Fundy Model Forest

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Final Report For Research Grant

for fiscal year: 2003 - 2004

Title of Project

Tree islands: Leave patches as refugia for vascular plants and bryophytes in harvest blocks

Project number (office use)	**Budget Approved (office use)**	**Date (office use)**

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biodiversity, bryophytes, disturbance, harvesting, herbaceous species, leave patches, stand structure, tree islands, understory, vascular plants

Summary
In the 2003-04 project year, we (1) continued monitoring vegetation and blowdown in permanent plots established in 6 patches in 2002, with emphasis on 2 large (1ha) islands; (2) increased replication of large patches with 2 new patches in the Pollett River Watershed; and (3) continued to monitor microclimate in one reference plots in an unharvested area. We completed field data collection on the 4 large patches: one-yr post harvest for 2, and pre-harvest for 2; post-harvest bryophyte identification is complete for the first two large islands. Blowdown was assessed at all experimental islands.
The following are our objectives and preliminary findings;

1. **Assess representivity of patches in harvest blocks vs. those patches that are delineated to protect wet areas or unusual habitats within harvest blocks.**
   Small islands established in wet areas (0.25 and 0.5 ha) did not differ from the surrounding harvest block in a range of structural features, however their bryophyte flora was considerably higher in both overall abundance and in species richness. Experimental large islands were similar in both structure and bryophyte abundance, but a number of liverworts found in the harvest block were absent from the islands.
2. **Determine thresholds of response of the understory layers in both patch types relative to distance from the patch edge (i.e., edge effect) after harvest.**
   The bryophyte data indicate that total cover declines more on the south and (to some degree) west faces, as far as 25m into the island. Richness increased in the islands, but declines in the clearcut and as far as the edge (0m) only on the south. Results for one island indicate that decline in richness in the clearcut is moderated near the island edge.
3. **Quantify amount of post-harvest blowdown.**
   Islands appear to shrink through blowdown beginning immediately after harvest, and frequency of blowdown by quadrant suggests that shrinkage is asymmetrical. However, it is too soon to predict rate, direction, or species patterns.
4. **Provide recommendations with respect to the placement, minimum size and configuration of patches to insure that refugia for vascular plants and bryophytes and their habitats are maintained.**
   <u>Preliminary conclusions:</u> the data indicate that (a) islands provide protection for a range of plant species, (b) “wet islands” do not contain many of the species at risk in the surrounding upland cutblock, however (c) both wet and dry islands are desirable to protect their respective floras. (d) Edge effects (as measured by plant responses) are likely to extend at least 25m on the south side. Given asymmetrical shrinkage and edge effects, (f) small (50x50m) islands are unlikely to provide sufficient protection to ensure a functional core, however large (1ha) islands appear to contain a function core of approx 0.6ha.

Introduction and background

Leave patches or “tree islands” that are left in clearcuts and variable retention harvest blocks appear to function as refuges for some sensitive species of the herbaceous layer (i.e. non-woody plants of the forest floor) and the structural elements upon which they depend (e.g. Fenton et al. 2003, Ross-Davis and Frego 2002, Fenton 2001, Ramovs 2001), but we do not know the critical patch characteristics that will ensure survival and reproduction of these. Accordingly, the overall goal of this project is to assess the functionality of leave patches of varying sizes as plant refugia and sources of critical elements of stand structure.

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In the previous two years, we found that patches left as part of “standard operating procedure” are smaller than the expected 0.25ha (Fig. 1), and are often lacking in species and critical elements of stand structure, such as snags, probably because the patches are delineated without these features or species in mind; in fact, they are often located in unique habitats, such as wet areas, within the harvest block. Because they tend to follow drainage features such as ephemeral streams, they are not isodiametric so edge:volume ratios are not minimized. Although it is too early to tell, we suspect that post-harvest microclimatic and other changes on the periphery of the patches extend so deeply into the patches that they are often too small to protect the habitats and species contained within.

Recommendations to follow from this project will include minimum patch size based on thresholds of response of understory species to edge effects in the patches, and number and placement of patches within harvest blocks, again based on threshold levels of species and structural features contained within the patches in comparison to the surrounding areas.

Objectives for entire project:

1. Assess representivity of patches in harvest blocks vs those patches that are delineated to protect wet areas or unusual habitats within harvest blocks. Which species are potentially protected in each type of patch?
2. Determine thresholds of response of the understory layers in both patch types to distance from the patch edge (i.e., edge effect) after harvest. How wide is the edge, in terms of (a) detectable habitat conditions, and (b) species responses? Conversely, how much of the patch is “functional core” that escapes the immediate influence of the surrounding cutover?
3. Quantify post-harvest blowdown. How does patch size, and hence the functional core size, change over time? Do patches shrink symmetrically?
4. Provide recommendations with respect to the placement, minimum size and configuration of patches to insure that refugia for vascular plants and bryophytes and their habitats are maintained.

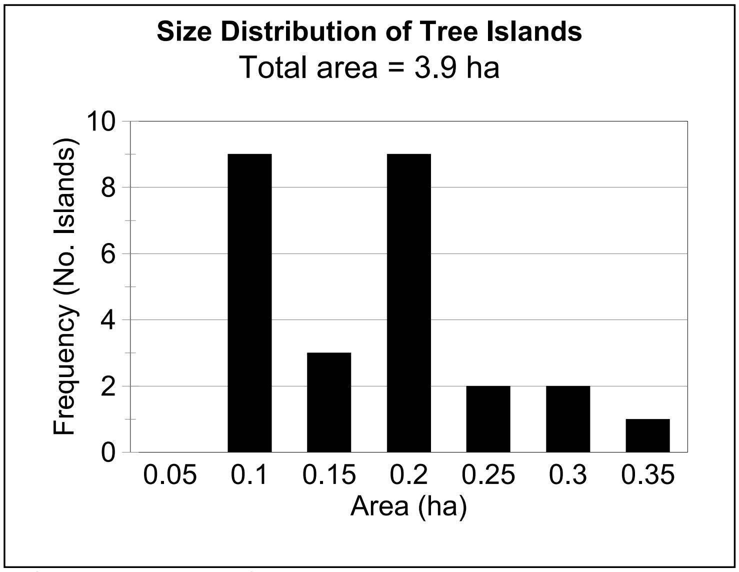

Figure 1. Size distribution of existing 1-2 yr old tree islands in Fundy Model Forest (n=26, sampled 2002).

