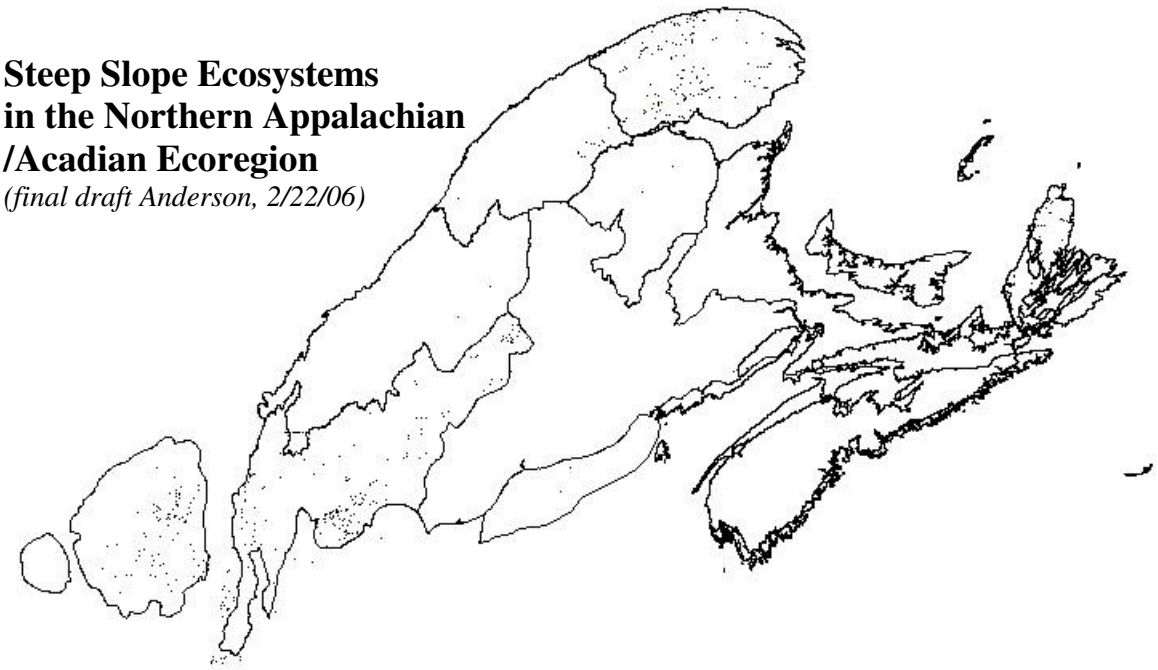
Steep Slope Ecosystems in the Northern Appalachian /Acadian Ecoregion

(final draft Anderson, 2/22/06)



Rocky crags, vertical cliffs, landslide scars, steep river bluffs and precipitous talus slopes contribute unmistakable character to the rugged landscapes of the region. Over 15,000 of these steep vertical features occur here, being concentrated in mountainous subregions but found across all elevation zones and bedrock types (Figure 1). Most steep slope features are small, averaging 27 acres, with 75% being less than 25 acres and accounting for 1% of the ecoregion in aggregate (Figure 2). At lower elevations steep slopes are associated with downcutting by rivers whereas at very high elevations, they intertwine with summits and hillcrests to form large complicated mountain features.

Figure 1. The distribution of steep slopes and cliffs across elevation and bedrock gradients in the Northern Appalachian / Acadian ecoregion.

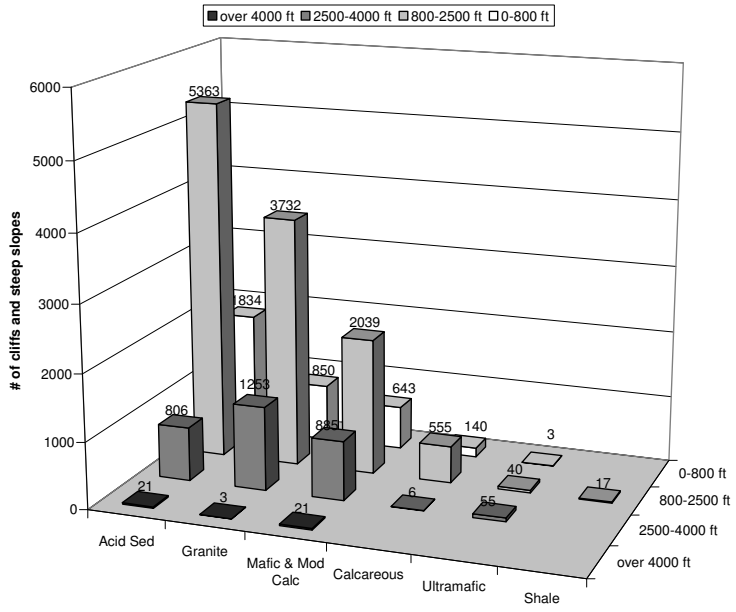
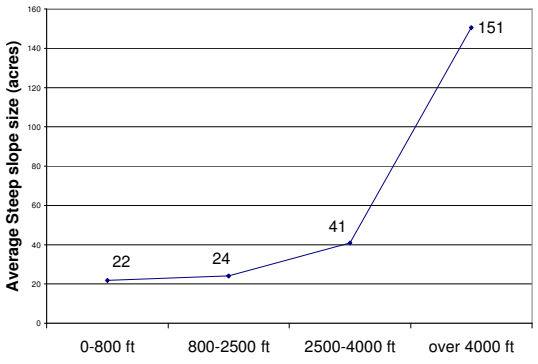


