To 4060 The Cape RNA

A checklist of the vascular plants at The Cape Research Natural Area, Green Mountain National Forest, Vermont.

Final Report on Cooperative Agreement #23-778 between Sterling College and Northeastern Forest Experiment Station

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During the summers of 1993 and 1994 a cooperative project between Sterling College and Northeastern Forest Experiment Station (Burlington) surveyed the flora and ecological conditions of The Cape Research Area (TCRNA). The primary purpose of the project was to determine the floristic diversity of an uncut deciduous forest. As a first approximation of diversity we compiled a checklist of the vascular flora and measured the richness (number of species) in different areas. This was done in a series of nested areas, thus deriving a species-area curve for the area. Additionally the study compared this number and pattern with richness in two adjacent parts of TCRNA which have had different past human uses.

Location

The Cape Research Natural Area (TCRNA) contains an enriched, deciduous, putative old-growth forest on the steep western front of the Green Mountains. Straddling the boundary between the towns of Grafton (Addison County) and Chittenden (Rutland County), Vermont, the Natural Area is roughly trapezoidal in shape extending from the ridgeline of Lookoff Mountain on the east to Baker Brook (or its northward extension) into the headwaters of Sugar Hollow Brook on the west (see Fig. 1 and a more detailed description in the establishment record). The roughly 117 ha area ranges from 475 m elevation at the southwest corner to 803 m at the top of a steep promontory on the ridge, called The Cape. The center of the area (grid point K4) is at 43° 48' 47"N 72° 59' 25"W. Grid point M3 has GPS (Geographic Positioning System) determined UTM coordinates at Zone 18T 66153W 4852535N. The Cape is entirely within the Green Mountain National Forest. It was established as a Research Natural Area on 18 November 1993.

Plot Methods

During 1993 the Sterling College field crew laid out a relocatable 100 meter grid covering the TCRNA. Jess Couture and Paul Brown spent 24 days measuring, locating, rectifying, and marking the grid. Starting along a true North (15 degree magnetic) baseline following Baker Brook, grid lines were surveyed by tape and sighting compass. The tape distances were corrected for slope so that the grid corresponds to a true (i.e. horizontal map not field/slope) area of 1 hectare cells. Orange flagging marked each grid intersection, labeled according to lettered east-west (A at the North to T at the South) grid lines and numbered north-south (1 at the West to 8 at the East) grid lines (see Fig. 1). Some 135 complete or partial ha-cells were enumerated with their northwest corners

corresponding with the letter and number of the grid intersection. Significantly a local magnetic anomaly centered near grid point K3 caused some deviation (±10 m surveying closure) from a rectilinear pattern, but true area, mapped positions, and compass relocations seem minimally affected.

In addition to the 1 ha cells, roughly every fourth grid intersection became the corner of an intensive generally 20 X 50 m (not slope corrected) ecological plot. In total, some 2.7 ha over 30 plots (20 plots on the "slope" proper), were intensively sampled (see Fig. 1). The intensive plots were marked with yellow flagging and a labeled 50 cm PVC pipe was driven half-way into the ground at the grid point as a permanent monument. This pipe was also the starting corner for an series of nested plots (10X10 cm, 31X31cm, 1X1m, 3.1X3.1m, 10X10m, 20X50m, and 100X100m) within each of which the vascular flora was tallied. Also in each intensive plot the cover (% ground obscured) of each vascular understory species was estimated by eye within a series of 10 regularly placed 1X1m plots.

Floristic Methods

On 18 separate days in 1993 and 1994 (seasonally from 27 May to 10 September), Charlie Cogbill (18 days), field taxonomic consultants Jerry Jenkins (2 days) and Brett Engstrom (9 days), and field assistants (5 days) conducted floristic surveys in TCRNA. All areas were visited during the 35 people-days of reconnaissance and 19 days were spent in quantitative intensive sampling. In the 30 intensive ha-cells a summary list was derived from an approximately two-hour intensive search of a 20X50m plot combined with a sweep of the center of the cell for additional species. Further reconnaissance of several edges of the cell were surveyed during at least two separate trips. An additional 64 ha-cells were surveyed with moderate intensity; thus relatively complete floristic data are available from 92 ha-cells (26 on the "slope") scattered throughout The Cape. The special areas associated with the open cliff in O4 and the beaver meadows in row 0 received extra attention.

Specimens were collected for all unrecognized taxa, and these were later determined, as much as possible, by the taxonomic consultants. Together with herbarium sheets of common species, selected determination vouchers will be deposited at the Northeastern Forest Experiment Station (Burlington) or the Sterling College Herbarium collections. Taxonomy is consistent with H.A Gleason. and A. Cronquist's (1991) Manual of Vascular Plants of Northeastern United States and Adjacent Canada, 2nd edition, and nomenclature, including families, follows the same. A complete list of species found in each of the surveyed 92 ha-cells is available in a "D-base" data file and copies are deposited at the Northeastern Forest Experiment Station (Burlington) and with the Ecologist of the Green Mountain National Forest (Rutland).

Divisions and Environment

For the purpose of analyses, TCRNA was divided into three units called "slope", "farmed", and "cut" (see Fig. 2). Dividing lines separating the units were mapped along the grid lines since the floristic data are referenced to and summarized according to ha cells (Fig. 2). These units represent different land uses and also directly correspond to different topography, bedrock geology, glacial geology history, and soils. The geomorphologic

differences are crudely recognized in different, mapped, Ecological Land Types (ELTs). Although the whole area would be classified as SAF Forest Cover Type No. 25: Sugar Maple-Beech-Yellow Birch, the forest can be considered various subdivisions of rich Northern Hardwoods in other classifications. The land use units potentially reflect differences in forest composition, ecological processes, and flora. Some 8 ha along the ridge line were excluded from any unit as trees had been recently cut and girdled during management operations lapping over the ridge (as well as having a different ownership history). Similarly 2 ha along Baker Brook at the western edge of the area have been excluded from any subdivision as the area supports a shifting series of beaver ponds, meadows, and wet streamside flats atypical of the forest.