Workplan objectives for 2003-4:

1. Continue monitoring vegetation and blowdown in permanent plots established in and outside patches in 2001 and 2002;
2. Increase replication of large upland patches (1.0 ha) with 2 new patches;
3. Quantify blowdown on existing islands; and
4. Account for closed forest conditions, including microclimate and natural rates of change, by establishing reference quadrats in unharvested areas. NB It is critical to compare community change in patch cores to that in reference areas to establish whether the centers are free of edge effect from anthropogenic disturbance. This objective was not completely achieved in 2003, and will be further developed in 2004.

METHODS

Three sizes of islands were established in 2002 and 2003. Small (0.25ha) and medium (0.50ha) islands were delineated by JDI personnel according to their current practice. These were all chosen to also protect seepage areas or ephemeral streams (hence these are termed “wet islands”). Four transects on cardinal directions were established, each passing through the center, with 1x1m quadrats at 5m intervals on each, i.e. 5 quadrats x 4 transects inside each island, and an equal number at equal spacing outside.

Large (1.0ha) islands were delineated by Primary Investigators and graduate students, with approval from JDI personnel, as experimental patches in upland cutblocks. Transects were established as above, but belts of 5 quadrats were set at 50 and 5 m from the island edge, in the area to be clearcut, and at 0, 25, 35 m inside the island (Fig. 2). A block of 10 quadrats was positioned at the center of the island; n=70 inside, 40 outside.

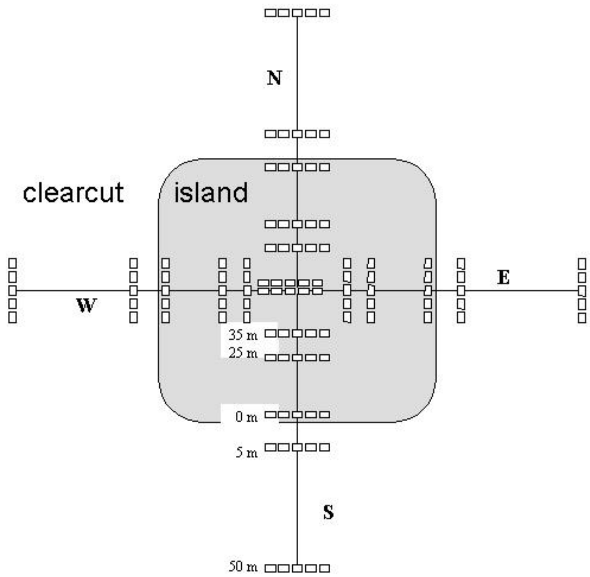

Figure 2. Schematic of sampling design for 1.0ha islands. 1x1m quadrats established in belts of 5, on 4 cardinal transects, at 50 and 5 m into future clearcut, and at 0, 25, and 35m inside island, with a block of 10 quadrats at island center, 50 m from island edge.

All quadrats were marked with short wooden stakes driven to ground level, and mapped with reference to the bases of the three nearest trees. All were sampled before harvest, recording abundance of vegetation (vascular and bryophyte species), environmental features (microtopography, canopy cover, etc.), and stand structure (sizes and numbers of trees, snags, saplings and shrubs, and amount of coarse woody debris).

1: Post-harvest monitoring of existing permanent plots. Permanent quadrats were sampled in 2002 (pre-harvest), relocated in spring 2003 (post-harvest), and resampled for both vegetation and environmental features, including disturbance conditions (slash, machine tracks, exposed mineral soil, etc. Microclimatic conditions (relative humidity, solar radiation and ground temperature) were monitored with dataloggers (2 each of models CR-10 and 21X Campbell Scientific, and 10 Hobo models) throughout the summer on selected plots representing the full gradient from the patch center to 50 m into the cutover.

2: Establishment and pre-harvest sampling of new areas. New sets of quadrats were established in 2 additional 1.0ha upland patches in the Pollett River watershed by the research team with the aid of JDI field personnel.

Combined with the previous patches, this constitutes a total of 4 replicates for the large patch treatment type. As in 2002, replicated permanent plots were established and marked on transects extending from the patch center to 50 m into the surrounding area (future cutover). Pre-harvest sampling (summer 2003) recorded vegetation composition, substrates, canopy cover and stand structure (sizes and numbers of trees, snags, saplings and shrubs, and amount of coarse woody debris). The cutblock was harvested in autumn 2004, and patch boundaries were mapped using GPS. Post-harvest sampling will begin in June 2004.

3: Blowdown. Existing patches were surveyed for all fallen trees, recording species, diameter, height and location (with GPS) within the patch.

ANALYSES

Representivity of island flora:

Pre-harvest forest floor communities of both types of islands (small-medium/wet vs large/upland) will be compared to the surrounding cutblock in terms of (a) species richness and (b) species composition. Further comparisons will incorporate environmental and structural features, and reference sites, to provide insight as to which types of patches are representative of the broader range of conditions in the study area.

Assessing post-harvest changes within islands:

Pre- and post-harvest vegetation, structure and environmental characteristics will be compared (a) within patches versus in the adjacent cutover, and (b) at various distances from the patch edge. Preliminary comparisons across patch sizes for the wet islands will utilize the existing 4 patches established in 2002. Comparison (a) will allow us to quantify post-harvest changes, relative to community dynamics in the centers of islands. Comparison (b) will allow us to address response thresholds to size and edge, and hence minimum patch size.

Blowdown and patterns of island shrinkage:

Blowdown will compared as total numbers and basal area, as well as by species. Location (compass quadrant) where blowdown occurs will be noted so that susceptible portions of patches, e.g. those exposed to prevailing winds, can be identified.

PRELIMINARY RESULTS

Delays and changes. This project has been subject to several delays and adjustments due to changes in personnel in 2003. Although all field data collection for vegetation, stand structure, environment, and blowdown have been completed, bryophyte identification is continues. Vascular plant, structure and environmental data have been compiled in spreadsheets, but have not been analyzed. To date, all bryophyte samples from pre- and post-harvest sampling of the two large (1.0ha) islands have been identified (n= 110 quadrats x 2 islands), as well as pre-harvest samples of the 4 small (0.25 and 0.5ha) islands (n = 40 quadrats x 4 islands). Identification of bryophytes from pre-harvest sampling of the new large islands is partially completed.