Figure 2. The distribution of steep slopes by size class and the average area of steep slope/cliff features by elevation zone.

Size Class	Total Acres	Total Number	% Num
S1: 2-25	110,756	12,386	0.76
S2: 25-75	132,513	2,884	0.18
S3: 75-240	124,839	925	0.06
S4: 240-2622	119,904	197	0.01
Total	488,011	16,392	1



Cliff, Talus and Steep slope Biodiversity

The various steep slope geomorphic features, although differing in genesis, share many ecological similarities. Their precipitous exposed faces slough off rock fragments and shed water, while accumulating soil and nutrients at their bases. This process creates contrasting habitats, the dry bedrock faces with little soil or nutrients, and moist nutrient-rich talus on the foot slopes.

Vertical cliff faces are choice settings for peregrine falcons and golden eagles which nest among the ledges and overhangs (57 nests of the former and 3 of the latter are known from steep slopes in the region). Snakes may be found sunning on south facing shelves. Wiry, tenacious herbs like birds eye primrose, slender cliff brake and fragrant cliff fern thread their roots into minute crevices while leathery liverworts find purchase directly on unbroken rock, extracting moisture from the air.

Talus of rock and rubble, accumulating at the slope bases, creates a structure preferred for denning by timber rattlesnake, rock vole, and Gaspe shrew. Tangles of vines, exploit this unstable substrate, crisscrossing the surface and rooting in pockets of soil. Other nutrient-loving plants like cranesbill, rock cress and knot weed are often found in the gravelly debris.

Communities associated with cliffs and steep slopes

Ecologists recognize several distinct, sparsely vegetated, communities on cliffs and talus slopes. The types are discriminated by floristic differences that correlate with bedrock and elevation. Enriched forests developing on the gentler undulating foot-slopes are discussed in the bowl/ravine section. Short descriptions of common steep slope ecosystems are provided below (from Basquill 2004, Anderson 1999).

Cliff and talus slopes on acidic substrates: Steep slopes on resistant granite, intermediate mafic rock or firmly cemented quartzite.

Alpine cliffs and talus: Landslide scars and scraped cirques at elevations over 4000 ft with open bedrock faces and unique alpine flora.

Mid -high elevation acidic cliffs and talus: Cliffs and vertical outcrops at elevations over 1700 ft with a flora of tough ferns and herbs such as Appalachian polypody, Rand's

goldenrod, and three-toothed cinquefoil. Sporadic rarities include fragrant fern, scirpus-like sedge and deer-hair sedge. Talus slope woodlands of red spruce and heart-leaved birch at high elevations shift to yellow birch and white ash at elevations below 2500 ft. Rock voles and long-tailed shrews nest in these areas.

Low elevation acidic cliffs and talus: Open cliffs below 1700 ft. with a flora consisting of infrequent small herbs, ferns and lichens such as harebell, heart-leaved aster and rock tripe. Low elevation talus slopes include a diversity of warmer climate woody plants such as yellow birch, hemlock, red oak, mountain maple and red-berried elder. Typical herbs include poison ivy, Virginia creeper, marginal wood fern, and rusty woodsia. Most of the 13 known timber rattlesnake populations in the Northern Appalachians occur on these low talus features.

Cliff and talus communities of Calcareous and Mafic substrates: Steep slopes on marble, limestone or hard mafic bedrock.

Mid -high elevation calcareous cliffs and talus: Cliffs over 1700 ft. with a flora consisting of slender thin herbs and ferns such as harebell, scirpus-like sedge, red columbine and Steller's cliff brake. Plant rarities like birds-eye primrose, Blake's milkvetch, lyre-leaved rock cress and purple-mountain saxifrage may occur in the richer, limestone derived examples. Rich talus slope woodlands of sugar maple, red spruce, paper birch and northern white cedar with shrubs such as mountain maple, green alder, purple-flowering raspberry and, occasionally, shrubby cinquefoil form in this setting.

