Ecological Reserve Monitoring
Project Update

White Pine, Gero Island

Andy Cutko
Maine Natural Areas Program
June 2005

Funding for this project has been provided by The Nature Conservancy, Maine Bureau of Parks and Lands, Maine Outdoor Heritage Fund, and the Sweetwater Trust

Table of Contents

Acknowledgements

This multi-year project has been funded by the Maine Outdoor Heritage Fund, The Nature Conservancy, the Sweetwater Trust, and the Maine Bureau of Parks and Lands. The Ecological Reserves Monitoring Committee (Sue Gawler, John Hagan, Mac Hunter, Ken Laustsen, Janet McMahon, David Publicover, Nancy Sferra, Barbara Vickery, and Joe Wiley) has provided continued oversight and feedback regarding monitoring methods and analysis. In particular, Ken Laustsen was helpful at providing summaries of data on Maine's forests and answering statistical questions. Comparative data for Big Reed Forest was provided by John Hagan, Shaun Fraver, and Alan White, and comparative road density data was provided by Barbara Charry. Analysis of coarse woody debris was facilitated by Chris Woodall of the U.S. Forest Service. Aquatic data was provided by Linda Bacon of the Maine Department of Environmental Protection.

Field efforts in 2004 were provided by Matt Arsenault, Andy Cutko, Rick Frisina, Jessica Hunter, Kersten Lamb, Kara Moody, Colleen Ryan, and Brooke Wilkerson. Staff of the Bureau of Parks and Lands, Maine Department of Inland Fisheries and Wildlife, and Maine Forest Service assisted with logistical issues. Del Ramey made the Chesuncook Village camp available for use, and Joe Wiley, Jim Frohn, and Courtney Hammond provided information about the prescribed fire in Cutler. MNAP staff (Molly Docherty, Emily Pinkham, Rick Frisina, Toni Pied, Sarah LaPlante) provided financial support, data management, report review, and GIS services.

Executive Summary

In 2000 the Maine Legislature established ~70,000 acres of Ecological Reserves, culminating over a decade's worth of research and advocacy. Reserves were established for the dual purposes of protecting biodiversity and serving as benchmarks for comparison with the state's vast "managed" forests. The Reserves include many of Maine's best examples of alpine meadows, lakes and streams, and old growth forests. Since 2000, three new Ecological Reserves have been added to the system, bringing the total acreage to over 80,000 (Figure 1). More recently, several parcels owned by the Maine Department of Inland Fisheries and Wildlife have been designated as Reserves.

Beginning in 2002, the Department of Conservation has worked with a multi-disciplinary committee to draft an *Ecological Reserve Monitoring Plan* that guides periodic data collection at the landscape, stand, and species levels. The monitoring program ties closely to other statewide and nationwide forest monitoring programs that use U.S. Forest Service Forest Inventory and Analysis (FIA) methods. Since methodology is spelled out in the *Monitoring Plan*, this annual update focuses on monitoring results rather than methodology.

Three Reserves were monitored in 2002 (Bigelow, Donnell Pond/Spring River Lake, and Salmon Brook Lake), three were monitored in 2003 (Deboullie, Duck Lake, Rocky Lake), and three more were monitored in 2004 (Mt. Abraham, Gero Island, Cutler). Natural communities have been mapped, 266 permanent plots have been established, and the locations of many rare species have been re-verified. Funding has been obtained to monitor the Nahmakanta Reserve in 2005.

This Project Update, the second since inception of the Monitoring Program, summarizes data collection and analyses conducted to date. Information collected on nine of the Reserves is assessed to suggest how forest structure and processes differ between forests managed for timber harvest and forests managed for natural processes. Initial data analysis based on data from 2002 and 2003 indicated that Ecological Reserves appear to have higher basal areas, more large trees (live and dead) and more coarse woody debris than the "average acre" of Maine woods according to Maine Forest Service Inventory and Analysis (FIA) data. Analysis with the updated dataset (2004) shows higher variability among Reserves. Gero Island exhibits characteristics of old, structurally complex forests, while Cutler forests indicate heavy past influence of fire, budworm damage, and harvesting, and Mt. Abraham plots reflect the high elevation conditions dominant on that Reserve. These measures are quantified in this report. Data such as these, coupled with information on well-studied old growth areas like Big Reed Forest, will continue to provide a better picture of how forests managed for natural process compare with forests managed for timber harvest.

Since the fall of 2004, four presentations have been given describing this project and the data produced, including those at the Eastern Canada/USA Forest Science conference in Fredericton, NB., and The Nature Conservancy's forest monitoring workshop in Keene Valley, NY. The methodology used for this project has recently been adopted for use on Maine lands owned by the Appalachian Mountain Club and The Nature Conservancy. This application will enable broader comparisons among conserved lands across the state and provide a more robust dataset for analytical purposes.

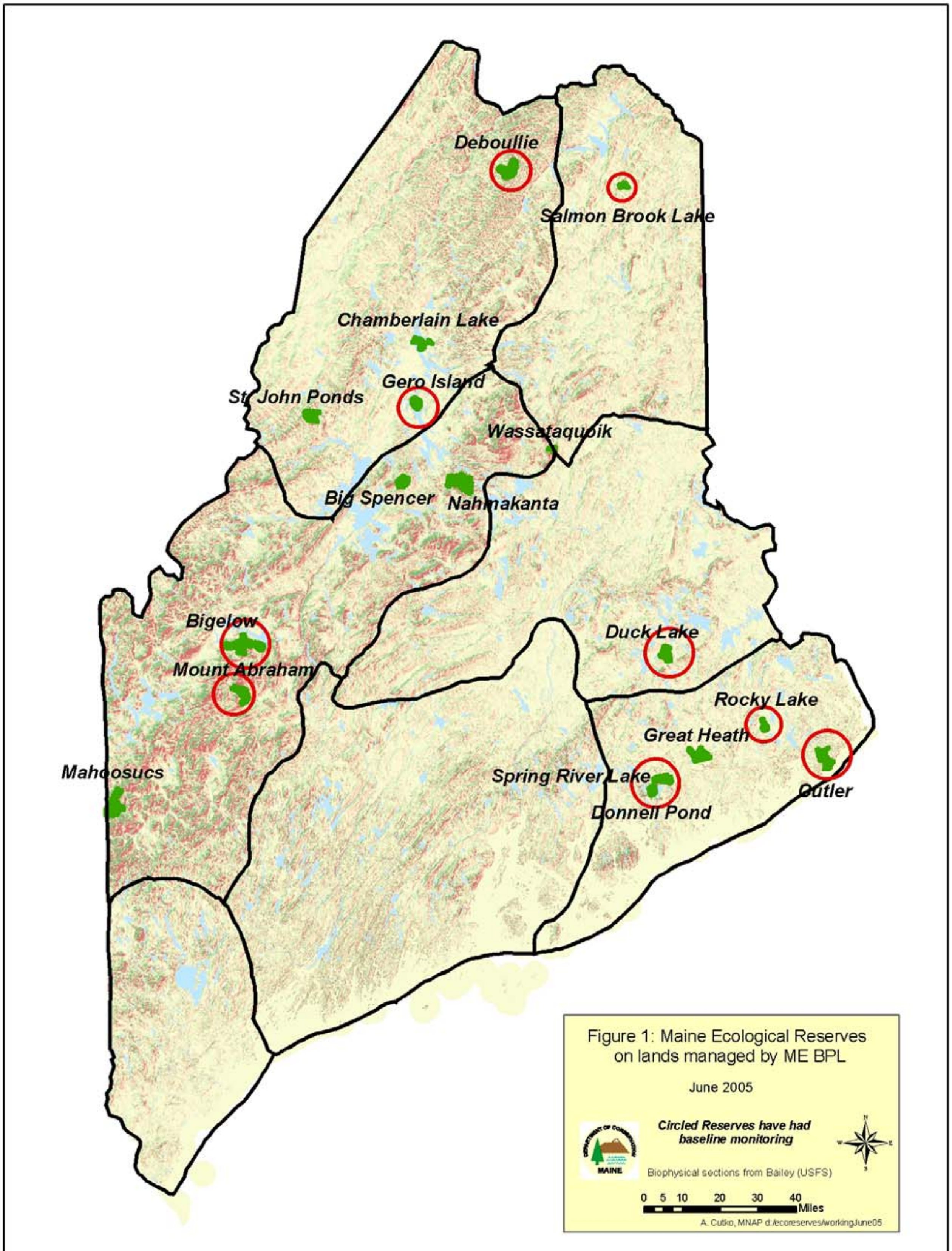

Figure 1: Maine Ecological Reserves on lands managed by ME BPL

Landscape Level Monitoring

Natural Community Mapping

Natural communities have been mapped for seven of the nine Reserves monitored to date using true color air photos at a scale of 1:15,840 (see example below, Figure 2). (Recent true color air photos were not available for Spring River Lake or Mt. Abraham.) For each polygon, a "primary" and "secondary" natural community type was assigned based on a combination of ground-truthed information (from Ecological Reserve monitoring plots and prior ecological inventory work) and BPL stand type maps. "Primary" types are the most likely natural community types; "secondary" types are alternate types that may be inclusions or transitional types. Where possible, polygons were assigned to the level of natural community, according to Maine's natural community classification (Gawler and Cutko, *in press*). In some cases where individual small or large patch community types could not be distinguished from air photos (e.g., alpine areas and some wetlands), polygons were assigned to the more general Ecosystem level. Draft natural community maps have been provided to BPL foresters for review and feedback.