Microclimatic data have been recorded in one reference area, but establishment of a second reference area, and vegetation sampling in reference area(s), were not done in 2003 due to time constraints.

Ramifications of delays. We are very disappointed that we were not able to sample the vegetation reference plots in 2003, as these are one of the features (along with pre-harvest sampling) that make our work innovative and more reliable than other studies of this kind. For useful reference data, these require sampling over a minimum of two years. Given adequate funding for this or related projects, we will set them up in 2004, and resample in 2005.

The high variability and floristic richness of wet islands indicates that we need more replicates to assess patterns to detect community change. Immediate post-harvest data, which we could not complete last season, is not critical to their assessment, as previous clearcut sampling shows continuing declines in species diversity over several years. We do not see last year's delays as having serious impacts on that component of the study.

Because (a) data collection continues in 2003-4, (b) all data must be integrated for analyses, and (c) all personnel are concentrating on bryophyte identification, limited statistical analyses have been undertaken at this time. The following constitute our preliminary findings.

(1) General observations.

The six islands established in 2002 were sampled with a total of 600 quadrats, and contained 128 bryophyte species (Fig. 3) – only a small increase in species compared to the entire Hayward Brook study with 159 quadrats. A large number of species were extremely infrequent (e.g. found in <5 quadrats overall) while a small number were ubiquitous (occurring in >150 quadrats). Several species are first reports for NB and even for the Atlantic region. Overall, this very basic information provides a better sense of broader scale patterns of bryophyte species richness in NB forests.

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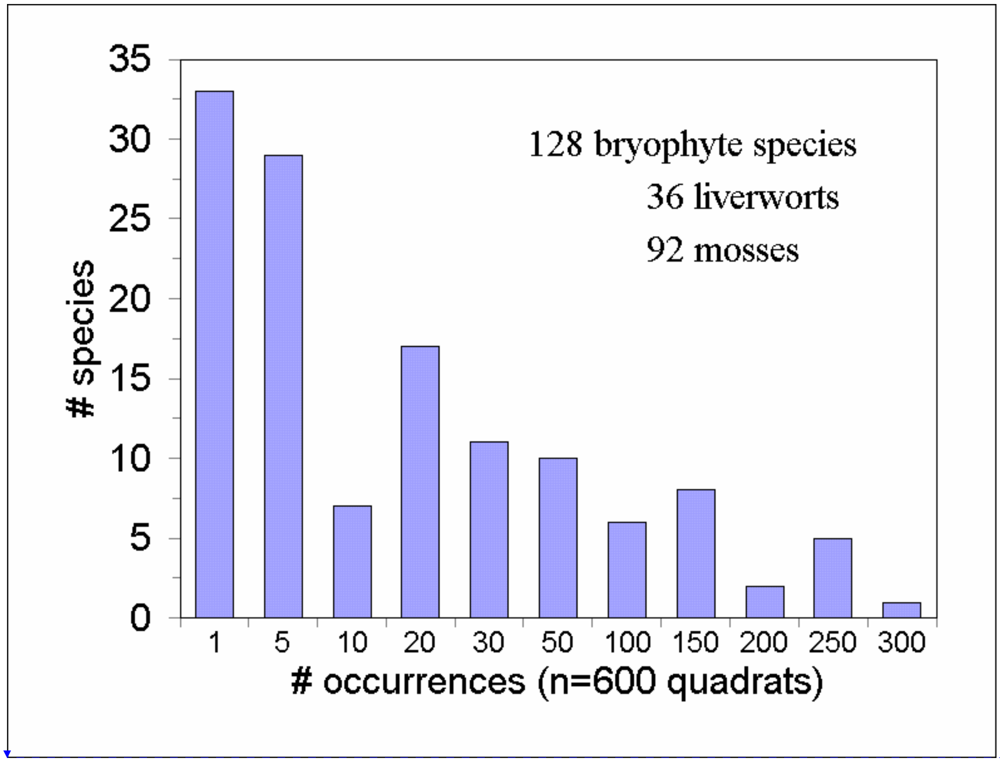

Figure 3. Pre-harvest frequency distribution of 128 bryophyte species in 600 1x1m quadrats, in 6 islands and their surrounding cutblocks.

(2) Representivity of island flora

(a) Bryophytes. Before harvest, bryophytes covered approx 10-25% of each quadrat (Fig. 4). Within-island quadrats in small and medium islands had significantly greater bryophyte cover than their surrounding cutblocks, whereas within- vs outside- island covers did not differ for large islands. This likely reflects the habitat heterogeneity of the wet islands vs their surrounding uplands.

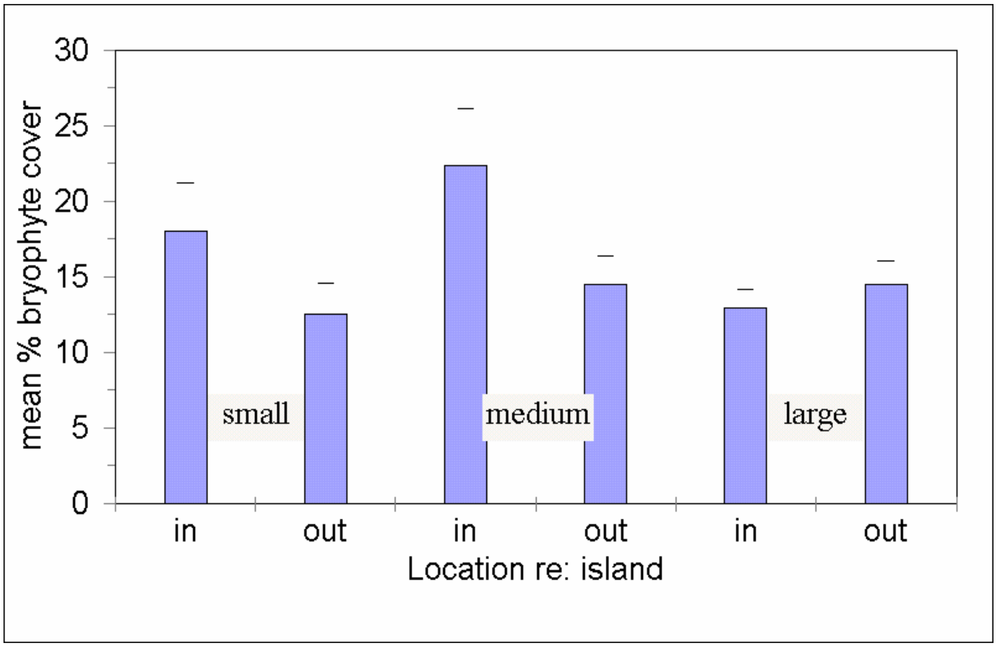

Figure 4. Mean (+se) pre-harvest bryophyte cover (as % of 1x1m quadrat), inside vs outside islands of three sizes.