The "slope" covering approximately 56 ha is west-facing and generally above 550 m. Underlain by Pinnacle formation shistose grawacke, the slope parent material is a well-drained loam derived from thin schisty till. This roughly corresponds to ELT 2d (very shallow, steep, and rocky soils derived from subglacial material). The slope is steep (20° to 38°) and covered either by deep colluvium with many seeps and enriched drainages or by bouldery talus below ledgy outcrops. There is a very strong gradient from dry, poor, denuded substrates on the upper slope to the enriched colluvial lower slope. Soil characteristics vary from an aggrading, deep dark organic surface layer at the toe to thin, poor, leached surfaces at the ridge. There is a loose correspondence with haplorthods soils, although there is a thick A horizon and little B development at the toe of the slope. The B horizon chemistry grades from base rich (pH 6.2 and Ca concentrations >3500mg/Kg) at the lower reaches to depleted (pH 3.4 and Ca 170mg/Kg) at the ridge. Most of the slope has never been cut, but is constantly disturbed by wind, land-slip, and overland water flow disturbances.

The "farmed" area is a rolling terrace at the base of the slope in the northwest quarter of the area. This roughly 24 ha includes a bench at 540 m with a steep face down to an entrenched stream at 510 m. Although all corresponding with ELT 103b (basal till soils from subglacial deposition), the area has two distinct habitats, a dry poor low ridge beside a wet rich bench. The bench is associated with a thin erodable layer of Forestdale dolomite with dolomitic sandstone and quartzite and the slope is underlain by Moosalamoo phyllite. The parent material is a deep well-drained sandy loam, but the flat terrace is a poorly drained, almost wooded-fen. Soils are generally spodosols with variable B horizon chemistry (pH 3.6 to 5.5 and Ca 40-900 mg/Kg) while some presumably dolomitic influenced sites have calcareous parent material with pH >7.5. This area has a distinctive history of clearance, including charcoal production and grazing (a barbed wire fence generally follows the 580 m contour). It is covered with second growth and associated with a nineteenth century farm located on the road paralleling the eastern boundary.

The "cut" area covers the lower slopes, gentle knobs, and small coves in the southwest. This roughly 26 ha area loosely corresponds to ELT 105b (coarse ablation till washed during glacial melt). Similar to the farmed area this slope has a reemergence of the dolomitic layer at 540 m (including a knobby ridge). It includes only one small wet meadow, but has a wide stream valley slope down to 475 m. The apparently Tunbridge soils are moderately well-drained sandy loams. B horizon chemistry is variable (pH 4.4-6.7 and Ca 1600-2500 mg/Kg) depending on the relative influence of the base-rich

material from bench and knobs. The talus and coves on the eastern side have a distinctly lush (i.e. wild onion fields) and diverse (i.e. Goldie's fern) ground cover and the western ridge is a distinctly poor (pH 3.4) and well-drained slope. The area was logged from southern access at least through the past 40 years. The past cutting closely follows an old lot (ownership) boundary and extends up to at least 620 m.

Results

The forests of TCRNA are dominated by sugar maple and yellow birch (Table 1). The "slope" forest has only 12 tree species and a low diversity of trees (exp H'= of 3.54 equivalent species on the slope). The "cut" unit has similar composition and diversity to the "slope", but presently supports slightly less basal area. The "farmed" area, is dominated by fast growing red spruce, white ash and black cherry with more basal area than the slope despite its recent establishment. The farmed area, surprisingly, has a higher number of tree species and higher equitability diversity (exp H'=4.72) than the slope, but is still fairly modest for a heterogeneous area with a history of different uses.

The richness of TCRNA is mostly expressed through the understory species. There are 76 vascular understory species abundant enough to have measurable cover in the sample of 198-m^2 plots (Table 2). Only 3 species are totally dominant: the annual yellow jewelweed, evergreen wood fern, and sugar maple. Roughly 2 dozen dominant species (14 abundant enough to have > 1% cover) in the understory are mostly indicators of rich woods. Scattered species are very common with 33% (57 of the 175 species) occurring in less than 10% of the hectares on the slope. The understory species abundance distribution (log of % cover plotted in decending order) shows a strongly logarithmic series, with few outlying dominants. The equitability diversity indices indicate moderately low dominance (1/ Simpson's index=11.54 equivalent spp.) with a moderately high evenness (exp H'=23.63 equivalent spp.). The few rare species are generally found in unusual habitats and the only state listed (threatened) species (*Blephilia hirsuta*) is locally common along the beaver meadows outside of the forest. Apparently there is a large species pool strongly dividing up resources and structured by higher-ranking species preempting space. This strong ordering of dominance and many scattered species shows in the "big, long tail" of occasional species. The strong division of the environment and abundant resources yields a relatively large turnover of species in a seemingly homogenous, if somewhat patchy (i.e. cliff, ledge, talus, slip openings, tree falls, toe slope, seeps, burns) habitat. Thus, there is an unremarkable plot richness (alpha-diversity= 6.7 spp./m^2-typical for mesic forests), but the strong, albeit gradual, environmental gradients (beta-diversity) yield a large species pool (is this gamma-diversity?) over the large (≥1 ha) scale.

This study documented 264 vascular plant species growing within the boundaries of the 117 ha TCRNA (see Table 1). Although half of the total area, the uncut "slope" is fairly homogenous and supports 175 species. The smaller areas previously used for farming or cutting contain a substantially different species pool (197 and 142 species, respectively). The obvious major factor in the overall diversity of a unit is the variety of environmental conditions not its "classification" (i.e. land use or ELT). The most variety was found in the peripheral habitats, especially the wetlands: beaver meadows,

streamsides, and woodland fens which were found at the western side of the TCRNA. Consequently the farmed area was especially heterogeneous.

