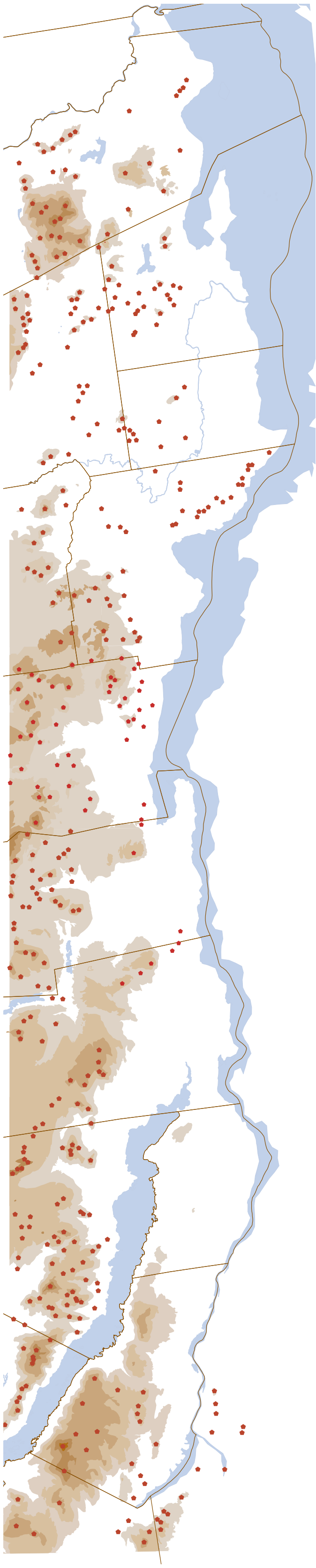
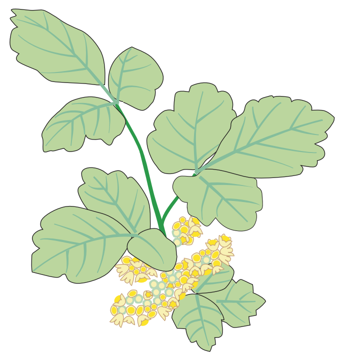


THE WEST CHAMPLAIN HILLS

PART I: GEOGRAPHY, RARE SPECIES, DISTURBANCE, THE TWO KINDS OF RICHNESS, AND THE CALCAREOUS OAK-HICKORY COMMUNITY



JERRY JENKINS

A JOINT WORKING PAPER, FROM THE

ADIRONDACK NATURE CONSERVANCY

AND THE

WILDLIFE CONSERVATION SOCIETY

DRAFT VERSION, APRIL, 2006; REVISED APRIL, 2008

GALLERY

The south summit has dry, hard rocks with little sign of rockfall or seepage. There were calcium indicators in the lower woods, but not on the upper slopes or near the summit.

TREMBLEAU MOUNTAIN, CHESTERTOWN, SOUTH SUMMIT FROM EAST

The south side of Rattlesnake is cliffy, with some fertile ravines; the summit (upper right) is open and acid. On the east side, roughly where indicated by the red line, there is a fertile bench with a rich oak-hickory forest.

RATTLESNAKE MOUNTAIN, WILLSBORO, FROM SOUTHEAST

A sheer, very open mountain, with sharp, talus-filled ravines which suggest recent rockfall. The woods at the base have been heavily logged. The western part of the summit, roughly in the area of the red circle, has had a recent fire and has many standing dead trees. There are few calcium indicators and no real oak-hickory community.

SKAGERACK MOUNTAIN, ESSEX, CHESTERTOWN, FROM SOUTH

DRAKE MOUNTAIN, CHESTERTOWN, FROM EAST

We visited only the south edge of these cliffs, near the red circle. There the rock was moist and crumbly, with a fertile, moist, wooded talus below it, and abundant maidenhair fern and a number of other calcium indicators.

WHIPPLE & FERGUSON MOUNTAIN, CHESTERTOWN, FROM SOUTHEAST

The summit areas of both of these mountains contain extensive oak-hickory glades with many calcium indicators. The notch between them is moist and contains a number of species of rich mesic woods. Allegheny vine, rare in the Adirondacks, occurred near the red circle.

Air photos taken 15 December, 2004, in partial overcast with snow showers. The light snow on the ground and low December light emphasize the rockiness of the hills, and make them seem less vegetated than they are. In the summer many of the rocks are covered by vegetation and cannot be seen.

North Boquet has hemlock-hardwoods forests on the lower slopes, open glades with moss and lichen slabs in the middle, and oak-hickory glades on the east slope near the summit.

NORTH BOQUET MOUNTAIN, ESSEX, FROM NORTHEAST

The summit area contains a dry oak-pine woods with mostly acid species. The mid-slopes contain oak woods with calcium indicators, and the ravine in the middle (red circle) contains a maple-basswood forest with many rich-mesic species.

COON MOUNTAIN, WESTPORT, FROM SOUTH

Rattlesnake and Discovery mountains are equally steep. Discovery, which has had several recent fires, is almost bare; Rattlesnake is lightly wooded. The north slope of Rattlesnake contains some older woods with large trees and many calcium indicators.

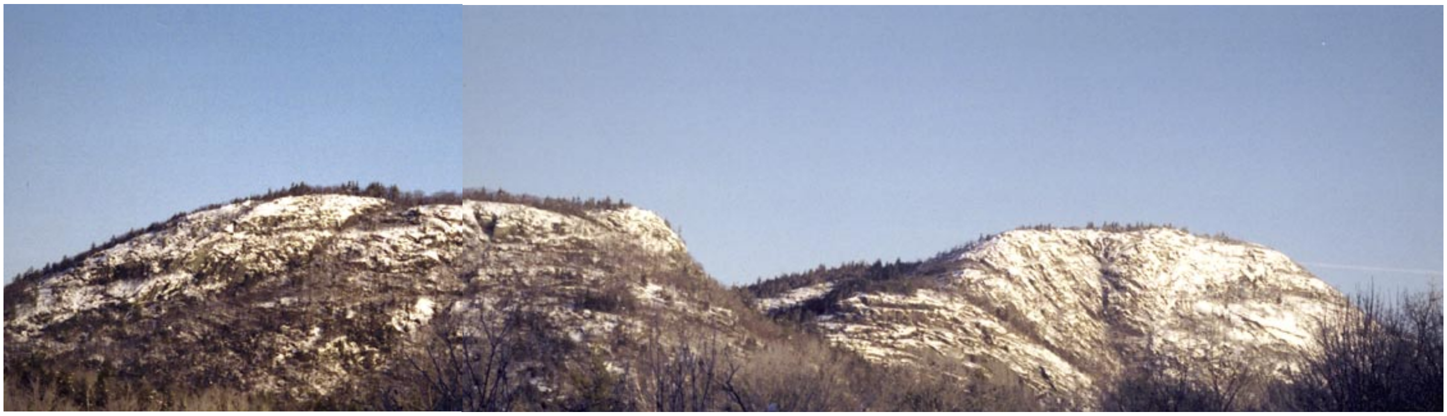
RATTLESNAKE (L), AND DISCOVERY (R) MOUNTAINS, WESTPORT, FROM NORTHEAST

The south face of Raven is formidably steep and ledgy but not particularly fertile. The lower cliffs are wetter than the upper and show signs of recent rockfall; they may avalanche in the winter.

RAVEN MOUNTAIN, LEWIS, FROM SOUTHEAST

The main summit of Discovery. The richest areas are the open woods (appearing as a fringe in this photo) to the west of the open summit. The bare rock and recently burned areas contain relatively few calcium indicators.

DISCOVERY MOUNTAIN, WESTPORT, FROM EAST



RATTLESNAKE (L), AND DISCOVERY (R) MOUNTAINS, WESTPORT, FROM EAST

Above, Rattlesnake and Discovery, though less that 1600 feet high, are barer than many alpine summits. Left, the south ravine at Coon Mountain, above the peak of the barn, contains fertile mesic woods and many calcium indicators.

COON MOUNTAIN, WESTPORT, FROM SOUTH

WHIPPLE MOUNTAIN, ESSEX, FROM SOUTHEAST

CONTENTS

This is a report on the West Champlain Hills, the oak-hickory communities within them, and on a particular ecological pattern, here referred to as dry richness, that they exhibit.

In 2002 we believed that the rich floras in the Champlain Valley were in the limy sites, and the limy sites were mostly on the Vermont shore. We knew of rich sites in New York on nonlimy rocks but thought they were anomalies. They were not.

Field work for this study was done at fourteen sites in the Champlain Valley and two outside of it in 2002, 2004, and 2005. It was augmented by previous fieldwork, over a period of twenty years, at a dozen or more other sites in both Vermont and New York.

The West Champlain Hills are low, bare, rugged, igneous, calcium-rich, and botanically diverse. No place else in the Northeast is like them.

The West Champlain Hills flora is a mosaic flora with southern calcareous, northern calcareous, and northern and southern acid elements. It is also an island flora, discontinuously distributed and sharply differentiated from the general regional flora, and noteworthy for the number of rare and scarce species.

Sadly but revealingly, the bryophytes of these unusual hills are very ordinary.

The West Champlain Hills have three signature vegetation types: dry rocky woods, moist coves and ravines, and open rocky slabs and summits. The first is both distinctive and diverse, the second diverse but less distinctive, and the third, for all its beauty, neither distinctive nor diverse.

The calcareous oak-hickory community in the West Champlain Hills has four ecological peculiarities that separate it from other calcareous woods in the region: it is xeric, found on igneous rocks, associated with convex terrain, and does not exclude acid species. It is also rich in southern species and often associated with fires but it is not unusually southern nor unequivocally fire dependent.

The ravines of the West Champlain Hills exhibit an ordinary and fairly well understood type of moist richness associated with concave terrain and groundwater movement. Their tops exhibit a less common and more puzzling type of dry richness that may depend on sheet wash and root-zone processes. The expression of dry richness apparently depends on the vegetation; it is strong in oak-hickory forests, suppressed by pines, and absent altogether from open bare rocks.

Coon Mountain is a very typical West Champlain Hill, with young woods at the base, acid woods at the summit and on the dry ledges, somewhat calcareous oakwoods on the southeastern slopes, and strongly calcareous maple woods in a narrow ravine.

Paintball Hill, a small hill twenty miles west of the Champlain Valley, illustrates the way vegetation is arranged at dry-rich sites. Its vascular plants include many calcium indicators, and their diversity increases from the base of the hill to the summit in an orderly way. The bryophytes include only a single calcium indicator; their diversity fluctuates with the availability of rocks and logs, and is unrelated to that of the vascular plants.

Most Champlain oak-hickory communities have been logged, have some weed invasion, and have had fires in the past. All are impacted by acid deposition and deer, and all will soon be affected by climate change. My guess is that weeds and acids are not serious threats. Likewise, light logging does not seem to be a threat but moderate logging may be. Fire is at least tolerated and perhaps needed, but may decrease diversity in the short term. Climate change and deer will certainly be consequential, and may well interact. The oak-hickory communities are likely to survive climate warming, but may lose diversity in the process and may not be able to expand because of pressure from deer.

The oak-hickory communities of the West Champlain Hills are lovely, highly diverse, sharply distinct from the more common communities, little impacted by human activity, and positioned by reason of their ecology and composition to survive in a climate-change century. They are largely in private ownership, and thus neither protected against logging nor permanently accessible to the public.

1 INTRODUCTION

This report describes the results of field studies on about forty rocky hills and small mountains on the west shore of Lake Champlain. The studies were intended to examine the oak-hickory woods of eastern Essex County—probably the Adirondacks' least-known plant community—and to look for rare species and exemplary sites.

The study found both. By 2008 we had located over 30 sites with oak-hickory forests and over 500 records of species that are rare or uncommon in northern New York. The oak-hickory forests were, as we had expected, a special and isolated community in the Champlain Valley and that, like many other special communities, they tended to have uncommon species.

The study found an unusual ecology as well. The oak-hickory woods were regularly associated with calcareous bedrock and, as a result, their overall diversity was quite high. Further, some of this diversity was of an unusual kind, different in geography and pattern from the diversity we commonly encounter in fertile northern forests.

These results were both unexpected and suggestive. They showed that the oak-hickory forests of the eastern Adirondacks were far more complex than we had realized, and were in fact more diverse and richer in rarities than any forests in the Adirondack Park. And they suggested that there were two kinds of diversity in the Champlain Valley. The commoner one, associated with calcareous maple-basswood forests, I will call *moist diversity.* The rarer one, associated with calcareous oak-hickory forests, I call *dry diversity.*

I have two goals in this paper. The first is to report on what we have learned about the West Champlain Hills. The second is to suggest that dry diversity is widespread, significant, and distinct. It occurs in many or most of the northeastern states, is associated with rare communities and rare species, and is separate in pattern, floristics, and ecology from wet diversity. The sites where it occurs contain unusual groups of species maintained by unusual processes, and deserve to be valued and protected accordingly.

The work I describe here grew out of conversations with Bill Brown and Chris Maron of the Adirondack Nature Conservancy. The Adirondack Nature Conservancy sponsored

A sample of the West Champlain Hills flora, showing eighteen species associated with dry, calcareous oak-hickory woods. All of these plants are uncommon or rare in both the Adirondacks and northern New York. Many are uncommon in Vermont as well.

SOME DISTINCTIVE DRY-RICH SITES AND SPECIES

the fieldwork and the data analysis. The Adirondack Communities and Conservation Program of the Wildlife Conservation Society, in which I work as a researcher, sponsored additional fieldwork and writing time. The Eddy Foundation kindly allowed us to use Black Kettle Farm as a field base for our 2007 work, and Harvard Forest provided time, though a Bullard Fellowship in 2007, to do a detailed analysis of the data. My own White Creek Field School provided the time necessary to do the maps and illustrations. Except for the maps on page 24-25, and the figures illustrating acid deposition and climate change on pages 48-49, all the maps and illustrations are new and published here for the first time.

This report is in three parts. Part I describes the West Champlain Hills and their flora, discusses the two types of richness, and summarizes what I learned about the condition of the West Champlain Hills and their importance for conservation. Part II summarizes the scientific results and gives a quantitative analysis of the community. Part III gives descriptions and species lists for each of the study sites.

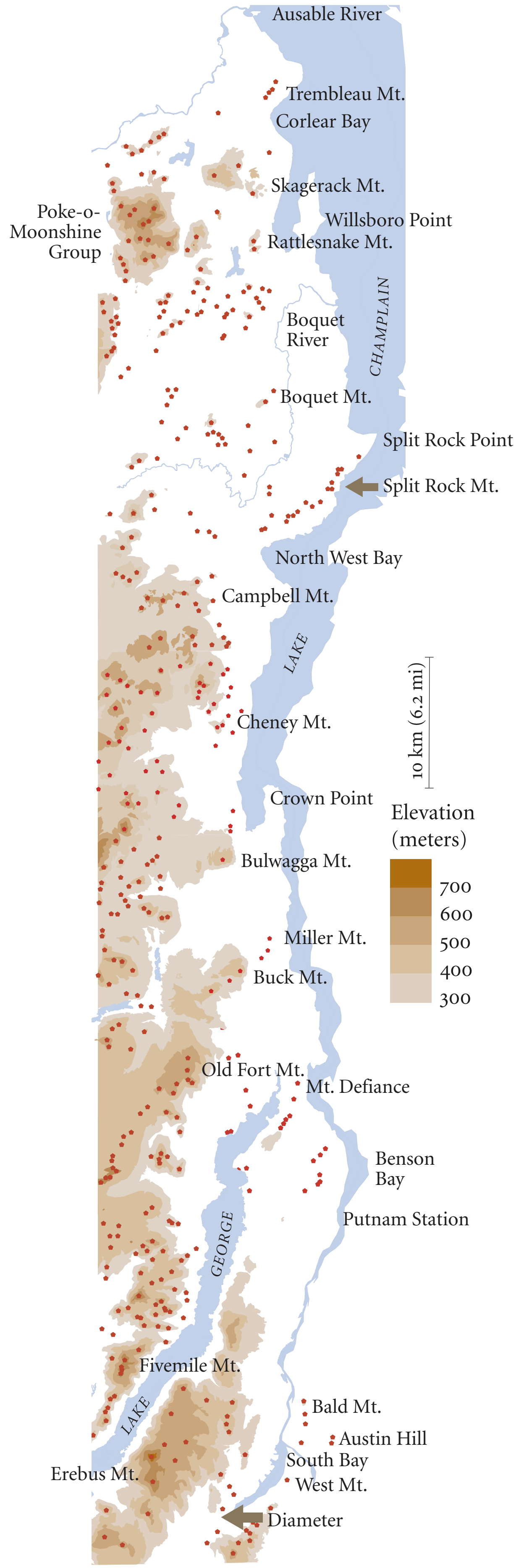
Part I of this report was originally written in 2005, revised in 2006, and then revised again in 2008. In 2005 we had records of about 125 ecologically specialized species from the Champlain Hills; now we have about 170 species. The text and figures in this version of the report have been revised to reflect our current knowledge.

2 WHAT WE KNEW IN 2002

Before turning to the results of the current survey, it is worth taking a moment to explain why the discovery of rich dry forests in the western Champlain Valley was surprising.

In 2002, when I began the work described here, I believed that most of the high diversity forests in the Champlain Valley were on carbonate rocks and that most of the carbonate rocks were on the Vermont side. This seemed to follow from the geological setting. The Champlain Valley is an elongate fault-block—a graben—that dropped below the highlands on either side in the mid-Jurassic rifting that created the Atlantic Ocean. When it dropped it took with it a layer of carbonate minerals.* These persisted along the east side of the lake, which had been geologically quiet since the rifting, but were eroded away from the west side during the lifting of the Adirondack Dome. As a result, the lake has, for the most

THE WEST CHAMPLAIN HILLS



Western Lake Champlain, from South Bay to the Ausable River, showing summits (in red), and lands over 300 meters elevation (shaded). The area shown in the map is about 120 km (75 mi) north to south, and extends 10 to 20 km (6 to 12 miles) west from the lake shore. The arrows indicate areas where there are major cliffs directly above the lake.

part, a limy east shore, and a nonlimy western one. Limy shores and ledges are found at many sites along the eastern shore and on the Vermont islands, but are rare on the west shore.

So far as I and other botanists knew in 2002, the plant geography of the lake reflected the distribution of lime. Most of the rich sites—Valcour Island, Warner Hill, Mt. Independence, Button Bay, Kelly Bay, Garden Island, Knights Island, Red Rock Point, and Appletree Point come quickly to mind—were on marble or dolomite. Since marbles and dolomites were rare on the west shore, we assumed that rich floras were equally rare.

There were, however, some west Champlain sites that did not fit this pattern. Mt. Defiance, Split Rock Mountain, and the Diameter are bare, dry, cliffy hills with igneous rocks. My field work in the 1980s and 1990s had shown that they nonetheless had rich floras with many calcium-indicating species. Some of these species, like sweet cicely and maidenhair fern, were common species that, while seeming out of place on dry igneous hills, were everyday plants in the Champlain Valley as a whole. Others—like fragrant sumac and the various rock cresses—were uncommon species that we had previously believed could only occur on the dolomites and marbles on the east side of the lake.**

At the time, these records made little impression on us. We believed richness meant carbonate rocks and carbonate rocks meant the Vermont shore. We did what scientists usually do in such cases: we voted with our preconceptions rather than the data, noted the records, and wrote them off as anomalies that for their own private reasons did not fit the regional pattern.