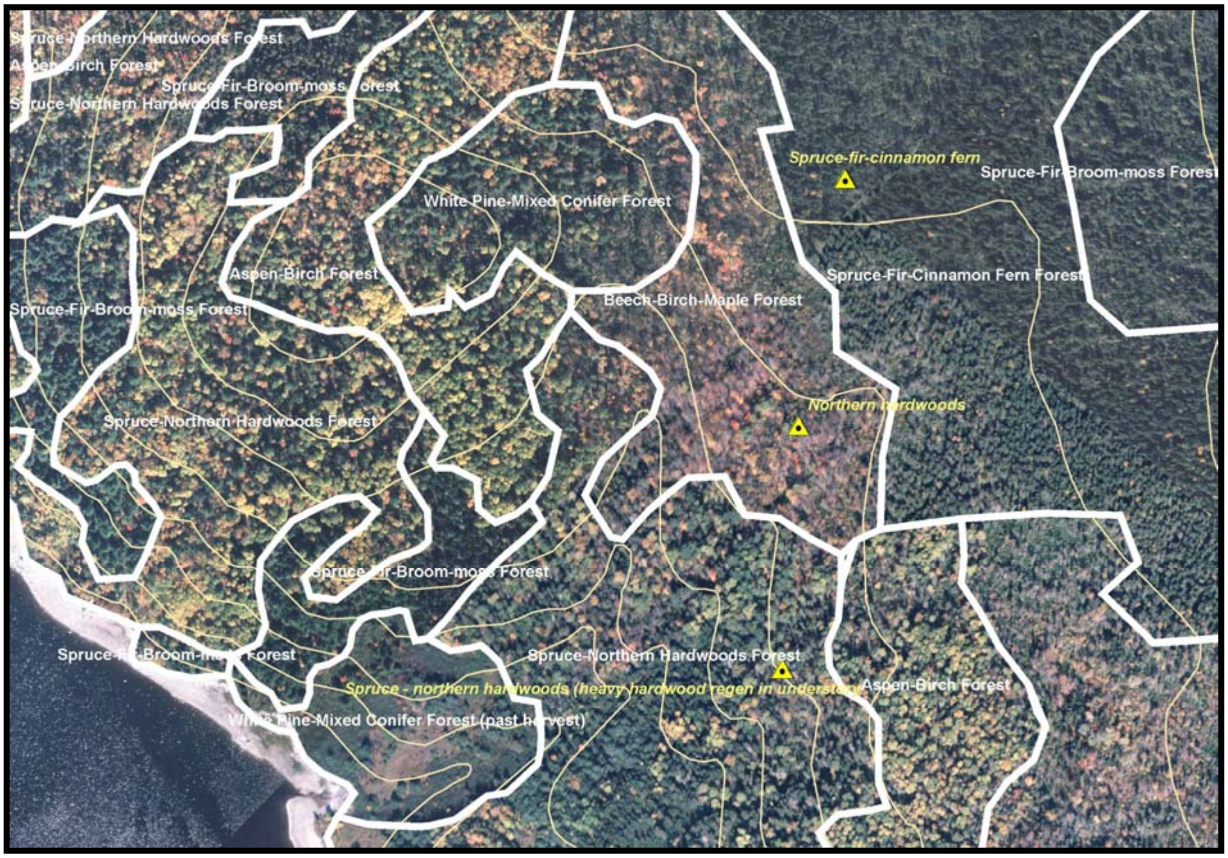

Figure 2: Sample of natural community map for Gero Island; points are monitoring plots with the assigned natural community type.

Landscape Context:

The following land uses and roads were mapped within ½ mile of the ten Ecological Reserves surveyed from 2001 through 2004. Ortho-rectified air photos and 2001 SPOT satellite imagery were used to digitize the following features:

- Mileage of paved roads
- Mileage of dirt roads
- Mileage of paved or dirt roads forming boundary
- Acreage of early regeneration
- Acreage of mature forest
- Acreage of conservation land
- Acreage of agricultural land
- Number of residences

As suggested by Table 1 and Figure 3, the landscapes surrounding Reserves varies widely, ranging from Salmon Brook Lake Bog, with over 450 acres of privately owned agricultural lands within the ½ mile buffer, to Gero Island, which is surrounded by Chesuncook Lake. However, even Salmon Brook Lake, with the least amount of conservation land in the buffer, has over 85 percent of its buffer in mature forest condition.

The road densities within buffers of several of the Reserves exceed average road densities in northern Maine, which range from 0.23 to 0.41 miles per square mile according to the Maine Audubon Society (Charry 2004). However, the degree to which roads serve as fragmenting features is a matter of scientific debate and relates to factors such as the amount of traffic, degree of canopy closure, and condition of the surrounding landscape. The Deboullie Reserve, for example, has a dirt road as a boundary for over four miles. This dirt road has partial to full canopy closure and light vehicular traffic and is likely not a fragmenting feature for many wildlife species.

Feature	Bigelow	Salmon Brook Lake	Spring River Lake	Donnell Pond	Rocky Lake	Deboullie	Duck Lake	Mount Abraham	Gero Island	Cutler	Nahm-akanta
Dirt Roads Within Reserve (miles)	0.00	0.00	0.00	0.00	0.00	2.33	0.00	2.71	0.00	0.00	7.23
Dirt Roads forming boundary (miles)	0.00	0.54	0.00	2.34	0.00	4.34	0.00	0.00	0.00	2.06	0
Paved Roads forming boundary (miles)	0.00	0.00	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0
Dirt Roads within buffer (miles)	3.48	5.92	1.50	3.77	0.00	9.84	1.85	7.16	0.22	8.81	2.20
Paved Roads within buffer (miles)	0.00	0.00	1.92	0.00	0.00	0.00	0.00	0.00	0.00	2.95	0
Buffer Road Density (miles/sq. mile)	**0.21**	**1.23**	**0.47**	**0.60**	**0.00**	**1.06**	**0.24**	**0.84**	**0.04**	**0.94**	**0.17**
Powerlines within buffer (miles)	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Agricultural Land (acres)	0	453	0	0	0	0	0	0	0	106	0
% Ag land in buffer	**0.0%**	**14.7%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**1.3%**	**0.0%**
Early regen (clearcut to 5 years) (acres)	0.0	0.0	0.0	0.0	150.8	0.0	37.7	355.5	0.0	341.8	1,000.6
# of structures	0	16	30+	0	0	0	0	0	0	6	2
Area in buffer (acres) (incl. water)	**10792**	**3081**	**4644**	**4050**	**3349**	**5940**	**4912**	**5454**	**3242**	**8031**	**8165**
Area in buffer (sq. miles)	17	5	7	6	5	9	8	9	5	13	13
Conservation land in buffer (acres)	9697	672	1025	2418	2386	5044	2256	856	3232	3075	5935
% conservation land within buffer	**89.9%**	**21.8%**	**22.1%**	**59.7%**	**71.2%**	**84.9%**	**45.9%**	**15.7%**	**99.7%**	**38.3%**	**72.7%**
Area of water in buffer (acres)	215	0	516	166	70	373	1079	0	2910	1464	1293
Mature Forest or Water in Buffer (ac)	10792	2628	4644	4050	3198	5940	4874	5098	3242	7583	7165
Mature Forest or Water in Buffer (%)	**100.0%**	**85.3%**	**100.0%**	**100.0%**	**95.5%**	**100.0%**	**99.2%**	**93.5%**	**100.0%**	**94.4%**	**87.7%**

Table 1: Land uses within ½ mile buffer of perimeter of Reserves

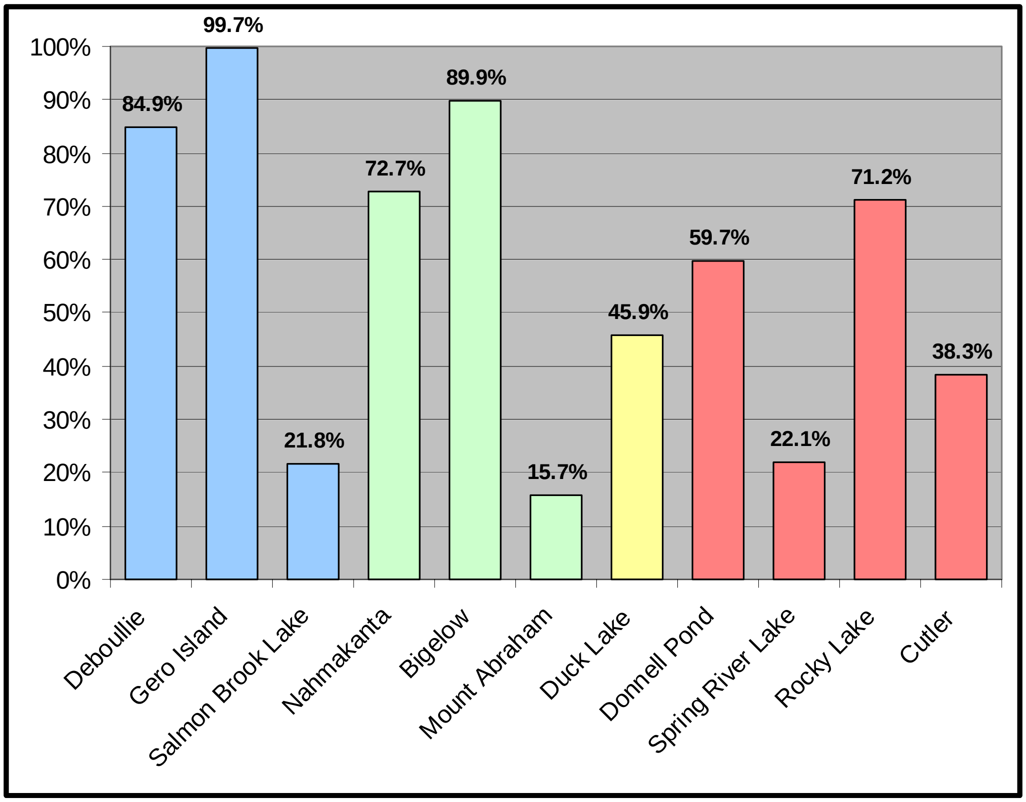

Figure 3: Proportion of ½ mile buffer zone in conservation ownership (or water).
Colors indicate biophysical "section" (geographic region) of the state in which Reserves occur.