The species richness at TCRNA "slope" increases at a constant rate relative to the logarithm of the area up to a scale of 1 hectare (Table 4). This curve indicates both a rich assemblage (moderate alpha-diversity) of species and a continuing turnover (moderate beta-diversity) with increasing size area. The "slope" flora is homogenous at any scale, but always incomplete, missing occasional species in the larger community. At scales greater than 1 ha the species-area curve accelerates above a relatively constant community turnover and "takes off". This pattern indicates the total species pool is an incorporation from several homogenous communities encountered as the area becomes large. The curve keeps climbing as rarer and more variable habitats (such as wetlands or cliffs) are incorporated in the area.

At a scale smaller than about 1 hectare there is little difference between the mean number of species in any units of TCRNA and the "slope" mean (i.e. 6.7spp./1m^2; 20.0spp/10m^2; 31.0spp./100m^2). Variability in the number of species for different areas is fairly large (s.d. $\cong \pm 7$ to 8 species between 100m^2 and 1 ha scales) and the coefficient of variation actually increases up to the 0.1 ha scale. At about 1 ha the variation plateaus at approximately 12% coefficient of variation indicating the most predictable richness in larger areas. Typical of many mesic forests, the linear-scaled species-area curves show a strong inflection point at 0.1 ha, defining the lower size limit of the understory "community" sample. The species-area curves for the farmed, cut, lower or upper slope substantially overlap (e.g. 42.2 to 51.2 spp./0.1ha) (Fig. 2). The "slope" is slightly richer than the "used" areas at the 0.1 ha scale, but it less rich at the 10m^2 scale. Due to the moderately high variance (e.g. average ±2.5 standard error), it is impossible to confirm any order and identify the richest unit. Similarly the "slope" curve is slightly higher (49.9spp./0.1ha), but is indistinguishable from determinations in the rich woods at Gifford Woods, VT (e.g. 46.2 spp./0.1ha) or the woods at Mount Horrid, VT (e.g. 44.5 spp./0.1ha.) Interestingly nearby Gifford Woods (117 species in a 2 ha enriched sugarbush) is especially rich at the 1 ha scale (99 species vs. 63.0 at TCRNA slope). Apparently all these areas have the same pattern of richness within a small area (<ca. 1ha), but distinctions begin to appear at larger scales where the habitat heterogeneity, not enrichment alone, influences the total species pool. Differences in human management effects on the species-area curve appear minimal and richness cannot easily be used as an index of past activity.

Checklist

The following listing of vascular plant species documented at The Cape is ordered alphabetically within alphabetically listed families. Authorities are cited and a few usual synonyms are indicated. Relative abundance is classified in 5 categories derived from both subjective and quantitative criteria:

abundant	= dominant in a common habitat;	>1% cover in quantitative plots
frequent	= important and easily found;	some cover in quantitative plots and in >10% of 85 sampled ha-cells
occasional	= widely scattered, but not difficult to find;	>5% presence in ha-cells
infrequent	= difficult to find;	<5% presence in ha-cells
rare	= very difficult to find, limited to uncommon habitats;	±1 ha-cell

The letter abbreviations indicate presence in one of the three land use units:
s=slope (56 ha)
f=farmed (24 ha)
c=cut (26 ha)
Plants present mostly in the special habitats of the open cliff in O4 or the beaver meadows in 0 rank or other unusual circumstances are included in annotations with a few taxa. Obvious alien species are indicated with an "*".

CAPE CHECKLIST

ACERACEAE

Acer pensylvanicum L. abundant s,f,c
Acer rubrum L. frequent s,f,c
Acer saccharum Marsh. abundant s,f,c
Acer spicatum Lam. abundant s,f,c

ADIANTACEAE

Adiantum pedatum L. frequent s,f,c

ANACARDIACEAE

Rhus typhina L. rare s, only at top of open cliff

APIACEAE

Hydrocotyle americana L. infrequent c, and along beaver meadows
Osmorhiza claytonii (Michx.) C.B. Clarke abundant s,f,c
Zizia aurea (L.) W.D.J. Koch infrequent f, and along beaver meadows

AQUIFOLIACEAE

Nemopanthus mucronata (L.) Loes. rare f

ARACEAE

Arisaema triphyllum (L.) Schott ex Schott & Endl. frequent s,f,c

ARALIACEAE

Aralia nudicaulis L. frequent s,f,c
Aralia racemosa L. occasional s,c
Panax quinquefolius L. infrequent s,f on Vermont watch list

ARISTOLOCHIACEAE

Asarum canadense L. frequent s,f,c

ASCLEPIADACEAE

Asclepias syriaca L. infrequent f

ASPLENIACEAE

Asplenium rhizophyllum L. infrequent s,f on calcareous boulders
Athyrium filix-femina (L.) Mertens frequent s,f,c

Athyrium thelypteroides (Michx.) Desv. abundant s,f,c
Cystopteris bulbifera (L.) Bernh. frequent s,f,c
Cystopteris fragilis (L.) Bernh. frequent s,f,c
Dryopteris campyloptera (Kunze) Clarkson occasional s,f
Dryopteris carthusiana (Villars) H. P. Fuchs infrequent only along beaver meadows
Dryopteris cristata (L.) A. Gray infrequent f,c
Dryopteris goldiana (Hook.) A. Gray frequent s,c only southern end
Dryopteris intermedia (Muhl.) A. Gray abundant s,f,c
Dryopteris marginalis (L.) A. Gray frequent s,f,c
Gymnocarpium dryopteris (L.) Newm. infrequent s,f
Matteuccia struthiopteris (L.) Todaro frequent s,f,c
Onoclea sensibilis L. occasional s,f,c
Polystichum acrostichoides (Michx.) Schott frequent s,f,c
Polystichum braunii (Spenner) Fee occasional s,f,c
Thelypteris noveboracensis (L.) Nieuwl. occasional f
Thelypteris phegopteris (L.) Slosson (=Phegopteris connectilis) frequent s,f