Twenty years and many hills later, this will no longer wash. We now know of over 30 eastern New York hills in which calcium-indicating plants occur in oak-hickory woods on igneous rocks. At these sites, besides the common calcium-requiring species of moist forests, there are at least 800 occurrences of some 74 drought-tolerant, calcium-requiring plant species that are not usually found in moist forests.

Clearly this is no longer a grab-bag of anomalies but rather a geographic pattern. What I suggest in this paper is that both these sites and their most characteristic species lie outside of the ecological boundaries of what we have called rich mesic forests and the moist calcareous flora and thus constitute a separate community, the *Champlain Hills Dry-Rich Community****, and a separate flora, the *dry calcareous flora*.

3 FIELD WORK

This report is based on field studies of about 40 sites in between 2002 and 2007. These are augmented by collateral studies of several hills in the Taconics, the Hudson Valley, and Vermont, and

* The principle carbonate minerals are dolomite ($CaMg(CO_3)_2$) and calcite ($CaCO_3$); they occur either as sedimentary dolostones and limestones or as dolomitic and calcitic marbles. On the west shore they occur at Ticonderoga Point and Bluff Point, on Valcour and Garden Islands, within Ausable Chasm, and on few dolomite outcrops in the Plattsburgh area.

**Previous summaries of fieldwork and historical data for the western side of Lake Champlain include:

Jerry Jenkins, 1989. *Summary of Fieldwork on the West Shore of Lake Champlain, With Notes on Plant Communities, Rare Species, Geology, and Physiography.*

Ibid., 1990. *Preliminary Report on the Vegetation of the Fort Ticonderoga Association Property.*

Jerry Jenkins and Debbie Benjamin, 1993. *Clinton County Biological Inventory: Historic Records and Bibliographic Information.*

Jerry Jenkins, 1993. *Brief Summary Report on Rare Vascular Plants and Shoreline Types in Eastern Clinton County, New York.*

Copies of these reports and their supporting data are archived with the Adirondack Nature Conservancy in Keene Valley, New York.

***This community is similar or closely related to the communities called *dry oak-hickory forest/woodland* in Vermont; *hickory-hop hornbeam forest/woodland, yellow oak dry calcareous forest,* and *dry rich acidic oak forest* in Massachusetts; *red cedar rocky summit* in New York; and *oak-hickory/hop hornbeam/sedge lawn* by Natureserve. I call it the calcareous oak-hickory community out of prejudice against names with slashes and because it seems important to stress that it is a calcium-rich community.

previous studies in the Champlain Valley between 1983 and the present. The current studies concentrated on rocky hills, mostly under 600 meters in elevation, within a few miles of the lake shore. The field work was done by the author, assisted at various times by Barbara Lott, Celia Evans, Peter Jenkins, Patti Smith, Leah Nelson, Bill Brown, John Davis, and on two memorable trips by Brett Engstrom. The older studies were done, variously, for the Vermont Nature Conservancy, the Adirondack Nature Conservancy, and the New York Natural Heritage Program and concentrated on the islands and shores of the lake. Most of the previous work on the northern New York shore I did alone. In the southern part of the lake, on both the New York and Vermont shores, I often worked with Bob Zaremba, and on the northern Vermont shores and on Valcour and other islands with Peter Zika.

The fall fieldwork done in 2002, 2004, and 2006 provided a good characterization of the general composition of the oak-hickory flora, in which a number of the uncommon species develop in late summer. But it missed some of the spring species (violets, toothworts and other ephemerals, some early grasses), and it made the identification of the early summer sedges much harder and sometimes impossible. Our work in July and July 2007 caught many of the earlier species, and showed that the community was even more diverse than we had previously known.

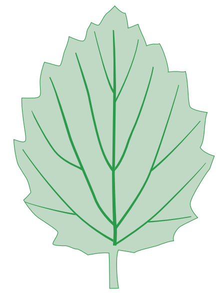
4 THE WEST CHAMPLAIN HILLS

The West Champlain Hills are a part of the larger Champlain Valley landscape. This section looks briefly at that larger landscape, and then at the features that make the West Champlain Hills unusual and allow them to support high-diversity forests.

General Geography. Lake Champlain as a whole has a flat northern end, a hilly western side and south end, and a flat eastern side. Its South Bay, which is completely within New York, has steep hills on the east and the spectacular cliffs and talus of the Diameter on the west. Bald Mountain, on the Vermont shore just to the north, is the only real mountain on the east side of the lake. From there to Benson Bay the east shore remains hilly; after that it flattens into a series of terraces and low hills and remains largely flat, save for few steep bluffs, all the way to Missisquoi Bay and the Canada border.

Because the Vermont shore of the lake is both flat and fertile, it was extensively cleared and farmed. As a result, *primary woods*—woods that have never been cleared—are rare on the Vermont shore, occurring mostly in the southern twenty miles of the lake and on a few rocky hills and headlands northwards. Elsewhere on the Vermont shore there are post-agricultural *secondary woods,* often pretty to look at but typically altered in composition, low

TWO CALCIUM-INDICATING SPECIES



Rafinesque's viburnum, *Viburnum rafinesquianum,* a characteristic shrub of dry, open calcareous slopes and ridgetops. It is a widespread species of the central-eastern United States that is near both its northern and eastern range limits here. It is frequent at low elevations in the calcareous parts of New York (p. 25) and the western edge of New England but absent from upland New York and eastern New England generally. It is frequent in oak-hickory communities of the West Champlain Hills and occurred at eight of the fifteen sites for which we have data. Rafinesque's viburnum belongs to the honeysuckle family, a relatively modern group that is represented by five species in dry-rich woodlands but only two in moist-rich ones.

A young flowering shoot of plantain-leaved sedge, *Carex plantaginea,* one of the commonest sedges of moist fertile woods. It is a species of the eastern U.S. and southern Canada and is near its northern range limits here. It is common in suitable habitats in most parts of New York but absent from much of the Adirondacks. It was uncommon in the West Champlain Hills; I saw it at four sites, mostly on moist slopes and in ravines.The sedge family, which is believed to be an ancient group, is extremely well-represented in rich, moist woodlands. It is also present (and can be locally dominant) in rich, dry woodlands but is considerably less diverse there.

in diversity, and often quite weedy. These woods may someday attain the complexity we associate with primary woods. But they have not done so yet and so, in consequence, are currently of little botanical interest.

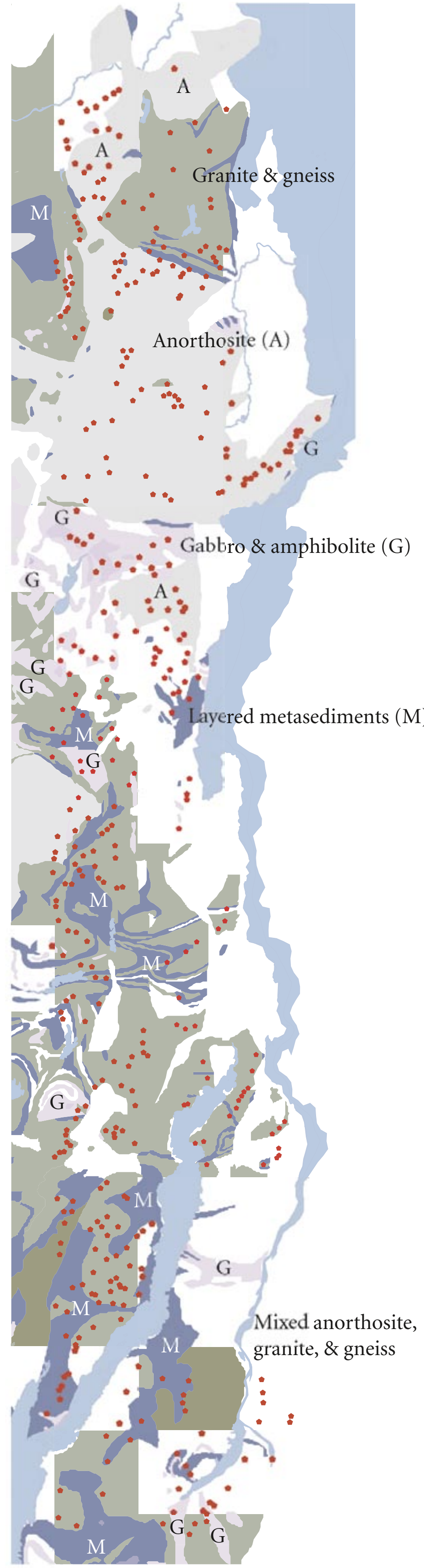
The New York shore is hillier and less farmed. The northeastern foothills of the Adirondacks reach the shore just south of the Ausable River at Trembleau Mountain (map, p. 10). They continue south to Rattlesnake Mountain in Willsboro, where they are interrupted by the Boquet Valley. They reach the shore again in the detached but spectacular line of hills south of Split Rock Point and again in the east-tending ridges that end at Cheney Mountain, Miller Mountain, and Mount Defiance. From there they run south along the lake from Putnam Station to South Bay, forming a continuous series of highlands between Lake George and Lake Champlain. Near Whitehall they cross to the eastern shore of the lake where they form West Mountain and even, though no geographer on either side of the lake has ever admitted it, cross the Poultney River and form Bald Mountain and the west side of Austin Hill in West Haven, Vermont.

I call the hills and small mountains near the west shore, from Ausable Point to South Bay, the *West Champlain Hills*. They are hills of distinctive character. Geographically they are numerous, evenly distributed, isolated from one another by agricultural lands in the north and connected to each other and to the rest of the Adirondacks in the south. Physiographically they are medium-sized, typically 600 to 1,800 feet in elevation, very steep to the west and south, and often spectacularly cliffy. The cliffs are most commonly interrupted by ravines and benches (which are themselves important in this story) but are continuous and sheer at the Diameter, on the famous 6.12 main face of Poke-o-Moonshine, and above Snake Den Bay on Split Rock.

Geology. The eastern Adirondacks are mostly old, hard, igneous rocks. The commonest rocks are Precambrian gneisses and granites, represented in gray on the map to the right. They typically have much quartz and orthoclase feldspar and are uniformly calcium poor and unlikely to support interesting plants.

Second most common and considerably more interesting are the anorthosites, which are granites containing large amounts of plagioclase feldspar. They are lighter in color and richer in calcium than the other granites, and tend to produce richer soils and more diverse woodlands.

BEDROCK GEOLOGY OF THE WEST CHAMPLAIN HILLS



Precambrian geology of the Champlain shore, simplified from the Adirondack Sheet of the *Bedrock Geology of New York.* The red dots are summits. Average granites and gneisses are in dark gray, anorthosite in light gray, gabbros and amphibolites in pink, and Precambrian metasediments in gray-blue. The white areas contain younger rocks or glacial deposits.

In the central Adirondacks anorthosites form the ridges and cliffs of the forty-six High Peaks. In the western Champlain Valley they underlay much of the Boquet Valley and part of the Ausable Valley, forming at least seventy-six hills and low mountains. These low anorthosite hills regularly contained highly diverse forests and were some of the most interesting of all our study sites.

Least common are the gabbros, amphibolites, and meta-sediments. The gabbros and amphibolites are mafic igneous rocks that occur as lumps or swirls within the main Grenville rocks and are very different from the country rocks around them. They are typically dark and coarsely granular and often rich in iron, magnesium, and calcium. They resemble basalt in composition and like it contain crystals of hornblende and other calcium-iron silicates that generate high-pH soils. They differ from basalt in their larger crystals and in often containing a matrix of plagioclase feldspar.

The metasediments are metamorphosed sediments that still retain some traces of their sedimentary layering. They vary greatly in chemistry. Commonly they are quartzites and schists which are chemically similar to granite and equally limiting for plant growth. Less commonly they are calcitic and dolomitic marbles that can have exceptional numbers of rare species.

Physiography and Ecology. The West Adirondack Hills are thin-soiled, ledgy, fire-prone, and very dry. Their southern and southeastern faces were steepened by scouring and plucking during the last glaciation and tend to have sheer cliffs and much bare rock. Their northern and western slopes tend to be gentler and better vegetated, but still can be very rocky. The north faces rarely have share cliffs but often have "moss slabs"—smooth, inclined rock outcrops with deep cushions of mosses and lichens.

Because the rocks of the West Champlain Hills are hard and convex, and because the hills themselves are small and do not have upper slopes to generate runoff, the summits and south cliffs tend to be very dry. There are very few streams or drainage channels and almost no springs or seeps. Most of the cliff faces I examined showed few signs of surface flow, and there was relatively little accumulation of ice on them in the early winter.

Because they are dry, the exposed rock surfaces are stable and probably quite old. Fracturing, rockfall, and mass-movement—all processes driven by water and ice—seem to be rare. Active taluses and gullies and their associated plant communities are largely absent.*

Also because of the dryness, the soils are thin and fires are frequent. The dry, rocky slopes generate very little soil of their own, and tend to lose the soil they do generate to erosion. The thin soils produce low, grassy, and very flammable forests; the frequent fires

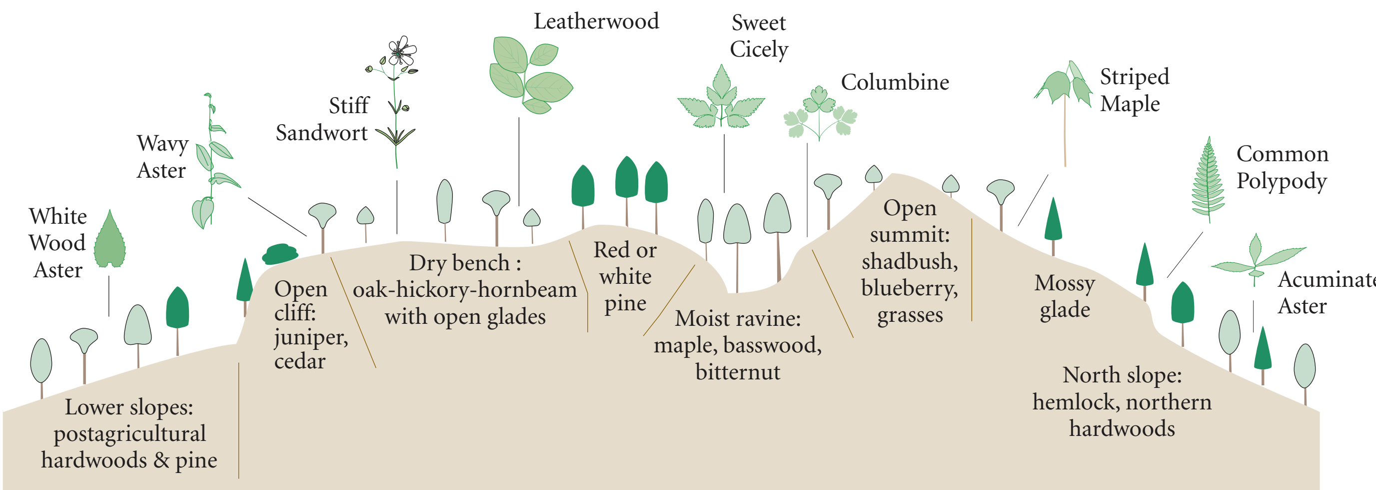
DARK ROCKS FROM A FERTILE HILL

Two samples of calcium-containing mafic rocks from the outcrops at Paintball Hill in Johnsburg. Both have dark grains of hornblende in a lighter matrix of feldspar. The upper one is fine-grained and relatively unweathered. The lower one is coarser, has weathered brown, and contains a dark mica (muscovite) in addition to the hornblende.

*Active cliffs with recent gullies and growing taluses occur at Poke-o-Moonshine, Skagerack, and the Diameter on the New York side and at Austin Hill and Bald Mountain in Vermont, and provide some fascinating ecological contrasts where they occur.

complete the cycle by encouraging soil erosion and exposing more rock.

THE MAIN VEGETATION TYPES IN THE WEST CHAMPLAIN HILLS



The typical forest and communities of the West Champlain Hills and a few species common in each type. The communities vary in their importance and distinctness. The northern hardwoods forest, maple-basswood-butternut (= rich mesic) forest, and oak-hickory-hornbeam forests are very distinct communities with a number of characteristic species. The postagricultural hardwoods forest is usually just a successional phase of the northern hardwoods forest, and the various ridgetop pine communities are to some extent low diversity variants of the oak-hickory-hornbeam forest. The vegetation on moist limy cliffs is often distinctive. Acid cliffs, and dry cliffs and summits in general, on the other hand, tend to have little vegetation. They are, in a sense, places where the surrounding vegetation is too thin to cover the rocks rather than places where the surrounding vegetation is replaced with something different.

Vegetation. The West Champlain Hills are mosaics of three or four principal types of forest vegetation (pp. 26-32). Around their bases they have mostly young, low-diversity, post-agricultural woods, typically mixing hardwoods, pine, and hemlock, often repeatedly and heavily cut. On their north and west sides they often have primary hemlock-hardwoods forests, also repeatedly cut and also low in diversity. On the steep south and east slopes, and especially on and mid-slope benches they have the high-diversity oak-hickory-hornbeam forests that are the focus of this report. On summits and upper slopes they often have red pine or white pine forests, typically mixed with red oak, and usually of fairly low diversity.

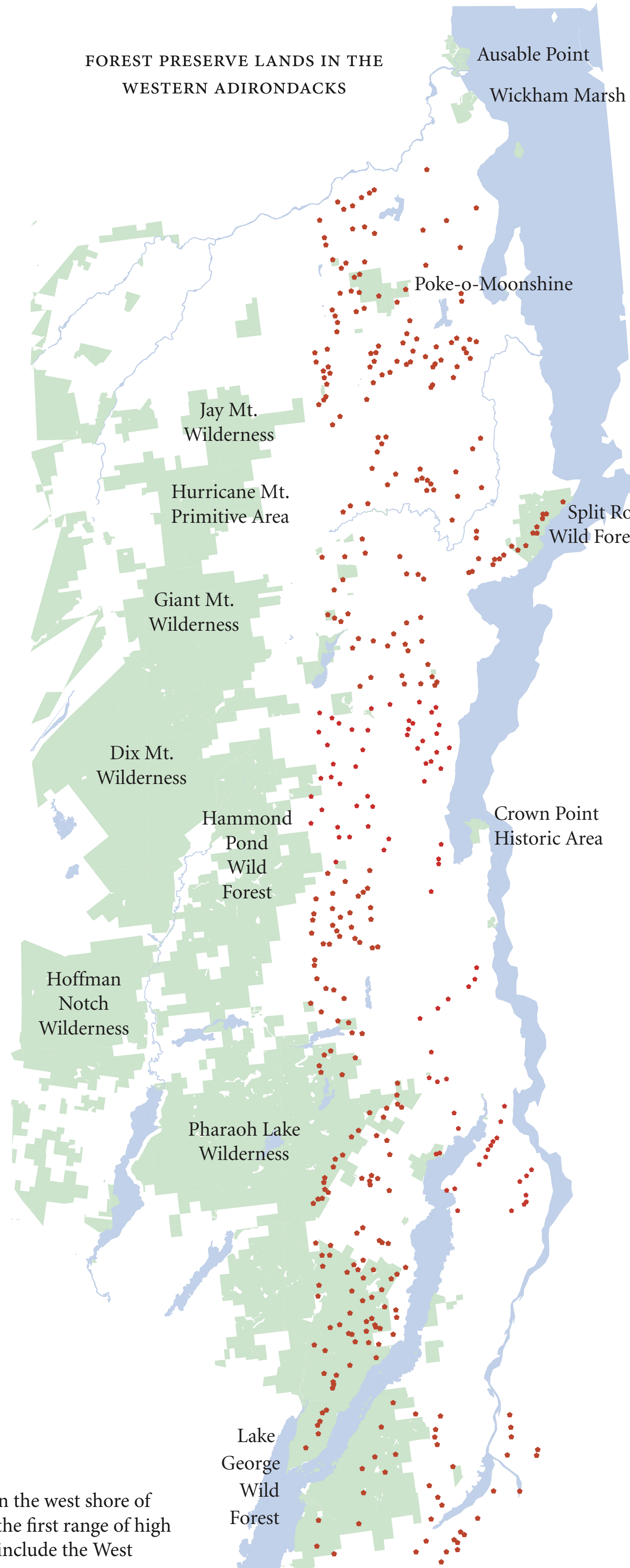
Within these four main types are small patches of other vegetation types. Rich mesic-forest vegetation occurs in ravines and at the bases of ledges. Interestingly, it seems to be commoner on southern slopes within the oak-hickory woods than on the northern slopes within the maple-beech woods. Partly shaded slabs and outcrops, again within the oak-hornbeam areas, have a specialized dry outcrop association that, while not rich in species, contains several interesting plants. Moister slabs, mostly within the northern hardwood forest, have the moss slab association mentioned on p. 14, which is attractive but relatively poor in species. And many of the summits have open rocky glades with a sparse flora of shrubs, grasses, and stunted trees, generally low in diversity and with mostly acid-soil species.

