
| + | = | 0-1%    |
| 1 | = | 1-5%    |
| 2 | = | 5-25%   |
| 3 | = | 25-50%  |
| 4 | = | 50-75%  |
| 5 | = | 75-95%  |
| 6 | = | 95-100% |

Counts of tree seedlings (height < 1 m) were made in these same ten plots. Percent cover of bryophyte species was estimated using the same system as for low vascular plants.

As a relative indicator of soil depth,  $\frac{1}{2}$  inch pointed steel probes on each of the 3 tall shrub intercept lines, giving a total of 6 samples per plot. The depth of penetration to rock was measured. Measurements of soil litter depth and collection of a soil sample of the top 10 cm of mineral soil were done at each of 2 randomly located points on the two outer shrub intercept lines, for a total of 4 samples. Percent cover of exposed surface rock was measured by the line-intercept method along the 3 tall shrub inter-

cept lines.

The slope was measured with an inclinometer and the aspect with a compass. The approximate position on the slope was recorded as upper, middle, or lower. Two trees that appeared to best represent the post-fire pioneer tree invaders were bored with an increment borer.

Our previous observations on post-fire stands have suggested that whether a burn is invaded by aspen or by birch is largely affected by the frequency of fires in the area. To test this hypothesis we sampled basal areas of these species in paired areas of the park, one member of the pair having been burned once in the past 180 years and the other, only once. Otherwise the areas were relatively similar in that they were geographically adjacent, were, on the average, the same elevation above Lake Superior and had similar topographic position. Decisions as to whether areas were burned once or twice were based upon (1) mention of recent burned areas or areas of "young growth" in the original land survey notes, (2) National Park Service fire records and (3) increment boring of trees. Basal area measurements within each area were made by use of a Bitterlich prism at randomly selected points along transects perpendicular to the general direction of ridges and valleys of the island.

Flora project. We continued to make inventories of vascular plants in areas representing various habitat

types. In each area selected, an assessment of the relative abundance of each species encountered was made on a 5-point scale of abundance ranging from rare to very abundant. All unfamiliar plants were collected for later identification. We were continually on the lookout for species that have not yet been recorded for Isle Royale. In particular we concentrated on aquatic areas since these have been the least studied.

Miscellaneous activities. We continued recording all observations made on the effects of moose and beaver on the vegetation as we traveled throughout the park. Kodachrome slides were taken throughout the summer of our activities, our study sites and species or ecological phenomena associated with our research project. One copy of each will be presented to the superintendent of Isle Royale National Park for administrative or interpretive purposes.

## RESULTS

Some of the variables measured in each forest plot existed before that forest was established and therefore did not result from the forest itself. Other variables came about as a result of the forest itself. Although the distinction between these two variable types is not always clear-cut, we shall attempt to treat them separately. To determine the

causes for a given forest type becoming established on a particular site, we would have to analyze the first of these categories of variables. In this study we consider these to be: (a) slope, (b) aspect, (c) topographic positions, (d) distance from the nearest exposed Lake Superior shore, (e) amount of exposed rock on the soil surface, (f) soil depth, (g) percent of clay in the soil, (h) soil calcium, (i) soil magnesium, (j) soil potassium, and (k) soil phosphorus.

Mean values and standard errors are given in Table 1 for the three forest types. The table values generally show that the greatest differences exist between jack pine stands and each of the other two deciduous type stands. In particular, the mean soil depth of jack pine stands is considerably less than that for aspen and birch and the amount of rock exposure is considerably greater. The topographic position data show that jack pine is most prevalent on the upper third of slopes. Most, in fact, were on the top of ridges. This undoubtedly is the reason for the shallower and rockier soils of these stands. It also accounts for the smaller mean angle of slope. The significantly shorter distance from Lake Superior of jack pine stands is probably because they are localized on just one peninsula, all points on which are relatively close to the lake, whereas aspen and birch stands are scattered throughout the entire park. Among soil nutrients, calcium and magnesium are significantly less in jack pine stands while phosphorus is significantly more. It is not possible to determine whether the pH factor listed in Table 1 is a factor which existed

Table 1. Mean and standard error of environmental variables for 3 forest types. \* between 2 columns means values in the columns are statistically significant (P=0.05).