ASTERACEAE

Aster acuminatus Michx. abundant s,f,c
Aster cordifolius L. occasional s,c
Aster divaricatus L. frequent s,f,c
Aster lateriflorus (L.) Britt. occasional s,f,c
Aster macrophyllus L. occasional s,f
Aster novae-angliae L. rare s,f in openings
Aster puniceus L. frequent f,c
Aster umbellatus Mill. occasional f
Cirsium sp. infrequent s
Erigeron annuus (L.) Pers. infrequent only along beaver meadows
Erigeron philadelphicus L. infrequent s,c
Erigeron pulchellus Michx. infrequent f
Eupatorium maculatum L. occasional s,f
Eupatorium perfoliatum L. occasional only along beaver meadows
Eupatorium rugosum Houtt. (Ageratina altissima) frequent s,f,c
*Hieracium paniculatum L. infrequent s
Lactuca sp. occasional s,f,c
Prenanthes altissima L. occasional s,f
Senecio aureus L. infrequent f and along streams
Solidago arguta Ait. occasional s
Solidago bicolor L. infrequent s
Solidago caesia L. occasional s
Solidago canadensis L. infrequent f
Solidago flexicaulis L. frequent s,f,c
Solidago gigantea Ait. rare f one wooded fen
Solidago macrophylla Pursh frequent s,f
Solidago rugosa Mill. frequent s,f,c
*Taraxacum officinale G. H. Webber ex Wiggers occasional s,f,c

BALSAMINACEAE

Impatiens capensis Meeb. frequent s,f,c
Impatiens pallida Nutt. abundant s,f,c

BERBERIDACEAE

Caulophyllum thalictroides (L.) Michx. abundant s,f,c

BETULACEAE

Alnus incana (L.) Moench frequent f and along beaver meadows
Betula alleghaniensis Britt. abundant s,f,c
Betula papyrifera Marsh. frequent s,f,c
Corylus cornuta Marsh. frequent s,f,c
Ostrya virginiana (P. Mill) K. Koch frequent s,f,c

BRASSICACEAE

Arabis hirsuta (L.) Scop. rare s only on open cliff
Cardamine concatenata (Michx.) Sw. infrequent s only northern end
Cardamine diphylla (Michx.) Wood occasional s,c
Cardamine pensylvanica Muhl. ex Willd. infrequent c

CAMPANULACEAE

Campanula rotundifolia L. rare s only on open cliff

CAPRIFOLIACEAE

Diervilla lonicera P. Mill occasional s,f
Lonicera canadensis Bartr. ex Marsh frequent s,f,c
Sambucus pubens L. frequent s,f,c
Viburnum cassinoides L. occasional f,c
Viburnum lantanoides Michx. abundant s,f,c

Viburnum opulus L. (= Viburnum trilobum) infrequent s,f

CARYOPHYLLACEAE

Stellaria sp. infrequent f,c

CHENOPODIACEAE

Chenopodium gigantospermum Aellen. rare s only on open cliff

CLUSIACEAE

Hypericum mutilum L. rare only along beaver meadow

CORNACEAE

Cornus alternifolia L. frequent s,f,c
Cornus canadensis L. infrequent f,c
Cornus rugosa Lam. rare s only at top of cliff

CYPERACEAE

Carex albursina Sheldon occasional s,c
Carex appalachica J. Webber & P. W. Ball frequent s,f,c
Carex arctata Boott ex Hook. frequent s,f,c
Carex blanda Dewey infrequent s,f
Carex bromoides Schkuhr ex Willd. occasional s,f and beaver meadows
Carex brunnescens (Pers.) Poir. ex Lam. frequent s,f,c
Carex communis Bailey frequent s,f,c
Carex crinita Lam. occasional f,c in wooded fens
Carex debilis Michx. occasional s,f
Carex deweyana Schwein. frequent s,f,c
Carex echinata Murr. infrequent only in beaver meadows
Carex gracillima Schwein. infrequent s,f
Carex gynandra Schwein. infrequent f and beaver meadows
Carex hystericina Muhl. ex Willd. infrequent only in beaver meadows
Carex intumescens Rudge frequent s,f,c
Carex laxiflora Lam. occasional s,c
Carex leptalea Wahl. rare s
Carex leptonervia (Fern.) Fern. infrequent s,f
Carex lurida Wahlenb. infrequent only in beaver meadows
Carex pedunculata Muhl. ex Willd. infrequent s,f
Carex pensylvanica Lam. rare f
Carex plantaginea Lam. frequent s,f,c
Carex radiata (Wahlenb.) Small infrequent f
Carex retrorsa Schwien. rare only in ridge wetland
Carex rosea Schukhr. ex Willd. frequent s,f,c
Carex scabrata Schwein. frequent s,f,c
Carex stipata Muhl. ex Willd. infrequent f,c and beaver meadows
Carex tribuloides Wahl. rare s
Carex utriculata Boott rare only in ridge wetland
Scirpus atrovirens (Willd.) infrequent only in beaver meadow
Scirpus cyperinus (L.) Kunth infrequent only in beaver meadow
Scirpus microcarpus J. & K. Presl. infrequent only in beaver meadow

DENNSTAEDTIACEAE

Dennstaedtia punctiloba (Michx.) T. Moore occasional s,f,c
Pteridium aquilinum (L.) Kuhn rare f