Of these eight vegetation types, the calcareous oak-hickory-hornbeam forests and the rich mesic woods are the most diverse and distinct, and seem to me to be separate communities. The total numbers of species and numbers of calcium-indicating species in the two communities are similar. The rich mesic woods community is the more widely distributed of the two communities in northern New York and Vermont and its species are much commoner regionally, even though it is less common in the West Champlain Hills. The oak-hickory community is much less common in northern New York and New England than the rich mesic woods community, and its species correspondingly rarer.

Ownership. Unlike the Adirondacks as a whole, the New York portion of the Champlain Valley contains very little public land. This is partly a question of history—most of the large, early 20th-century acquisitions were in or near the original blueline, which was 20 to 40 miles west of Lake Champlain—and partly of neglect. In any event, in the lower 70 miles of the Champlain Valley that concern us there are only five significant pieces of New York State Forest Preserve land. The two largest, and the only two that contain large amounts of natural forest, are the Split Rock and Poke-o-Moonshine Wild Forests. There are also important town lands at the mouth of the Boquet River, Fort Ticonderoga Association lands on both sides of the Narrows at Ticonderoga, and Nature Conservancy lands at Coon Mountain and several smaller sites. But compared to the impressive chain of wildernesses and wild forests between Jay Mt. and Lake George there is very little public land on or near the shores at all.

The same is true in Vermont. There are several large state forests and wildlife management areas a few miles back from the lake and some small but important woodlands in city parks at Red Rocks, and Appletree Point, and state parks at Button Bay and Chimney Point. But in the lower two thirds of the lake there are only five major public holdings of natural lands on the lake shore: the wetlands at the mouth of the Otter, Little Otter, and East Creeks; the forests and ledges at Mt. Independence, a state historical site; and Bald Mountain, a Nature Conservancy Preserve.

FOREST PRESERVE LANDS IN THE WESTERN ADIRONDACKS



New York State Forest Preserve lands on the west shore of Champlain. The state lands are mostly the first range of high mountains west of the lake and do not include the West Champlain Hills.

5 THE WEST CHAMPLAIN HILLS PLANTS

This section considers the composition of the flora, its calcium and moisture preferences, and its geographic limits. My thesis is that it is an unusually specialized flora, and that its specialization reflects, quite accurately, the ecological conditions of the West Champlain Hills.

The Flora as a Whole. The total flora of the forests and ledges at the sites we studied was about 450 species. This is, by northern New York standards, very diverse for upland forests. A similar study in northern hardwood forests would probably produce less than 200 species; a similar one in boreal forest would probably produce less than 100 species.

About 40% of these species are widespread and fairly common ecological generalists that are not restricted to particular elevations or soils. The marginal wood fern and striped maple belong to this group; so do hemlock, sugar maple, Canada mayflower, false Solomon's seal, bracken, blueberries, and many others.

These generalists are the workaday plants of moist acid woods, praiseworthy because they cover the hills and make the ecological wheels go round but too common everywhere to tell us much about local ecology or geography.

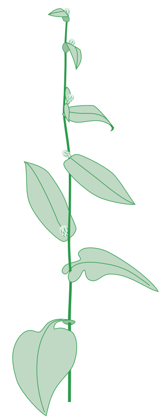
The remainder of the West Champlain Hills flora, about 170 species, are plants that require special soils and moisture conditions or a certain range of altitudes or exposures. They include a wide variety of plants whose common feature is that they don't like moist acid woods. I call them ecological specialists here, remembering when I do so that all plants are to some extent ecological specialists and that it would be more accurate, though clumsier, to call them "plants that prefer uncommon habitats."

The ecological specialists include both common and uncommon species. Columbine and early saxifrage, for example, are common species of moist, calcareous ledges; New Jersey tea and common pinweed are species of dry, acid sands. The sedges *Carex scirpoidea* and *Carex hitchcockiana* are rare species of dry, calcareous woods and ledges.

All six of the species just mentioned are near or at their range limits here. *Carex scirpoidea* is a northern species that is widely distributed north of the Champlain Valley and very rare south of it. The other four are southern species whose range limits lie just slightly north of us, in southern Canada.

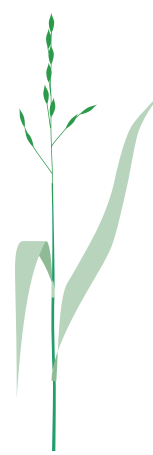
The association between ecological specialization and range limits is a common biogeographic pattern. Many of our specialists are in fact common species in other landscapes. They seem

CHARACTERISTIC DRY-WOODS SPECIES OF THE CHAMPLAIN OAK-HICKORY COMMUNITY

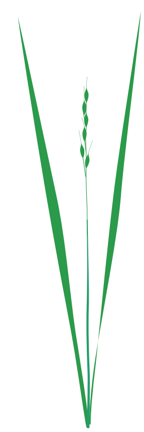


WAVY ASTER, *Aster undulatus*

WOODLAND SUNFLOWER, *Helianthus divaricatus*



BROAD-LEAVED MOUNTAIN RICE, *Oryzopsis racemosa*



ROUGH-LEAVED MOUNTAIN RICE, *Oryzopsis asperifolia*

These four plants were found in most or all of the study sites and are commoner in the oak-hickory forests than in other communities. Their calcium-status varies. Broad-leaved mountain rice typically grows in high-calcium habitats. The other three occur on acid soils south of us, but in our area are almost always found on calcareous soils. In this respect they are typical of a number of species that seem to require more calcium as they approach their range limits.

specialized to us simply because the places they prefer are hard to find here.

Appendix 1, on p. 56, list the specialized species by ecological groups, and provides several estimates of their relative abundance. The pie-chart to the right shows the relative proportions of northern and southern species in each group..

Since our general flora is moist, acid, and northern, our specialized flora is predominantly xeric, calcareous, and southern. Eighty-one percent of the specialized plants require or are strongly associated with calcium-rich soils. A remarkable 71% are at or near their northern range limits in the Champlain Valley, and fully 62% are restricted to dry, relatively open sites.

What is striking about the specialized species is how many of them there are. About 37% of all the species of the West Champlain Hills have ecological or geological specializations; 30% are calciphiles, 30% are at or near their northern range limits, and 24% are restricted to xeric habitats.

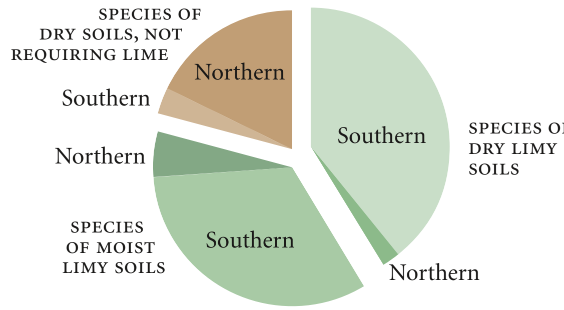
I interpret these numbers to mean that the West Champlain Hills are in some sense ecological islands. Like real islands they have sharp ecological boundaries and, because of these boundaries and again like real islands, they have large numbers of specialized species that are rare or absent everywhere else.

Thus the West Champlain Hills flora is both distinct and rich. Both of these properties have conservation importance and merit a closer look.

An Island Flora. The commonest upland plant communities in the western Champlain Valley, and indeed in all northern New York, are moist acid woodlands. Moist calcareous forests and ledges are much rarer, but do occur in coves and ravines, usually associated with outcrops of marble or anorthosite. Dry calcareous woods and ledges are rarer yet; so far as we know, they are limited to the band of hills that is our focus here.

The result is that many of the ecologically specialized species on the West Champlain Hills see northern New York as an inhospitable ocean, with only scattered islands of suitable habitat. This is probably most true for the species of dry limy habitats, which seem to occur only in rocky south-facing woods. It is less true for the species of moist limy habitats which, though never common in the Adirondacks, can occur here and there in ravines and at the bases of cliffs, where mineral-rich groundwater surfaces and there are pockets of deeper soil. And it is probably least true for the plants of open, dry, acid summits. But even the acid summit plants have significant restrictions. Many of them require open summits below tree-line; such summits are common in the West Champlain Hills, but much less common elsewhere in northern New York.

THE ECOLOGICAL SPECIALISTS IN THE WEST CHAMPLAIN HILLS FLORA



The geography and acidity preferences of the 170 West Champlain Hills species that are ecological specialists (Tables on pp. 56 to 59). Plants of wide regional distribution (including all the species of moist acid soils) are not included. *Southern*, as used here means that the species has almost all of its range to the south of us. *Northern* means only that the species has a significant range north of us; it may also range far to the south as well.

Since the common soils of the region are moist and acid, much of the specialized flora consists of species that are dry (62%), calciphilic (79%), or both (44%).

A SPECIALIZED SPECIES OF DRY ACID SOILS

New Jersey tea, *Ceanothus americanus,* is a low shrub of dry sandy soils that is most common at acid sites but may occur on limy ones as well. It is a wide ranging eastern U.S. species that is near its northern range limits in the Champlain Valley and is much scarcer here than in southern New York.

The combined effect of the ecological preferences of the specialized flora and the discontinuous distribution of suitable habitats is that the calcareous habitats in the West Champlain Hills have sharp boundaries. Going into them is like going into a bog; you cross an ecological boundary, flora changes suddenly and a whole group of new species appears. The boundaries are often surprisingly abrupt; in ten yards you can pass out of ordinary woods with no specialized species and into calcareous woods where half the species are ecological specialists.

We can estimate the strength of these ecological boundaries by counting what J.T. Curtis and other American ecologists have called *modal species*. These are species that reach their greatest abundance in a particular community or at a particular group of sites. Some of these may be relatively common species, like wavy aster and woodland sunflower, which occur in limy oak-hickory woods but are rare elsewhere. Others are rare species like Douglas's knotweed, which in our area occurs on a few dry, open calcareous ledges and nowhere else.

My estimate, subject as always to our incomplete knowledge of the biology of a number of rare species, is that there are at least 73 modal species in the calcareous oak-hickory woods and their associated ledges, and at least 7 more on dry acid summits. These are marked with asterisks in the table on pp. 20-21.

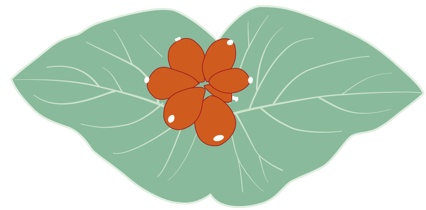
There may also be modal species among the moist-rich plants of the West Champlain Hills, but if so we do not yet know who they are. Some species like maidenhair spleenwort and zig-zag goldenrod are common in the West Champlain Hills and rare outside of them and may reach their greatest local abundance here. But they are also widely distributed within at moist-rich sites within northern forests, making it very hard to know where there abundance peak really is

Uncommon and Rare Species. Because the West Champlain Hills are ecological islands with many range limit species, they contain a number of species that are uncommon or rare in northern New York.

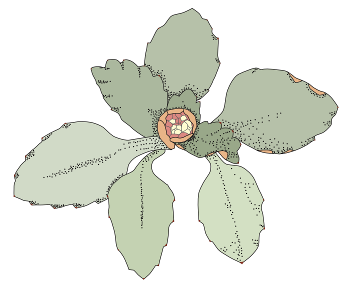
Just how many of these species there are depends on what you call uncommon and rare. Appendix 1 gives three differing estimates: the Heritage designations from New York and Vermont, which are based on the total number of records per state, and my own estimates, which are based on frequency relative to habitat.

The New York Natural Heritage Program considers a species "critically imperiled" (s1) if it occurs at five or fewer sites (roughly one in every twelve counties) in New York and is not common anywhere in the state. It considers the species as "imperiled" (s2) if it occurs at six to twenty sites in the state. In theory it also considers species "rare" (s3) if they occur at 21 to 100 sites in the state, but

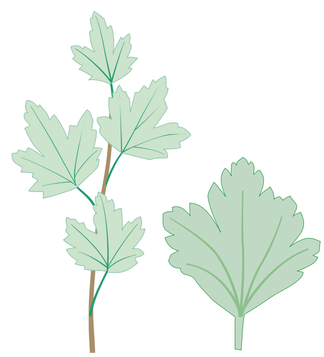
THREE SPECIALIZED WEST CHAMPLAIN HILLS CALCIPHILES



LIMBER HONEYSUCKLE, *Lonicera dioica*



EARLY SAXIFRAGE, *Saxifraga virginiensis*



BRISTLY GOOSEBERRY, *Ribes hirtellum*

Three species associated with limy soils in the Champlain Valley. Limber honeysuckle is an eastern U.S. species of dry rocky hills that is near its northern range limits here. It is frequent in the oak-hickory woods of the West Champlain Hills but rarely occurs in other communities. Early saxifrage is a common species of moist ledges in fertile mesic woods, but it crosses ecological boundaries to some extent and is also found on dry shaded ledges in oak-hickory woods. Bristly gooseberry is an eastern North American species of calcareous rocky woods that ranges north to Newfoundland and Labrador. It is frequent in the West Champlain Hills but very rare elsewhere in the Adirondacks.

in practice the Heritage Program does not track many species at this level of rarity, and most s3 species are not listed.

By these definitions the West Champlain Hills have one New York State s1 species, four New York State s2 species, and, since the list of s3 species is incomplete, an unknown number of s3 species.

The Vermont Natural Heritage Program uses similar definitions but applies them to an area one sixth the size. In Vermont a "very rare" (s1) species occurs one to five times, or in about one county in five; a "rare" (s2) species occurs six to twenty times, and an "uncommon" (s3) species over twenty times but not so often as to be "secure." Unlike New York, they have tried to make a fairly complete listing of s3 species. According to their lists, 6 of the West Champlain Hills species are very rare in Vermont, 3 are rare in Vermont, 16 are uncommon in Vermont, and another 9 fall in between these ranks. The total is 34 species, seven times more than are listed in New York, showing the extent to which rare lists vary with the assumptions and thoroughness of the listers.

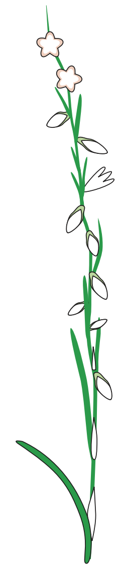
Both of these estimates are reasonable as state-wide assessments. But neither helps much for the Adirondacks, which after all are an area the size of Vermont, and have just as much right to have a rare list of their own. In particular, many species that are frequent or common in Vermont or in New York as a whole are rare in the Adirondacks. This is especially true of the southern species of dry calcareous habitats, many of which are frequent in southwestern Vermont and western New York but very rare in the Adirondacks.

An additional problem is that both the New York and Vermont estimates are based on the total number of known sites, which is only meaningful if the sampling has been relatively complete. In a preliminary survey like this one we rarely know how many sites there are for, say, basswood or bladdernut. But we do know their relative abundance in suitable habitat. Basswood, for example, is present in almost every moist-rich forest; bladdernut, on the other hand, is rarer than its habitat and only occurs in a few of the many shaded taluses where it might possibly occur.

These observations of relative abundance can be turned into a rough-and-ready measure of frequency that is suitable for preliminary surveys. My practice is to call a species *frequent* in the Adirondack region if its habitat is common and it occurs regularly in the proper habitat. I call a species *uncommon* if it is found in half or fewer of the sites with proper habitat, or if there are only a limited number of Adirondack sites with proper habitat; and I call it *rare* if it is found in only a few of the sites with proper habitat, or if its proper habitats are themselves quite rare.*

By my definitions over 70 Champlain Hills species are uncommon or rare within the Adirondack region.

AN UNCOMMON SPECIES OF DRY ROCKS



Douglas's knotweed, *Polygonum douglasii,* is a species of the western and northwestern mountains that is rare in the east. It is a slender annual that grows on open, sloping slabs and ledges. The downwardly pointed flowers and fruits are its best field mark, and separate it from the otherwise similar *Polygonum tenue.* It has been reported, very sporadically, from northern Maine, northern New Hampshire, western Vermont, and northern and eastern New York. Despite the very sporadic distribution it may be uncommon rather than rare in the Champlain Valley. In 2004 we relocated a small population on Twin Mt. in western Vermont, almost exactly where I had seen it 18 years before, and found new populations on Cheny Mountain, Whipple Mountain, and Phinney Hill. Doubtless there are others yet to be found.

*I use this definition of frequency because it captures what we actually see in the woods, and because it uses a set of observations – the number of sites with suitable habitat at which the species did *not* occur – that are ecologically important. In survey work we rarely know how many populations there are or what the total population sizes are. But we do know how often we have encountered a given habitat and how frequently we have seen particular species within it.

Comparing these estimates, the New York Heritage Program's numbers, which are biased by the omission of S3 ("rare") species, are clearly too low. Regardless of how many Adirondack species may be rare in the 49,000 square miles of New York State as a whole, there clearly are far more than five rare upland species in the eastern Adirondacks!

The Vermont estimate, which is that 34 of the West Champlain Hills species are rare or uncommon in Vermont, seems much better. But it needs to be corrected for the geological differences between the two sides of the lake (p. 13). Dolomites and marbles are common in Vermont, and rare in the Adirondacks. As a result, a number of calcium-dependent species like bladdernut and large-seeded goosefoot which are frequent in Vermont seem to be rare or absent in the Adirondacks*.

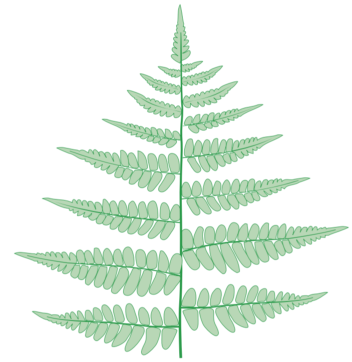
My working estimate that there are over 70 uncommon or rare species in the West Champlain Hills is of course provisional. Exploring more hills, and re-exploring the ones described here earlier in the season, would doubtless produce more records and reveal that some species are commoner than they thus far appear. But it might also discover some new species, or prove that some moist-rich species whose frequencies are currently unknown are actually uncommon or rare. And so additional survey might produce compensating changes and not change the total number of uncommon and rare species that much.