| <u>Variable</u>           | <u>quaking<br/>aspen</u> |   | <u>white<br/>birch</u> |   | <u>jack<br/>pine</u> |
|---------------------------|--------------------------|---|------------------------|---|----------------------|
| slope                     |                          |   |                        |   |                      |
| mean (degrees)            | 7.9                      |   | 8.6                    | * | 4.2                  |
| s.e.                      | 1.2                      |   | 1.7                    |   | 0.6                  |
| aspect (from south)       |                          |   |                        |   |                      |
| mean (degrees)            | 55                       | * | 120                    |   | 100                  |
| s.e.                      | 8                        |   | 9                      |   | 11                   |
| no. stands - Lower slopes | 13                       |   | 5                      |   | 1                    |
| no. stands - Mid slopes   | 9                        |   | 20                     |   | 7                    |
| no. stands - Upper slopes | 8                        |   | 5                      |   | 22                   |
| distance from L. Superior |                          |   |                        |   |                      |
| mean (meters)             | 1978                     |   | 1900                   | * | 908                  |
| s.e.                      | 208                      |   | 290                    |   | 55                   |
| % exposed rock            |                          |   |                        |   |                      |
| mean (meters)             | 1.4                      | * | 5.7                    | * | 17.4                 |
| s.e.                      | 0.5                      |   | 1.5                    |   | 2.9                  |
| soil depth                |                          |   |                        |   |                      |
| mean (meters)             | 55.3                     |   | 47.7                   |   | 17.6                 |
| s.e.                      | 4.6                      |   | 2.5                    |   | 1.3                  |
| soil clay                 |                          |   |                        |   |                      |
| mean (%)                  | 8.5                      |   | 6.9                    | * | 10.6                 |
| s.e.                      | 0.9                      |   | 0.5                    |   | 0.5                  |
| soil calcium              |                          |   |                        |   |                      |
| mean (microg/g)           | 20.6                     | * | 16.1                   | * | 6.7                  |
| s.e.                      | 1.9                      |   | 1.4                    |   | 0.8                  |
| soil magnesium            |                          |   |                        |   |                      |
| mean (microg/g)           | 5.3                      |   | 3.9                    | * | 1.5                  |
| s.e.                      | 0.6                      |   | 0.3                    |   | 0.1                  |
| soil potassium            |                          |   |                        |   |                      |
| mean (microg/g)           | 0.47                     |   | 0.57                   |   | 0.60                 |
| s.e.                      | 0.04                     |   | 0.08                   |   | 0.02                 |
| soil phosphorus           |                          |   |                        |   |                      |
| mean (microg/g)           | 17.7                     |   | 15.3                   | * | 18.7                 |
| s.e.                      | 2.2                      |   | 1.3                    |   | 1.3                  |
| soil pH                   |                          |   |                        |   |                      |
| mean                      | 5.5                      | * | 5.2                    |   | 4.8                  |
| s.e.                      | 0.1                      |   | 0.1                    |   | 0.04                 |

prior to the establishment of the vegetation or whether it is an effect of the vegetation type. Quite possibly it is both of these. In any case the lower pH value of the jack pine stands as compared to the two deciduous stands is quite typical of coniferous and deciduous stands in general.

Differences between aspen and birch stands are considerably more subtle. The most striking differences here are that birch stands are considerably more northward in aspect and have much greater amounts of exposed rock than aspen stands. Calcium and magnesium are significantly greater in aspen stand soils than in birch but differences in other soil nutrients are not significant. With regard to topographic position, aspen stands seem to favor lower positions on slopes, while birch favors mid slopes. This suggests that aspen prefers a somewhat more moist site than birch. All other differences in environmental variables associated with these two stand types are not statistically significant.