Stand/Natural Community Monitoring

Plot Placement

To date 266 permanent forest plots have been placed on nine Reserves (Table 2). Plot density averages 1 plot/162 acres but ranges from 1 plot per 75 acres at Salmon Brook Lake to 1 plot per 220 acres at both Deboullie and Bigelow. As noted in the *Ecological Reserves Monitoring Plan*, attempts were made to stratify plots among three basic forest types according to the proportion of each type in each Reserve. 63 plots have been placed in hardwood stands, 108 in softwood, and 95 in mixed-wood.

In addition, non-forested monitoring transects have been placed at Rocky Lake, Bigelow, and Cutler. At Rocky Lake, three transects were placed in the emergent wetland, with 52 separate meter-squared plots (15, 18, and 19) placed along the transects. Vegetation was identified to species, and percent cover was assigned for each species in

Reserve	Year	# of Plots	Plot Density (Ac/plot)
Bigelow	2002	48	220
Salmon Brook Lake	2002	14	75
Donnell/Spring River	2002	48	124
Rocky Lake	2003	10	152
Duck Lake	2003	26	149
Deboullie	2003	33	220
Cutler	2004	35	149
Mt. Abraham	2004	29	185
Gero Island	2004	23	138
TOTAL		***266***	***1 plot/162 ac***

Table 2: Plot density on nine Ecological Reserves

each plot. At Bigelow, three transects were placed across the Appalachian Trail, with twelve meter-squared plots (four on each transect) placed. (The number of plots placed was less than anticipated, due primarily to weather and time restrictions.) At Cutler, plots were placed in the Bluejoint Meadow community in the coastal portion within sections that burned and sections that did not burn (control). (See description below for details.) At all three Reserves, non-forested monitoring transects were permanently marked at either end (with PVC pipe at Rocky Lake and Cutler and red paint on rocks at Bigelow), photos were taken, witness trees marked, and coordinates recorded with GPS.

Cutler Prescribed Burn

In the past several decades the Bluejoint Meadow grasslands in Cutler have been periodically burned by the Maine Forest Service, in partnership with the Maine Bureau of Parks and Lands, to maintain the open grassland habitat. It is not known whether these areas have a natural fire regime that requires periodic burning, but research from the University of Maine (Dieffenbacher-Krall 1996) suggests that fire was not frequent prior to the mid-1800s. Research also suggests that Bluejoint Meadow grasslands historically have been "self-maintaining" without fire, instead relying on the creation of a shady, thick mat of vegetation that prevents tree species from regenerating. Because many local residents consider periodic burns an important means of maintaining wildlife habitat, if controlled burns are eliminated illegal burns on state lands may take their place.

In an April 2004 controlled burn of a ~170 acre section grassland in the coastal unit, one four-acre and another ten-acre section of the grassland were left unburned (Figure 4). This meadow, within the Ecological Reserve, is being monitored using air photos and on-the-ground plots to determine how burning affects the extent and quality of the community.

Figure 4: Cutler prescribed fire: fire control line (left) showing burned and un-burned areas; Bates College students collecting plot data (right).

Nine transcects were placed in the meadow prior to the burn, each consisting of ten meter-squared plots spaced either five or ten meters apart, for a total of 90 meter-squared plots. Five transects (fifty plots) were placed in the section to be burned, and four transects (forty plots) were placed in the un-burned control. Figure 5 illustrates the composition of the grassland prior to burning, based on the aggregate of 90 plots. Presumably repeated fires will reduce the proportion of alders and woody species in general. This information may be used to guide Bluejoint Meadow management practices in the future. Initial observations following the burn indicate that the fire intensity was too low to kill many of the alders that are encroaching on the open meadow.

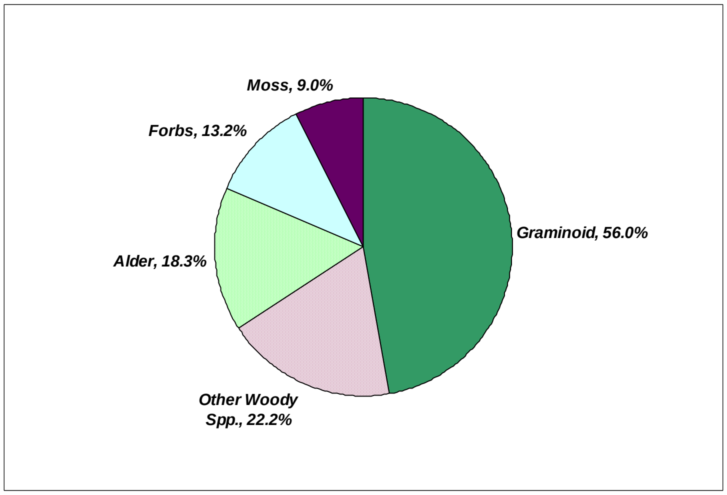

Figure 5: Vegetation composition in the Black Point meadow grassland, prior to burning in April 2004.

Forest Structure

For comparative purposes, Ecological Reserves data are compared to data collected from: (1) the rest of Maine's forests, through the Forest Inventory and Analysis Project (FIA), from annual reports from the U.S. Forest Service and Maine Department of Conservation; and (2) data collected from the ~5,000 acre Big Reed Forest, the largest known "old growth" site in the state.

Based on the initial data analysis, trees cored on Ecological Reserves were not as old as many trees on Big Reed Forest (Figures 6 and 7), although thousands more trees were cored at Big Reed than on Ecological Reserves. (Data from Big Reed have been provided by Fraver [2004] and Hagan [2004]). However, Ecological Reserves appear to have older trees, higher basal areas, more large trees (live and dead), more dead trees, and more coarse woody debris than the "average acre" of Maine woods (Figures 7, 8, 9 and 10; all confidence intervals in figures are at the 90% level).

There is wide variability among Reserves, reflecting differences between regional forest types and disturbance histories. For example, the Bigelow Reserve, with an abundance of well-stocked northern hardwoods and spruce-fir forest, has a higher average basal area and more large trees than the overall Reserve average. Cutler, on the other hand, has experienced fire, budworm damage, and heavy past harvesting, resulting in the lowest basal area of all Reserves.