But even considering the uncertainties, it still seems conservative to say that there are over 50 species in the Champlain Hills flora that are rare or uncommon in the Adirondacks as a whole. This is a remarkable number. The Adirondack alpine community, considered very special, contains only about 20 rare and uncommon species. The Lake Champlain shores and the Adirondack lowland boreal, also very special, are somewhat more diverse, though not in proportion to their size, with about 25 rare and uncommon species each. And so, by this standard, the West Champlain Hills must be very, very special: they not only have the most diverse flora of any upland forests in the Adirondacks but are the richer in rarities than any other Adirondack communities.

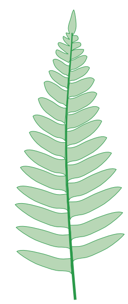
A Geographical and Ecological Mosaic. While the West Champlain Hills flora is dominantly dry, southern, and calcareous, it is by no means exclusively so. An interesting feature, and one that gives it complexity and ecological depth, is that it incorporates species from other ecological groups as well.

This can happen in several ways. Sometimes the ecologically discordant species are segregated in particular habitats and form, in effect, a subflora. This is the case for many of the species of rich mesic woods (maidenhair fern, blue cohosh, wild leek…) which occur mostly in ravines and below moist, shaded ledges, and do

TWO ACID-TOLERANT SPECIES IN THE LIMY MOSAIC



MARGINAL WOOD FERN,
Dryopteris marginalis



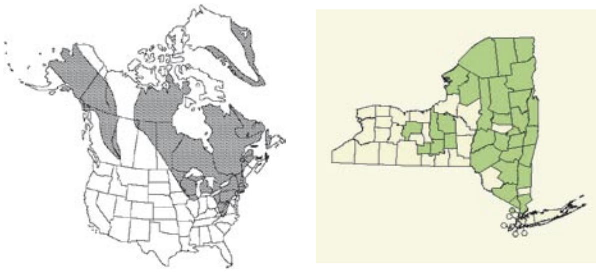
COMMON POLYPODY,
Polypodium virginianum

Two ferns that are very widely distributed in northern New York. Both are common in ordinary acid woods and so are not considered ecological specialists.

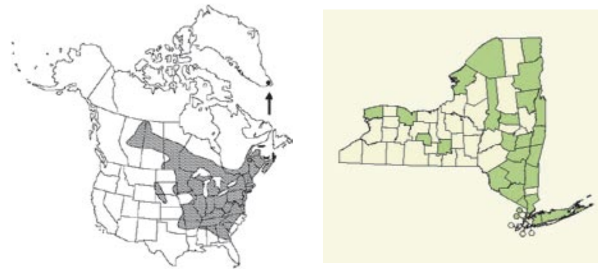
*The reverse is also true in a few cases: several species of dry sandy soils (*Carex siccata, Oryzopsis pungens…*) which are rare in Vermont are uncommon but not rare in the eastern Adirondacks.

THE GEOGRAPHICAL MOSAIC I

Northern species of rock outcrops

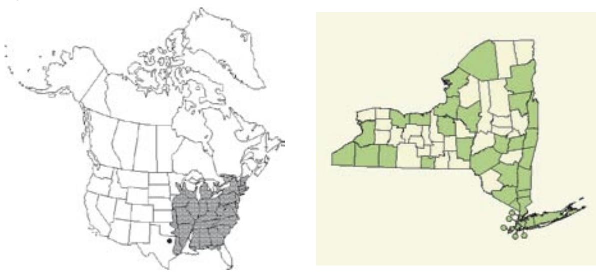


Rusty Woodsia

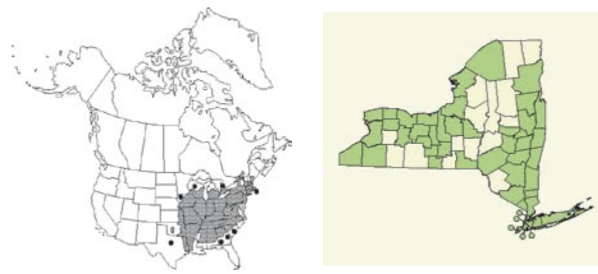


Rock Spikemoss

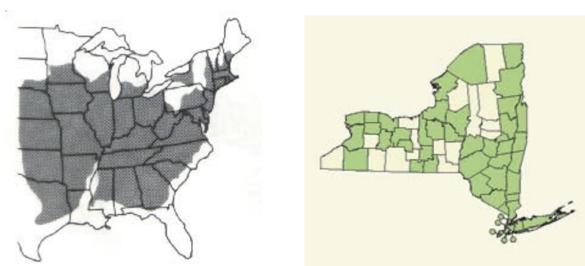
Southern trees



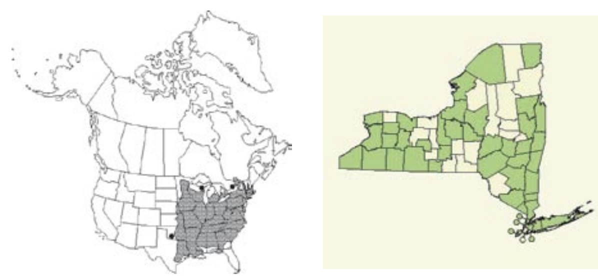
White Oak



Shagbark Hickory



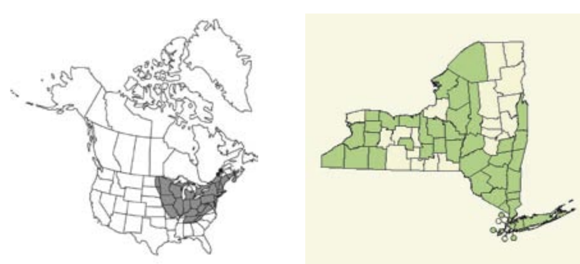
Red cedar



Bitternut Hickory

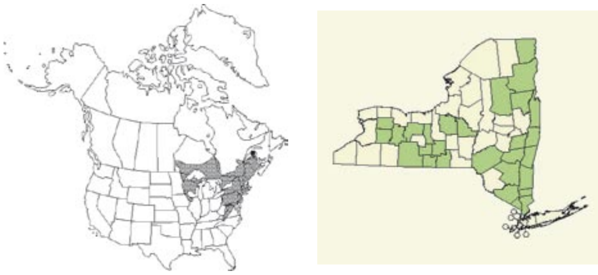
Two common calciphiles of mesic woods

Slippery Elm



Wild Leek

A scarce northern calciphile



Purple Clematis

Range maps from the *Flora of North America* (http://www.efloras.t) and the New York Flora Association (http://atlas.nyflora.org), showing the geography of some typical West Champlain Hills species. Here I use *southern* to mean a species whose northern range limit is in (red cedar) or near (white oak) the Champlain Valley. *Northern* is used for any species that has a significant boreal and Canadian range: such species may, like rusty woodsia, be dominantly northern, or may, like rock spikemoss and purple clematis, have a significant Appalachian range as well.

THE GEOGRAPHICAL MOSAIC II

Southern calciphiles of dry woods, frequent in northeastern New York


Rafinesque's Viburnum


Wavy Aster


Broad-leaved Mountain Rice


Woodland Sunflower


Broad-leaved Panic Grass


Leatherwood


Limber Honeysuckle


Sicklepod Mustard

Southern calciphiles of dry sites, uncommon in northeastern New York

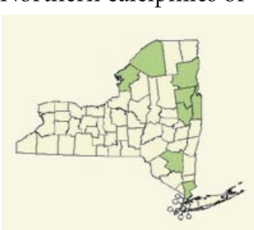

Stiff Sandwort


Kalm's Brome


Four-leaved Milkweed

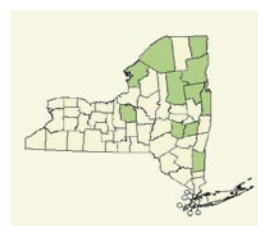

Panicled Tick-trefoil

Northern calciphiles of dry sites, rare in northeastern New York

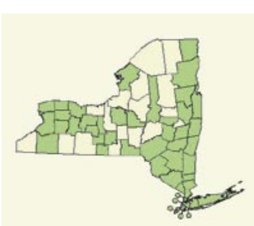

Douglas's Knotweed

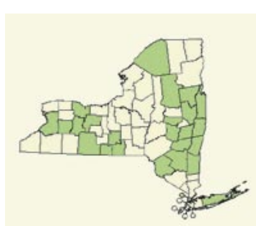

Fragrant Sumac


Missouri Rockcress

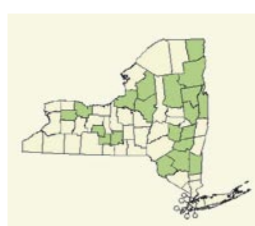

Back's Sedge

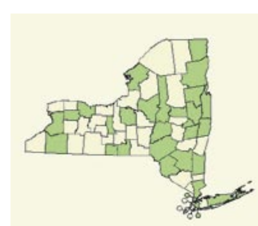
Southern acidiphiles, frequent in northern New York


New Jersey Tea


Common Pinweed

Northern acidiphiles, uncommon in northern New York


Oryzopsis pungens


Carex siccata

not mix with the xeric species of the oak glades. And it is also the case for a number of acidophile species (bearberry, juniper, pale corydalis, pinweed…) which are restricted to the open, sparsely vegetated summits.

Often and characteristically, plants of different ecologies and geographies mix in the same community. The oak-hickory woods are particularly striking in this respect. They contain a mixture of northern and southern species (bristly currant, say, and prickly currant), calciphiles and acidophiles (blue-stemmed goldenrod and marginal fern), and even, despite their overall dryness, a mixture of xeric and mesic species (*Oryzopsis pungens* and *Carex pedunculata*). The geographical implications of this kind of mixing are fascinating: some sense of the patterns involved may be gained by examining the range maps on the pages 23 and 24.

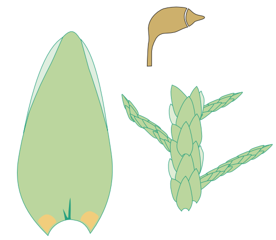
This mixture of ecologies and geographies is what I call the *mosaic character* of the West Champlain Hills flora. It is most pronounced in the calcareous oak-hickory woods and may in fact be a defining feature of them and a major source of their diversity. In contrast, the acid pine-oak woods to our south have few northern species and usually no mesic or calcareous ones; and the rich mesic maple-red oak woods elsewhere in New England and northern New York have almost no acid or xeric species. Seeing, say, a pinweed or a barren strawberry next to a hepatica or a columbine would be unheard of in a rich mesic woods. In the calcareous oak-woods it is part of the normal fabric of the community.

6 MOSSES AND LICHENS

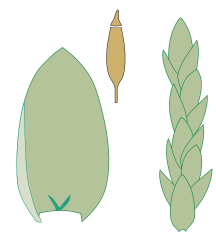
While I did not do extensive moss and lichen collecting, I did look at the dominant species of mosses and lichens in all the sites I visited and did a detailed, meter-by-meter study of the mosses on Paintball Hill (Johnsburg, N.Y., west of the West Champlain Hills). The results were surprising. Given the high vascular plant diversity and large number of calcium indicators in the West Champlain Hills, I expected that the same thing would be true of the mosses and lichens. But it was not. The moss and lichen cover in the oak-hickory forests was often quite high, especially considering how dry they were, and individual species—*Cladonia*, *Cladina,* and *Peltigera* lichens, *Dicranum, Pleurozium,* and *Polytrichum* mosses, the liverwort *Ptilidium*—were often large and conspicuous. But the diversity was quite low and the flora completely lacked the calciphilic genera (*Tortella, Abietinella, Anomodon, Mannia, Solenostoma, Caloplaca*) that are common on exposures of carbonate rocks.

The only places that I saw calcium-indicating mosses were in a few ravines where groundwater was seeping though cracks in ledges. These often had a few specialized mosses (*Gymnostomum*

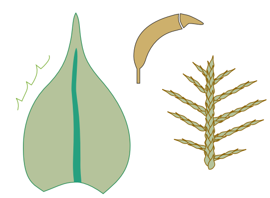
THREE MOSSES OF ROCKY HILLS



Pleurozium schreberi

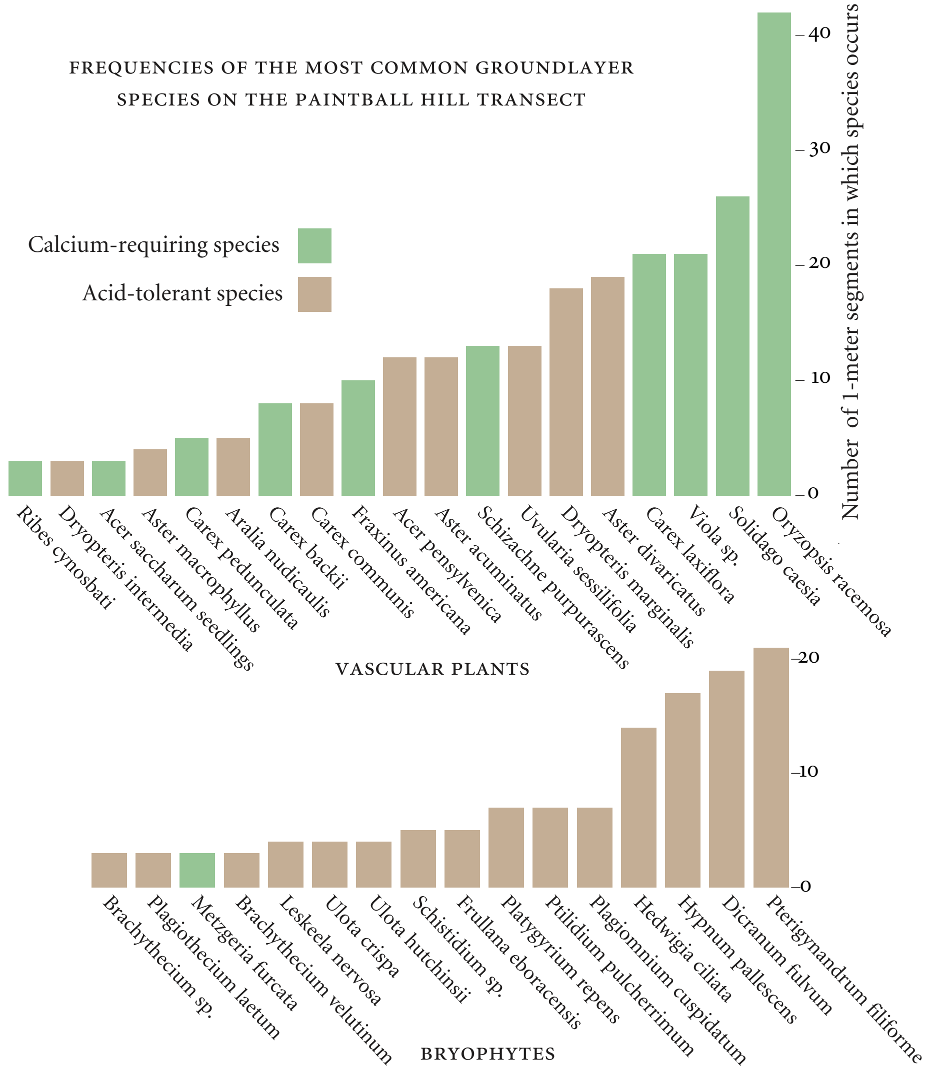


Pterigynandrum filiforme



Abietinella abietina

Three mosses that are common on rock outcrops. *Pleurozium schreberi* is a large moss of moist, acid forest floors, common on duff under conifers and on moist rocks. It is a characteristic species of the moss slabs on the north slopes of the West Champlain Hills but uncommon in the oak-hickory community. *Pterigynandrum filiforme* is a small moss that is frequent on tree bases and dry rocks in a variety of habitats. We normally think of it as an acidophile, but it occurs on calcium-rich igneous rocks at Paintball Hill. *Abietinella abietina* is a strong calcium indicator. It is one of the dominant mosses on dry dolomite and marble outcrops in Vermont, but apparently absent from the calcium-rich igneous rocks in the West Champlain Hills.



The frequency of the most common vascular plants and bryophytes on a 100-meter transect at Paintball Hill. Paintball is a small hill in Johnsburg with mafic rocks and a number of calcium indicators. See p. 42 for more information about the site, and pp. 44-45 for a community diagram. Frequency is measured as the number of 1+-meter segments in which the species occurs. The graph shows all the ground-layer species with a frequency of 3% or higher. The total vascular flora is 28 species, of which 15 are calcium indicators. The total moss and liverwort flora is 34 species, of which only 1 is a calcium indicator. The 19 vascular plants in the graph, which occur mostly on soil, have an average frequency of 10%. The 17 bryophytes, which are restricted to rocks, logs, and tree bases, still have an average frequency of 6%.

aeruginosum, Mnium marginatum, Myurella sibirica). But even there the habitat was limited and the diversity low.

7 MAIN VEGETATION TYPES

Forests and Glades. The West Champlain Hills contain three or four main types of forest vegetation and three or four other types associated with ledges and summits. The diagram on p. 15 shows a typical sequence of vegetation types on a generalized hill.

The lower slopes, which often have been farmed and always have been cut heavily, contain a variety of successional forests with varying mixtures of pine, northern hardwoods, and occasionally hemlock. Using the New York Natural Heritage Program names, these are a mixture of *successional northern hardwood, pine-northern hardwood,* and *hemlock-northern hardwood* forests. Despite the three names and the variation in age and canopy composition, all the successional forests all have a simple flora, generally low moss-lichen glades in northern hardwoods forest on north boquet mountain

open calcareous oak-hickory forest on north boquet mountain

ROCKY OAK-HORNBEAM WOODS ON SOUTH BOQUET MOUNTAIN

Rocky woods near the summit of South Boquet Mt. The woods are mostly red oak and hop hornbeam, with a sparse shrub layer of blueberries and bristly gooseberry and an understory dominated by *Carex pensylvanica* and a number of herbs. Common herbs are blue-stemmed goldenrod, four-leaved loosestrife, marginal wood fern, bracken fern, pale corydalis and lance-leaved wild liquorice. This is a transitional community with relatively few calcium indicators and many acid-soil species.

in diversity and largely without calcium indicators or ecologically specialized species.

Upper slopes usually have older forests that have never been cleared for farming. Red oak and white pine are common on south slopes, and hemlock and northern hardwoods on the north ones. Red pine occurs on a few summits. The composition is similar to that of the lower slope forests and the same Heritage names apply. The understory diversity is low in the upper slope hardwood stands, and close to zero in the stands dominated by pines and hemlock.

Like the lower slope forests, most of the upper slope forests have been repeatedly cut and have fairly small trees. A few, by luck or inaccessibility, have small patches of older forest and some trees over two feet in diameter.

Rocky, south-facing slopes at middle elevations often have open grassy oak-hickory forests with a grassy understory. The dominants are typically red oak, white oak and shagbark hickory, with hop hornbeam in the understory and gaps. The soils are often or always calcareous and the herb and shrub flora is quite rich and contains many calcium indicators.

The rocky slope forests differ dramatically from the other forests just discussed are in fact a distinct community. This community doesn't have an exact name. It resembles the New York Natural

Opposite, top, a "moss-slab" community on the north slope of North Boquet Mt. These communities develop where groundwater flowing over sloping rocks is intercepted by cushions of mosses and lichens. The picture shows the reindeer lichen *Cladina rangiferina,* cushions of the mosses *Pleurozium schreberi* and *Polytrichum juniperium,* clumps of rusty woodsia (a small fern), the hair-grass *Deschampsia flexuosa,* and dried up plants of the common St. John'swort, *Hypericum perforatum.*

Opposite bottom, grassy oak-hickory glades on the south slope of North Boquet Mt., just below the summit. The sparse canopy and grassy understory are typical of dry summits in the West Champlain Hills. The commonest trees are red oaks and shagbark hickories. The understory is moderately diverse and contains several calcium indicators.