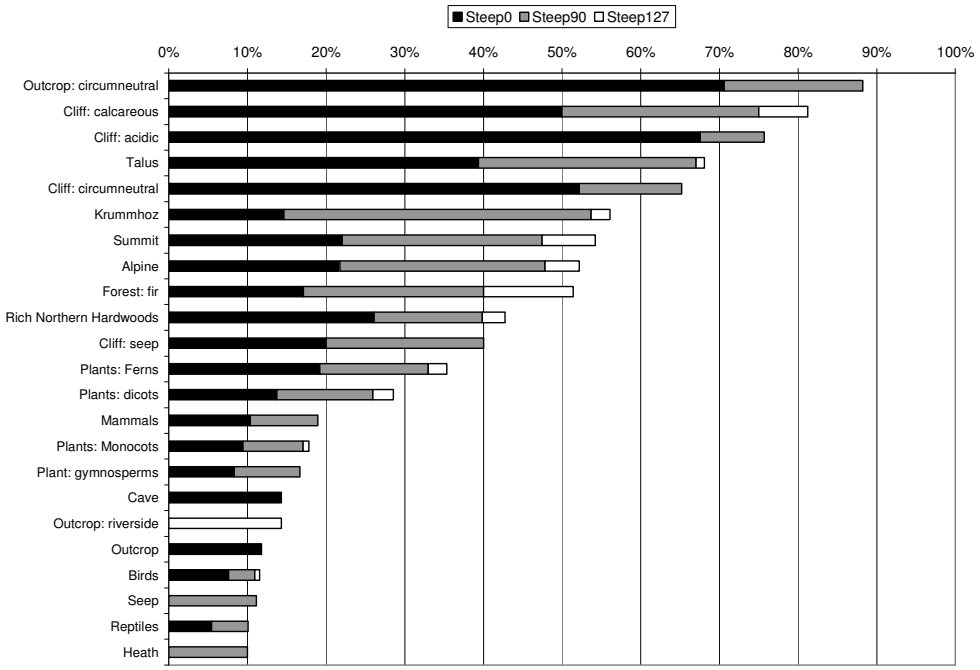
Low elevation calcareous cliff and talus: Cliffs below 1700 ft cliff with a flora of characteristic ferns and herbs such as ebony sedge, bulbet fern, wild columbine, purple-stemmed cliff brake, and wall rue. The low elevation talus slopes include a diversity of nutrient requiring woody species such as basswood, white ash, shagbark hickory, bitternut hickory and butternut. Vines and creeping shrubs such as mountain maple, Virginia creeper, and bladdernut are typical as are herbs like wild ginger, Herb Robert, clearweed and white snakeroot.

Riverside outcrop & erosional river bluffs: Waterfalls and gorges along major rivers develop steep slope communities analogous to those described above. These are mostly found at lower elevations and are often associated with richer calcareous soils. Herbs and vines that root on the vertical outcrops include harebell, red columbine, fringed loosestrife, Canada anemone, virgins bower and spreading dogbane.

Relationships between communities, rare species and the steep slope occurrences.

Compositional variation among the different community types correlate with recognizable bedrock-elevation combinations. Although the locally-defined community types do not conform precisely to physical factors, there was strong correspondence in the data between known community locations, steep slope features and the various bedrock types and elevation zones (Figure 3). To ensure that we located the best examples of steep slope ecosystems across the full spectrum of types we set a goal of locating 20 occurrences for each of 19 bedrock-elevation combination.

Figure 3: Biodiversity found on steep slopes. Bars show the primary mode of community and species occurrence as a percentage of all occurrences that were located on a steep slope feature. Black indicates the occurrence was located directly on the feature, grey indicates it was within 90 meters and white bars indicate it was within 127 meters. These (data provided by the Northeast US Natural Heritage programs and the Canadian CDCs).



Steep Slope Portfolio of Critical Sites

The screening criteria used to locate and identify the steep slope features most critical to maintaining biodiversity required that each qualifying occurrence:

- Was large and contiguous: over 25 acres.
- Was in good landscape settings (Land Cover Index < 20).
- Was in good condition based on ground surveys and expert opinion (corroboration by at least one source).
- Contained other confirmed biodiversity features (verification by element occurrences).