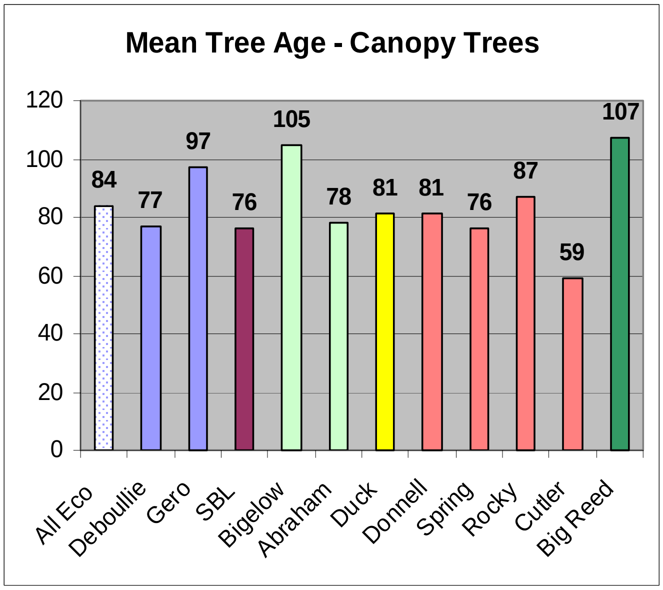

Figure 6: Mean tree age on Ecological Reserves and Big Reed Forest

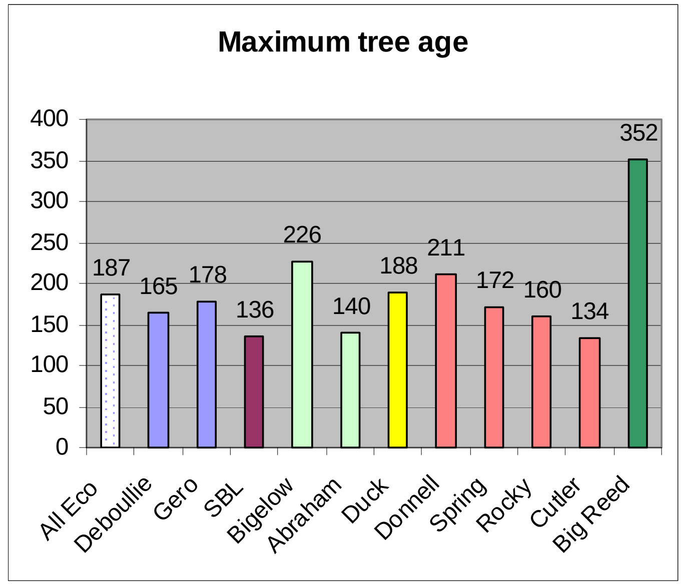

Figure 7: Maximum tree age on Ecological Reserves and Big Reed Forest

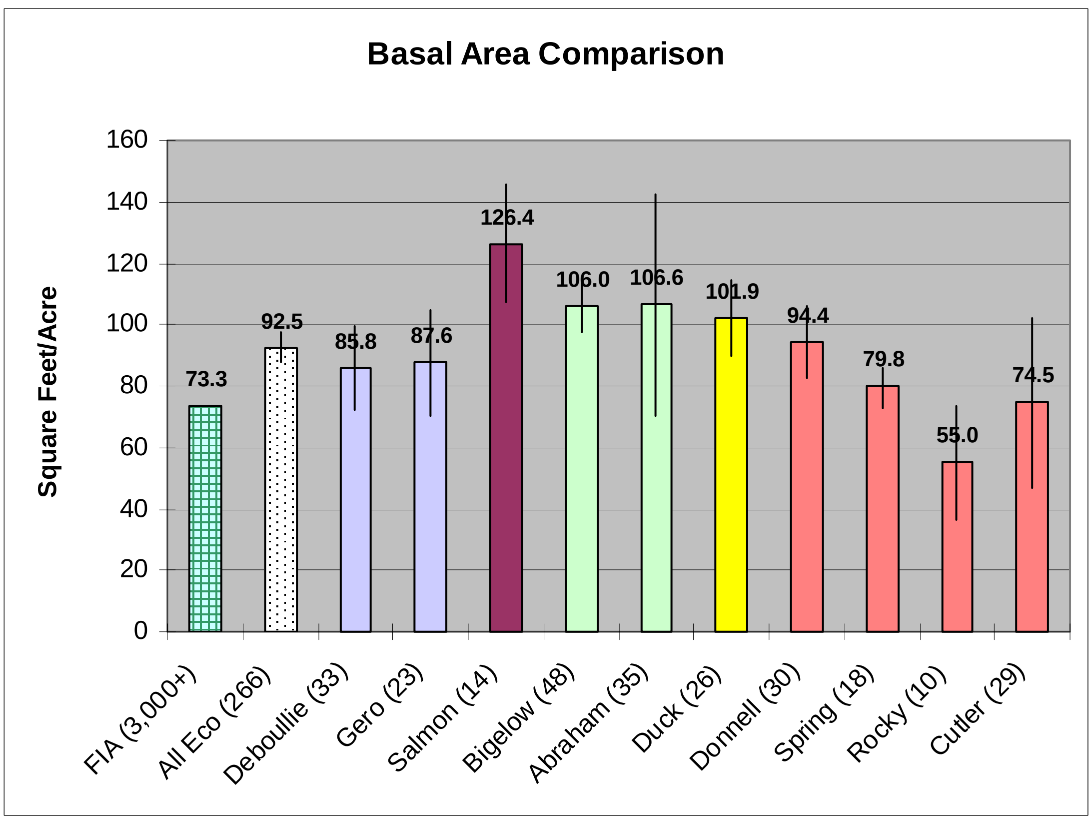

Figure 8: Live basal area of trees ≥5" on Ecological Reserves and Maine's FIA plots, with number of plots shown in parentheses

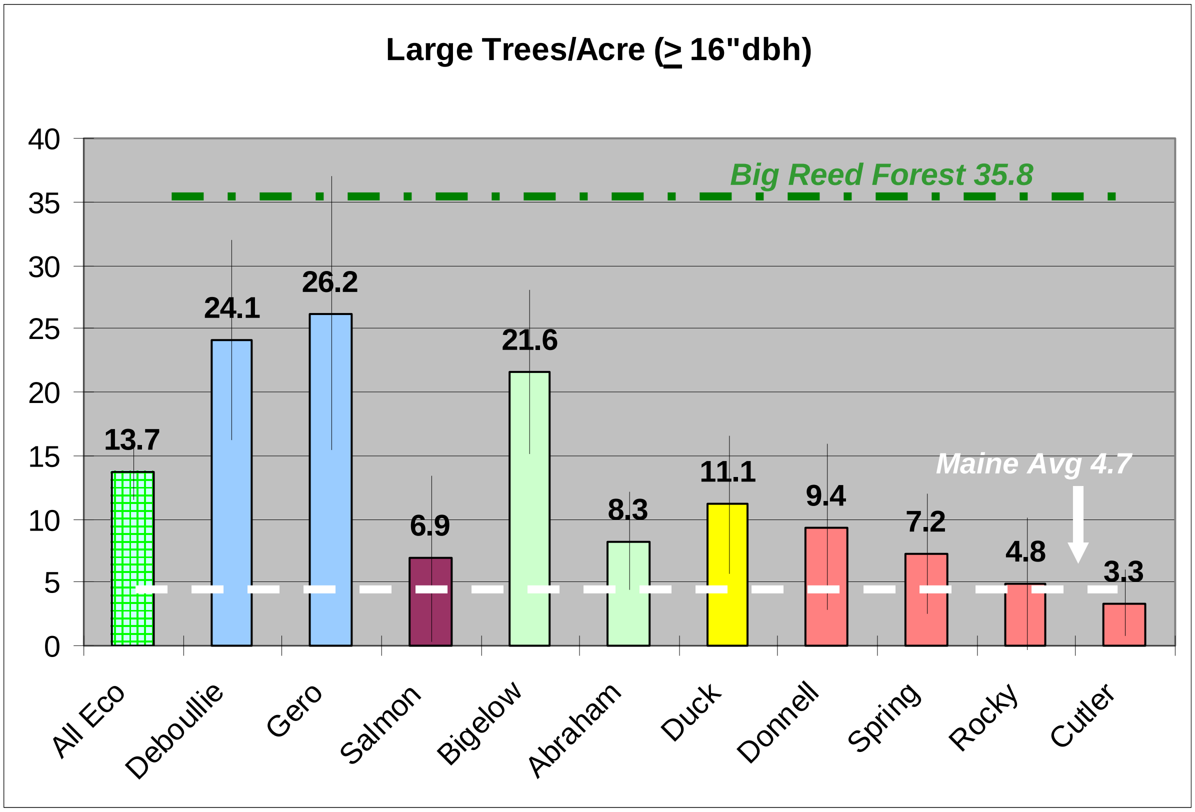

Figure 9: Large live trees on Ecological Reserves, Big Reed Forest, and Maine average

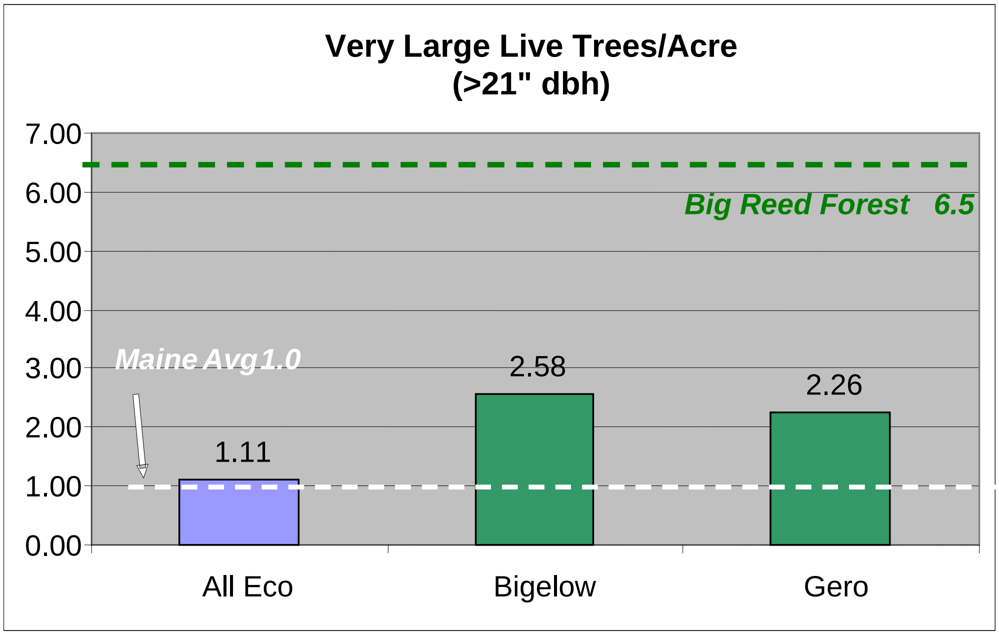

Figure 10: Very large live trees on Ecological Reserves, Big Reed Forest, and Maine average (FIA)