A comparison of the attributes of the three forest types is summarized in Table 2. In the sequence aspen - birch - pine most of these attributes show either increasing or decreasing trends. Tree density is greatest for pine, and least for aspen. The trend for basal area, however, is just the reverse. This implies a considerable difference in average tree diameter, aspen being the largest and pine the smallest. This reflects, not differences in tree ages but differences in rates of growth. From the increment cores we computed the ratio of tree diameter to age to be 0.37, 0.30, and 0.22 cm/

Table 2. Mean and standard error of various forest attributes for 3 forest types. \* between 2 columns means values in the columns are statistically significant (P=0.05).

| <u>Variable</u>           | <u>quaking<br/>aspen</u> |   | <u>white<br/>birch</u> |   | <u>jack<br/>pine</u> |
|---------------------------|--------------------------|---|------------------------|---|----------------------|
| tree density              |                          |   |                        |   |                      |
| mean (trees/ha)           | 790                      | * | 968                    | * | 160.6                |
| s.e.                      | 47                       |   | 70                     |   | 94                   |
| tree basal area           |                          |   |                        |   |                      |
| mean (m <sup>2</sup> /ha) | 40.0                     | * | 32.2                   | * | 28.9                 |
| s.e.                      | 1.9                      |   | 1.7                    |   | 0.9                  |
| tall shrub cover          |                          |   |                        |   |                      |
| mean (%)                  | 23.0                     | * | 15.9                   | * | 3.1                  |
| s.e.                      | 4.4                      |   | 2.9                    |   | 0.7                  |
| herb cover                |                          |   |                        |   |                      |
| mean (%)                  | 83.4                     | * | 56.7                   | * | 19.0                 |
| s.e.                      | 4.8                      |   | 5.2                    |   | 2.7                  |
| bryophyte cover           |                          |   |                        |   |                      |
| mean (%)                  | 2.8                      | * | 4.7                    | * | 27.7                 |
| s.e.                      | 0.5                      |   | 1.0                    |   | 3.9                  |
| windfalls                 |                          |   |                        |   |                      |
| mean (trees/ha)           | 13.3                     |   | 16.6                   | * | 30.9                 |
| s.e.                      | 1.6                      |   | 1.7                    |   | 2.4                  |
| depth Aoo litter          |                          |   |                        |   |                      |
| mean (cm)                 | 2.30                     | * | 2.40                   | * | 1.80                 |
| s.e.                      | .08                      |   | .05                    |   | .05                  |
| depth A. litter           |                          |   |                        |   |                      |
| mean (cm)                 | 5.50                     |   | 5.20                   | * | 3.90                 |
| s.e.                      | 0.27                     |   | 0.22                   |   | 0.10                 |
| Available nitrogen        |                          |   |                        |   |                      |
| mean (microg/g)           | 90.4                     |   | 79.6                   | * | 31.4                 |
| s.e.                      | 11.0                     |   | 11.6                   |   | 2.7                  |

year for aspen, birch, and pine respectively.

The items listed as tree basal area, tall shrub cover, herb cover, and bryophyte cover are measures of the dominance of the various layers of vegetation in these forest stands. Tree, tall shrub, and herb dominance are strikingly greatest for aspen stands and least for jack pine. Only in the bryophyte layer is this trend reversed. All in all, as indicated by the fastest rate of tree growth, and greatest dominance in the tree, tall shrub, and herb layer, aspen stands appear to be the most productive while the pine stands are the least productive. This could well be related to the fact that aspen stands have the highest soil nutrient status and, because of their low average topographic position, they have the greatest amount of soil moisture. The pine stands have the lowest soil nutrient status and the lowest soil moisture because of their high topographic position and shallow soils. Birch stands are intermediate in regard to all of these parameters.

Windfalls are considerably more abundant for pine stands than for aspen and birch stands. Greater winds associated with the high topographic position of pine stands as well as shallower soils undoubtedly account for this. The shallower soil litter layer depths ( $A_{00}$  and  $A_0$ ) of jack pine stands was unexpected since coniferous tree litter generally decomposes much more slowly than deciduous tree litter. Possibly the stronger winds on the ridge tops are blowing the jack pine

litter away from their typical ridge top positions to lower elevations.

Available nitrogen is listed in the table because it is more likely to be determined by the vegetation rather than being inherent in the physical site. Aspens and birch stands are both considerably higher in available nitrogen than pine stands. The difference between aspen and birch is not statistically significant.