Pre-harvest individual quadrats within and surrounding small (0.25ha) and medium (0.50ha) islands contained significantly more bryophyte species overall than did large islands (1.0ha) (Fig. 5). The higher richness is likely attributable to habitat diversity and to the more hydric habitats within these islands: the islands themselves were selected to protect ephemeral streams and other wet areas, while the surrounding cutblocks were higher and drier. Large islands were more similar to their surrounding cutblocks as both were relatively homogeneously high and dry. However, liverwort and moss richness tended to be higher in the cutblocks than in the large and medium islands (Figs. 6-7). This is particularly intriguing because sampling intensity was higher within the large island than outside by 10-fold.

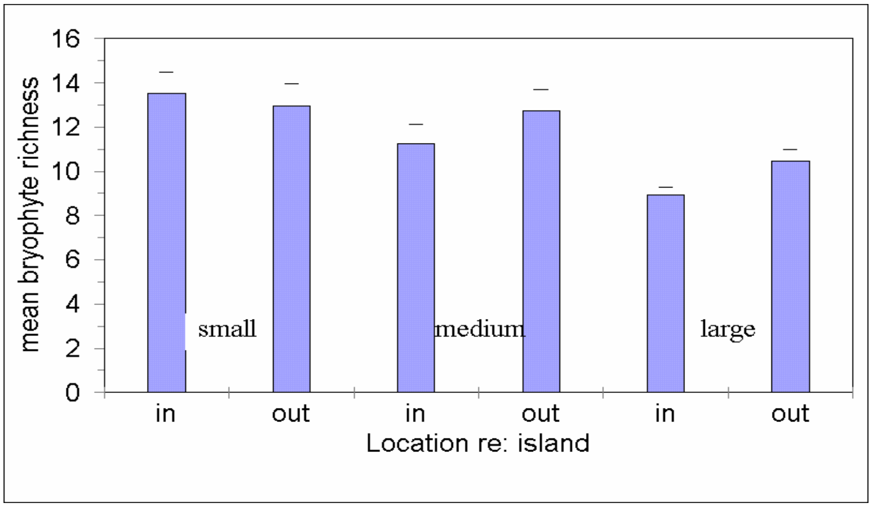

Figure 5. Mean (+se) pre-harvest bryophyte richness per 1x1m quadrat, inside vs outside islands of three sizes: 0.25ha, 0.50ha, and 1.0ha.

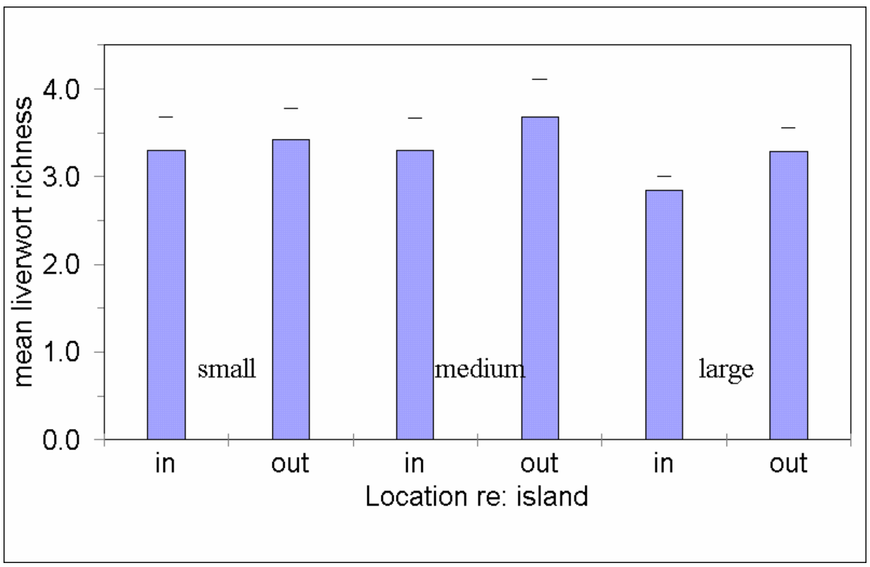

Figure 6. Mean (+se) pre-harvest liverwort richness per quadrat, inside vs outside islands of three sizes.

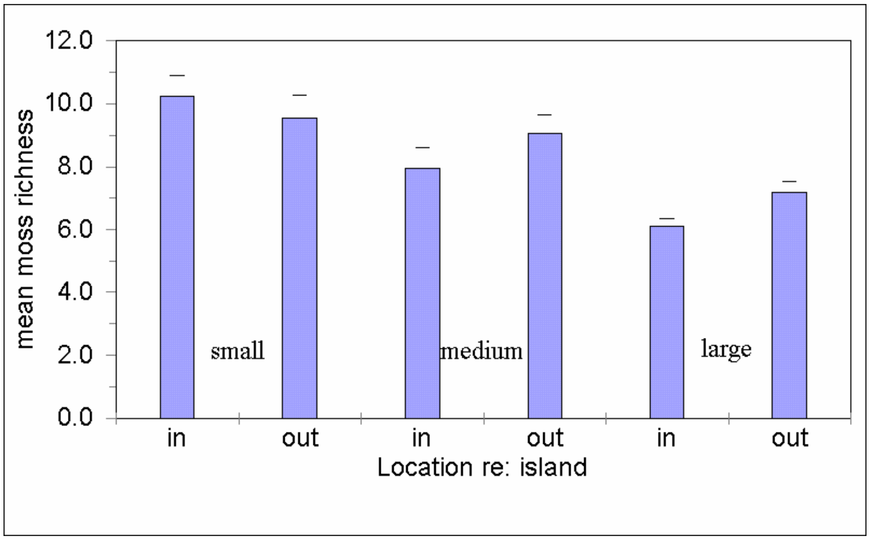

Figure 7. Mean (+se) pre-harvest moss richness per 1x1m quadrat, inside vs outside islands of three sizes.

