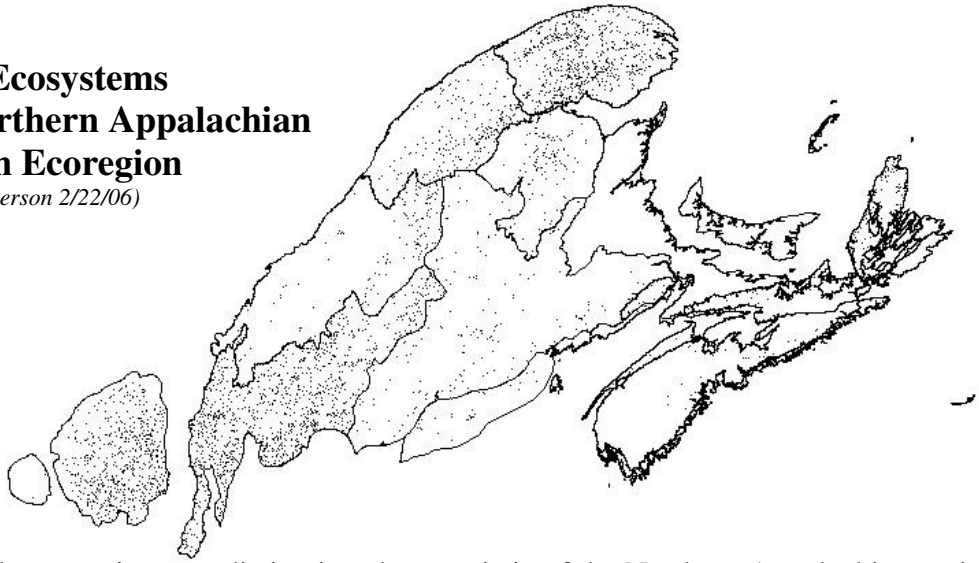
Summit Ecosystems in the Northern Appalachian / Acadian Ecoregion

(final draft Anderson 2/22/06)



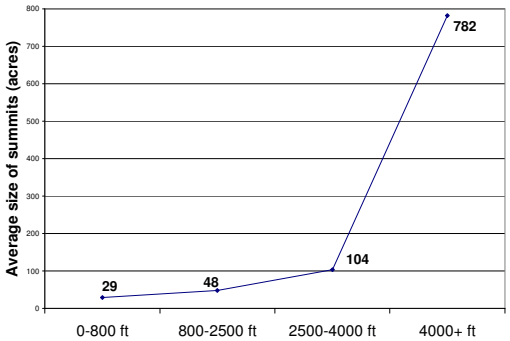
Rocky summits are a distinctive characteristic of the Northern Appalachian region which boasts over 100,000[1] examples of mountain peaks, bony ridges and stony hilltops. Some are dramatic features like the crest of Mt Katadin in Maine –the point of first light in the eastern US - others are simply hilltops in an otherwise flat plain. Concentrated along the backbone of ancient mountains, these well loved places are favorite haunts of ravens, buteos and naturalists availing themselves of the unique vantage point to contemplate the landscape.

Summits form where hard bedrock resists weathering. Thus, biodiversity differences among summits correlate strongly with bedrock types additionally influenced by elevation and climate. High elevation summits, composed of granitic rock or resistant quartsites, sport thin acidic soils, bouldery outcrops, sparse, stunted trees, and a distinct flora. Low elevation summits typically exhibit open-canopy woodlands and tend to be dry, thin soiled and fire-prone. Pines (jack, pitch, red or white) show a preference for these low rocky hilltops.

Overall, summits cover 3% of the ecoregion (2,758,928 acres), but 75% of them are smaller than 30 acres in size and the average summit is 26 acres (+- 55 acres). At high elevations summits aggregate and fuse into large contiguous features defining our important mountain ranges (Figure 1). The Gaspe, Adirondacks and Green/White Mountain subregions contain the largest summits of the region (28 of them over 1000 acres) including the 78 summits higher than 4000 feet that exhibit true alpine conditions.