Relative cover of ground cover species for the three forest types is tabulated in Table 3 for species having values greater than 1%. Quaking aspen stands are not significantly different with respect to the relative cover of Aster macrophyllus (big - leaf aster) and Aralia nudicaulis (wild sarsaparilla). Rubus parviflorus (thimbleberry), however, though second in abundance in both forest types, has a much higher relative cover value in aspen stands. This agrees with our previous studies. Other significant differences are the greater dominance of Pteridium aquilinum (bracken fern) in aspen stands and the greater dominance of Chimaphila umbellata (pipsissewa) and Cornus canadensis (Canada dogwood) in birch stands. Otherwise the two stand types are quite similar. The pine stands however are very different in ground cover composition than the two deciduous stand types. Vaccinium angustifolium (blueberry), less than 1% in the deciduous stands, is the most abundant ground cover in the pine stands. Aster microphyllus though second in abundance

Table 3. Relative cover and standard error of most abundant (>1%) ground cover species for 3 forest types.

quaking aspen

| <u>species</u>      | <u>%<br/>rel.<br/>cover</u> | <u>s.e.</u> |
|---------------------|-----------------------------|-------------|
| Aster macrophyllus  | 34.6                        | 2.5         |
| Rubus parviflorus   | 31.4                        | 3.4         |
| Aralia nudicaulis   | 14.6                        | 1.5         |
| Pteridium aquilinum | 4.3                         | 1.7         |
| Diervilla lonicera  | 3.2                         | 0.6         |
| Clintonia borealis  | 2.8                         | 0.7         |
| Streptopus roseus   | 2.2                         | 0.7         |
| Lonicera canadensis | 1.2                         | 0.4         |

white birch

| <u>species</u>       | <u>%<br/>rel.<br/>cover</u> | <u>s.e.</u> |
|----------------------|-----------------------------|-------------|
| Aster macrophyllus   | 34.5                        | 3.5         |
| Rubus parviflorus    | 18.9                        | 2.7         |
| Aralia nudicaulis    | 18.5                        | 2.9         |
| Clintonia borealis   | 3.6                         | 0.7         |
| Chimaphila umbellata | 3.4                         | 1.2         |
| Cornus canadensis    | 2.3                         | 0.5         |
| Diervilla lonicera   | 2.3                         | 0.7         |
| Lonicera canadensis  | 1.1                         | 0.5         |
| Corylus cornuta      | 1.1                         | 0.5         |
| Streptopus roseus    | 1.1                         | 0.4         |
| Pteridium aquilinum  | 1.0                         | 0.5         |

jack pine

| <u>species</u>          | <u>%<br/>rel.<br/>cover</u> | <u>s.e.</u> |
|-------------------------|-----------------------------|-------------|
| Vaccinium angustifolium | 24.7                        | 4.6         |
| Aster macrophyllus      | 22.4                        | 3.6         |
| Arctostaphylos uva-ursi | 12.9                        | 3.6         |
| Miainthemum canadense   | 7.6                         | 2.5         |
| Chimaphila umbellata    | 5.4                         | 2.3         |
| Juniperus communis      | 4.9                         | 2.5         |
| Linnaea borealis        | 3.4                         | 0.8         |
| Lonicera canadensis     | 2.6                         | 1.1         |
| Aralia nudicaulis       | 1.9                         | 1.1         |
| Deschampsia flexuosa    | 1.7                         | 1.4         |
| Diervilla lonicera      | 1.6                         | 0.8         |

in pine stands has a considerably lower relative cover here than in the deciduous stands. The otherwise very ubiquitous Rubus parviflorus has a relative cover of less than 1% in pine stands. The high cover of Arctosaphylas uva-ursi (bearberry) as compared with less than 1% in deciduous stands is another outstanding difference. Aralia nudicaulis is also conspicuously scarce in the pine stands.

The tall shrub layers of all stand types were made up mostly of sapling stages of tree species. The following table gives the mean percent cover values for each of the forest stand types for only the truly shrub species in this layer:

|                         | <u>quaking<br/>aspen</u> | <u>white<br/>birch</u> | <u>jack<br/>pine</u> |
|-------------------------|--------------------------|------------------------|----------------------|
| <i>Corylus cornuta</i>  | 3.70                     | 5.10                   | 0                    |
| <i>Amelanchier</i> spp. | 0.20                     | 0.20                   | 0.15                 |
| <i>Alnus rugosa</i>     |                          | 0.60                   |                      |

Diversity in this layer is extremely low.