The size criterion was intended to insure that examples selected for the portfolio contained all their inherent species diversity and ecosystem functions. We determined the size minimum by examining over 1000 ground inventory points representing 298 species found on or directly adjacent to a steep slope feature. Of the species found on steep slopes, 69% were found only on examples greater than 25 acres, suggesting that larger features were more likely to contain a full complement of associated species. Restricting the analysis to a more narrowly defined set - species with three or more occurrences found consistently on steep slopes - 46 species were found only on examples over 25 acres, and no species were restricted to small examples. Included in the former group were much of the alpine flora, long-tailed rock shrew, rock vole, bald eagle, smooth cliff fern, mistassinica primrose, scirpus-like sedge, White Mt. saxifrage and many others (Tables 2 and 3). On average 88 % of the occurrences for any given species were likely to be on a slope over 25 acres.

Table 1 Species of larger slopes. Columns 4-7 give the % of known occurrence by size class.

Group	Com. Name	Standard Name	2-25 acres.	25-75 acres	75-240 acres	>240 acres	Tot#
Dicot	Mountain-heath	Phyllodoce caerulea				100%	9
Dicot	Moss Bell-heather	Cassiope hypnoides				100%	8
Dicot	Pale Painted-cup	Castilleja septentrionalis				100%	8
Dicot	Moss Campion	Silene acaulis var. exscapa				100%	6
Dicot	Mountain Sorrel	Oxyria digyna				100%	4
Monocot	Alpine Timothy	Phleum alpinum				100%	4
Fern	Alaskan Clubmoss	Diphasiastrum sitchense				100%	4
Dicot	Alpine Marsh Violet	Viola palustris				100%	3
Dicot	Mt. Cudweed	Gnaphalium supinum				100%	3
Monocot	Head-like Sedge	Carex capitata ssp. arctogena				100%	3
Monocot	Wavy bluegrass	Poa fernaldii			4%	96%	23
Dicot	Cutler's Goldenrod	Solidago cutleri			13%	88%	8
Dicot	Tea-leaved Willow	Salix planifolia			17%	83%	6
Dicot	Alpine Bitter-cress	Cardamine bellidifolia			20%	80%	5
Monocot	Heart-leaved Twayblade	Listera cordata			20%	80%	5
Monocot	Mountain Hairgrass	Deschampsia atropurpurea			20%	80%	5
Dicot	Purple Crowberry	Empetrum atropurpureum			22%	78%	18
Dicot	Alpine Azalea	Loiseleuria procumbens			22%	78%	9
Dicot	Common Butterwort	Pinguicula vulgaris			25%	75%	4
Dicot	Silver Willow	Salix argyrocarpa			25%	75%	4
Monocot	Pickerings Reed Bentgrass	Calamagrostis pickeringii			25%	75%	4
Dicot	Alpine Willow-herb	Epilobium alpinum			33%	67%	3
Dicot	Boreal Wormwood	Artemisia campestris ssp. borealis			50%	50%	4
Monocot	Black Sedge	Carex atratiformis			67%	33%	3
Fern	Alpine Cliff Fern	Woodsia alpina		9%	9%	83%	9
Dicot	Dwarf Birch	Betula glandulosa		13%	23%	65%	9
Monocot	Deer's Hair Sedge	Trichophorum cespitosum		7%	20%	73%	15
Dicot	Boot's rattlesnake root	Prenanthes boottii		9%	18%	73%	11
Dicot	Empetrum eamesii	Empetrum eamesii ssp. atropurpureum		17%	33%	50%	6
Monocot	Small-flowered Rush	Luzula parviflora		25%	25%	50%	4
Dicot	Purple Mountain Saxifrage	Saxifraga oppositifolia		17%	50%	33%	6
Monocot	Bentgrass	Calamagrostis stricta ssp. inexpansa		11%	33%	33%	9
Fern	Appalachian Firmoss	Huperzia appalachiana		40%	20%	40%	17
Dicot	Baked Apple Berry	Rubus chamaemorus		50%	25%	25%	4
Dicot	Blake's Milk-vetch	Astragalus robbinsii var. minor		33%	33%	33%	6
Dicot	Primula mistassinica	Primula mistassinica		33%	33%	33%	3
Dicot	Purple Clematis	Clematis occidentalis var. occidentalis		33%	33%	33%	3
Dicot	Rock-cress	Draba arabisans		46%	46%	8%	10
Dicot	White Mountain-saxifrage	Saxifraga paniculata		40%	20%	40%	5
Dicot	Hyssop-leaved Fleabane	Erigeron hyssopifolius		20%	40%	40%	5
Dicot	Squaw-root	Conopholis americana		25%	75%		4
Dicot	Squirrel-corn	Dicentra canadensis		50%	50%		4
Dicot	Dwarf Willow	Salix herbacea		20%		80%	5
Monocot	Lily-leaved Twayblade	Listera convallarioides		33%		67%	3
Fern	Fir Clubmoss	Huperzia selago		33%		67%	3

Table 2. Species of any size slopes. Columns 4-7 give the % of known occurrence by size class.