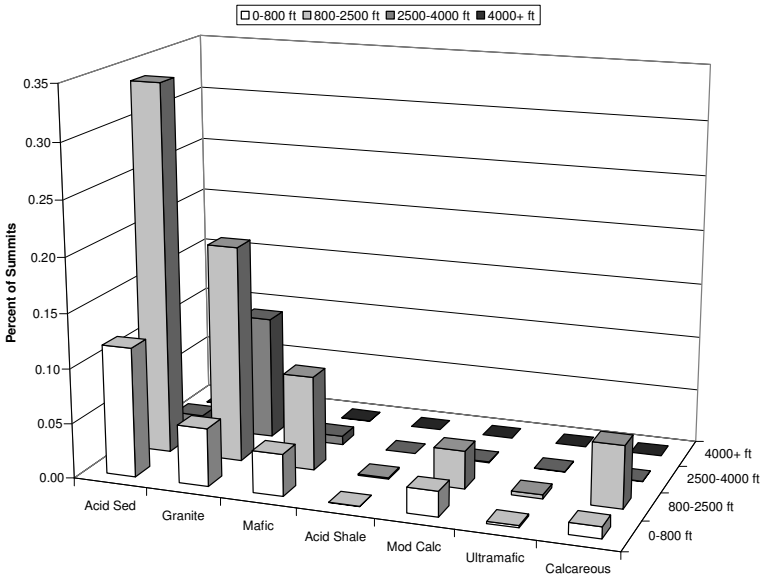
Figure 1. The relationship of summit size to acreage, percent, average size and elevation

Size class	Total Acres	Number	%	Ave Size
2-30 acres	666,208	79,695	76	8
30-70 acres	685,861	15,432	15	43
70-160 acres	722,828	7,200	7	98
160 + acres	684,030	2,418	2	251
	2,758,928	104,745	100%	



[1] Contiguous summits over 2 acres

Figure 2. The distribution of NAP/Acadian summits by bedrock and elevation.



Summit Biodiversity

Summits occur across all bedrock and elevation settings (Figure 2). Ecologists describe distinct summit communities on calcareous rock, shale, and ultra-mafic serpentine, although most occur on acidic bedrocks such as granite, anorthosite, or metamorphosed sandstones. Among the acidic types, floristic analysis distinguishes communities based on elevation zones and exposure. Short descriptions of common summit ecosystems are provided below (adapted from Basquill 2004, Anderson 1999).

Alpine summits: Mountain-top ecosystems at or above 4000 ft with a unique flora and a mosaic of snowbank, ridgetop, and meadow communities. Stunted spruce, known as "krumholz" and wind-blasted balsam fir forests are typical. Characteristic species include lance-leaved arnica, Boott's rattlesnake-root, dwarf white birch, mountain avens, wavy bluegrass, Robbins' cinquefoil and moths and butterflies such the Katahdin arctic or the White Mountain fritillary. Bicknell's thrush and American pipit nest in this setting.

Serpentine summits: Open barren communities on serpentine rock with soil toxic to many plants species. Plant rarities abound: minuartie de la serpentine, saxifrage del la Gaspe, gnaphale de Norvege, athyrie alpestre and green mountain maidenhair fern. The serpentine region of Quebec's Gaspe Peninsula hosts a small woodland caribou herd.

Montane spruce-fir summits: High elevation summits below the alpine zone but over 2500 feet occurring mostly on granitic or meta sedimentary bedrock. Subalpine fir forests, stunted spruce-fir woodlands and heath communities are common along with landslide and cliff features. Rarities include fir clubmoss, mountain sandwort, small-flowered rush and long-tailed shrew

Calcareous summits: Mid elevation summits on calcareous bedrock with diagnostic outcrop and talus communities. Plant rarities include ram's-head lady's-slipper, daisy

fleabane and smooth cliff fern. Hibernacula and populations of Indiana and Small-footed bats are associated with summit and slope regions on calcareous substrates.

Low - mid elevation summits: On acidic substrates jack pine, pitch pine, red pine or oak woodlands predominate over open sparse grasslands and heath communities. Smooth sandwort, silverling, and slender cliffbrake are associated plant rarities. Peregrine falcons often nest on these features.