Heritage Program's the *red cedar rocky summit* and *Appalachian oak-hickory* communities, but differs in significant ways from both of them.* Thinking that the gain in accuracy is worth the cost of a new name, I call it the *Champlain Hills dry-rich community,* and note that it is a calcareous oak-hornbeam-hickory community with a grassy herb layer and extensive rock outcrops and glades. I discuss it in more detail in the next section of this document, and give it a formal definition in Part II of this report.

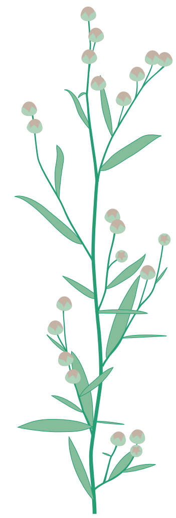
Within this community there are often open, sparsely vegetated rock slabs. They have relatively few vascular species and are probably not worth treating as a separate community, but are still notable because they seem to be the preferred habitat for several uncommon species, (stiff sandwort, Douglas's knotweed, rock spikemoss, rusty woodsia) and one rare one, the field chickweed.

Similar but better-vegetated slabs, creating what I call *moss glades*, are common within the northern-hardwood forests on many of the West Champlain Hills, especially on moist north and west slopes. Typically they are open, sloping, somewhat rounded rock slabs with a sparse vascular cover of grasses and ferns and a dense, cushion-like cover of mosses (*Dicranum, Hylocomium, Pleurozium*) and *Cladina* lichens. These glades are common in the eastern Adirondacks, and not restricted to the West Champlain Hills. They seem to occur on hard, convex igneous rocks, in moist forests where there is enough water flow over the rocks to sustain a moss community but not enough soil to support trees and shrubs. Several that I examined had signs of recent burns, and may have been denser communities that were opened up by fire. Interestingly, given their commonness in the eastern Adirondacks, they are rare or absent from much of the central Adirondacks. It may be that the hills are steeper in the east, or that the slabs there in the central Adirondacks are for some reason better able to revegetate and return to forest.

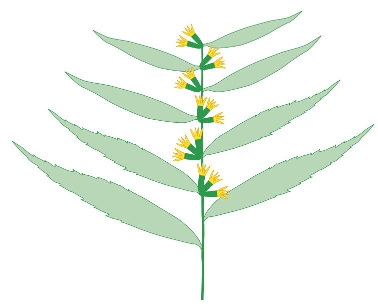
The flora of the moss glades is typically very simple but does share two species of interest with the dry slabs mentioned above. The rusty woodsia, a small northern fern of acid rocks, is very common in them. It is widespread in the Adirondacks and certainly not restricted to the glades, but it is strikingly abundant here. The rock spikemoss, a small mosslike fern ally that is near its northern range limits here, is frequent in the glades. It is an uncommon plant in our area and seems unusually abundant in the moss glades. I found it 11 times in the Champlain Hills, and have yet to find it anywhere in the Adirondacks outside of them.

Summits and Ledge-Tops. The West Champlain Hills have both open and forested summits. The open summits are almost always barren and rocky and low in diversity. Typically a few acid-soil plants (juniper, hairgrass, bearberry, corydalis, blueberries, *Panicum linearifolium*, *Carex umbellata s.l.* …) dominate the flora.

TWO SPECIES OF SUMMITS



COMMON PINWEED,
Lechea intermedia



BLUE-STEMMED GOLDENROD,
Solidago caesia

Two common species of rocky summits in the West Champlain Hills. Both are southern species that are near their northern range limits in the Champlain Valley. The pinweed is a species of dry acid sandy soil that occurs on open rocky summits and at the top of ledges, generally in small pockets of bare soil. It is frequent but somewhat local and occurred at eight of the study sites. The goldenrod is a species of open woodlands with dry fertile soils that occurs in open woods and glades. It is very common in calcareous oak-hickory forests and occurred at 14 sites in the study.

*It differs from the red cedar rocky summit community in having only small amounts of red cedar, not being restricted to summits, and often being a closed forest rather than an open woodland. It differs from the Appalachian oak-hickory community in being more calcareous and diverse, containing a significant amount of northern species, and not being in the Appalachians.

The forested and partly forested summits are higher in diversity and may have either pine or oak communities.

The open summits—we might call them bare-rock summits—correspond well to the Heritage Program *red pine rocky summit* community, except that they don't always have red pine. (This is, as with the red cedar rocky summit community, a weakness of naming communities by dominant species.) They are relatively common in the Adirondack foothills as a whole and can be very pretty and have spectacular view, but they are low in diversity and have few or no uncommon or rare species.

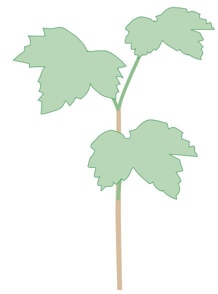
The second type—the continuously vegetated oaky summits—are a phase of the Champlain Hills community. They are much less common than acidic summits, but exactly how common I don't know. And they are, like the Champlain Hills community as a whole, diverse and rich in unusual species.

Just what determines the difference between the two sorts of summits is not clear. It may be differences in bedrock (harder and hence less fertile rocks capping some of the hills), elevation (the oak-hickory community doesn't seem to occur above about 2000 feet elevation), or exposure (the barren summits are too dry to develop much soil) Or it may be biological differences in the depth of soil and its ability to hold water and maintain an active root zone. In the first case the physical factors dominate the vegetation, and a barren summit will stay barren for ever. In the second case the fertility is generated by the vegetation itself, and physically similar hills with different histories and different soil depths might display different levels of fertility and diversity. In this model—toward which some of my observations incline me—a barren hill could gradually revegetate and increase its diversity. Likewise a vegetated one, subject to fires or erosion, could lose soil and decrease its diversity. Barren and diverse would then be alternate states of a single system, and, in a scientific but thoroughly Zen way, the difference in the richness of the vegetation would be the vegetation itself.

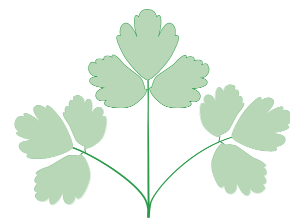
Fertile Woods and Ravines. Considering how dry the south slopes of the West Champlain Hills are, it is somewhat surprising that at least 66 species associated with moist calcareous woods occur on them. Broad-leaved sedge, for example, occurred at 29 sites, basswood at 25, fragile fern at 21, Robert's geranium at 18, and white snakeroot at 15.

In almost all cases the moist woods species were limited to small pockets of special habitat. At Split Rock, Coon, Rattlesnake, and Whipple Mountains they occur on the lower slopes of ravines; elsewhere they were on moist shaded ledges, or on vegetated talus slopes immediately below ledges. All were in hardwood forest, usually with sugar maple and often with basswood or butternut, in

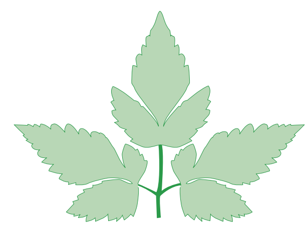
THREE SPECIES OF MOIST, FERTILE WOODS



PRICKLY GOOSEBERRY,
Ribes cynosbati

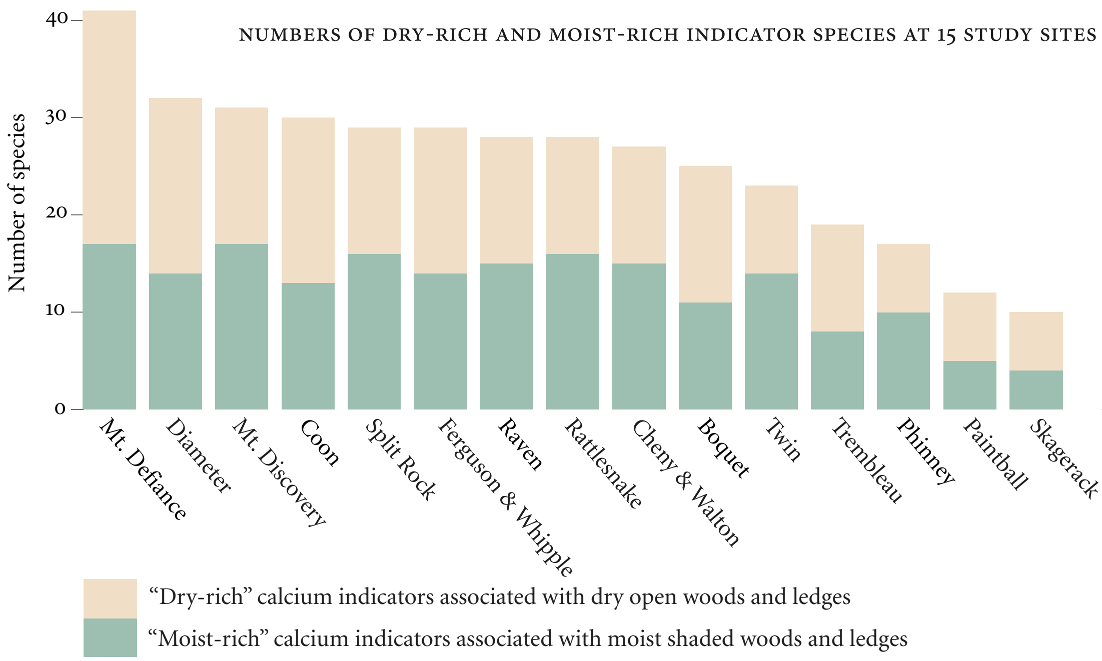


COLUMBINE,
Aquilegia canadensis



SWEET CICELY,
Osmorhiza claytonii

Three widespread species of moist limy woodlands. Prickly gooseberry, which is near its northern range limits in the Champlain Valley, is limited to fairly moist habitats; it is common in the Taconics and western Vermont but uncommon in the West Champlain Hills. Columbine, which is also a southern species, is frequent on moist ledges and also occasionally found on soil in the oak-hickory community. Sweet cicely is a northern species (and has rare relatives that are even more northern). It most commonly occurs in ravines and below moist ledges but, like columbine, can also occur in the oak-hickory community.



concave terrain where there were pockets of deep soil. Almost all were in sheltered areas with some southern exposure: none were seen in the hemlock-dominated ravines on the northern slopes.

In areas like Vermont and western Massachusetts, the moist-rich species cover large areas and we consider them to be separate communities (*rich northern hardwood forest*, *temperate calcareous cliff*) or as pockets of specialized habitat within less fertile hardwood forests. In the West Champlain Hills, where the examples are small and often have only a few indicator species, I prefer to regard them as special habitats within the larger northern hardwood and oak-hickory communities.

The difference is mostly a question of scale. If you like communities big and well differentiated then a small part of a cliff with one or two indicator species is not a community; if you like them small and gradational, then it may be.

Whether or not the moist ledges and ravines in the West Champlain Hills are communities in full, they make a significant contribution to the overall plant diversity. The graph above shows that, in spite of the very limited habitat available for them, the number of moist calcium indicators equalled or exceeded the number of dry calcium indicators at half the sites.

Above, the numbers of dry-rich and moist-rich calcium indicators at the 15 study sites, based on fall surveys through 2005. The dry-rich species mostly occur in oak-hickory woods, the moist-rich species in ravines and on moist cliffs. See Table 1, pp. 20-21 for lists of the species in each category. Twin Mt. is in Vermont and Paintball Hill in Johnsburg, New York, west of the Hudson River. The other sites are in the West Champlain Hills.

With the exception of the last four sites, which are either small (Paintball, Phinney) or on fairly acid rocks (Trembleau, Skagerack) the numbers of dry-rich and moist-rich species are surprisingly constant, suggesting that the number of indicators may be controlled more by general features of geography and bedrock than by the ecological details of the particular sites. Even more surprising, given that much more habitat is available for dry-rich species than for moist-rich ones, the numbers of dry-rich and moist-rich species are nearly equal at most sites. At no site do the moist-rich indicators constitute less than 40% all indicators; at 7 of the 15 sites the number of moist-rich species exceeds the number of dry-rich species.

8 MORE ABOUT THE CHAMPLAIN HILLS COMMUNITY

In the preceding sections I have referred a number of times to the Champlain Hills dry-rich community. Here I attempt to characterize it more accurately and describe its ecology and geography in detail. First a definition:

What is the Champlain Hills dry-rich community? It is a calcareous oak-hickory-hornbeam community, best developed in the Champlain Valley, that :

1 Develops on dry, thin soils derived from calcium-rich rocks, on southeast-facing to west-facing slopes with many bedrock exposures.

2 Contains patchy forests of red oak, white oak and shagbark hickory, usually with hop hornbeam in the understory, and usually with openings and glades within it.

3 Has an open and usually diverse understory of grasses, sedges, shrubs, and herbs.

4 And has a flora that includes both acid-tolerant and calciphilic species.

Some species with a high frequency in this community in the Champlain Valley are white oak, shagbark hickory, bristly currant, round-lobed hepatica, Rafinesque's viburnum, broad-leaved panic grass, woodland sunflower, bottle-brush grass, wavy aster, blue-stemmed goldenrod, and broad-leaved mountain rice. Many other species (stiff sandwort, sicklepod mustard, Douglas's knotweed, round-leaved dogwood, limber honeysuckle …) also appear to be locally faithful to this community but occur at lower frequency.

What are its ecological limits? Within the Champlain Valley the calcareous oak-hickory community is:

1 Limited to well-drained hills with thin rocky soils and some southern exposure.

2 Found on both silicate and carbonate rocks in both igneous and sedimentary terranes but apparently restricted to rocks with calcium-rich minerals.

3 Best developed below 2000 feet elevation, on sites which are flat enough and protected enough to develop continuous soils and support at least scattered trees.

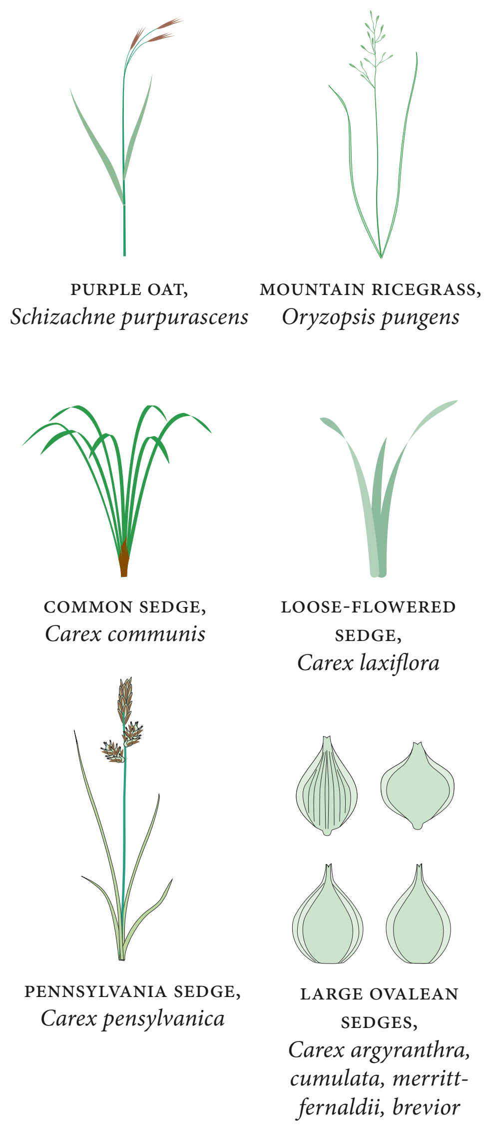
4 Almost always found on sites that have a history of fire.

5 Not found on glacial outwash or thick till and, so far as I know, never found on abandoned agricultural lands.

6 Found on sites that have been logged lightly, but not thus far on ones that have been logged heavily and repeatedly.

What are its geographic limits? The form of the community just described occurs throughout the Champlain Valley and is most abundant along the middle western shore of Lake Champlain,

GRASSES & SEDGES OF DRY OPEN WOODS



Grasses and sedges of oak-hickory woods. At least 17 species of grasses and sedges occur in the calcareous oak-hickory woods of the West Champlain Hills, and a diverse grassy understory like that shown on pp. 28-29 is a common and indeed diagnostic feature of this community. The purple oat and mountain rice grass are northern species, one lime-requiring and one characteristic of acid soil. The common and loose-flowered sedges are most often seen in moist woods, but also occur frequently in dry woods. The Pennsylvania sedge is, along with the species of *Oryzopsis* shown on p. 17, one of the most characteristic plants of dry woods, and often a dominant species in the ground layer. The large Ovalean sedges are fascinating and somewhat vexing plants, hard to find and hard to identify once you have found them, whose status in this community is still uncertain.

where it occupies almost every suitable site. Related communities, occur in the Taconic Mountains in New York, Massachusetts, and Vermont, in the valley between the Green Mountains and the Taconics and on the traprock (basalt) ridges of central Massachusetts. The Champlain Valley occurrences seem to be the northern limits of the community; it does not, so far as I know, occur in New Hampshire, eastern Vermont, the interior Adirondacks, or the northern Connecticut Valley.

Where do similar communities occur? Oak-hickory communities of one sort or another occur throughout much of the eastern United States. The question is which ones are similar enough to those of the Champlain Valley that they may be regarded as geographical variants of the same community.

Somewhat surprisingly, since American ecologists have been computing community similarity indices for over fifty years and Heritage Programs have been inventorying communities for twenty, there are no public databases of communities that can be used to answer this. Heritage program community descriptions suggest that other rich oak-hickory communities occur in southern New York and Pennsylvania, but are not detailed enough for me to assess their similarity.

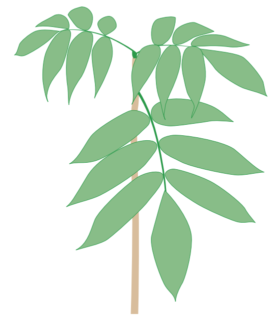
Farther away there are still general similarities but the details are different. The oak-hickory forests in Wisconsin that J.T. Curtis and his associates called southern dry-mesic forests have some of the same indicator species as the oak-hickory forests in the West Champlain Hills. But they also have significant differences. Maidenhair and rattlesnake ferns, which are absent from our oak-hickory forests, are abundant in theirs. Woodland sunflower and blue-stemmed goldenrod, two of our commonest herbs, are absent in their forests; stiff sandwort, a dry ledge plant in our forests, has moved to their dry prairies; and narrow-leaved mountain-rice, one of our commonest oak-woods grasses, is a boreal forest species in Wisconsin*.

The lesson in this is that any description of a plant community that is detailed enough to be useful is necessarily local. If we follow almost any community (save perhaps those of boreal forests and wetlands) for more than a few hundred miles it loses its identity: the characteristic dominants acquire new associates, and the characteristic habitats new dominants.

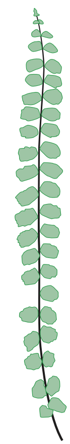
How does the Champlain Hills community differ from other forests in the region? It differs from northern hardwood forests in having white oak and hickory; from the valley-bottom oakwoods of central New England in its thinner soils, the presence of hornbeam, and the absence of acidophilic shrubs; from the ridge-top oakwoods of central New England and New York by the presence of hornbeam and the absence of scrub oak and chestnut oak; from rich mesic

MOIST-RICH PLANTS

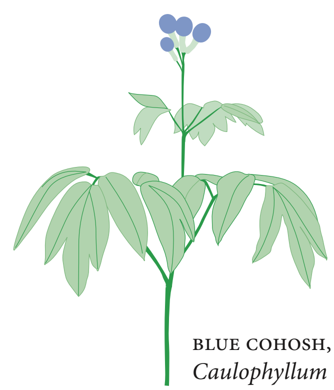
WILD LEEK, *Allium tricoccum*



RED ELDERBERRY, *Sambucus pubens*



MAIDENHAIR SPLEENWORT, *Asplenium trichomanes*



BLUE COHOSH, *Caulophyllum thalictroides*

As a group, the moist-rich species tend to develop and flower early; many of the herbs have a determinate architecture with a fixed number of leaves, and many have compound leaves.