(b) Stand structure

Details of results can be found in Russell (2004), and will be included in a final report. Structural features are summarized by island (Table 1).

Comparisons of islands with their surrounding cutblocks showed similar frequency distributions for tree heights in intervals of 5m, with no significant differences in percent live crown, tree density, and total basal area. Three of the four small/medium islands differed in tree species composition relative to their cutblocks, with higher proportions of coniferous species in two, and higher deciduous content in one. The large islands and their cutblocks did not differ in tree species composition.

Islands and their cutblocks showed no significant differences in shrub density, nor CWD by either decay class or size class.

Table 1. Mean values (and standard deviation) of structural attributes in the six leave patches. Attributes that are significantly different at 95% confidence ($p \leq 0.05$) (one-way ANOVA analysis) are shaded.

	Island					
Stand Structure attributes	**1 (0.25ha)**	**2 (0.5ha)**	**3 (1.0ha)**	**4 (0.5ha)**	**5 (0.25ha)**	**6 (1.0ha)**
Trees:						
Height (m)	11.7 (3.8)	12.0 (5.7)	10.3 (4.3)	9.1 (4.0)	13.5 (5.6)	13.2 (5.8)
DBH (cm)	13.3 (5.2)	18.3 (10.1)	15.1 (11.0)	13.1 (6.9)	18.0 (10.3)	16.4 (6.6)
BA (m2/plot)	6.3 (5.5)	13.5 (13.0)	10.9 (18.7)	6.9 (8.8)	13.4 (16.4)	9.8 (7.4)
Live crown (%)	44.8 (17.9)	42.4 (13.9)	38.1 (28.0)	35.9 (30.6)	42.1 (21.2)	49.6 (26.5)
Shrubs:						
Sapling density (# stems/plot)	16.6 (11.3)	26.0 (10.8)	6.6 (0.5)	10.0 (4.6)	9.2 (4.0)	33.2 (27.8)
DWD						
Decay class I	.001 (.003)	.000 (.000)	.123 (.254)	.000 (.000)	.000 (.000)	.000 (.000)
Decay class II	.002 (.005)	.024 (.036)	.006 (.009)	.007 (.010)	.000 (.000)	.088 (.075)
Decay class III	.027 (.034)	.031 (.043)	.001 (.001)	.009 (.017)	.086 (.068)	1.09 (2.19)
Decay class IV	.079 (.101)	.009 (.020)	.021 (.029)	.032 (.069)	.004 (.010)	.094 (.082)
Size – fine	.006 (.007)	.016 (.022)	.120 (.257)	.009 (.009)	.008 (.014)	.040 (.105)
Size – coarse/medium	.053 (.060)	.047 (.057)	.031 (.043)	.009 (.017)	.050 (.064)	1.14 (2.24)
Size – coarse/large	.051 (.113)	.000 (.000)	.013 (.028)	.031 (.070)	.033 (.073)	.089 (.099)

(2) Changes with harvest.

(a) Bryophytes. Data from two 1.0ha island have been assessed. As in the Hayward Brook study, bryophyte cover (Fig. 8) and species richness (Fig. 9) declined markedly in the clear-cut (i.e. at –50 and –5m), with greatest loss of liverworts (Fig. 10).

Within the islands, there was a consistent decline in cover and increase in richness. It is too soon to tell whether this may be attributable to "observer error" (different personnel sampled 2002 vs 2003), however it is clear that the otherwise consistent pattern changes toward the edges of the islands, i.e. at 0 (edge), on all transects. The decline in cover appears to be greater on the south and west (Fig. 8). Similarly, the trend towards increased richness in 2003 does not apply to the south-facing edge (Fig. 9). Together, these suggest that the edge effect of the adjacent clear-cut (as detected by community response) is asymmetrical, extending further into the islands on the south, and to a lesser extent on the west.

Further analyses are needed to determine the nature of the changes, i.e. which species and life strategies are affected. However, the preliminary analyses for Island 3 (one 1.0ha island, Fig. 10) suggest a general decline in liverworts and increase in robust mosses in the clearcut, as was found in previous studies (e.g. Fenton et al. 2003). Changes within the islands support previous findings of unexpectedly dynamic communities, but require careful investigation to rule out other factors.

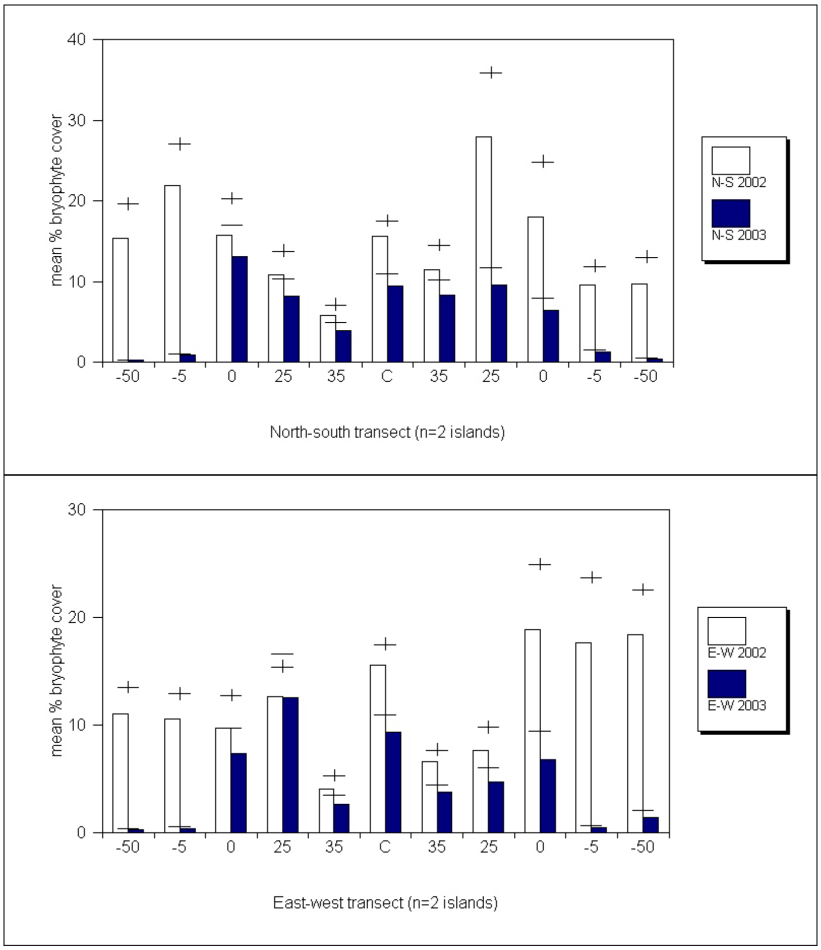

Figure 8. Bryophyte cover in 1m^2 quadrats located on N-S (above) and E-W transects (below) through two 1.0ha islands. Bars are means of 10 quadrats, + and – are markers for 1se above mean. Values on x-axis are meters from centre of island. Open bars are pre-harvest (2002), closed are post-harvest (2003).