Coastal zone summits: Very low elevation resistant outcrops on acidic substrates. White and red spruces predominate with fir and white cedar. Summits in the wave zone may have sea-spray tolerant plants.

Summit Portfolio Summary

The screening criteria used to locate and identify the summits most critical to maintaining biodiversity required that each qualifying example:

- Was large and contiguous: minimum 30 acres, preferably over 70 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 almost 1000 ground inventory points representing 204 species found on or directly adjacent to a summit. Of the species examined, many were only recorded from summits over 70 acres but none were restricted to summits under 30 acres (Table 1) suggesting that larger summits were more likely to contain a full complement of associated species. Notable species in this group were most alpine plants and rare species such as silverling *(Paronychia argyrocoma)*, Bicknell's thrush, and long-tailed shrew. On average 94% of the occurrences for any given species were likely to be on a summit over 30 acres..

In agreement with the earlier discussion of biodiversity, the presence of certain species on certain summits correlated strongly with differences in elevation (Table 2) and bedrock (Table 3). To make sure that we represented all summit biodiversity we set goals for locating and selecting a minimum of 20 qualifying examples for each of 22 bedrock/elevation combination. This amounted to a minimum goal of identifying 440 total occurrences distributed across the ecoregion. After examining the distribution of larger (>30 acre) summit occurrences we redistributed the 20-per-type numeric goal across the geology/elevation gradients in proportion with the number of possible occurrences (Table 4).

Table 1. Species associated with summits over 30 acres, final column gives the # of occurrences.

STANDARD NAME	COMMON NAME	<30 acres	<70 acres	<160 acres	160+ acres	#
Asplenium trichomanes-ramosum	Green Spleenwort				100%	3
Calamagrostis stricta	Bentgrass				100%	3
Carex atratiformis	Black Sedge				100%	5
Castilleja septentrionalis	Pale Painted-cup				100%	5
Crotalus horridus	**Timber Rattlesnake**				100%	5
Diphasiastrum sitchense	Alaskan Clubmoss				100%	3
Huperzia selago	Fir Clubmoss				100%	4
Minuartia groenlandica	Mountain Sandwort				100%	13
Solidago cutleri	Cutler's Goldenrod				100%	12
Sorex dispar	**Long-tailed or Rock Shrew**				100%	3
Vaccinium caespitosum	Dwarf Blueberry				100%	3
Vaccinium uliginosum	Alpine Bilberry				100%	6
Huperzia appalachiana	Appalachian Fir-clubmoss			7%	93%	14
Catharus bicknelli	**Bicknell's Thrush**			9%	91%	11
Luzula parviflora	Small-flowered Rush			11%	89%	9
Empetrum nigrum	Black Crowberry			14%	86%	22
Diapensia lapponica	Diapensia			9%	86%	47
Empetrum atropurpureum	Purple Crowberry			16%	84%	19
Geocaulon lividum	Northern Comandra			24%	76%	17
Paronychia argyrocoma	Silverling			25%	75%	4
Rhododendron lapponicum	Lapland Rosebay			25%	75%	8
Solidago multiradiata	Alpine Goldenrod			25%	75%	12
Osmorhiza chilensis	Mountain Sweet-cicely			33%	67%	3
Pinus banksiana	Jack Pine			33%	67%	3
Prenanthes nana	Dwarf Rattlesnake-root			38%	63%	8
Empetrum eamesii	Purple Crowberry			40%	60%	5
Dicentra canadensis	Squirrel-corn			67%	33%	3
Epilobium ciliatum	Ciliated Willow-herb			67%	33%	3
Calamagrostis stricta	Northern Reedgrass			100%		3
Trichophorum cespitosum	Deer's Hair Sedge		6%	18%	76%	17
Agrostis mertensii	Boreal Bentgrass		6%	13%	81%	16
Juncus trifidus	Arctic Rush		10%	10%	80%	10
Phyllodoce caerulea	Mountain Heath		13%		88%	8
Cassiope hypnoides	Moss Bell-heather		14%		86%	7
Prenanthes boottii	Boott's Rattlesnake Root		14%	7%	79%	14
Calamagrostis pickeringii	Pickering's Reed Bent-grass		14%	29%	57%	7
Paronychia argyrocoma	Silverling		14%	29%	57%	7
Polygonum douglasii	Douglas' Knotweed		14%	43%	43%	7
Geum peckii	Mountain Avens		16%		84%	19
Minuartia glabra	Smooth Sandwort		18%	36%	45%	11
Deschampsia atropurpurea	Mountain Hairgrass		25%		75%	4
Woodsia glabella	Smooth Cliff Fern		29%	29%	43%	7
Rhododendron lapponicum	Lapland Rosebay		38%		63%	8
Cryptogramma stelleri	Slender Cliffbrake		50%	25%	25%	4
Impatiens pallida	Pale Jewel-weed		50%	33%	17%	6