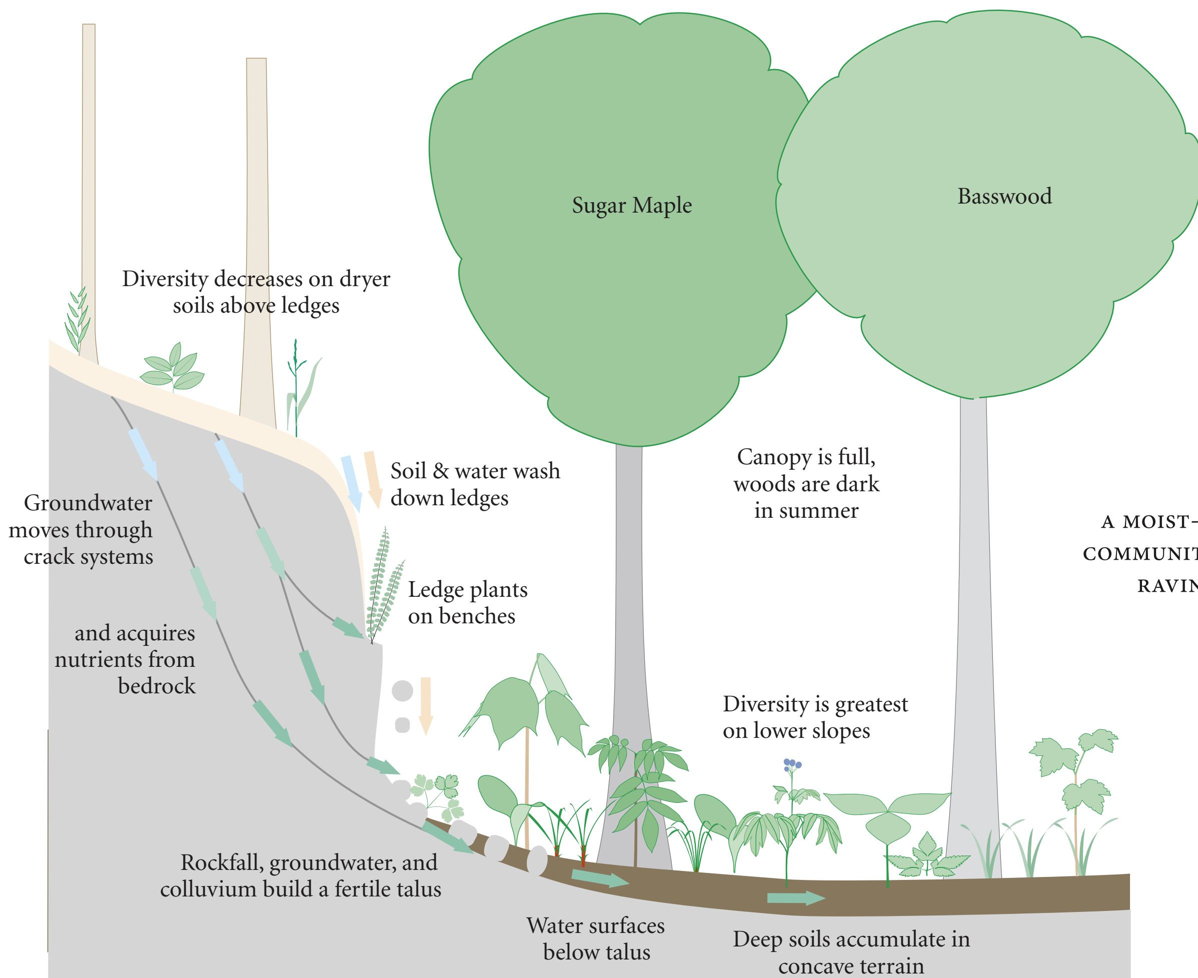
* Data on Wisconsin communities from Curtis, J.T., *The Vegetation of Wisconsin: An Ordination of Plant Communities* (University of Wisconsin, 1959).

forests by the absence of moisture-requiring herbs and shrubs; and from all of these by the abundance of xeric, calcareous herbs and grasses in the understory.

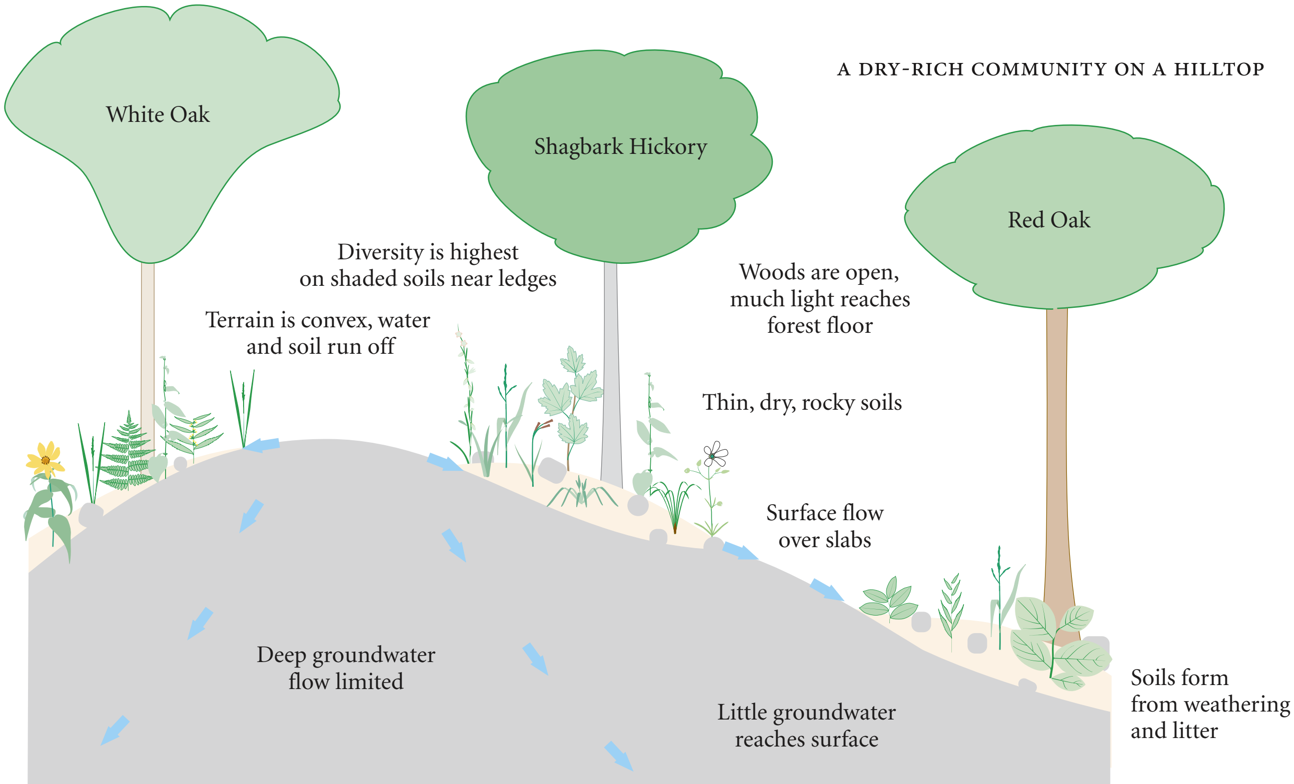
What other names are used for this community? The Vermont Natural Heritage Program calls it the *dry oak-hickory forest/woodland community.* It has been extensively studied in Vermont, and a number of the examples are known for their high diversity and rare species. I would note only that *every* upland Vermont example I have seen of this community is on limy bedrock, and that if you were to call their communities *rich dry oak-hickory forests* their circumscription of the community would be essentially identical to mine.

Massachusetts uses the names *hickory-hop hornbeam forest/woodland, yellow-oak dry calcareous forest,* and *dry rich acidic oak forest* for various phases of this community. This may be more names than are really necessary. I have some doubt as whether the *rich acidic oak forest* really is acid, and in the Berkshires yellow oak

Below, moist richness in a ravine. Moist-rich sites tend to develop on concave terrain, under maple-basswoods forests, and often below ledges or steep slopes which feed groundwater and soil into the community. They are associated with deep soils, downslope accumulation of colluvium (soil moved by gravity and surface flow), and groundwater seepage. They tend to be dark in summer, and have their greatest diversity in ravines and hollows.



A MOIST-RICH COMMUNITY IN A RAVINE



A dry-rich community on a rounded knoll. Dry-rich communities tend to develop on convex terrain, either in the open or within oak-hickory-hornbeam forests. They are associated with shallow but stable soils that develop in place, and usually have much surface flow but little groundwater seepage. They are most diverse on benches and knolls where the canopy is patchy and the forest floor is well-lit, allowing the development of a late-flowering flora that is rich in grasses and tall herbs.

often mixes with white oak and hickory and may not be a separate community.

New York describes the openest and rockiest phase of this community as the *red cedar rocky summit* community, and notes three sites in the Adirondacks. But, as noted on p. 29, they define this community somewhat narrowly as an open, ridgetop community dominated by red cedar and red oak. Our oak-hickory forests are never dominated by red cedar, are not always open and patchy, are not restricted to ridgetops, and are often dominated by white oak instead of red oak.

9 THE TWO TYPES OF RICHNESS

I have referred several times to the notion of a rich woods and to my hypothesis that the richness in oak forests is different from that in maple forests. It is now time to make these notions explicit.

What is richness and what spatial patterns does it display? I define richness as a local increase in plant diversity, commonly driven by increases in the pH and base content of the soil, which in turn are driven by bedrock and surficial geology and by the way water moves over and through soils. It is my thesis that there are two kinds of richness, each with its own spatial, geological, and botanical pattern.

The first, and best known type of richness, I call *moist richness.* This is richness that is associated with deep, moist soils or mineral-rich groundwater. The moist-rich plants need places where calcium-rich soils accumulate and places where calcium-rich ground water surfaces. For them, fertility is less about finding an intrinsically fertile place than about intercepting the flows of soil and nutrients that are moving by them.

For the moist-rich plants what really matters is not the bedrock under them, but rather where the soil on that bedrock has come from and what kind of groundwater flows through it. The base of a low-calcium ledge may still be a very fertile place if groundwater seeps down the ledge and soil accumulates there. A detached boulder of high-calcium rock may be infertile because water only moves over it and not through it.

Spatially, moist richness is best developed in concave topography and in areas with thick soils. It is common in ravines, at the base of ledges, on talus slopes, and below glacial terraces. It tends to decrease as you move uphill, and often vanishes altogether on ridgetops. In the Taconics where I live, many hills with limy maple-basswood forests on their lower slopes have acid chestnut oak-huckleberry forests on their crests.

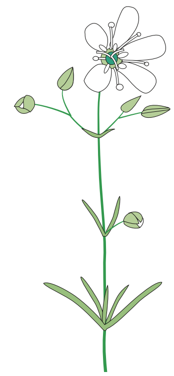
Because moist richness is dependent on the movement of groundwater and soil, it is best developed in places that are permanently wet and geomorphologically active. Soft, wet, dirty, well-fractured ledges near the base of mountains that accumulate ice in the winter and have active gullies and taluses often have rich woods below them; hard, dry, stable, ledges near the tops of mountains rarely do.

Geologically, moist richness is best developed on carbonate rocks—limestones, dolomites, marbles, and limy schists—and in areas with deep calcareous tills. It occurs, as explained on p. 31, on calcium-rich igneous rocks, but apparently in a much more restricted form. Thus far, while I have observed almost all the moist-rich *species* on igneous rocks, I have only observed very limited development of moist-rich *communities* on igneous rocks.

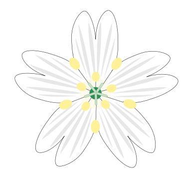
Botanically, moist richness is usually found in maple woods and select for species that require deep moist soils and can tolerate deep summer shade. These species tend to develop and flower early in the season and usually have a determinate growth pattern with a fixed number of leaves, and often have multiply compound leaves. Early saxifrage, maidenhair fern, Goldie's fern, cohosh, meadow rue, red and white trillium, leeks, and toothworts are common moist-rich species.

Dry Richness. The second, and less-known kind of richness, is dry richness. This is richness that is associated with open communities on thin, dry, rocky soils. In our area it occurs on rocky benches and

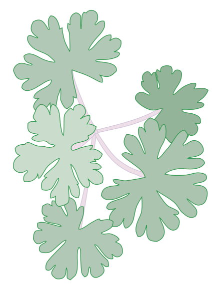
DRY-RICH WILDFLOWERS



STIFF SANDWORT,
Minuartia michauxii



FIELD CHICKWEED,
Cerastium arvense



BICKNELL'S GERANIUM,
Geranium bicknellii

As a group the dry-rich plants tend to be drought tolerant and shade intolerant. Many flower late, have simple or once-compound leaves, and an indeterminate growth pattern, meaning that they continue to add leaves in the summer. Several common species are shown on p. 17-19 and 33. The three shown here are less common. The stiff sandwort is a southern species, near its northern range limits here, that often grows at the edge of open slabs where water moving through the soil comes to the surface. The field chickweed is an extremely wide ranging species of high latitudes in North and South America, Europe, and Asia that is found on both calcium-rich and magnesium-rich rocks. Bicknell's geranium is a North American species with a northern distribution that often grows on recently disturbed soil.

knolls, sometimes in the open but more often in glades in sparse woods. The places where it occurs are often a complex mixture of loose rocks, small ledges, pockets of soil, and plants. They tend to look very grassy in late summer and fall, and I think of them, both functionally and botanically, as relatives of the oak glades and goat-prairies of the midwest that have somehow ended up on top of our hills.

Spatially, dry richness develops on convex, often sloping terrain, usually with a south, southeast, or southwest exposure, and usually below 2000 feet in elevation. Unlike moist richness, dry richness increases uphill; benches are usually more fertile than the slopes below them, and ledge crests and the tops of knolls often more fertile than their bases.

Geologically, dry richness is found on marbles, dolomites, and calcium-rich igneous rocks, particularly gabbros, anorthosites, and basalts. It also develops on calcareous schists but may—here I am generalizing from inadequate information—be less common on them than on other rocks.

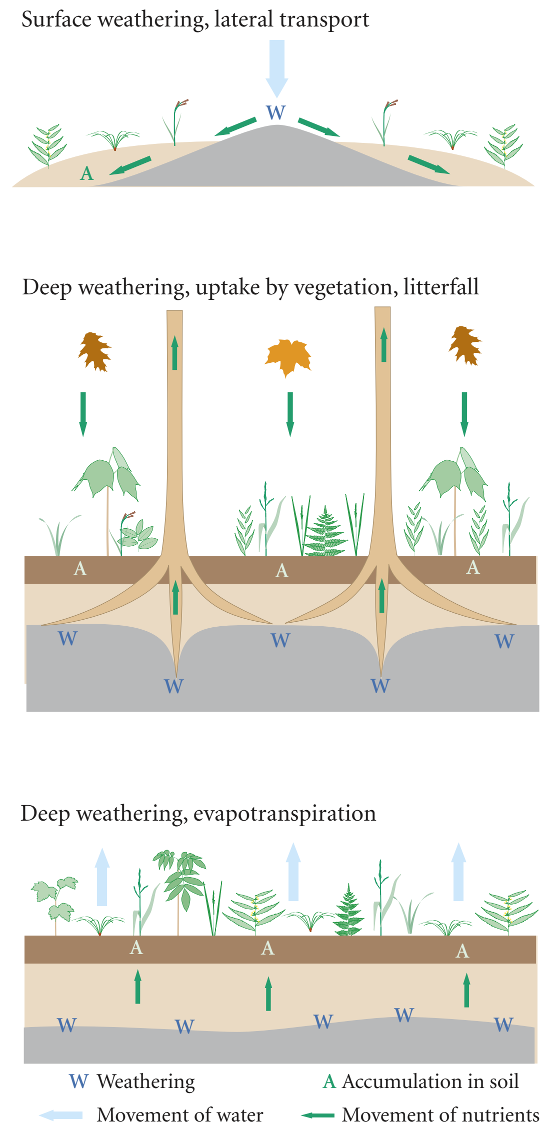
Geomorphologically, dry richness occurs on stable sites without soil movement, usually in places where there is no evidence of groundwater seepage. It is associated with thin but well-vegetated soils that have usually formed in place. So far as I know, it never occurs on deep till or outwash. It seems to develop best in places where there is a mosaic of bare rock and vegetated soil, and it may be that the surface movement of particles and dissolved minerals from outcrops to adjacent pockets of soil is one of the processes that make nutrients available to plants.

Botanically, dry richness is usually associated with oak-hickory woods, and involves a distinctive group of species that are drought tolerant but shade intolerant. These species tend to have southern and western distributions, develop late in the growing season, and have simple leaves and indeterminate growth. Some characteristic dry-rich species in the West Champlain Hills are woodland sunflower, broad-leaved mountain rice, round-lobed hepatica, broad-leaved panic-grass, bottle-brush grass, stiff sandwort, limber honeysuckle, and bristly currant.

How strongly does dry richness differ from moist richness? In the Champlain Valley, very strongly. Dry richness occurs in different forest types in different topographic positions. It has a distinct group of indicator species, many of which differ in architecture and phenology from the moist-rich species, and does not seem to require either deep soils or ground water seepage, both of which are commonly associated with moist richness.

How similar are the dry-rich communities on carbonate rocks in Vermont to those on calc-silicate rocks in the West Champlain Hills?

SURFACE PROCESSES THAT MAY RELEASE AND TRANSPORT MINERALS LOCALLY IN DRY SOILS



Because the dry soils in the oak-hickory stands of the West Champlain Hills are usually on convex terrain, they have relatively little water flowing through them or through the bedrock under them. As a result, soil movement and groundwater seepage, the two most important mineral-transfer processes in wet soils, are probably unimportant in dry ones. My guess is that there is little long-distance transport of minerals through dry soils, and that instead the local process shown above are the main ways that minerals are moved and concentrated.

I find them very similar in indicator species and overall pattern. The main difference I have noted is that the carbonate rocks have, and the calc-silicate rocks seem to lack, a group of plants that I call "contact calciphiles" that live directly on limy rocks. These include several small ferns (wall rue, purple-stemmed cliff brake, walking fern), and many mosses, particularly in the genera *Abietinella, Anomodon, Barbula, Didymodon, Encalypta, Seligeria, Tortella, Tortula,* and *Weissia.*

Do dry-rich communities occur in red oak-maple forests as well as white oak-hickory forests? Yes. I have seen them in the Taconics and Brett Engstrom has described them to me from the Winooski Valley in Vermont. Relatively few have had botanical study; the observations I have suggest that they have somewhat fewer calcium indicators than the oak-hickory communities.