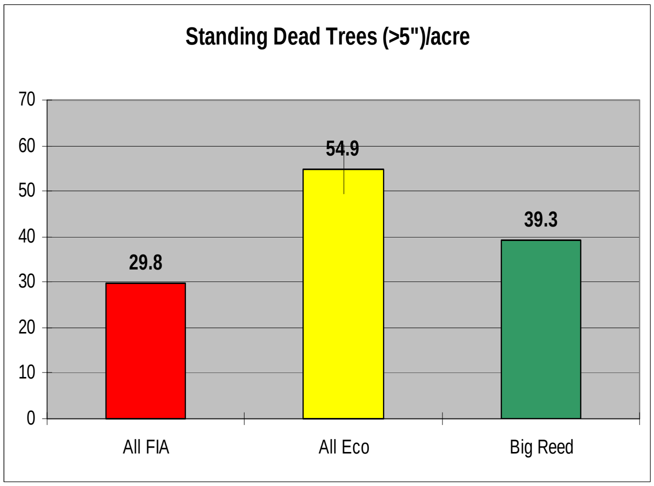

Figure 11: Standing dead trees >5"/ac

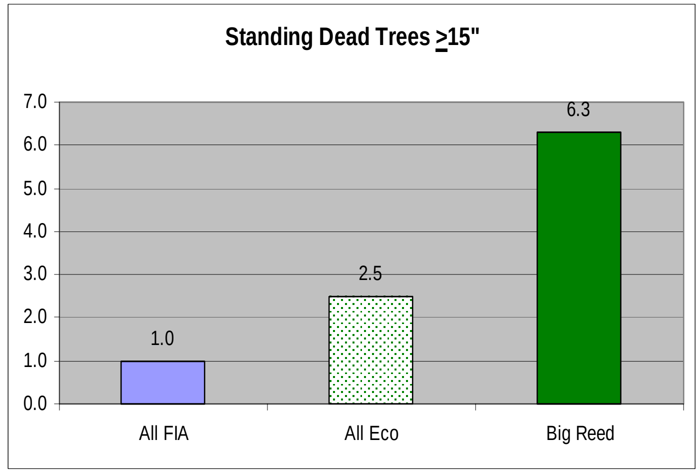

Figure 12: Standing dead trees >15"/ac

The abundance of standing dead trees on Ecological Reserves (exceeding even Big Reed Forest) is likely attributable to a combination of natural disturbance factors that are most strongly apparent on the Reserves in Downeast Maine and higher elevation areas, which together comprise six of the nine Reserves surveyed to date. These factors include:

- Weather damage at high elevation. Although less than 1% of Maine's landscape is alpine or sub-alpine (e.g., over 2700' in elevation), over 14% of Ecological Reserve acreage is high elevation. Reserve plots reflect this bias -- nearly half the plots (17 of 35) at Mt. Abraham are over 2700' elevation.
- Insect damage. Spruce budworm has combined with heavy weather damage on high elevation forests in Bigelow and Mt. Abraham as well as low elevation softwoods at Rocky Lake, Cutler, and Gero Island. Beech scale has decimated hardwood forests of Donnell Pond and Spring River Lake.
- Ice storm damage. Ice storm (1998) damage is most evident in hardwood stands of Donnell Pond and Spring River Lake.
- Fire. Fire within the last century has resulted in the presence of decadent stands of aspen and paper birch within Donnell Pond, Spring River Lake, Duck Lake, and Cutler (Figure 16).

However, as Figure 12 indicates, Reserves have much fewer *large* dead trees than Big Reed Forest, suggesting that past human and natural disturbance on Ecological Reserves has been severe and/or frequent enough to prevent trees from becoming large. (Big Reed Forest, in contrast, has had comparatively little heavy disturbance from insects and no evidence of significant fire events.)

These patterns are evident in coarse woody debris (downed dead wood) as well. While Ecological Reserves and Big Reed Forest have comparable numbers of down dead wood *pieces* (Figure 13), the Reserves lack the large pieces (Figure 14), and therefore down dead wood volume is lower on Reserves than on Big Reed. (Big Reed data courtesy of Hagan [2004]). Down dead wood volume is nonetheless larger on Ecological Reserves than on an average acre of Maine woods (Figure 15) and is near the upper limit of natural range suggested for the Fundy Model Forest (Woodley and Forbs 1997).

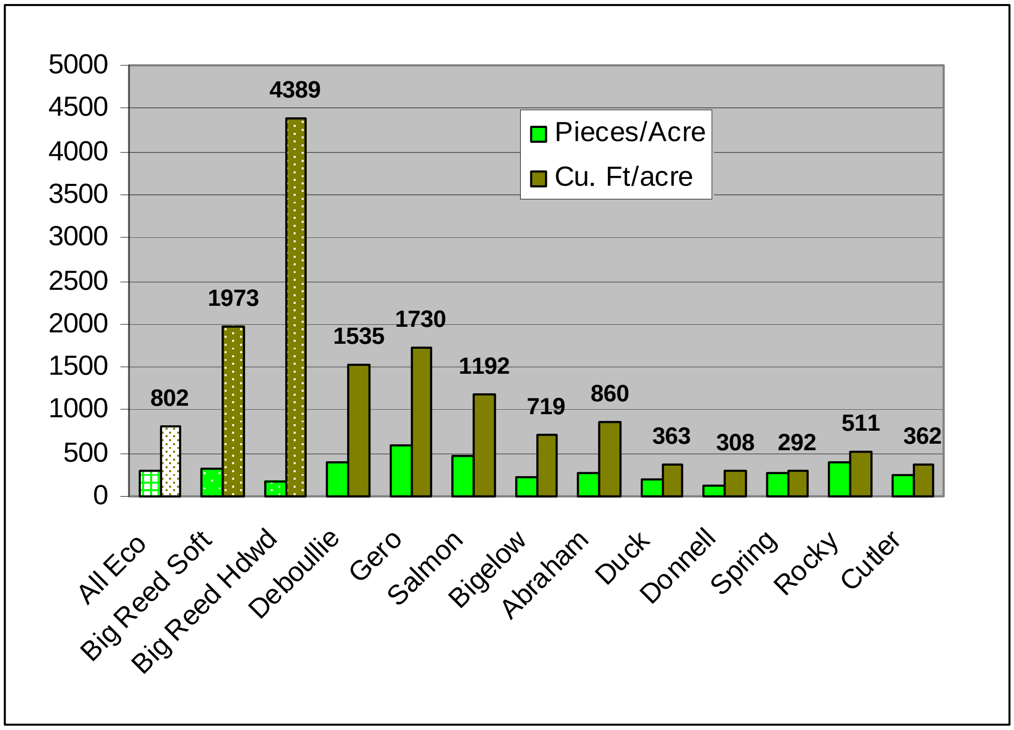

Figure 13: Down coarse woody debris on Ecological Reserves and Big Reed forest

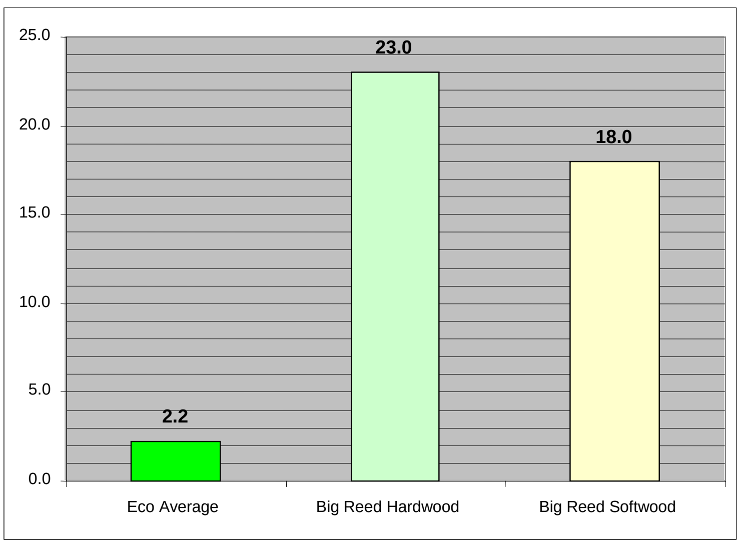

Figure 14: Percent of downed dead wood larger than 35 cm (17.7")

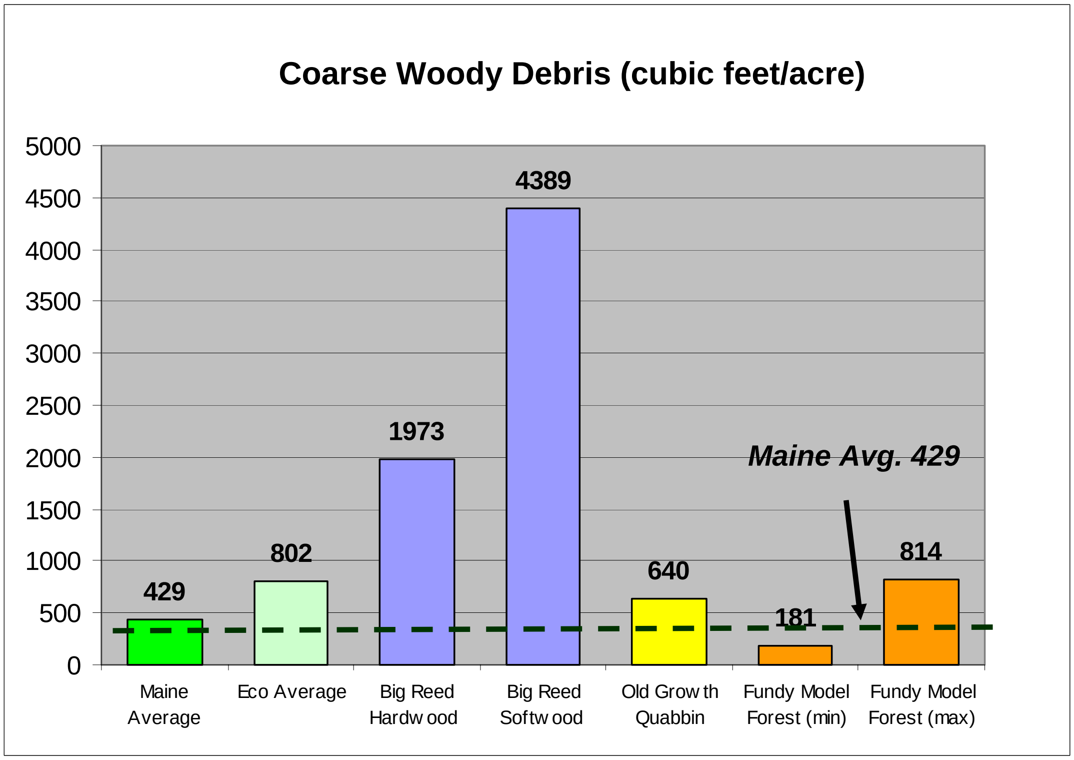

Figure 15: Coarse woody debris (cubic foot/acre) in Ecological Reserves and other representative natural forest sites