Table 2. Species -Summit relationships with respect to elevation (species with 5+ occurrences)

GNAME	GCOMNAME	0-800 ft.	800-1700 ft.	1700-2500 ft.	2500-4000 ft.	4000+ ft.	Total
Anarta melanopa	**A Noctuid Moth**					100%	8
Betula glandulosa	Dwarf Birch					100%	12
Cassiope hypnoides	Moss Bell-heather					100%	7
Castilleja septentrionalis	Pale Painted-cup					100%	5
Phyllodoce caerulea	Mountain Heath					100%	8
Rhododendron lapponicum	Lapland Rosebay					100%	16
Salix herbacea	Dwarf Willow					100%	5
Silene acaulis var. exscapa	Moss Campion					100%	7
Loiseleuria procumbens	Alpine Azalea				8%	92%	13
Geum peckii	Mountain Avens				11%	89%	19
Trichophorum cespitosum	Deer's Hair Sedge				12%	88%	17
Betula minor	Dwarf White Birch				14%	86%	22
Poa fernaldiana	Wavy Bluegrass				14%	86%	22
Salix uva-ursi	Bearberry Willow				14%	86%	29
Arctostaphylos alpina	Alpine Bearberry				14%	86%	7
Hierochloe alpina	Alpine Sweet Grass				18%	82%	28
Prenanthes boottii	Boott's Rattlesnake Root				21%	79%	14
Luzula spicata	Spiked Woodrush				23%	77%	13
Prenanthes nana	Dwarf Rattlesnake-root				25%	75%	8
Solidago cutleri	Cutler's Goldenrod				25%	75%	12
Empetrum nigrum	Black Crowberry				27%	73%	22
Diapensia lapponica	Diapensia				30%	70%	47
Carex bigelowii	Bigelow's Sedge				31%	69%	42
Agrostis mertensii	Boreal Bentgrass				31%	69%	16
Agrostis borealis	Boreal Bentgrass				33%	67%	18
Solidago multiradiata	Alpine Goldenrod				36%	64%	14
Juncus trifidus	Arctic Rush				40%	60%	10
Catharus bicknelli	**Bicknell's Thrush**				82%	18%	11
Luzula parviflora	Small-flowered Rush				89%	11%	9
Vaccinium uliginosum	Alpine Bilberry				100%		6
Empetrum atropurpureum	Purple Crowberry			8%	38%	54%	24
Carex scirpoidea	Canadian Single-spike Sedge			10%	40%	50%	10
Geocaulon lividum	Northern Comandra			12%	47%	41%	17
Calamagrostis pickeringii	Pickering's Reed Bent-grass			14%	29%	57%	7
Vaccinium boreale	Alpine Blueberry		8%	3%	29%	61%	38
Huperzia appalachiana	Appalachian Fir-clubmoss		14%		21%	64%	14
Minuartia groenlandica	Mountain Sandwort		15%		62%	23%	13
Paronychia argyrocoma	Silverling		18%	18%	55%	9%	11
Woodsia glabella	Smooth Cliff Fern		29%	29%	43%		7
Myotis leibii	**Eastern Small-footed Myotis**		63%	25%	13%		8
Minuartia glabra	Smooth Sandwort		64%	27%	9%		11
Polygonum douglasii	Douglas' Knotweed		86%		14%		7
Falco peregrinus	**Peregrine Falcon**	11%	33%	33%	22%		9
Calamagrostis stricta	Northern Reedgrass	14%	29%		43%	14%	7
Grand Total of all EOs		1%	11%	7%	25%	56%	939