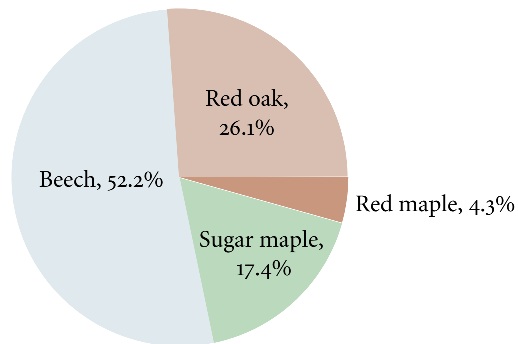
What surface processes make the minerals from the bedrock in rich communities available to plants? I know of little research on this subject, and my answers are speculative. In both dry- and moist-rich communities, surface weathering and root-zone processes release nutrients from bedrock. In dry-rich communities where there is little groundwater flow, I assume that the processes are fairly local: nutrients are brought to the surface by uptake and litter-fall, especially by deep-rooted woody plants, and moved laterally for short distances by surface flow. They may also be brought to the surface by evaporation, as happens elsewhere in arid soils.

In moist-rich communities the processes seem to act over longer distances. Uptake and litterfall are probably still important, but they are greatly augmented by the movement of soil and groundwater.

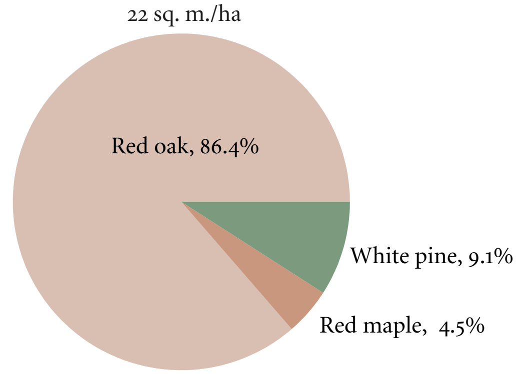
In any given habitat one or two processes likely dominate the others. On isolated boulders and summits with much bare rock surface weathering and surface flows must predominate. Since bare-rock silicate summits typically have few calcium-indicating plants compared to carbonate summits, I assume that the rate of surface weathering is higher for carbonate rocks than silicate rocks. In oak-hickory communities on benches with little deep-groundwater, I assume that root-zone weathering, litterfall, and lateral movement by surface flows predominate. Since such communities are often much richer in indicators than the communities on bare rocks, I assume that root-zone weathering is more effective than surface weathering. And finally, in seepage areas on the faces of ledges and below rocky taluses, I assume that deep groundwater is the principal source of nutrients. Since such areas often have far more calciphilic species than dry rocks without internal flow, I assume that deep groundwater is exceptionally effective at transporting nutrients.

PRISM SAMPLES FROM COON MOUNTAIN

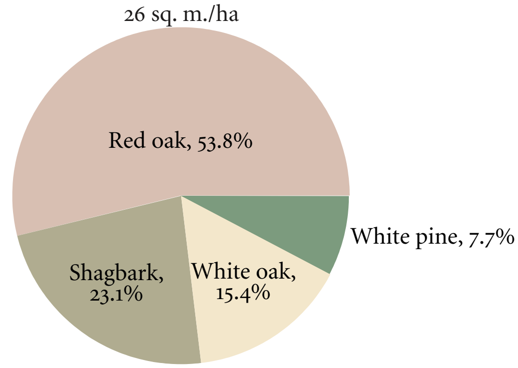
WOODS BELOW SOUTH CLIFF,
23 sq. m./ha



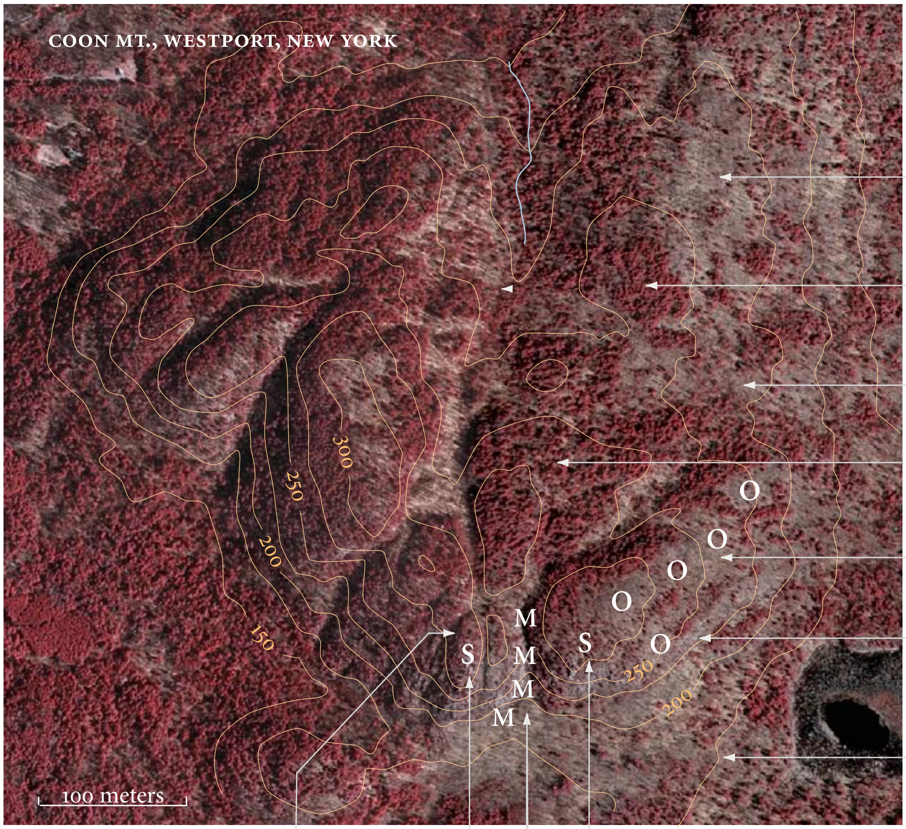
WOODS NEAR SOUTHWEST SUMMIT,
22 sq. m./ha



WOODS ON SOUTHEAST SLOPE,
26 sq. m./ha



The basal area of trees over 10 cm DBH at Coon Mountain. The number under the each caption is the estimated total basal area of the stand in square meters per hectare. The upper graph is for second-growth hardwoods along the trail; the middle one for oak-pine woods near the southwest summit, and the third for oak-hickory woods on the southeast slopes.



Northern hardwoods

Low diversity white pine-hemlock

Northern hardwoods

Low diversity white pine-hemlock

Oak-hickory glades on east side, medium diversity

Band of ledges

Post-agricultural woods, low diversity

Red oak-white pine woods, medium diversity

SW cliffs and summit

SE cliffs and summit

Mesic woods in fertile ravine, high diversity

Coon Mt. in winter, from the 2003 infrared orthophoto quads of Essex County from the New York State GIS Cooperative. Conifers are red, hardwoods an indistinct gray. The southern ridgetops and upper slopes are a pine-oak forest of moderate diversity but with few calcium indicators. The southeastern slopes are open oak-hickory woods (O) which have a number of calcium indicators, but do not have an exceptionally diverse flora. The ravine between the two southern summits has rich mesic woods (M) with a number of uncommon species. The remainder of the forests, including about 90% of the mountain, are northern conifer and northern hardwoods forest of low diversity.

Why do moist-rich and dry-rich habitats have different species? There is a clear ecological reason and perhaps a historical reason as well. The sugar maple forests that develop on moist-rich sites are quite dark in the growing season, and so favor large-leaved, early-season, shade-tolerant herbs. These include a number of old-fashioned "arcto-tertiary" genera like *Carex, Ranunculus, Arisaema,* and *Caulophyllum* that evolved in the moist-temperate forests of thirty million years ago. Relatively few of these species can tolerate drought.

The dry-rich sites have thinner forests and are both brighter and dryer in summer. They cannot provide the moisture that many of large-leaved, early-season species need, and so favor drought-tolerant species with less leaf area. These species tend to be late developing and shade intolerant. Their need for light may account for the characteristic development of dry-rich communities on convex topography and under patchy canopies. They include a number of species from groups like the grasses, beans, and composites that proliferated in the open prairies ten to twenty million years ago. These groups were much less common in the arcto-tertiary forests than in the open communities that replaced them, and some of the difference between the moist- and dry-rich communities may be that they have different histories and are drawing their plants from different sources.

Why do many ridges in the Taconics and Berkshires with moist-rich communities on their sides have dry-poor chestnut oak rather than dry-rich white oak-hickory communities on their crests? This is a good question for which I do not have a good answer.

Why do some of the West Champlain Hills have dry-rich oak-hickory communities on their summits and others have dry-poor red pine-white communities. Again, I do not know. I am not sure if this is a local bedrock difference, or if the oak and pine communities are alternate states, differing in their soil chemistry and nutrient cycling, that can develop on the same bedrock (p. 29). I speculate that hot fires may encourage low-diversity, pine-dominated communities, but it is only speculation.

10 EXAMPLE I: COON MOUNTAIN

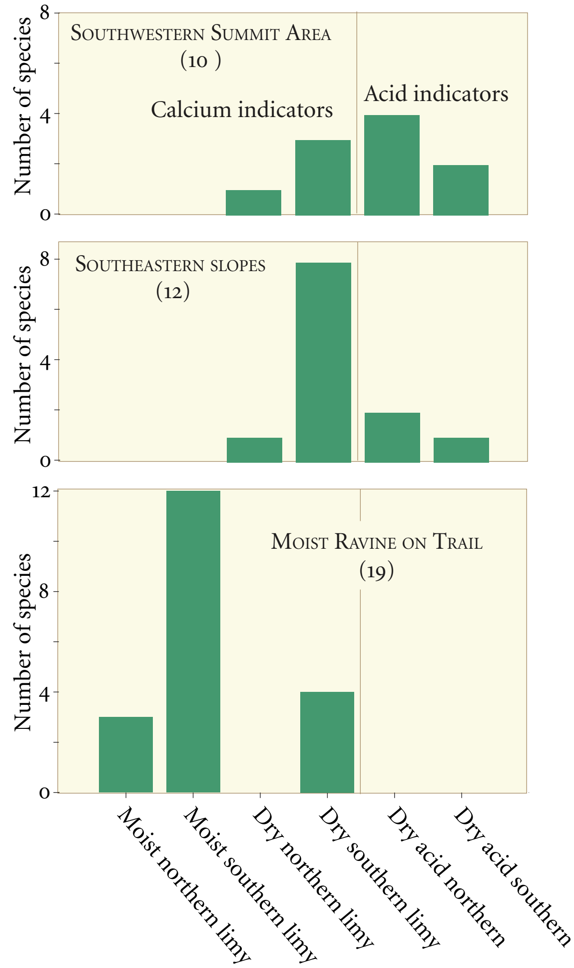
Coon Mountain, in Westport, shows how the various communities are distributed on one of the mountains in the study. The pictures on pp. 4 and 6 show the southern face and the orthophoto on p. 40 shows the arrangement of communities on the south and southwestern slopes.

The *lower woods,* which form a skirt around the base of the mountain, are a mixture of white pine, hemlock, and northern hardwoods. The canopies are closed but the diameters are mostly under 30 cm at breast height, and the stocking (total volume of timber) is about half or two-thirds that of a mature stand. The regeneration is often dominated by beech and there are very few calcium indicators, suggesting that the soils are fairly acid. One stand I sampled had 23 square meters of basal area per hectare, a typical value for this sort of woods (p. 39). About half the basal area of this plot was in beech and the remainder divided between red oak and sugar maple. Red oak is a handsome component of this forest, but does not seem to be reproducing at all.

The *open cliffs* on the south and southwest faces are sparsely vegetated with typical species of dry pine-oak forests. No calcium indicators occur on their exposed faces or at their bases

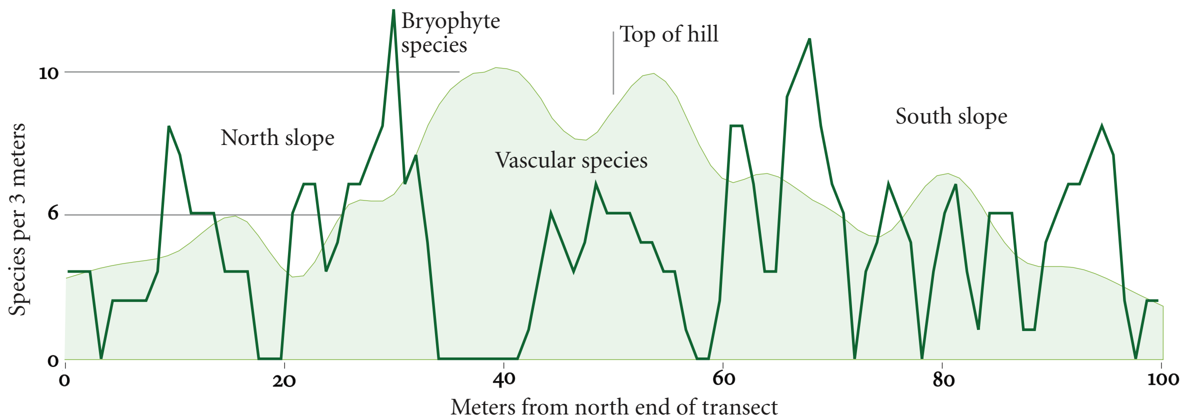
The *fertile ravine* between the southeast and southwest cliffs is steep and narrow, with moist, partly vegetated rock walls and a small, well-vegetated talus. The forest in the ravine is a patchy mixture of sugar maple, basswood and bitternut hickory. It was too small and uneven to sample accurately and so I did not take a prism sample. The ravine bottom and rock walls have a well-developed rich mesic flora, with maidenhair fern, Goldie's fern, wood nettle, lopseed, sharp-lobed hepatica, and several rich-woods

NUMBERS OF ECOLOGICALLY SPECIALIZED SPECIES IN THREE COMMUNITIES ON COON MT.



The numbers of ecologically specialized species in different eco-geographical groups, based on Table 1, p. 20, for three communities on Coon Mt. The southwestern summit and adjacent oak-pine woods are dominated by species of dry, acid communities; they have a total of 10 indicator species, of which 6 are acid indicators and 4 calcium indicators. The oak-hickory woods on the southeast slopes are marked more calcareous, with 9 calcium indicators and 3 acid indicators. No moist-rich species occur in either community. The mesic woods in the ravine between the two summits are the most calcareous by far, with 19 calcium indicators and no acid ones. Interestingly, although 15 of the 19 indicators in the ravine are moist-rich species, 4 dry-rich species occur as well.

SMOOTHED PLANT DIVERSITY ON THE PAINTBALL TRANSECT



A comparison of vascular plant and bryophyte (moss + liverwort) diversity on the Paintball transect. See pp. 44-45 for a community diagram. The graph gives the number of species per three meter segment, computed as a sliding average at one-meter increments. The vascular plant diversity is a smooth curve that follows the contours of the hill and peaks on the two summits. It suggests that dry-rich diversity is closely related to topography and outcrops. The bryophyte curve is jagged and patternless (and would be even more jagged if it had been computed for one-meter segments). It reflects the presence and absence of suitable microhabitats (trees, rocks, logs), but apparently nothing about the overall structure of the hill.

sedges. All told there are 19 calcium indicators, mostly common moist-rich species with southern ranges, but also some northern and xeric species too.

The *woods near the southwest summit* are dominated by red oak and white pine with an understory of blueberry, huckleberry and bracken. Small amounts of hemlock and red pine are mixed in. A number of small oaks occur, which may indicate recent reproduction, or simply that the growth rates here are very slow. The total basal area is about the same as in the lower woods but the trees are lower and the timber volume probably smaller.

These woods look at first like a typical dry, acid, ridgetop oak community, but turn out to have a surprisingly diverse understory flora of about 35 species of herbs and shrubs, including four calcium indicators (limber honeysuckle, wavy aster, bristly gooseberry, and broad-leaved panic grass). They are neither highly diverse nor strongly calcareous, but seem to be transitional to woods that are.

The *woods below the south-eastern summit* also have white pine and red oak, but these are now mixed with white oak and shagbark hickory and so are an example of our West Champlain Hills oak-hickory community. The canopy is quite patchy. In the place where I did my prism count (p. 39), the basal area was comparable to the southwest summit woods, though the diameters averaged smaller. In other places there were rock outcrops—tilted slabs and small ledges—and the canopy was open and the basal area quite low.

This oak-hickory community on the southeast slopes was definitely calcareous: it had about ten calcium indicators, including wavy aster, Kalm's bromegrass, woodland sunflower, and two species of wild liquorice. In addition, as is typical in this community (p. 23), there were several acid tolerant species: pinweed and rusty woodsia, both characteristic of open dry ledges, and *Bulbostylis capillaris* and *Oryzopsis pungens,* both characteristic of dry sandy soils.

As is also typical in the West Champlain Hills, the oak-hickory community was limited to the south and southeast slopes and only extended a few hundred meters. As soon as the ridge began to

AN UNCOMMON SEDGE

Back's sedge, *Carex backii,* (named for Sir George Back, a British explorer who accompanied Franklin on several of his arctic trips), is a northern sedge which in our area is usually found in dry, rocky calcareous woods. It is occasional in limy oak and maple woods on the east shore of Lake Champlain. It was rare in our survey, but it is somewhat hard to separate from the common *Carex laxiflora* in the fall and may be more common in the West Champlain Hills than our records show.

slope to the north the soils became moister and deeper, and the oak-hickory woods were replaced by hemlock-hardwoods forest. I followed this to the north for about a kilometer to see if I could find more hickory but I couldn't; apparently the oak-hickory community only occurs on the thin soils on the southwestern slopes.

11 EXAMPLE II: PAINTBALL HILL

In the fall of 2005 I prepared a detailed map of the vegetation on a hundred-meter transect on Paintball Hill, in Johnsburg, New York (pp. 42-43). Paintball is located about twenty miles west of the West Champlain Hills but is still relevant to them. My thought was that by studying how plant diversity varied within a small dry-rich site I might be able to get a better sense of the processes that drive it.

Paintball Hill is a small hill (75 meters high, with a 250-meter-long summit) lying just west of Huckleberry Mountain and north of Crane Mountain. Both of these are typical east-Adirondack granitic mountains with, so far as I have been able to determine, no calcium-indicating species at all.

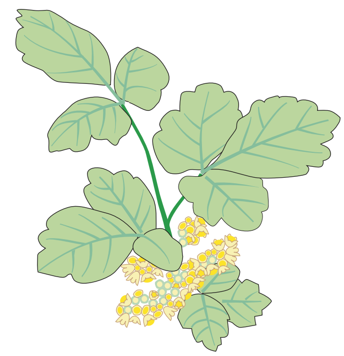
Paintball Hill, though near Crane and Huckleberry, is unlike them. Its rocks (p. 14) are black and in places weathered and crumbly, with black mica and grains of pyroxene or hornblende. It has red oaks and hornbeams on its summit and about a dozen calcium-indicating herbs and shrubs in its understory, including leatherleaf, blue-stemmed goldenrod, both species of mountain rice, and Back's sedge.

My map (pp. 42-43) shows a diversity pattern common on dry-rich hills. The diversity is low on the lower slopes and increases upwards; the calcium indicators, many of them southern-xeric species, are most abundant on the shaded rock outcrops and the south slope. There is no seepage, and few "contact calciphiles" (p. 37) that grow directly on the rocks.