Harvest History

No harvesting evidence was noted on roughly half of the plots (Figure 17). However, many of the plots with no harvesting evidence occurred within the Donnell Pond, Rocky Lake, Duck Lake, and Spring River Lake Units (Figure 18). These four Reserves occur in parts of Downeast Maine that burned heavily in 1947 or in other years in the past century. Many other un-harvested plots are in high elevation, wet, or otherwise inoperable areas.

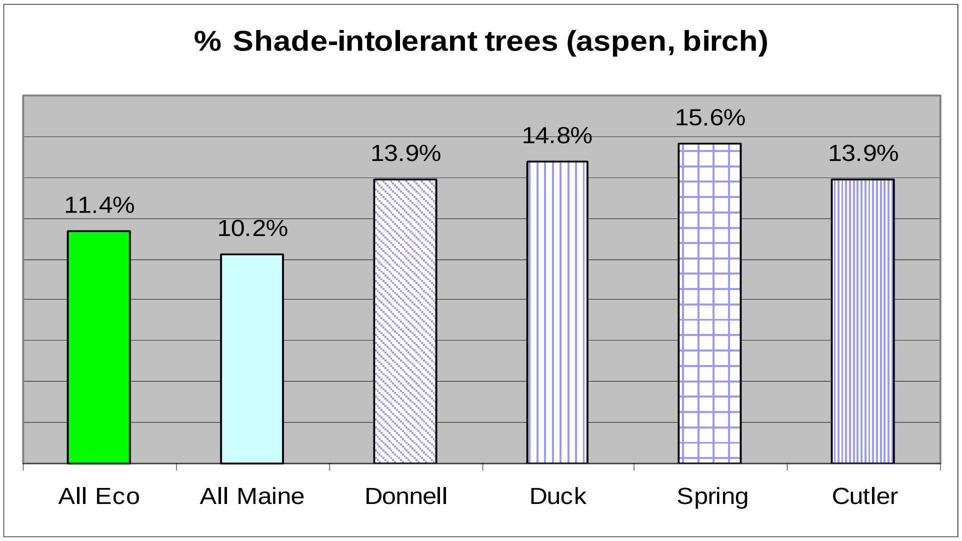

Figure 16: Percent shade intolerant trees (aspen, paper & gray birch)

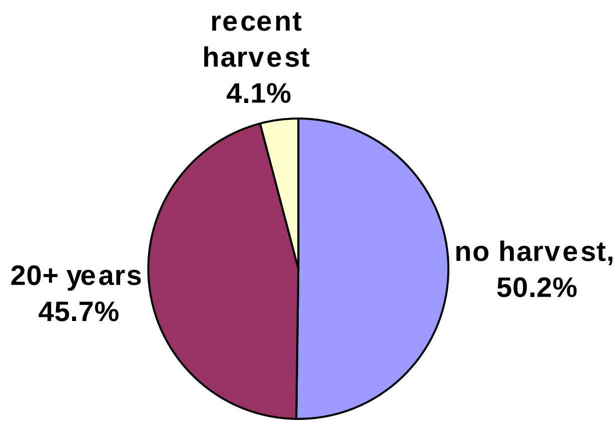

Figure 17: Ecological Reserves: harvest history noted on plots (05)

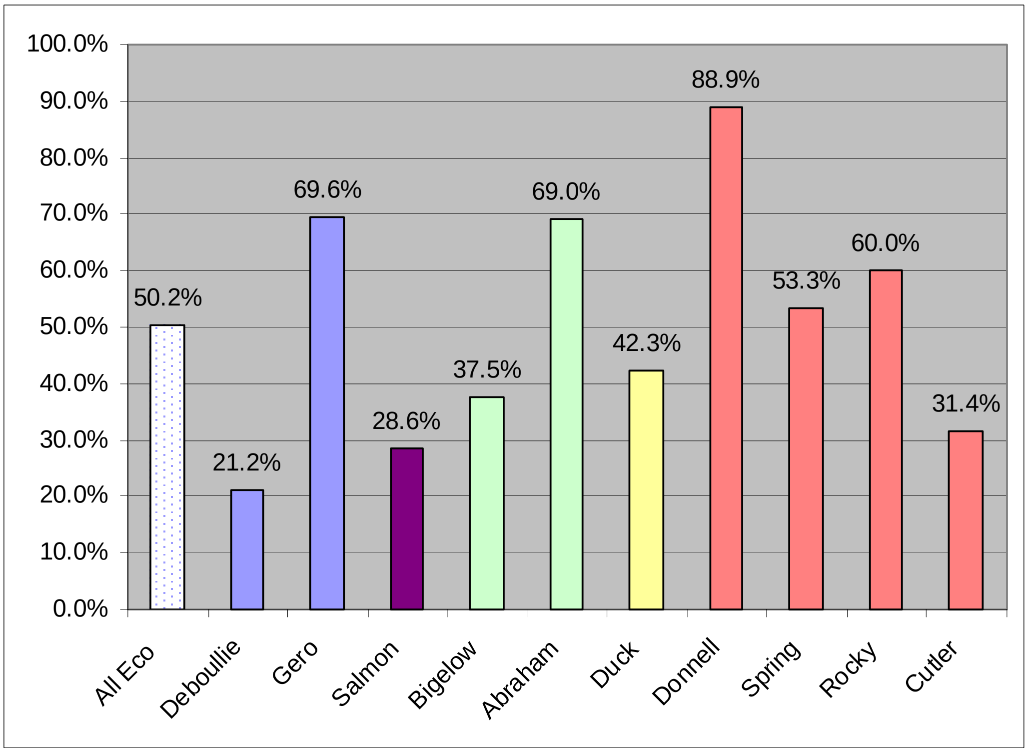

Figure 18: Proportion of plots with no harvesting evidence

Comparison to Manomet's "Late Successional Index"

Recently the Manomet Center for Conservation Science created a "Late Successional Index" for assessing forest structure (Whitman and Hagan 2004). This index was established in recognition of the biodiversity importance and possible decline of older forest stands. Ecological Reserve data were applied to the tree component of this index (data on the appropriate late-successional lichens were not available). Based on this rudimentary analysis, Deboullie, Gero Island, and Bigelow contain forest structure approaching late-successional status. This conclusion is evident by applying the LS index to the Reserves as a whole (Figure 19) and by calculating the proportion of plots that qualify as LS forests (Figure 20).

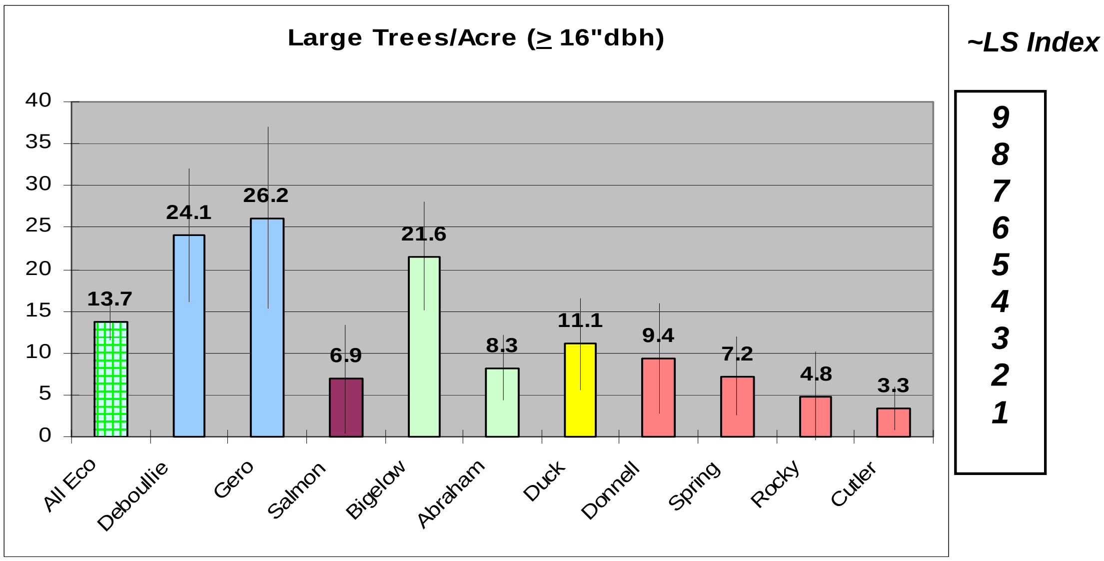

Figure 19: Ecological Reserves and the Late Successional Index (tree component only; hardwood index and softwood index are averaged here)