Table 3. Species to summit relationships with respect to Bedrock. Sd = sedimentary or metasedimentary, Gr = Granitic, Ma = mafic or intermediate granitic, Mc = moderately calcareous. Ca = calcareous, Um = ultra mafic (e.g. serpentine) # = total # of occurrences. Percentages indicate the % of the total occurring on this bedrock type.

STANDARD NAME	COMMON NAME	Sd	Gr	Ma	Mc	Ca	Um	#
Adiantum aleuticum	Aleutian Maidenhair-fern						100%	2
Adiantum viridimontanum	Green Mt Maidenhair-fern						100%	2
Moehringia macrophylla	Large-leaved Sandwort						100%	2
Erigeron hyssopifolius	Daisy Fleabane		50%			50%		2
Astragalus robbinsii minor	Blake's Milk-vetch	50%				50%		2
Myotis sodalist	**Indiana Bat**			50%		50%		2
Cypripedium arietinum	Ram's Head Lady's-slipper			20%	20%	60%		5
Solidago multiradiata	Alpine Goldenrod		7%	86%	7%			14
Huperzia appalachiana	Appalachian Firmoss		43%	50%	7%			14
Oryzopsis pungens	Slender Mountain-rice	50%			50%			2
Juncus trifidus	Arctic Rush	30%		70%				10
Prenanthes nana	Dwarf Rattlesnake-root			100%				8
Trichophorum cespitosum	Deer's Hair Sedge		18%	82%				17
Empetrum nigrum	Black Crowberry	18%	5%	77%				22
Agrostis mertensii	Northern Bentgrass	13%	19%	63%	6%			16
Polygonum douglasii	Douglas' Knotweed		100%					7
Minuartia glabra	Smooth Sandwort	9%	91%					11
Minuartia groenlandica	Mountain Sandwort	38%	54%		8%			13
Loiseleuria procumbens	Alpine Azalea	77%	15%	8%				13
Luzula spicata	Spiked Woodrush	77%	15%	8%				13
Woodsia glabella	Smooth Woodsia	57%	29%			14%		7
Phyllodoce caerulea	Mountain-heath	75%	25%					8
Agrostis borealis	Boreal Bentgrass	78%	22%					18
Geum peckii	Mountain Avens	79%	21%					19
Arctostaphylos alpine	Alpine Bearberry	86%	14%					7
Luzula parviflora	Small-flowered Rush	89%	11%					9
Total of all Occurrences		48%	26%	21%	2%	1%	1%	939

Results

Our goal was to locate a minimum of **20 exemplary occurrences per 22 bedrock/elevation combinations.** Our results identified 1,938 critical occurrences, four times more than we needed to meet our total goal (Table 4). With small exceptions for shale and mid elevation calcareous summits we met our adequacy goals for identifying sites within each combination as well, thus, the portfolio is fully sufficient with respect to summits.

Defacto Candidate and Supporting Occurrences

In addition to the critical occurrences, this analysis encompassed a large number of less notable or poorly surveyed summits 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. 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. Because conserved examples of these occurrences may serve to bolster biodiversity protection we included them for context in some of our analyses. However, c*andidate and supporting occurrences were not counted as contributing to the portfolio goals.*

Table 4: Portfolio Goal Summary based on Summit occurrences over 30 acres. The only inadequacy is for moderately calcareous or mafic slopes below 800'. Legend below.