Group	Common Name	GNAME	2 -25 acres	25-75 acres	75-240 acres	>240 acres	Tot#
Dicot	Bearberry Willow	Salix uva-ursi	8%	12%	12%	68%	25
Dicot	Alpine Blueberry	Vaccinium boreale	10%	12%	16%	62%	26
Fern	Green Spleenwort	Asplenium trichomanes-ramosum	13%	13%	13%	63%	8
Monocot	Bigelow's Sedge	Carex bigelowii	9%	9%	23%	60%	35
Dicot	Empetrum nigrum ssp. hermaphroditum	Empetrum nigrum ssp. hermaphroditum	12%	6%	24%	59%	17
Dicot	Lapland Diapensia	Diapensia laFernonica	7%	9%	11%	73%	32
Monocot	Northern Bentgrass	Agrostis mertensii	7%	14%	22%	57%	18
Dicot	Dwarf Rattlesnake-root	Prenanthes nana	13%	13%	25%	50%	8
Dicot	ARNICA	Arnica lanceolata	13%	13%	25%	50%	8
Monocot	Scirpus-like Sedge	Carex scirpoidea	4%	17%	39%	39%	23
Dicot	Alpine Bilberry	Vaccinium uliginosum	25%	25%	25%	25%	4
Dicot	Northern Mountain-ash	Sorbus decora	25%	25%	25%	25%	4
Monocot	Pond Reed Bent-grass	Calamagrostis lacustris	25%	25%	25%	25%	4
Fern	Fragrant Fern	Dryopteris fragrans	30%	34%	28%	7%	22
Dicot	Ginseng	Panax quinquefolius	37%	35%	16%	13%	22
Dicot	Hornemann Willow-herb	Epilobium hornemannii	21%	17%	5%	57%	14
Monocot	Highland Rush	Juncus trifidus	6%	32%	12%	50%	12
Dicot	Mountain Sandwort	Minuartia groenlandica	9%	45%	9%	36%	11
Dicot	Alpine Goldenrod	Solidago multiradiata var. arctica	15%	8%	31%	46%	13
Dicot	Northern Comandra	Geocaulon lividum	7%	7%	37%	50%	12
Bird	Peregrine Falcon	Falco peregrinus	16%	35%	30%	19%	57
Fern	Smooth Woodsia	Woodsia glabella	13%	40%	27%	20%	15
Dicot	Ciliated Willow-herb	Epilobium ciliatum	20%	40%	20%	20%	5
Reptile	Timber Rattlesnake	Crotalus horridus	38%	15%	31%	15%	13
Dicot	Silverling	Paronychia argyrocoma	20%	5%	45%	30%	15
Dicot	Mountain Avens	Geum peckii	11%		11%	79%	19
Monocot	Alpine Sweet Grass	Hierochloe alpina	4%		24%	72%	26
Monocot	Boreal Bentgrass	Agrostis borealis	14%		21%	64%	14
Monocot	Spiked Woodrush	Luzula spicata	8%		31%	62%	13
Dicot	Alpine Bearberry	Arctostaphylos alpina	11%		33%	56%	9
Monocot	Northern Reedgrass	Calamagrostis stricta	33%		33%	33%	3
Dicot	Lapland Rosebay	Rhododendron laFernonicum	7%		15%	78%	10
Dicot	Solidago simplex var. randii	Solidago simplex var. randii	43%		29%	29%	7
Monocot	White Bluegrass	Poa glauca	25%			75%	4
Dicot	Mountain Sweet-cicely	Osmorhiza chilensis	25%	25%		50%	4
Monocot	Green Adder's-mouth	Malaxis unifolia	25%	50%		25%	4
Bird	Bicknell's Thrush	Catharus bicknellii	33%	50%		17%	6
Dicot	Smooth Rockcress	Arabis laevigata	50%	50%			4
Bird	Golden Eagle	Aquila chrysaetos	67%	33%			3
Monocot	Summer Sedge	Carex aestivalis	67%	33%			3
Fern	Slender Cliffbrake	Cryptogramma stelleri	59%	25%	16%		5
Dicot	Smooth Sandwort	Minuartia glabra	38%	25%	38%		8
Monocot	Wild Leek	Allium tricoccum	33%	33%	33%		3
Fern	Goldie's Wood-fern	Dryopteris goldiana	33%	33%	33%		3
Dicot	Douglas' Knotweed	Polygonum douglasii	29%	43%	29%		7
Dicot	Pale Jewel-weed	Impatiens pallida	50%		50%		4

Results

Our goal was to identify a minimum of **20 exemplary occurrences per 19 bedrock/elevation combinations** totaling to a minimum goal of 380 total occurrences distributed across the ecoregion. After examining the distribution of larger (>25 acre) steep slope occurrences we redistributed the 20-per-type numeric goal across the geology/elevation gradients in proportion with the number of possible occurrences acres (Table 3).