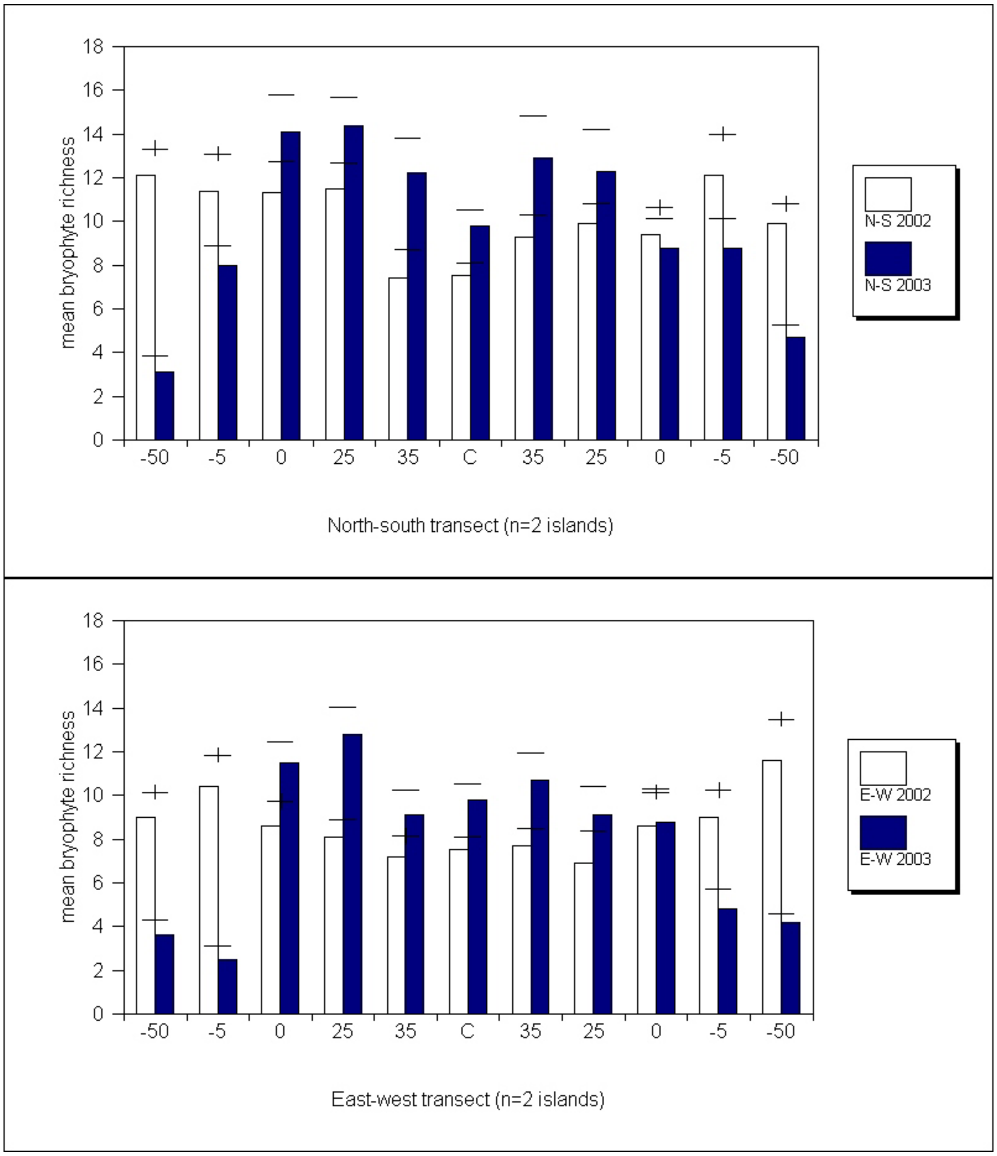

Figure 9. Bryophyte richness in 1m^2 quadrats located on N-S (above) and E-W transects (below) through two 1.0ha islands. Bars are means of 10 quadrats, + and – are markers for 1se above mean. Values on x-axis are meters from centre of island. Open bars are pre-harvest (2002), closed are post-harvest (2003).

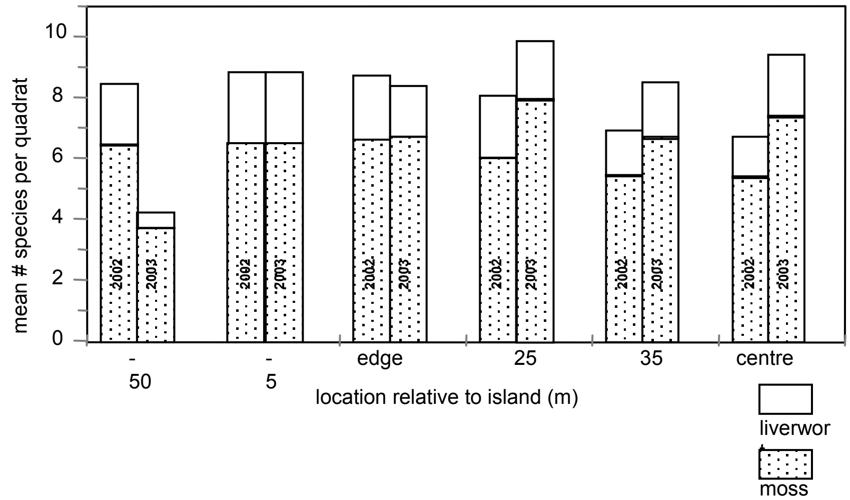

Figure 10. Comparison of mean pre (2002) and post harvest (2003) species richness for mosses vs liverworts with location relative to Island 3, all transects pooled. Centre = centre of island, 50m from all edges, and –50m is in clearcut, 50m from island edge. N=40 quadrats, except centre n=10.