ELEV.	BEDROCK	% Goal	CU	CP	PC	PS	OU	T	%	D
0-800'	Sedimentary	26	149	22	45	8	1250	1474	6%	145
	Calcareous	2	36	9	2		57	104	0%	43
	Granitic	14	28	25	56	4	662	775	3%	39
	Mafic	6	22	6	18	1	278	325	1%	22
	Mod calc.	3	36		6		146	188	1%	33
	Ultramafic	2	1	1				2	0%	0
800-2500'	Sedimentary	176	714	89	413	26	8765	10007	40%	627
	Shale	2	1				6	7	0%	-1
	Calcareous	27	72	29	34	2	1404	1542	6%	74
	Granitic	94	105	80	1729	109	3315	5338	21%	91
	Mafic	38	104	49	541	23	1464	2181	9%	115
	Mod calc.	16	18		31	2	837	888	4%	2
	Ultramafic	2	18	6	2		70	96	0%	22
2500-4000'	Sedimentary	12	61	46	115	4	432	658	3%	95
	Calcareous	2		1	2		27	30	0%	-1
	Granitic	16	30	37	460	13	354	896	4%	51
	Mafic	8	41	67	245	5	74	432	2%	100
	Mod calc.	2	2		1		39	42	0%	0
	Ultramafic	2	4	9	1		9	23	0%	11
>4000'	Sedimentary	2		5	9			14	0%	3
	Granitic	2		8	3			11	0%	6
	Mafic	2		7	10			17	0%	5
Grand Total		453	1442	496	3723	197	19189	25050	440	1485

%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
D = the difference between the amount identified for the portfolio and the specified goal.

Sites and Occurrences

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

Counting occurrence numbers can be deceptive. Many of the summit features occur in close proximity to each other and might be more usefully thought of as one mega-occurrence then many adjacent occurrences. If the portfolio is counted by survey sites, it totals to a set of 393 sites, with each site containing from 1 to 413 critical occurrences (the latter being the Chic-Choc highlands of Quebec) and amounting to over 270,000 acres of summit features. The survey sites also contain another 3500 acres of the *defacto* candidate and supporting occurrences.

Current Protection Levels of Critical Features.

Critical summit occurrences amount to 2% by count and 9% by area of all the summit features in the ecoregion – thus amounting to roughly 0.03% of the entire region by acreage (Table 5). Currently 35% of the critical sites (95,041 acres) are on lands protected for biodiversity leaving 65% acres remaining for active protection efforts.

Table 5. Overall Summit Portfolio protection levels by acreage and count. Legend as for Table 4.

	CU	CP	PC	PS	OU	T
Total Acres	175,494	95,041	373,380	88,612	2,026,400	2,758,928
% Acres	6%	3%	13%	3%	73%	100%
Total Count	1459	895	3724	7387	91,280	104,745
% Count	1%	0.08%	3%	7%	87%	100%

Protection levels vary with elevation and bedrock type. Above 4000 ft critical summits are virtually all protected. Below 2500 ft summits are less than 40% protected (Figure 3). Granites, ultramafic, intermediate granite and mafic bedrocks are all close to 60% protected while calcareous, sedimentary and shale summits are all less than 40% protected (Figure 4). Across the ecoregion high elevation granitic summits occur largely on lands protected for biodiversity. In contrast low elevation, sedimentary hilltops largely occur on lands that are managed for extraction or wholly unprotected.