We identified 829 critical occurrences, 449 more than we needed to meet our minimum goal. With one exception we met our goals for identifying sites within each bedrock/elevation combination as well and thus, the portfolio is generally sufficient with respect to steep slopes except on low moderately calcareous or mafic bedrock (Table 3).

Candidate and Supporting occurrences

In addition to the critical occurrences, this analysis encompassed a large number of less notable, or poorly surveyed steep slopes that did not meet our screening criteria for being a critical feature. We accounted for their potential contributions to biodiversity by sorting them into two categories and totaling the amounts of each.

- *Candidate occurrence:* A feature that met the criteria for size and landscape context but for which we had no verification or corroboration as to their condition and biodiversity contribution. Many of these may be added to the portfolio after ground verification and are a logical place to focus inventory efforts.
- *Supporting occurrence:* A feature that did not meet the criteria for size and landscape context but may play a supporting role in supplementing the critical sites.

Many of the candidate and supporting occurrences already occur on protected reserves and thus are part of the *defacto* conservation picture for the region. As protected examples may serve to bolster biodiversity protection we included them in some of our analyses for context. However, c*andidate and supporting occurrences were not counted as contributing to the portfolio goals.*

The importance of recognizing the *defacto* examples was provided by the few, single-occurrence steep slope species that were known only from small occurrences (e.g. northern stick seed).

Sites and Occurrences

In this analysis a "site" could consist of either a survey site associated with an exemplary individual steep slope feature or an important natural complex comprised of many co-occurring steep slope features. In some of the latter cases, not every individual slopes met our selection criteria but most did and as an aggregate the area did as well. This allowed a few smaller slopes to qualify as "critical".

Counting the steep slope occurrences can be deceptive. Many of the steep features occur in close proximity to each other and might be more usefully thought of as one mega-occurrence. If the portfolio is counted by survey sites instead of individual occurrences, it totals to a set of 346 sites containing not only the 829 critical occurrences but also another 1037 small occurrences. Within the survey sites this amounts to 134,198 acres of steep slope features (Appendix 1).

The selected critical occurrences accounted for 10% by count, and 27% by area, of all the steep slopes features in the ecoregion. Protected candidate occurrences account for another 30% by count and 27% by area.

Table 3: Portfolio Summary based on steep slope occurrences over 25 acres. The only insufficiencies are for moderately calcareous or mafic slopes below 800'. Legend below.

ELEV.	BEDROCK	% Goal	CU	CP	PC	OU	T	%	TC	D	S
0-800'	Sedimentary	37	83	17	52	272	424	10%	100	63	Y
	Calcareous	2	8	6	2	11	27	1%	14	12	Y
	Granitic	19	21	20	91	91	223	5%	41	22	Y
	Mod Calc/ Mafic	14	10	2	66	90	168	4%	12	-2	N
800-2500'	Sedimentary	121	227	41	131	1000	1399	32%	268	147	Y
	Calcareous	8	23	9	11	53	96	2%	32	24	Y
	Granitic	62	36	42	362	277	717	16%	78	16	Y
	Ultramafic	2	2	2		5	9	0%	4	2	Y
	Mod Calc/ Mafic	37	66	32	131	199	428	10%	98	61	Y
2500-4000'	Sedimentary	22	12	34	74	135	255	6%	46	24	Y
	Granitic	32	16	51	221	88	376	9%	67	35	Y
	Ultramafic	2	4	13		7	24	1%	17	15	Y
	Mod Calc/ Mafic	21	11	28	168	37	244	6%	39	18	Y
4000+'	Sedimentary	1	1	7	3		11	0%	8	7	Y
	Granitic	1	0	1			1	0%	1	0	Y
	Mod Calc/ Mafic	2	0	4	1		5	0%	4	2	Y
Total		380	520	309	1313	2265	4407	1005	829	449	Y

%Goal = the portfolio goal
CU = Critical occurrences that occur on lands managed for extraction or are unprotected.
CP = Critical occurrences that occur on lands explicitly protected for biodiversity.
PC = Candidate occurrences that occur on lands explicitly protected for biodiversity.
PS = Supporting occurrences that occur on lands explicitly protected for biodiversity.
OU = Other occurrences that occur on lands managed for extraction or are unprotected.
T = total # of occurrences larger than 25 acres,
% = percent of the total occurrences in this bedrock/elevation combination,
TC = total critical occurrences (unprotected + protected)
D = the difference between the amount identified for the portfolio and the goal,
S = portfolio sufficiency in finding occurrences to represent this element

Current Protection Levels of Critical Features.