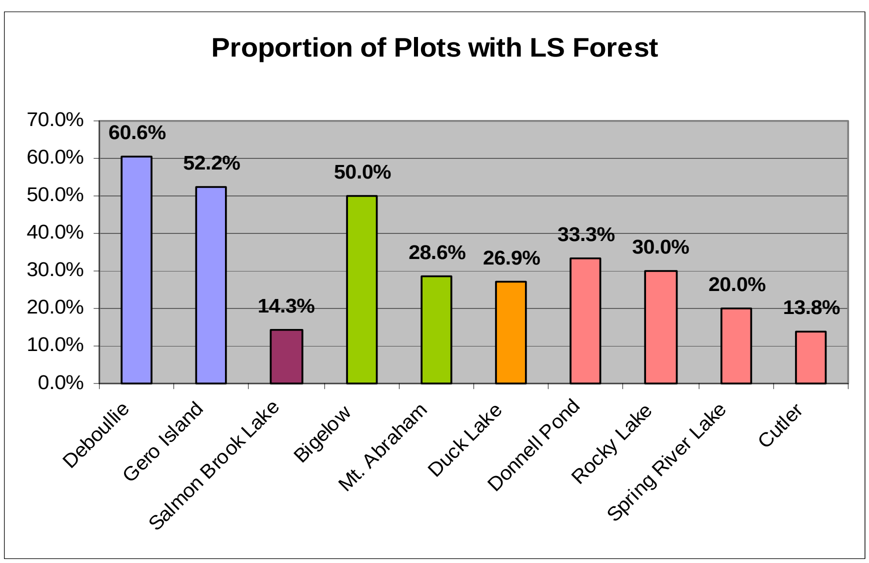

Figure 20: Proportion of Ecological Reserve plots with late-successional forest

Post-Stratification of the Data

With three years of data collection and 266 plots, the statistical power of the dataset is beginning to enable further stratification of the data for analytical purposes. There are numerous ways to approach this, including comparisons between forest types (Figure 21), regional comparisons (Figure 22), and numerous others, such as stratification by natural community type, by elevation, by harvest history, by wetland vs. upland, etc. For comparison to managed forests, FIA data could be similarly stratified. Stratification of the data presents inherent trade-offs between confidence intervals and the level of stratification; i.e., the finer the breakdown, the smaller number of plots, and the lower the statistical power.

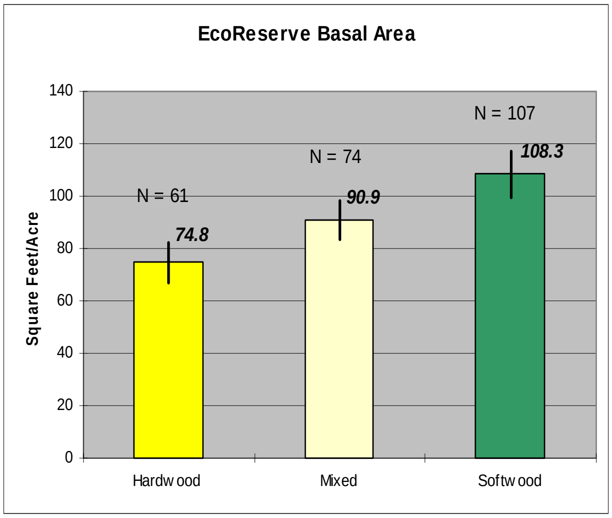

Figure 21: Basal area comparison of forest types within Ecological Reserves

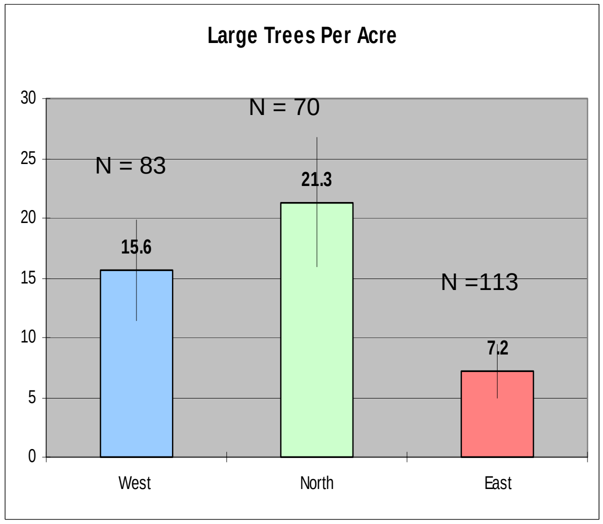

Figure 22: Large tree comparison among Eco Reserves in different region of the state

Rare Plant Monitoring

Table 3 lists the rare plants known from four of the six Reserves monitored in 2002 and 2003. (There are no rare plants known from Duck Lake or Rocky Lake). On these six Reserves, 20 of the 28 known rare plant sites were re-located and occurrence ranks were assigned or updated. In addition, seven new rare plant populations have been found during the past three years of surveys. The eight sites that were not re-located include two that were not searched for because of logistical and time considerations, three that are historic (not seen in over 20 years and not found in 2004), one found to be taxonomically questionable, and two extant recent records that were not re-located despite searching, including the only globally rare plant of the 28 (Boot's rattlesnake root, on Bigelow's West Peak). The revised occurrence ranks reflect current MNAP ranking standards and will serve as a baseline for change detection in future monitoring rounds.

Figure 23: Northern commandra (Geocaulon lividum)

Field forms for all rare plants were completed and retained at the MNAP offices, and rare plant data were entered into the Program's Biotics system.

Common Name/ State Status	Scientific Name	Location	S-Rank	G-Rank	Last Obs.	EO Rank/Comments
Cutler						
Carex wiegandii	Wiegand's sedge			G3	2004	New record 2004
Geocaulon lividum	Northern commandra				2004	New record 2004
Achillea millefolium var. borealis, SC	Northern yarrow		G5T5	S1	1992	1992 specimen reviewed; incurred ID; this variety no longer occurs in Maine
Gero Island						
Juncus subtilis, T	Slender Rush	Northwest shore of island	G3	S1	2004	In shallow water; population extent not determined
Mt. Abraham						
Betula x minor, E	Dwarf White Birch	South of main summit	G3G4Q	S1	1997	D; Not re-verified 2004
Carex bigelowii, SC	Bigelow's Sedge	Main summit	G5	S2	2004	C; small but healthy population subject to trampling
Diapensia lapponica, SC	Lapland Diapensia	Main summit	G5	S2	2004	B; scattered near trail
Diapensia lapponica, SC	Lapland Diapensia	Southeast peak	G5	S2	2004	B; new record 2004
Epilobium hornemanni, E	Hornemann's Willow-herb	Norton Brook	G5	S1	2004	E ; new record; full extent not known
Epilobium hornemannii, E	Hornemann's Willow-herb	Un-named stream	G5	S1	2004	B; healthy population in remote stream
Geocaulon lividum, SC	Northern Comandra	Southeast summit	G5	S2	2004	A; new record 2004
Geocaulon lividum, SC	Northern Comandra	Main summit ridge	G5	S2	2004	C; scattered plants
Huperzia selago, T	Alpine Clubmoss	Norton Brook	G5	S1	2004	E; new record 2004
Vaccinium boreale, T	Alpine Blueberry	Main summit	G4	S2	2004	C; scattered plants
Vaccinium boreale, T	Alpine Blueberry	Southeast summit	G4	S2	2004	A; new record 2004

Table 3: Rare Plant Status in Ecological Reserves Monitored in 2004

Remaining Challenges

Aquatic Monitoring

Several of the Ecological Reserves contain entire or nearly entire watersheds of streams, ponds, and lakes, and are therefore well suited to long-term monitoring of aquatic systems. In 2003 the *Ecological Reserves Monitoring Plan* identified an aquatic component as an important monitoring need. Since April 2004 selected staff from the Department of Environmental Protection (DEP) have been developing an aquatic monitoring plan for the Reserves. To date discussion has focused on which biological, chemical, and physical components to monitor; what classification systems to use; how to build a monitoring program that would complement existing statewide aquatic monitoring efforts, and what other partners should be involved. A written plan is tentatively scheduled for completion by the end of 2005.