Table 4 shows the tree size structure for the three stand types. From this, some inferences on reproduction habits and succession may be made. It appears that white birch is phasing out in all three stands. Although seedling germination appears to be abundant, very few survive to the sapling stage. Aspen is also phasing out. More seedlings survive, however, than in the case of birch but few of the saplings are recruited into the tree category since there are fewer trees in

Table 4. Densities (stem/hectare) of seedlings, saplings, and trees by centimeter diameter class for 3 stand types.

|                     |                  | trees by diameter class (cm) |                 |               |                |                |                |                |                        |
|---------------------|------------------|------------------------------|-----------------|---------------|----------------|----------------|----------------|----------------|------------------------|
|                     |                  | <u>seedlings</u>             | <u>saplings</u> | <u>5 - 15</u> | <u>15 - 25</u> | <u>25 - 35</u> | <u>35 - 45</u> | <u>45 - 50</u> | <u>total<br/>trees</u> |
| QUAKING ASPEN PLOTS | White Birch      | 667                          |                 | 23            | 44             | 7              | 2              |                | 76                     |
|                     | Quaking Aspen    | 6167                         | 2333            | 24            | 196            | 281            | 73             | 3              | 577                    |
|                     | Balsam Fir       | 6833                         | 1233            | 41            | 15             | 6              |                |                | 62                     |
|                     | White Spruce     | 833                          | 122             | 51            | 13             | 3              | 3              |                | 70                     |
|                     | White Cedar      |                              | 11              | 1             |                | 1              |                |                | 2                      |
|                     | Shade Intolerant | 6834                         | 2333            | 47            | 240            | 288            | 75             | 3              | 653                    |
|                     | Shade Tolerant   | 7666                         | 1366            | 93            | 28             | 10             | 3              |                | 134                    |
| WHITE BIRCH PLOTS   | White Birch      | 2000                         | 67              | 133           | 353            | 143            | 26             | 4              | 659                    |
|                     | Quaking Aspen    | 4333                         | 1222            | 7             | 12             | 7              | 4              |                | 30                     |
|                     | Balsam Fir       | 9167                         | 1411            | 65            | 50             | 8              |                |                | 123                    |
|                     | White Spruce     | 333                          | 89              | 74            | 75             | 4              |                |                | 158                    |
|                     | Black Spruce     |                              | 33              | 3             |                |                |                |                | 3                      |
|                     | White Cedar      | 333                          | 11              |               |                |                |                |                |                        |
|                     | Shade Intolerant | 6333                         | 1289            | 140           | 365            | 150            | 30             | 4              | 689                    |
|                     | Shade Tolerant   | 9833                         | 1533            | 142           | 130            | 12             |                |                | 284                    |
| JACK PINE PLOTS     | White Birch      | 2667                         |                 | 33            | 8              |                |                |                | 41                     |
|                     | Quaking Aspen    | 333                          | 100             | 9             | 18             | 2              |                |                | 29                     |
|                     | Jack Pine        |                              |                 | 394           | 697            | 41             | 1              |                | 1133                   |
|                     | Balsam Fir       | 2167                         | 167             |               | 2              |                |                |                | 2                      |
|                     | White Spruce     | 333                          | 57              | 50            | 2              |                |                |                | 52                     |
|                     | Black Spruce     | 1000                         | 144             | 54            | 6              |                |                |                | 60                     |
|                     | White Cedar      | 500                          | 11              |               | 2              |                |                |                | 2                      |
|                     | Shade Intolerant | 3000                         | 100             | 436           | 723            | 43             | 1              |                | 1203                   |
|                     | Shade Tolerant   | 4000                         | 379             | 104           | 12             |                |                |                | 116                    |

the 5 - 15 cm class than in subsequent classes. Jack pine is phasing out much more dramatically in the pine stands since the seedlings and saplings are completely absent. Both white spruce and balsam fir appear to be increasing in importance. Our previous studies indicate that as succession proceeds, the shade-intolerant species such as birch, aspen, and jack pine are gradually replaced by shade-tolerant species such as balsam fir, white spruce, white cedar, and black spruce. We have tabulated the totals for shade-intolerant and shade-tolerant species for each stand. From these it can be seen that succession has progressed the most rapidly in the birch stands and the least rapidly in the pine stands. All stand types, though quite different initially, seem to be progressing toward stands dominated by balsam fir and white spruce. In the case of jack pine stands, however, black spruce (Picea mariana) appears to be becoming equally dominant.