The critical steep slope occurrences amount to 10% by count and 27% by acreage of all the steep slope features in the ecoregion – amounting to roughly ¼ of 1% of the entire region by acreage (Table 4). Currently 64,000 acres are on lands protected for biodiversity leaving 70,250 acres remaining for active protection efforts.

Table 4. Protection levels of the portfolio by acreage and count .Legend as for Table 3.

	CU	CP	PC	PS	OU	Total
Total Acres	70,249	63,949	106,818	25,826	221,169	488,011
% Acres	14%	13%	22%	5%	45%	100%
Total Count	1272	594	1680	3868	10852	18266
% Count	7%	3%	9%	21%	59%	100%

Protection levels vary with elevation. Above 4000 ft critical slopes are virtually all protected. Below 2500 ft., slopes are mostly less than 60% protected with sedimentary, calcareous and shale occurrences being less than 30% protected. The exception is the rare ultramafic slopes that have a 90% protection level (Figure 4 & 5.).

Figure 4. Protection levels of critical occurrences by bedrock/elevation combinations

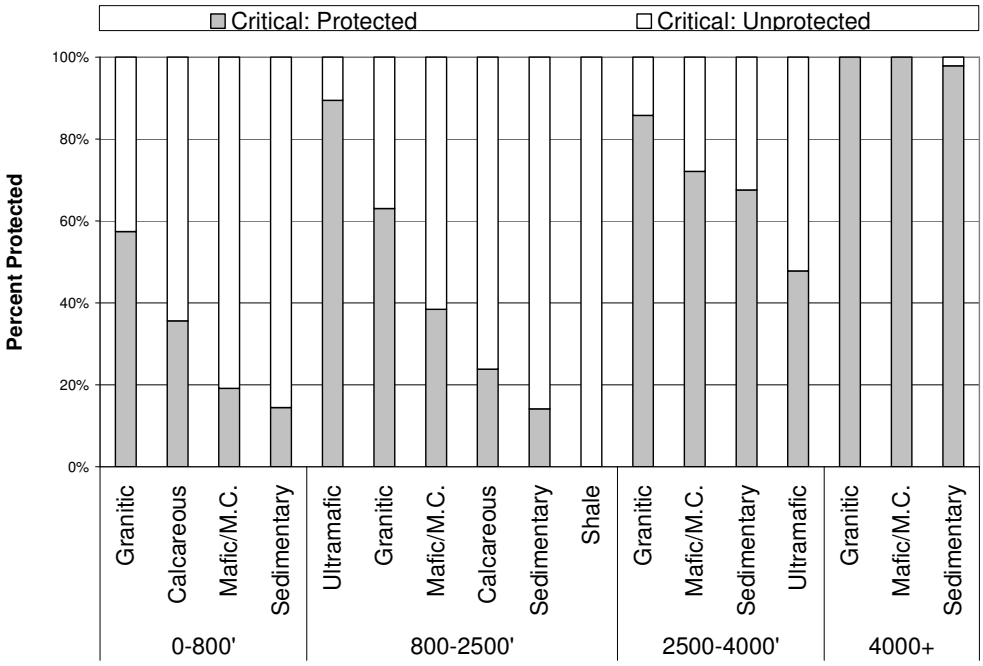
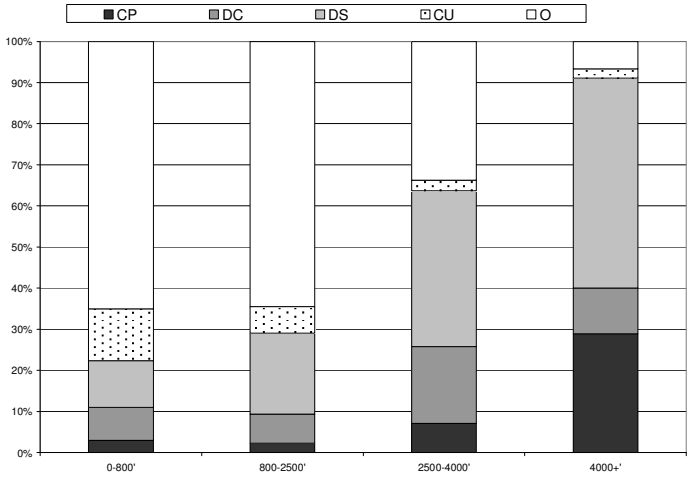
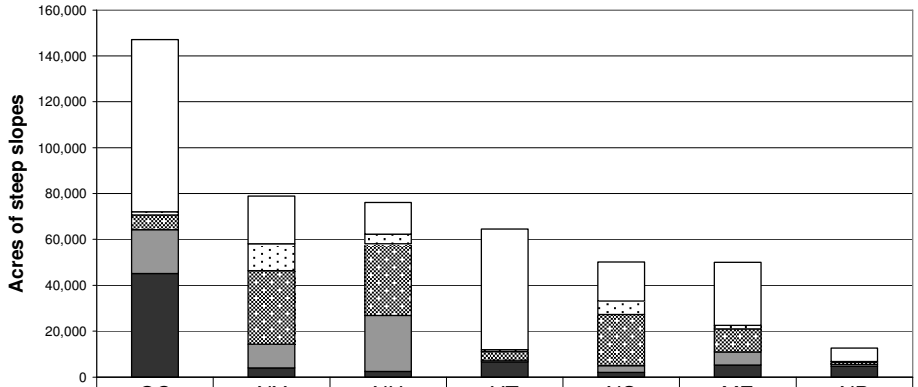