EQUISETACEAE

Equisetum arvense L. occasional f,c
Equisetum hyemale L. rare s

ERICACEAE

Vaccinium angustifolium A.t. rare f

FAGACEAE

Fagus grandifolia Ehrh. frequent s,f,c
Quercus rubra L. rare f only one germinating acorn

GERANIACEAE

Geranium robertianum L. frequent s,f,c

GROSSULARIACEAE

Ribes cynosbati L. frequent s,f,c
Ribes glandulosum Grauer infrequent s,f
Ribes lacustre (Pers.) Poir. occasional s,f,c

HYDROPHYLLACEAE

Hydrophyllum virginianum L. abundant s,f,c

JUGLANDACEAE

Juglans cinerea L. infrequent s,c only three trees seen

JUNCACEAE

Juncus effusus L. infrequent only in beaver meadows

LAMIACEAE

Blephila hirsuta (Pursh) Benth. occasional only along beaver meadows Vermont threatened list
*Galeopsis tetrahit L. occasional s,c
Lycopus uniflorus Michx. occasional f and beaver meadows
Mentha arvensis L. occasional s,f
*Prunella vulgaris L. infrequent f
Satureja vulgaris (L.) Fritsch. infrequent s,c
Scutellaria laterifolia L. infrequent f
Stachys sp. infrequent f

LILIACEAE

Allium tricoccum Ait. abundant s,f,c
Clintonia borealis (Ait.) Raf. frequent s,f,c
Erythronium americanum Ker-Garl frequent s,f
Maianthemum canadense Desf. frequent s,f,c
Medeola virginiana L. frequent s,f,c
Polygonatum pubescens (Willd.) Pursh frequent s,f,c
Sisyrinchium sp. rare c only in wet opening
Smilacina racemosa (L.) Desf. (=Maianthemum racemosum) frequent s,f,c
Streptopus roseus Michx. frequent s,f,c
Trillium erectum L. frequent s,f,c
Trillium undulatum Willd. occasional s,f,c
Uvularia grandiflora Sm. frequent s,f,c
Uvularia sessilifolia L. occasional s,f,c
Veratrum viride Ait. occasional s,f

LYCOPODIACEAE

Lycopodium clavatum L. infrequent f
Lycopodium digitatum Dillen. infrequent f
Lycopodium lucidulum Michx. frequent s,f,c
Lycopodium obscurum L. occasional s,f,c

MONOTROPACEAE

Monotropa uniflora L. occasional s,f,c

OLEACEAE

Fraxinus americana L. abundant s,f,c
Fraxinus nigra Marsh. occasional s,f

ONAGRACEAE

Circaea alpina L. frequent s,f,c
Epilobium ciliatum Biehler occasional s,f,c

OPHIOGLOSSACEAE

Botrychium virginianum (L.) Swartz occasional s,f,c

ORCHIDACEAE

*Epipactis helleborine (L.) Crantz occasional s,f,c
Habenaria dilatata (Pursh) Hook. (=Plantathera habenaria) infrequent c
Habenaria sp. s,f

OROBANCHACEAE

Epifagus virginiana (L.) W. Bart. occasional only on high ridge

OSMUNDACEAE

Osmunda cinnamomea L. infrequent s,f
Osmunda claytoniana L. frequent s,f
Osmunda regalis L. infrequent f

OXALIDACEAE

Oxalis acetosella L. (=Oxalis montana) abundant s,f,c
Oxalis stricta L. infrequent only in beaver meadow

PAPAVERACEAE

Dicentra canadensis (Goldie) Walp. frequent s,f,c
Dicentra cucullaria (L.) Bernh. frequent s,f,c
Sanguinaria canadensis L. infrequent f

PINACEAE

Abies balsamea (L.) Miller rare f
Picea rubens Sarg. frequent s,f,c

POACEAE

Agropyron repens (L.) Beauv. rare
Agrostis perennans (Walt.) Tuckerm. occasional s,f
Brachyeletrum erectum (Schreb. ex Sprengl.) Beauv. infrequent s,f
Calamagrostis canadensis (Michx.) Beauv. infrequent f
Cinna latifolia (Trev. ex Goepp.) Griseb. frequent s,f,c
Festuca obtusa Biehler (=F. subverticillata) frequent s,f,c
Glyceria grandis S. Wats. infrequent only in beaver and ridge meadows
Glyceria melicaria (Michx.) F.T. Hubbard frequent s,f
Glyceria striata (Lam.) A.S. Hitchc. frequent s,f,c
Milium effusum L. occasional s,f,c
Muhlenbergia mexicana (L.) Trin. rare s only on open cliff
Poa alsodes Gray infrequent s
Poa palustris L. infrequent f and along beaver meadows
Poa pratensis L. infrequent c and along beaver meadows

POLYGONACEAE

Polygonum cilinode Michx. frequent s,f,c
Polygonum sagittatum L. infrequent only in beaver meadows
*Rumex crispus L. infrequent f,c

POLYPODIACEAE

Polypodium virginianum L. occasional s,f,c

PORTULACACEAE

Claytonia caroliniana Michx. occasioanl s

PRIMULACEAE

Lysimachia terrestris (L.) B.S.P. infrequent only in beaver meadow
Trientalis borealis Raf. frequent s,f,c