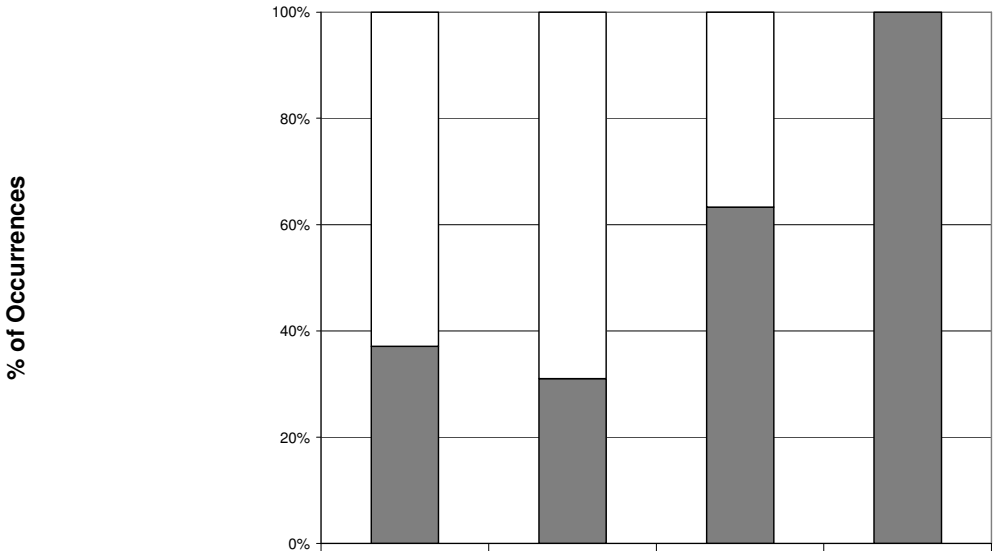
Across provinces and states Quebec had the most acreage of critical summits (over 600,000 acres) with about 50,000 acres of that currently on protected lands. New York was next with over 400,000 acres of critical summits and over half of that already on lands protected for biodiversity. Nova Scotia had that least acreage at roughly 125,000 acres with 4,000 acres on protected land (Figure 5). If counted by individual occurrences as opposed to total acreage, New York had the most and the best protected summits (Figure 6)

Summary:

Of the 104 thousand summits in the ecoregion, our portfolio highlights 3 percent that are the most critical to biodiversity conservation of summit communities and species. This important subset, found in 393 key sites, is well distributed across bedrock and elevation gradients and is 35% unprotected. About 65% (175K acres) of the summit

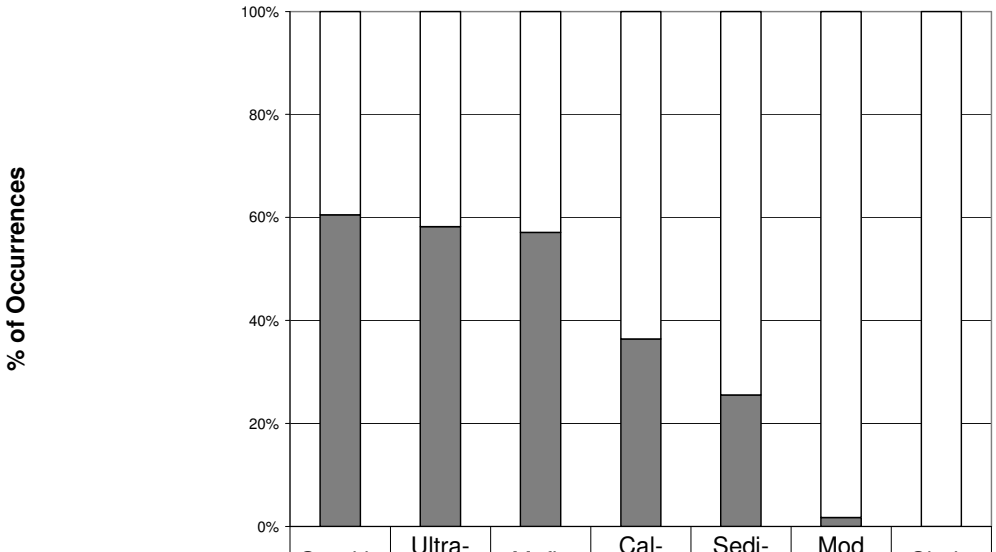
portfolio remains to be protected. Particularly urgent are low elevation and sedimentary summits

Figure 3. Protection level of critical occurrences by elevation. High elevations and granitic bedrocks have the highest protection. Low elevations and sedimentary settings have the lowest.