Figure 5. Correlations between Protection level and Elevation zone: over 90% of the alpine slopes are in reserves while only 21% of slopes at low elevations are protected.



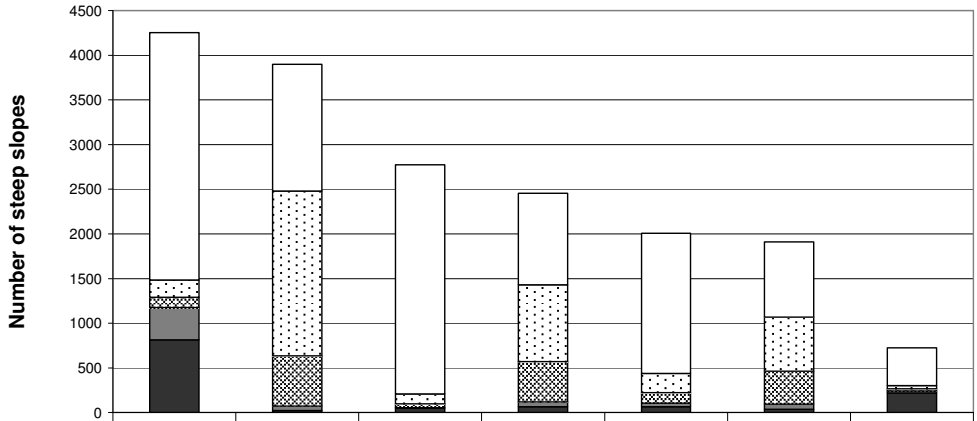
Protection levels vary by state and province in accordance with the relative amount of steep slopes present. Quebec leads the region in both acreage and protection level. New York, New Hampshire, Nova Scotia and Maine all have significant amounts of candidate site that would benefit from inventory and evaluation (Figures 6 & 7.)

Figure 6.Protection levels of critical occurrences (CU, CP) and protected candidate (DC) or protected supporting (DS) steep slope occurrences. Chart shows total acreage by state or province. Legend as for Table 3



	QC	NY	NH	VT	NS	ME	NB
OU	75,060	20,893	13,800	52,684	16,973	27,571	5,849
DS	1,364	11,726	4,212	770	5,948	1,514	292
DC	6,509	32,032	31,223	3,794	22,330	9,998	932
CP	19,043	10,370	24,361	661	2,846	5,784	885
CU	45,181	3,931	2,480	6,637	2,067	5,222	4,666

Figure 7.Protection levels of critical (CU), critical protected(CP), protected candidate (DC) or protected supporting (DS) steep slope occurrences. Chart shows total number by state or province. Legend as for Table 3



	QC	NY	VT	NS	ME	NH	NB
OU	2768	1419	2562	1026	1569	841	422
DS	191	1846	114	861	214	606	36
DC	117	562	40	450	118	369	24
CP	362	51	8	52	39	59	23
CU	814	21	48	67	66	36	219

Summary

Of the half million acres of steep slopes in the ecoregion, this analysis identifies e portfolio highlights the 346 sites most critical for biodiversity conservation (10 percent by number or 27 percent by area). The key sites, are well distributed across bedrock and elevation gradients and are about 1/3 protected (3% by count /16%) by area. Conservation is needed mostly for low elevation slopes on calcareous and sedimentary features.

Sites: Site lists are found in Appendix A