PYROLACEAE

Pyrola elliptica Nutt. occasional s,f
Pyrola secunda L. infrequent s,f

RANUNCULACEAE

Actaea pachypoda Ell. frequent s,f,c
Actaea rubra (Ait.) Willd. frequent s,f,c
Aquilegia canadensis L. infrequent s,c
Caltha palustris L. infrequent c and in beaver meadows
Clematis occidentalis (Hornem.) DC. occasional s,f
Clematis virginiana L. infrequent f
Coptis trifolia (L.) Salisb. infrequent f
Hepatica acutiloba DC. (=Hepatica nobilis) infrequent s
Ranunculus abortivus L. occasional s,f,c
Ranunculus acris L. rare c
Ranunculus hispidus Michx. infrequent c
Ranunculus recurvatus Poir. rare f
Thalictrum dioicum L. infrequent s,f
Thalictrum pubescens Pursh occasional s,f,c

RHAMNACEAE

Rhamnus cathartica L. rare f

ROSACEAE

Agrimonia gryposepala Wallr. infrequent f and in beaver meadows
Amelanchier arborea (Michx.) Fern. infrequent s,f
Fragaria virginiana Duchesne occasional s,f
Geum canadense Jacq. infrequent f
Geum rivale L. occasioanl f,c and beaver meadows
Malus sylvestris P. Mill occasional f
Potentilla norvegica L. infrequent only in beaver meadow
Prunus pensylvanica L. occasional s,f,c
Prunus serotina Ehrh. frequent s,f,c
Prunus virginiana L. frequent s,f
Rubus allegheniensis Porter frequent s,f,c
Rubus idaeus L. frequent s,f,c
Rubus odoratus L. frequent s,f,c
Rubus pubescens Raf. frequent s,f,c
Sorbus americana Marsh. occasional s,f
Spiraea latifolia Du Roi infrequent f

RUBIACEAE

Galium arpine L. rare f
Galium asprellum Michx. occasional f,c and beaver meadows
Galium palustre L. infrequent f
Galium triflorum Michx. frequent s,f,c
Mitchella repens L. infrequent f,c

SALICACEAE

Populus grandidentata Michx. infrequent c
Populus tremuloides Michx. infrequent f,c
Salix alba L. infrequent c and beaver meadows
Salix eriocephala Michx. infrequent f and beaver meadows

SAXIFRAGACEAE

Chrysosplenium americanum Schwein. ex Hook. occasional s,f,c
Mitella diphylla L. frequent s,f,c
Saxifraga pensylvanica L. occasional f
Saxifraga virginiensis Michx. occasional s,c
Tiarella cordifolia L. frequent s,f,c

SCROPHULARIACEAE

Chelone glabra L. frequent s,f,c
Mimulus ringens L. infrequent only in beaver meadows
Veronica officinalis L. infrequent s,f,c
Veronica americana (Raf.) Schwein. infrequent f

SPARGANIACEAE

Sparganium sp. infrequent only in beaver meadow

TAXACEAE

Taxus canadensis Marsh. rare c only at southern streamside

TILIACEAE

Tilia americana L. frequent s,f,c

TYPHACEAE

Typha latifolia L. infrequent c in wet meadow

ULMACEAE

Ulmus americana L. frequent s,f,c

URTICACEAE

Laportea canadensis (L.) Wedell abundant s,f,c
Pilea pumila (L.) Gray rare s
Urtica dioica L. occasional s,f,c

VIOLACEAE

Viola blanda Willd. frequent s,f
Viola canadensis L. frequent s,f,c
Viola pubescens Ait. occasional s
Viola rotundifolia Michx. frequent s,f,c
Viola sororia Willd. occasional s,f,c

Table 1. Forest composition of TCRNA composite land use units (absolute basal area m^2/ha of trees >5cm in intensive plots)

	slope	farmed	cut
number of plots	18	5	5
Acer saccharum	17.13	5.58	13.63
Betula alleghaniensis	6.03	5.81	5.60
Fraxinus americana	1.70	2.46	0.17
Picea rubens	1.33	12.46	-
Betula cordifolia	1.23	0.21	-
Acer pensylvanicum	0.92	1.05	1.31
Fagus grandifolia	0.60	0.10	1.33
Acer spicatum	0.53	0.15	0.04
Tilia americana	0.24	0.05	-
Ostrya virginiana	0.16	-	-
Cornus alternifolia	0.01	-	t
Prunus pensylvanica	0.01	-	0.48
Ulmus americana	-	0.01	0.15
Acer rubrum	-	0.20	0.42
Prunus serotina	-	2.26	-
Amelanchier arborea	-	0.28	-
Fraxinus nigra	-	0.05	-
Total	29.94	31.26	24.12
s.d.	6.42	9.03	6.87
exp H'	3.54	4.72	3.34
1/Simp.	2.67	4.22	2.63

Table 2. Composite understory vascular composition of the slope forest in TCRNA (based on 198 1X1m plots regularly placed in 20 intensively sampled 0.1 ha plots; also same species in 26 comprehensively sampled 100X100 cells covering the same area)

	% cover	% freq	%presence
	-----in 198	1m^2-----	in 26 hectares
Impatiens pallida	14.15	66	93
Dryopteris intermedia	5.84	47	96
Acer saccharum	5.04	52	96
Laportea canadensis	3.26	10	78
Athyrium thelypteroides	2.70	12	85
Hydrophyllum virginianum	2.44	30	93
Acer spicatum	2.38	32	93
Aster acuminatus	2.08	19	85
Allium tricoccum	2.00	12	70
Viburnum lantanoides	1.68	7	81
Osmorhiza claytonii	1.48	19	81
Caulophyllum thalictroides	1.40	12	81
Acer pensylvanicum	1.23	17	89
Oxalis acetosella	1.00	13	52
Dryopteris marginalis	0.92	10	78
Cornus alternifolia	0.83	3	85
Viola canadensis	0.82	17	85
Maianthemum canadense	0.82	10	56
Aralia nudicaulis	0.80	10	67
Arisaema triphyllum	0.70	33	85
Athyrium filix-femina	0.70	7	81
Clintonia borealis	0.56	10	78
Sambucus pubens	0.56	7	89
Tiarella cordifolia	0.47	9	96
Adiantum pedatum	0.45	4	78
Dryopteris goldiana	0.42	2	19
Solidago flexicaulis	0.40	3	70
Aster divaricatus	0.39	8	96
Smilacina racemosa	0.38	7	89
Rubus idaeus	0.36	4	74
Lycopodium lucidulum	0.32	8	63
Fagus grandifolia	0.30	8	93
Lonicera canadensis	0.30	2	63
Viola rotundifolia	0.28	3	63
Polygonatum pubescens	0.26	8	93
Cinna latifolia	0.25	9	96
Ribes cynosbati	0.25	5	81
Polystichum acrostichoides	0.23	9	96
Prenanthes altissima	0.19	2	41