(3) Vascular plants – post harvest only

Pre-harvest data have not been concatenated with post-harvest. The post-harvest data (alone) from the two large islands indicate several interesting patterns.

Richness shows distinctive differences with distance from island edge, that also vary with cardinal direction (Fig. 11). On the north, east and west transects, richness declines at the edge and 5m into the clearcut, but rises at 50m into the clearcut; however on the south, richness increases from 25m to edge and 5m into the cut, but declines at 50m into the cut. Follow-up must examine species composition to interpret these levels.

Second, preliminary assessment of composition using DCA (Fig. 12) shows that quadrats inside the islands tend to differ from those outside. As expected, the latter contained a higher abundance of typically pioneer species such as sedges, sarsasparilla (*Aralia hispidula*), and seedlings of white birch (*Betula papyrifera*) and pincherry (*Prunus pensylvanica*). Edge quadrats showed a range of species, with some containing higher proportions of pioneers than others.

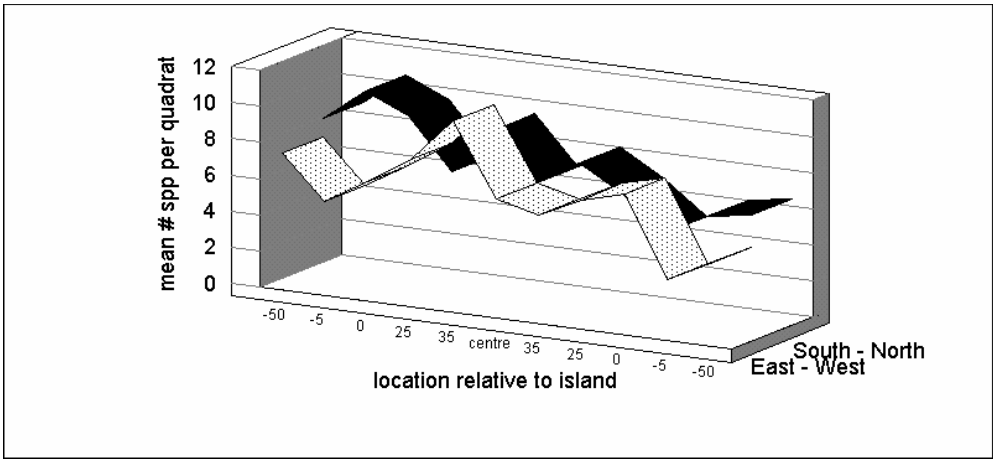

Figure 11. Vascular plant richness (mean, n=5) along two transects through 2 large islands.

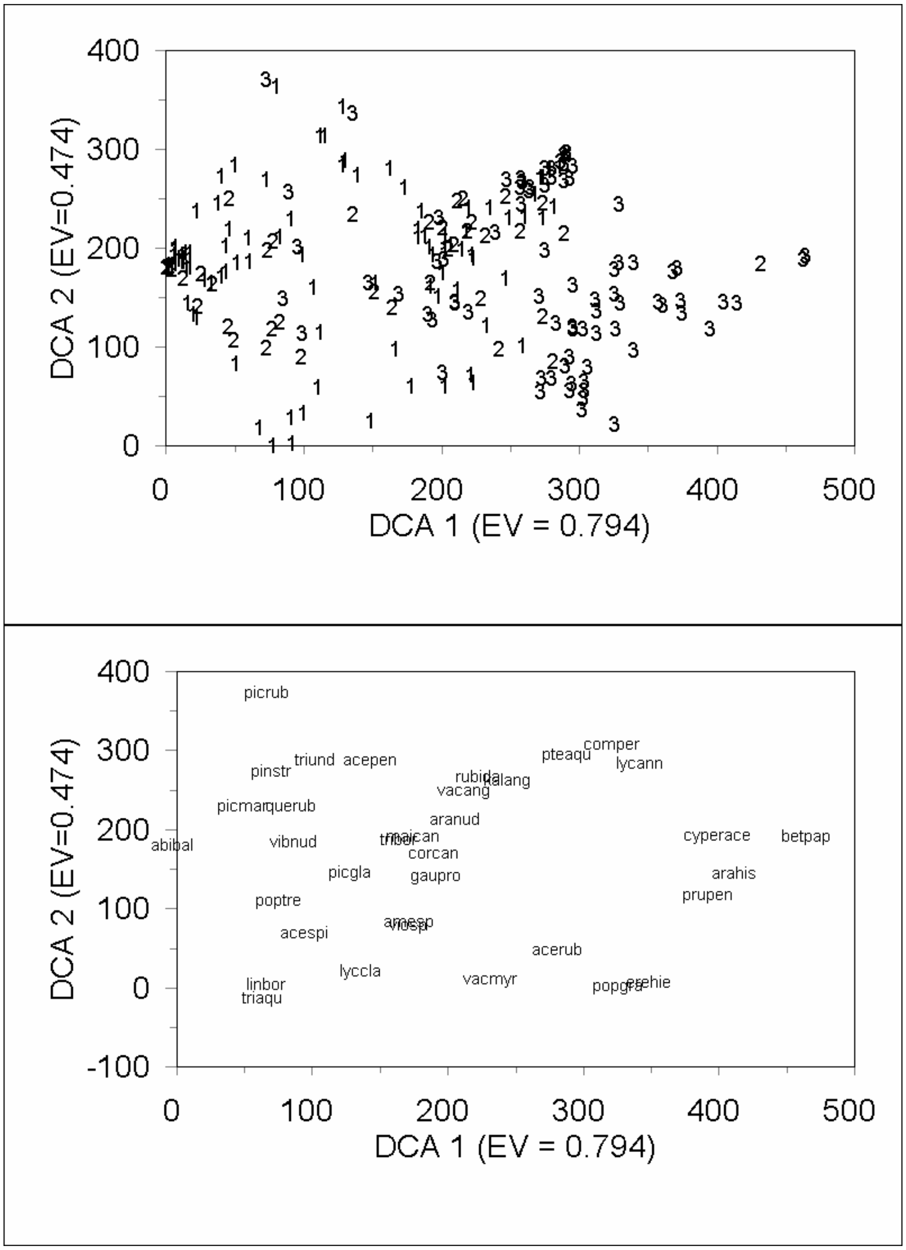

Figure 12. Detrended correspondence analysis (DCA) for two large islands based on vascular plant compositon post harvest (2003). (Above) Quadrat scores, 1=inside, 2=edge, 3=clearcut. (Below) Species scores, labels are genus species.