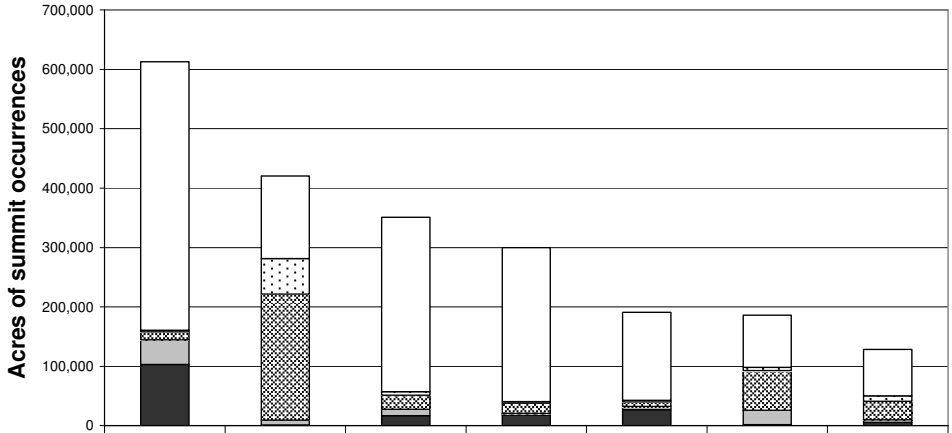
	0-800'	800-2500'	2500-4000'	>4000'
☐ Critical: Unprotected	278	1042	139	0
■ Critical: Protected	164	469	240	22

Figure 4. Protection level of critical occurrences by bedrock type (right). Granitic bedrocks have the highest protection while sedimentary settings have the lowest.



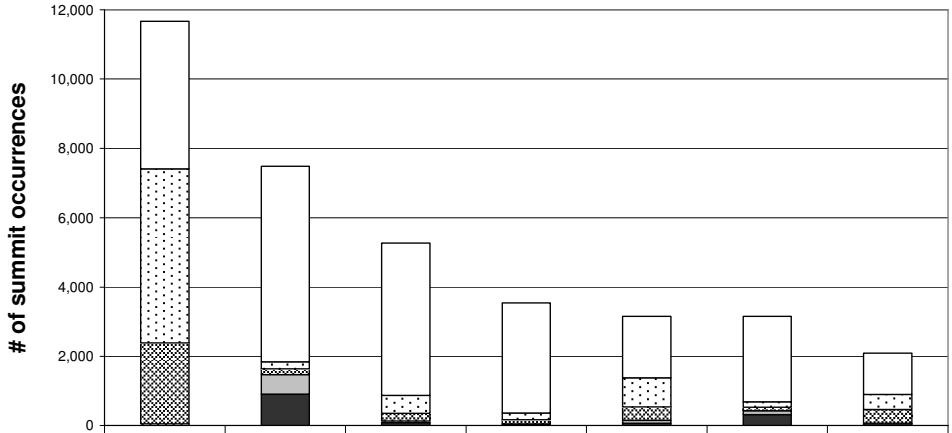
	Granitic	Ultra-mafic	Mafic	Cal-careous	Sedi-mentary	Mod calc.	Shale
☐ Critical: Unprotected	165	23	169	110	935	56	1
■ Critical: Protected	253	32	225	63	321	1	

*Figure 5.Protection levels of critical and defacto summit occurrences. Chart shows **Total Acreage** by state or province. Legend as for Table 4 (with slight difference PC = DP, PS = DS) Summits are all over 30 acres except in protected supporting category.*



	QC	NY	ME	VT	NB	NH	NS
OU	451,934	138,668	293,433	258,981	148,625	87,466	77,831
DS	3,014	59,870	5,828	2,662	2,270	5,762	9,206
DC	13,616	212,436	24,210	17,362	7,711	66,619	31,427
CP	40,975	7,902	10,528	2,436	5,193	23,930	4,079
CU	103,371	1,579	16,971	18,246	27,382	2,152	5,724

*Figure 6.Protection levels of critical and defacto summit occurrences. Chart shows **Total Number** by state or province. Legend as for Table 4 (with slight difference PC = DP, PS = DS). Only summits over 30 acres are shown except in protected supporting category.*



	NY	QC	ME	VT	NS	NB	NH
OU	4,263	5,644	4,389	3,178	1,773	2,463	1,196
DS	5,022	206	517	198	845	163	436
DC	2,338	163	230	117	383	94	399
CP	36	564	38	7	89	115	46
CU	14	908	90	46	64	318	18

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