Table 2. Composite flora of the slope at TCRNA continued

	% cover ---in 198	% freq 1m^2---	%presence in 26 hectares
Trillium erectum	0.17	5	93
Onoclea sensibilis	0.17	1	11
Dryopteris campyloptera	0.12	2	19
Fraxinus americana	0.10	3	74
Rubus pubescens	0.10	2	37
Betula alleghaniensis	0.10	1	89
Dennstaedtia punctiloba	0.10	1	11
Actaea pachypoda	0.09	2	74
Carex scabrata	0.07	t	4
Galium triflorum	0.06	4	70
Actaea rubra	0.06	2	70
Picea rubens	0.06	1	63
Ribes lacustre	0.06	1	56
Carex plantaginea	0.06	1	33
Viola pubescens	0.05	t	22
Carex arctata	0.04	6	56
Asarum canadense	0.04	1	70
Cystopteris fragilis	0.03	2	74
Streptopus roseus	0.03	2	63
Carex communis	0.02	1	44
Ulmus americana	0.02	1	30
Polygonum cilinode	0.02	1	19
Festuca obtusa	0.02	t	26
Glyceria melicaria	0.02	t	4
Betula papyrifera	0.01	3	59
Carex deweyana	0.01	1	22
Carex intumescens	0.01	t	41
Carex rosea	0.01	t	37
Solidago arguta	0.01	t	22
Solidago rugosa	0.01	t	22
Polypodium virginianum	t	2	59
Prunus virginiana	t	1	44
Circaea alpina	t	1	59
Solidago macrophylla	t	1	15
Mitella diphylla	t	t	59
Uvularia grandiflora	t	t	37
Saxifraga virginiensis	t	t	19

Sum 60.3%cover by 76 species

Diversity indicies	exp H'	23.63 equiv spp.	evenness
	1/Simps	11.54 equiv spp.	dominance

Table 2. Composite flora of the slope at TCRNA continued

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Sum 60.3%cover by 76 species

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Table 3. Summary floristic data from TCRNA forests.

Species	Pteridophytes	Gymnosperms	Dicots	Monocots	Total
slope	23	1	106	45	175
farmed	28	2	120	47	197
cut	18	1	87	36	142
whole RNA	29	3	163	69	264

# taxa	Slope (56 ha)	Complete CRNA (117 ha)
species	175	264
genera	110	151
families	52	64

Table 4. Measures of richness of vascular species on the slope at TCRNA.

	n	# spp.	±s.d.
mean in 1X1m ($1m^2$)	198	6.7	
mean in 3.1X3.1m ($10m^2$)	20	15.0	3.9
sum in 10 non-contiguous m^2	20	20.0	
mean in 10X10m ($100m^2$)	20	31.0	7.1
sum in 100 non-contiguous m^2	2	66.5	
mean in 0.1 ha	20	49.9	8.0
mean in 1 ha	20	63.0	7.7
mean in 10 ha	4	116.7	14.2
total in 56 ha	1	175	

Fig. 1. Map of The Cape Research Natural Area showing topography, 100 m grid (ha-cell), and three land use areas.