(4) Island shrinkage with blowdown

New data from experimental islands have undergone only preliminary analyses, however it appears that there is significantly less basal area lost to blowdown (including both tip-ups and snap-offs) in the NW quadrant (Fig. 13) in the small islands. This is in direct contrast to the results of Roberts' previous survey of 26 existing islands, in which blowdown was highest in the NW quadrant (Fig. 14). The two large experimental islands assessed to date show no discernable pattern, but very high variability (Fig. 13).

Roberts' earlier survey suggested that Red Spruce (rS) dominated the blowdown at one site (Fig. 14), but we can detect no overall pattern to the species susceptible to blowdown, to date.

Both data sets indicate that blowdown begins immediately after harvest, hence islands will shrink over time, with the edges encroaching disproportionately faster on certain sides.

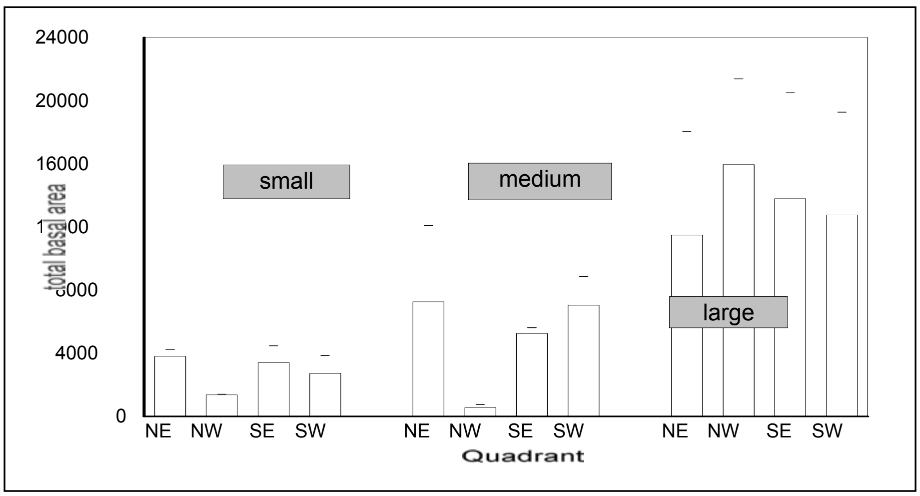

FIGURE 13. Mean (+se) total blowdown for three island types (n=2 each), one year post harvest, by quadrant. Bars represent total basal area of trees, dash represents mean + 1 standard error of mean.

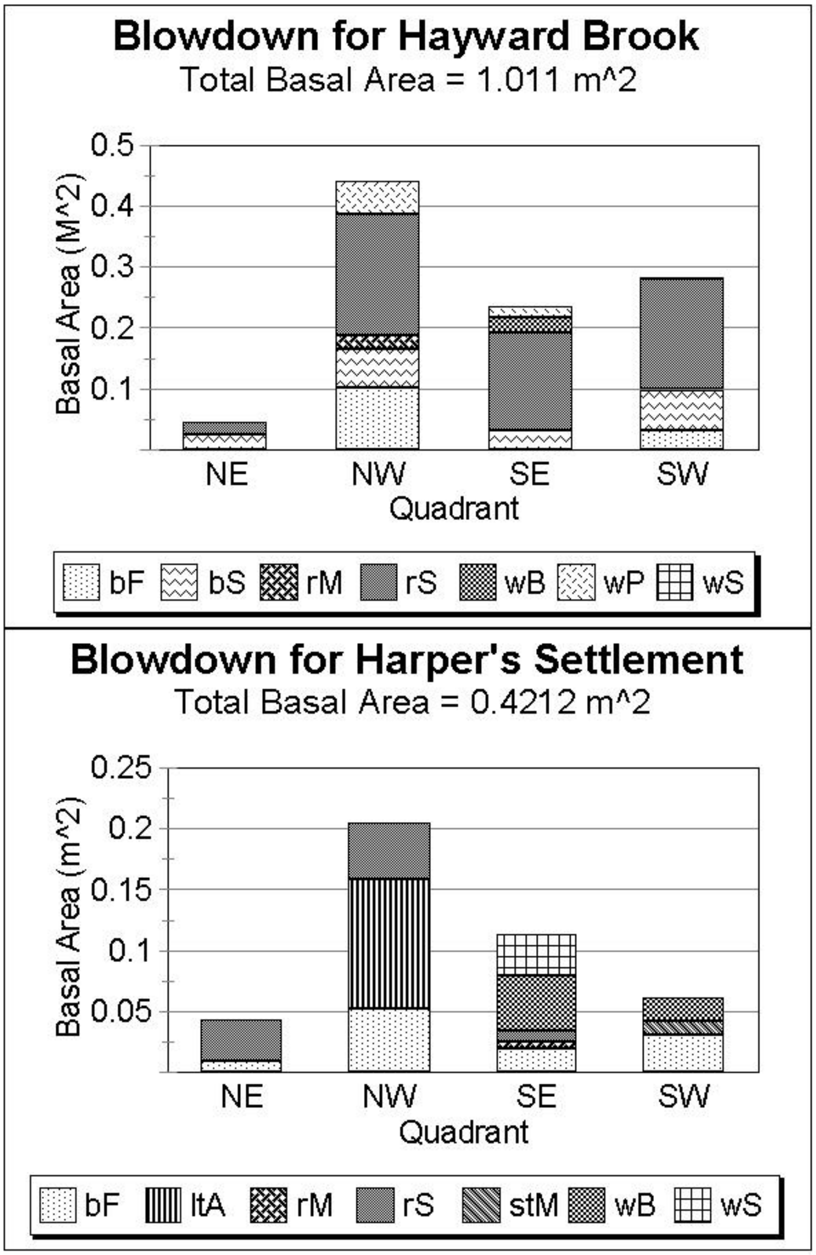

Figure 14. Total blowdown for 1-2yr old islands at two sites. Bars represent total basal area of trees, by species, by island quadrant.

FINANCIAL REPORTS (attached)

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