Reserve/Water body	***2001***	***2002***	***2003***	***2004***
Donnell/Spring River				
Little Long	C,D,P,Z	C,D,P,Z	C	
Mud	C,D,P,Z	C,D,P,Z	C	
Rainbow		C,D,P,Z	C,D,Z	C,P
Salmon	C,D,P,Z	C,D,P,Z	C	
Tilden	C,D,P,Z	C,D,P,Z	C	
Wizard		C,D,P,Z	C,P,Z	C,P
Nahmakanta				
Gould	C,D,P,Z	C,D,P,Z	C	
Fourth Debsconeag	C,D,P,Z		C,Z	
Fifth Debsconeag	C,D,P,Z	C,D,P,Z	C	
Sixth Debsconeag	C,D,P,Z	C,D,P,Z	C	
Seventh Debsconeag	C,D,P,Z	C,D,P,Z	C	
Nahmakanta	C,D,P,Z			
Deboullie				
Black		C,D,P,Z	C,P	C,D,P,Z
Little North Black		C,D,P,Z	C	C
Little South Black		C,D,P,Z	C	C
Crater		C,D,P,Z	C	C
Deboullie		C	C,D,P,Z	C
Denney		C,D,P,Z	C	C
Galilee		C,D,P,Z	C,P,Z	C
Gardner		C	C,D,P,Z	C
Island		C,D,P,Z	C,P,Z	C
Pushineer		C,D,P,Z	C,P,Z	C
Togue			C,D,Z	
Upper		C,D,P,Z	C,P,Z	C
Duck				
Duck			C,D,P,Z	
Gassabias			C,D,P,Z	
Bigelow				
Cranberry				C,D,P,Z
The Horns				C,D,P,Z

Table 4: Summary of pelagic lake samples collected from Maine's Ecological Reserves 2001 – 2004 (from Maine DEP). C = chemistry (transparency, temp/dissolved oxygen, total phosphorus, chlorophyll. D = Surface sedimented diatoms. P = Phytoplankton. Z = Zooplankton)

In the meantime, aquatic sampling has occurred in selected Ecological Reserves by DEP in 2002, 2003, and 2004, focusing on pelagic sampling of lakes (Table 4). Biological samples have not yet been analyzed, but chemical samples have. A broader biological sampling effort is scheduled for Deboullie in 2005, using a watershed approach to sample littoral macrophytes and aquatic macro-invertebrates. Using methodology adapted from the U.S. EPA, selected wetlands will be assessed for water chemistry, phytoplankton, diatoms, epiphytic algae, and macro-invertebrates. Larger streams will be visited for the collection of habitat data, macroinvertebrates, and selected chemical parameters. This is a pilot approach to evaluation of the aquatice resource at the watershed scale.

In addition, sampling of water chemistry has continued in the Tunk Lake area as part of a long-term project by researchers at the University of Maine. Moreover, with permission of DEP and DOC, in 2005 researchers temporarily manipulated a small stream within the Reserve to test the buffering capacity of the watershed.

Herbaceous Sampling and Data Analysis

The *Ecological Reserves Monitoring Plan* employs a herbaceous sampling methodology that mirrors that used by the U.S. Forest Service's FIA program (Phase 3, or 'P3'). This approach was selected for two reasons: first, the FIA results would potentially be a useful source of comparative herbaceous data from Maine's managed lands, and second, FIA protocol presumably was developed with similar research questions and a sampling intensity designed to answer them. As of June 2005, this national effort is still being tested and modified based on limited sampling in a few selected areas, and very little data analysis has been conducted to date. In Maine, herbaceous sampling will occur at a broader scale in 2006.

Research questions currently considered at the national level include such issues as presence/absence of invasive species, mean richness per plot, mean number of species found in an ecoregion, and ozone damage. These questions and the sampling intensity are geared toward assessing trends and patterns across multi-state regions and may be substantively different from questions relevant at the state level (e.g., presence/absence and abundance of certain plants considered "indicators" of young/disturbed forest or mature forest.) At the national level, herbaceous vegetation is collected at only the Phase 3 (P3) level of one plot per 96,000 acres. In Maine, MNAP is considering the applicability of the Floristic Quality Index as a tool for detecting change over time. This Index assesses a vegetation community based on the tolerance of its component species to disturbance. The FQI and related assessments have been applied primarily to wetlands in the past but may have potential for upland natural communities. A chief drawback is that significant time and expertise are needed to create the "coefficients of conservatism" for each species in a sample.

In 2004 Brooke Wilkerson assessed the current monitoring methodology and its statistical capability of answering questions relating to both change over time and comparison between managed forest and Reserves. She concluded that the variability of the herbaceous data is high and its statistical power is low. She also evaluated plot placement and found that, (1) the minimal correlation between plots is not a cause for concern, but (2) the plots do not fully capture the diversity of natural community types on each Reserve. Based on these findings, MNAP has tripled the sample size and altered the shape of plots used for assessing cover of herbaceous data, with the goal of reducing the variability in order to improve statistical power.

Mapping of Natural Disturbance

The *Ecological Reserves Monitoring Plan* proposes the following questions regarding natural disturbance: What types of major natural disturbance are occurring in reserves? What is the frequency and size of long-lived natural disturbances? As indicators for these questions, the plan notes canopy gap, size, shape, and distribution, and cause of disturbance. Disturbed canopy "gaps" are defined as:

> *"…a continuous break in the canopy strata, with no trees within 50% of the average canopy height. Gap size will be measured from the vertically-projected edge of the foliage (i.e., the dripline). For instance, if the canopy height averages 65' tall, no trees within the ½ acre gap may be more than 33' tall. Canopy gaps greater than 1/2 acre will be noted from 1:15,840 air photos. Canopy gaps greater than 1/10 acre (i.e., gaps roughly the diameter of one down tree length) will be noted during the course of plot sampling by the line-intercept method along transects."*

In practice, both the air photo and field components of gap mapping have proven to be problematic. Areas of severely disturbed forest are recognizable from air photos, but delineating disturbance polygons based on the strict gap criteria defined is an inexact science. On the ground, most disturbed areas appear more uneven-aged, patchy, or "ragged" than the definition above, with a few scattered trees remaining within the gap (Figure 17). In over 30 transects covering six Reserves, with each transect either 3168 or 3960 feet long, only two gaps greater than 0.1 acre were intercepted. This suggests a gap occurrence of only 0.06% of the landscape, representing a much lower gap frequency and return interval for northeastern forests than those reported by Seymour et al (2001). It is possible that the gap definition used in the Monitoring Plan is too restrictive and should be broadened.

Assigning a predominant cause of disturbance also proved difficult. Most "disturbed gaps" appeared to occur as a result of a combination of factors: insect (spruce budworm) or disease (*Nectria* complex), coupled with wind or ice damage. It may be possible to assign a damage agent only in cases where the cause is obvious (e.g., recent fire).

Data Quality Control: Field Check Plots

In 2004 two plots were re-checked by a different field crew to test the variability among observers. To detect change over time, it is important that variability over time is greater than any variability among observers.

The overwhelming majority of data on trees and counts of saplings and seedlings was recorded consistently between crews, suggesting that data analyses conducted to data have little observer error. For example, there were no differences between crews as to which trees were within or outside of the plot. However, tree height data and herbaceous data varied considerably between crews. While no analyses have yet been conducted on these data, tree heights may be used to calculate forest biomass (relevant to issues of carbon sequestration) or in stand visualization software to depict stand structure. Tree heights, measured with an electric clinometer, were within 10 feet 83% of the time but within 5 feet only 41% of the time. In 2005 we will test a more expensive, presumably more accurate clinometer.

Measurements of the same herbaceous plots by the two crews resulted in only 55.8% overlap in herbaceous species and a Sorensen's Similarity Index of only 37%. These differences are likely caused by inconsistencies in bearings from plot center that resulted in the crews placing plots slightly off-line from one another. Herbaceous plots are placed along transects a set distance and bearing from plot.) This source of error will be corrected in the future by permanently marking herbaceous plots.

Literature Cited

Charry, B. 2004. Road densities from northern Maine. Personal communication.

Fraver, S. 2004. Spatial and temporal patterns of natural disturbance in old-growth forests of northern Maine, USA. PhD. dissertation. University of Maine, Orono, ME. 185 pp.

Hagan, J. 2004. Unpublished forest structure data from Big Reed Forest. Manuscript in prep.

Laustsen, K.M., and D.M. Griffith. 2002. Second Annual Inventory Report on Maine's Forests. U.S. Forest Service and Maine Department of Conservation. Augusta. ME. 23 pp.

Laustsen, K.M., and D.M. Griffith. 2003. Third Annual Inventory Report on Maine's Forests. U.S. Forest Service and Maine Department of Conservation. Augusta. ME. 34 pp. + appendices.

Laustsen, K.M., Griffith, D.M., and J.R. Steinman, 2004. Fourth Annual Inventory Report on Maine's Forests. U.S. Forest Service and Maine Department of Conservation. Augusta. ME. 55 pp. + appendices

Maine Natural Areas Program. 2003. Ecological Reserve Monitoring Plan. Maine Department of Conservation. 26 pp.

Seymour, R.S., White, A.S., DeMaynadier, P.G. 2001. Natural disturbance regimes in northeastern North America – evaluating silvicultural systems using natural scales and frequencies. Forest Ecology and Management. 5621: 1-11.

Whitman, A., and J. Hagan, 2004. A Rapid-Assessment Late-Successional Index for Northern Hardwoods and Spruce-Fir Forest. Forest Mosaic Science Notes. Manomet Center for Conservation Sciences. 8 pp.

Wilkerson, B. 2004. Plot Size and Power Statistics: An Assessment of Maine's Ecological Reserve Monitoring Plan. A report prepared for the Maine Natural Areas Program. 68 pp.

Woodley, S. and G. Forbes. 1997. Forest Management Guidelines to Protect Native Biodiversity in the Fundy Model Forest; Canada Parks Service; Fundy Model Forest, Sussex, New Brunswick. 35p.