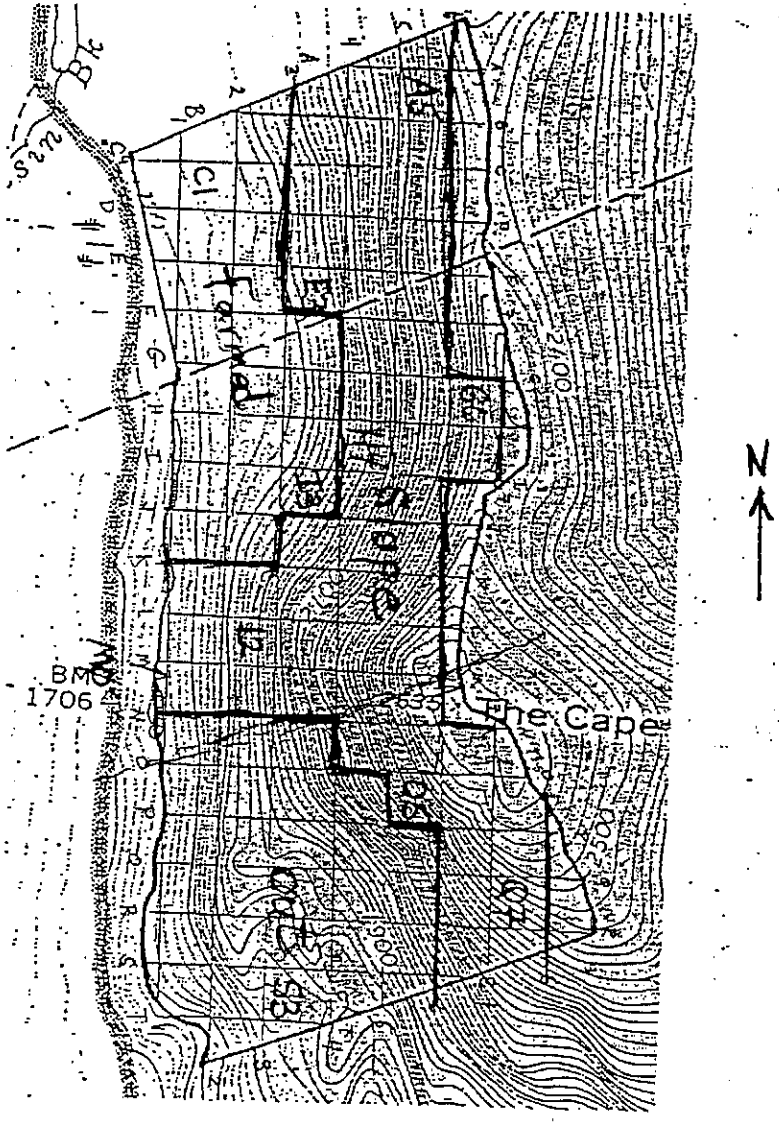


Fig. 2. Location of intensive research plots at The Cape

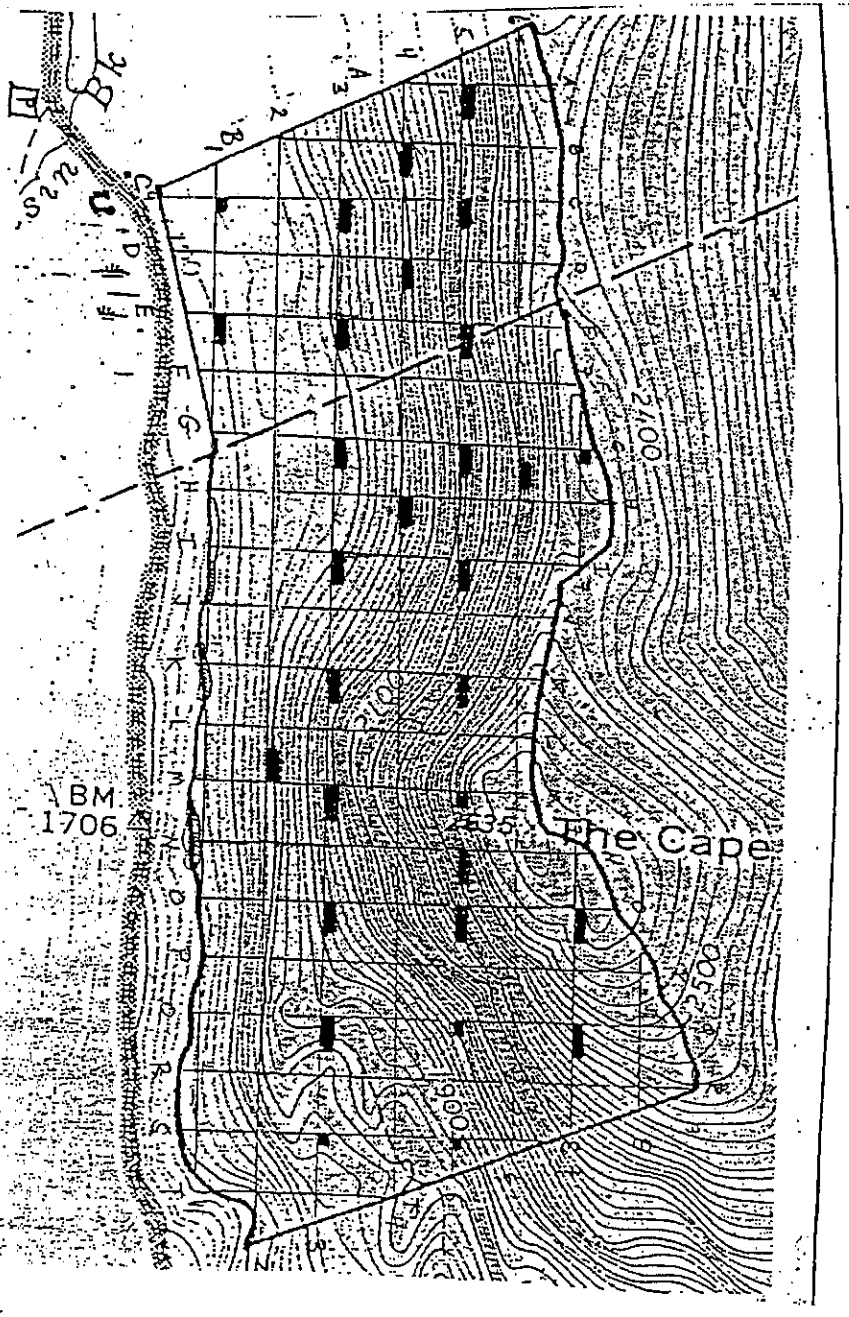
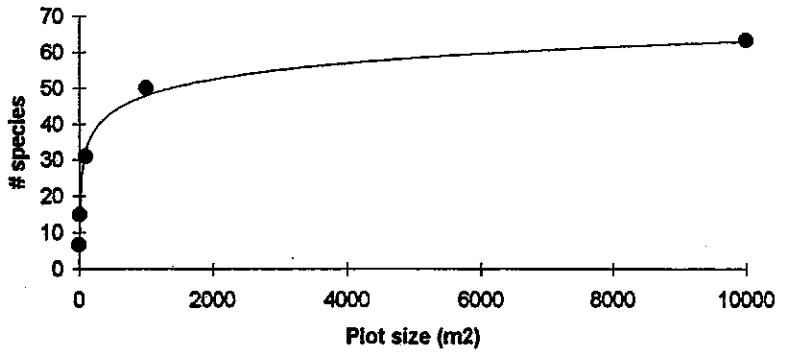


Fig. 3 Species-area curve for The Cape slope



Log Curve in various forests