The Bitterlich prism data taken at points in areas burned once and in areas burned twice in the past one and a half century yielded basal areas of aspen and of birch for each point sampled. Average basal areas of each species were determined for each burn history area. The ratio of aspen basal area to the total basal area of both species was then computed. These values along with their standard errors are as follows:

|              | <u>ratio</u> | <u>s.e.</u> |
|--------------|--------------|-------------|
| burned once  | 0.31         | 0.03        |
| burned twice | 0.41         | 0.03        |

This ratio is significantly greater for areas burned twice than for areas burned once. This suggests that a history of frequent fires would favor aspen over birch.

Continued progress was made on the flora project and the project dealing with the effects of moose and beaver on vegetation. A report on these shall await the completion of this project in May 1983.

#### SUMMARY AND RECOMMENDATIONS

Jack pine post-fire forest stands on Isle Royale are associated primarily with ridge tops, shallow soils, abundant rock-outcropping, low pH, and low soil nutrients as compared with the two deciduous forest stand types dominated by quaking aspen and white birch. Differences between aspen and white birch forest types are more subtle. Compared with aspen stands, birch stands tend to become established on slopes with more northerly aspects, with less rock outcropping and somewhat more fertile soils with lower pH. Aspen prevails on lower slopes while birch prevails on mid slopes.

With regard to attributes of the 3 forest types:

- (a) Pine stands are the densest; aspen stands the least dense.
- (b) Pine stands have the least basal area; aspen the greatest basal area.

- (c) The tree, tall shrub, and herb layers of pine stands are the least productive; those of aspen stands, the most productive.
- (d) The bryophyte strata is richest in pine stands; sparcest in aspen stands.
- (e) Windfalls are most numerous on pine stands; least numerous on aspen stands.
- (f) Soil litter depths are least on pine stands; greatest on aspen stands.
- (g) Available soil nitrogen is least on pine stands; greatest on aspen stands.
- (h) Each of the three forest types is characterized by a unique array of vascular ground cover plants. The greatest differences occur between jack pine stands and either of the two deciduous stands. The greatest similarity exists between aspen on birch stands.
- (i) In birch stands, Corylus cornuta (hazelnut), and small amounts of Amelanchier spp. (sugar plum) and Alnus rugosa (tag alder) occur as tall shrubs. For aspen stands, Corylus cornuta and a small quantity of Amelanchier spp. occur, while for pine stands, only a small quantity of Amelanchier spp. occurs.
- (j) All three stand types tend to be increasingly dominated by balsam fir and white spruce as succession proceeds. For the pine stands, black spruce also becomes more dominant with time.

Succession seems to be occurring the most rapidly in birch stands and the slowest in the pine stands.

Aspen densities seem to be greater in areas that have a greater frequency of fire.

These results represent important baseline information necessary for the understanding of Isle Royale forest ecosystems. As such it should be made available to persons doing research in the park, to persons charged with responsibility of managing the park resources and to those involved in the interpretation of the park's resources to visitors.

However, much more basic information about Isle Royale's vegetation needs to be gathered. The following areas are as yet relatively untouched:

- (1) Aquatic vegetation communities.
- (2) The sugar maple - yellow birch forest type in the higher more interior portions of the island.
- (3) The relationships of moose and wolf population sizes to the various stages of forest succession.

Furthermore, certain phases of our present study should be continued beyond the termination date of this project. Sampling should continue in the plots we have established in recent burns and more plots should be set up in future burns as they occur. Some of our 250 forest succession plots should be established as permanent plots and resampled

periodically in the future so that successional changes can be monitored directly.

We therefore recommend that continued support be given to vegetation studies beyond the expiration date of our present study. A complete set of data on the park's vegetational resources is paramount not only for the proper management of its resources but for its status as a biosphere reserve.