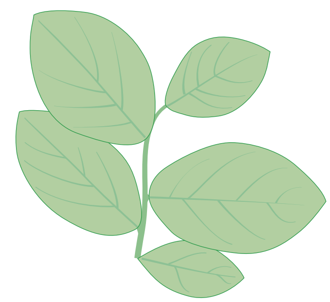
The absence of contact calciphiles is reflected in the difference between the diversity patterns of vascular plants and bryophytes (graphs, pp. 25, 40). The 28 vascular plants grow mostly in small pockets of soil. Over half of them are calcium indicators, and their diversity increases smoothly towards the rocky top of the hill, suggesting that their abundance is tied to hillslope processes and part of an overall dry-diversity pattern. The 34 mosses and liverworts grow mostly on rocks, logs, and tree bases. Only one of them is a calcium indicator. Their abundance fluctuates independently of topography, suggesting that it is not tied to the overall diversity pattern.

Paintball Hill differs from the West Champlain Hills in several ways. It is much smaller than most of them, and its forests, though containing red oak, are sugar-maple dominated. It does not have white oak or hickory, and has only about half as many dry-rich

TWO DISTINCTIVE SHRUBS OF DRY CALCAREOUS WOODS



FRAGRANT SUMAC,
Rhus aromatica



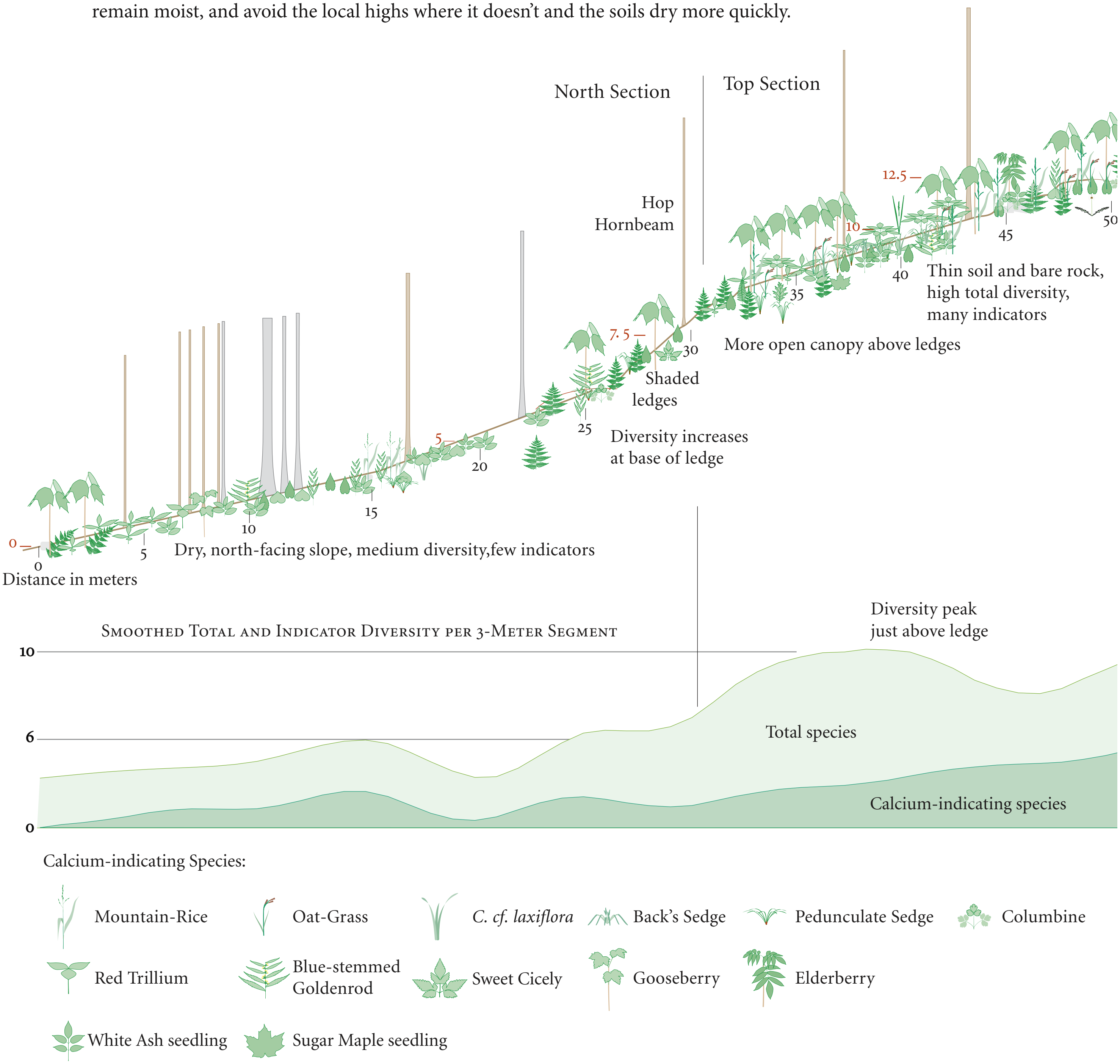
LEATHERWOOD,
Dirca palustris

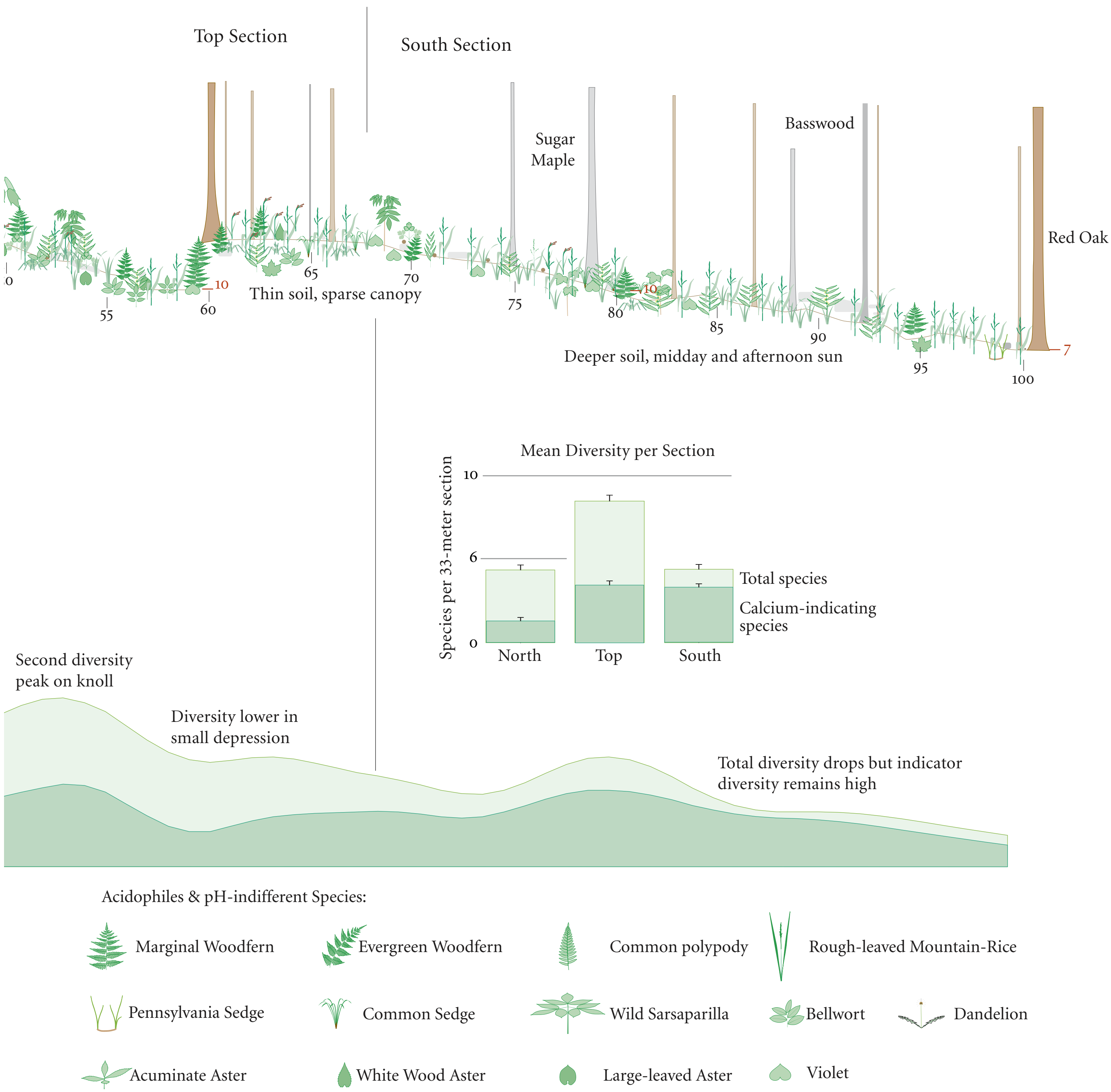
Two uncommon species of dry limy woods. Fragrant sumac is an extremely wide-ranging species or species complex that ranges from Quebec to Florida in the east and stretches across the continent, reaching Alberta, California and Mexico in the west. It is near its northeastern range limits here – it occurs in western Vermont but not in eastern Vermont or Massachusetts – and is limited to fairly exposed sites on dry rocky hills. I found it at three sites in this survey, and recently at a fourth site examined after the survey was concluded. No site seemed to have more than a few plants, making it one of the scarcest species in the survey.

Leatherwood is an eastern U.S. species near its northern range limits here which occurred, usually in small quantities, in five sites in this study. It has small, pretty, yellow flowers which appear early in the spring and are not as well known as they should be. It occurs in both moist and dry woods, always on fertile sites; I have listed it with the dry woods species here because most of the West Champlain Hills records were from dry rocky sites.

VEGETATION DIVERSITY & PATTERN ON PAINTBALL HILL, JOHNSBURG, N.Y.

The vegetation of dry, dark-rock summits like Paintball is structured by aspect, rock-exposure, and surface runoff. Diversity is high overall on summits and south slopes, and high locally where there are rock exposures and where surface flows are intercepted and accumulate. Acidophiles and calciphiles mix in a complicated way. The flora is adapted to gaps, shallow soils, and intermittent moisture. On Paintball it is rich on ledge-crests and convexities and poor at ledge bases and in depressions. But even the ledge-tops microtopographic control is important, and a number of species seek out local lows – crack, channels, edges of stones – where water accumulates and the soils remain moist, and avoid the local highs where it doesn't and the soils dry more quickly.




Top Section
South Section
Sugar Maple
Basswood
Red Oak
55
60
10
65
70
Thin soil, sparse canopy
75
80
10
85
90
95
100
7
Deeper soil, midday and afternoon sun
Mean Diversity per Section
Species per 33-meter section
10
6
0
North
Top
South
Total species
Calcium-indicating species
Second diversity peak on knoll
Diversity lower in small depression
Total diversity drops but indicator diversity remains high
Acidophiles & pH-indifferent Species:
Marginal Woodfern
Evergreen Woodfern
Common polypody
Rough-leaved Mountain-Rice
Pennsylvania Sedge
Common Sedge
Wild Sarsaparilla
Bellwort
Dandelion
Acuminate Aster
White Wood Aster
Large-leaved Aster
Violet

indicators as the best Champlain Valley sites (graph, p. 32). But it is also interesting for precisely these reasons. It shows that dry diversity is limited neither to oak-hickory forests nor to the Champlain Valley, and that when it develop in other settings it still keeps its characteristic spatial and botanical signatures.

12 DISTURBANCE AND THE CHAMPLAIN HILLS COMMUNITY

I use disturbance here for a wide range of events and processes—fire, logging, storms, acid deposition, changes in climate, the arrival of weeds—that alter the structure or composition of vegetation. Disturbance may be largely natural, like historical windstorms, largely man-made, like logging and acid deposition, or a complex mixture of the two, like climate change and the increase of deer populations.

To understand the oak-hickory community, we need to know what disturbance has done to it in the past. My quick answer, subject to much uncertainty, is that thus far wind, ice, acid, and weeds have been relatively unimportant and logging and fire relatively important.

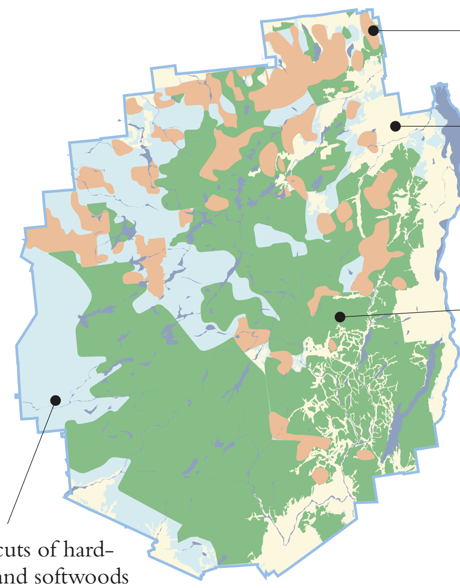
To conserve the oak-hickory community, we need to anticipate which disturbances will be important in the future. My estimate here, subject to even more uncertainty, is that fire suppression, rising deer populations, and changing climates will be very important in the next fifty years, though in what ways and with what eventual outcomes I can't predict.

My thinking, and the limited number of facts I have available, are as follows:

Storms. Historically, the west shore of Lake Champlain lies outside the areas known to have been affected by the large windstorms of 1938, 1950, and 1995 but within the area affected by the ice storm of 1998 and Hurricane Floyd in 1999. I saw extensive ice damage and perhaps blowdown as well on the ridge and around the south summit of Boquet Mountain, but little elsewhere and none in the oak-hickory areas. Thus my tentative judgement is that wind disturbance has not been important in the calcareous communities in the recent past, though of course it might become so in the future.

Weeds. Nonnative herbs and shrubs do not seem a problem at the present time, but might easily become one in the future. The mostly

HISTORIC FARMS AND FIRES



Above, a simplified version of the New York State *Fire Protection Map of 1916, from* Jenkins, J. 2004. *The Adirondack Atlas: A Geographic Portrait of the Adirondack Park*. Syracuse University Press. Syracuse, NY. The Champlain Valley, including the West Champlain Hills, was considered principally agricultural land rather than forest in 1916, though of course there were many woodlots and most of the upper mountain slopes were forested. The large fires associated with charcoal-making and industrial logging were mostly in the interior of the park.

Left, fires in the Champlain Valley between 1890 and 1915, also from the *Fire Protection Map*. The area is about the same as that in the map on p. 10. Although the large fires were in the interior, there were some fires in the Champlain Valley, and apparently some in the West Champlain Hills.

widely distributed alien herbs were the common St. Johnswort (nine sites), wild savory (seven sites), and yarrow (four sites). St. Johnswort in particular was well established and locally common in open woods and summit areas, as it is on roadsides and in open ground throughout our area. But there was no evidence that it was becoming a dominant or displacing other species.

The most widely distributed woody aliens were Morrow's honeysuckle (6 sites), common barberry (5 sites), and common buckthorn (14 sites). All three occurred as small scattered plants, mostly in northern hardwoods but occasionally in oak-hickory forests as well. Currently the populations are small, but since these species have all proven to be formidable invaders of dry calcareous woods elsewhere they bear watching.

Logging. Logging is widespread in all but the steepest and thinnest communities on these hills. The northern hardwoods on the lower slopes of the mountains have all been cut heavily, and have mostly relatively small and presumably young trees. In some cases, as for instance on the lower slopes of Coon Mt., the forests are recovering and the growing stock looks good. Elsewhere, as in the large area of highlands north of Skagerack and east of Drake Mountain, the woods have been picked down to scraps, and currently the growing stock looks awful and recovery will likely be slow.

Higher up a few of the mountains there are sometimes larger trees and small patches of what appear to be older woods. These patches are few and far between but can be very handsome and add greatly to the beauty and potential conservation value of the hill. I saw large trees in the saddle south of Mt. Discovery, on the ridge between Raven and Little Raven, and in a ravine on the southeast side of Rattlesnake (Willsboro). There are likely others I didn't see.

Within the existing oak-hickory communities there is, for the most part, less evidence of logging than elsewhere. Although oak and hickory are valuable woods, the ridgetops and benches tend to be inaccessible, and the trees low and crooked. I found stumps within some oak-hickory stands, but no signs of heavy logging. But I did see signs of heavy logging adjacent to several oak-hickory communities, and think it very possible that heavily logged oak-hickory stands may not regenerate to oak and hickory but rather to lighter-seeded trees like birch, pine, and maple. Thus logging might convert an oak-hickory stand, either permanently or for a forest generation, to some commoner forest type.

I have observed conversions of this sort in logged red oak-hickory stands in the Taconics and so know that they can occur. But I have no idea how common they are or whether they have occurred in the West Champlain Hills.

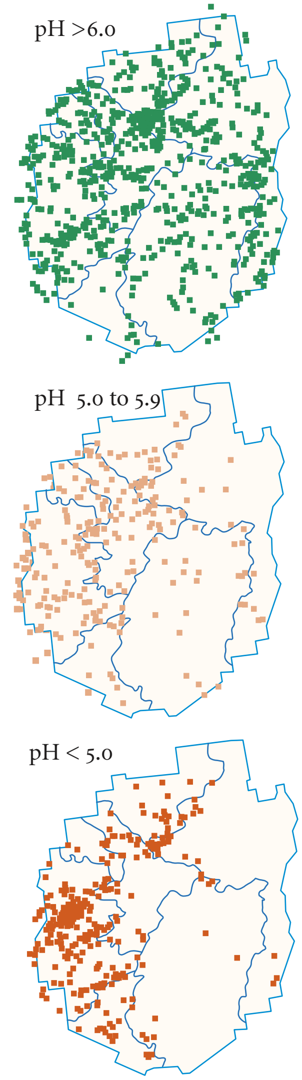
This uncertainty is part of a larger information gap. So far as I know, we do not really know very much about the biodiversity effects of logging on rich calcareous woods. It is clear that both dry-rich and moist-rich woods can tolerate small to moderate amounts of selective logging. But it is not clear to what extent they can tolerate either the soil disturbance or the rapid fluctuations in understory composition caused by heavy logging. My guess, and it is only a guess, is that much depends on which trees regenerate after the logging. In woods that were intensely managed for good regeneration—the coppice woods of southern England, New England maple orchards, farm woodlots growing oak timber in the midwest—the ground-layer plants fluctuate in abundance after a cut but the overall composition doesn't change much. But in woods where the dominate trees regenerate poorly, cuts can change the canopy composition dramatically, and it seems likely that the understory will change as well.

Fire. The effects of fire on the summit and oak-hickory communities deserve a systematic historical study. Lacking that, I can only make two counterbalanced observations. The first is that probably most or all of the West Champlain Hills have had fire at sometime or other. Charcoal is common in the soil and fire scars are common on trees. Red pine, a fire-dependent species, occurred on seven hills, and recent burns, likely within the last five years, occurred on three hills. So it is clear that the oak-hickory community regenerates after fires, and it is possible, though certainly not proven, that it depends on fires to maintain its openness and to suppress northern hardwoods species that might otherwise take over.

But it is not in the least clear that the rich oak-hickory stands can tolerate frequent fires. In the three recent burns I examined* there was much bare rock, and the communities were very low diversity associations of acidophilic species without any of the characteristic calcium indicators of the oak-community. I do not, of course, know whether these were natural or man-made fires, or what the diversity had been before they occurred. But I do want to raise the possibility since the oak-hickory woods apparently depend on litterfall from trees and nutrient cycling in a thin soil mat, a fire that killed too many trees or removed too much soil could be a very severe disturbance, and one that it would take a long time to recover from.

Atmospheric Acids. The West Champlain Hills currently receive moderate amounts of sulfuric and nitric acids from acid deposition, but because they are low calcareous hills in the rain shadow of higher ones, there is no evidence that the acids are a major ecological problem. In the Champlain Valley the current deposition rate of sulfate is estimated to be 2.3–3.5 kg S per hectare per year,

LAKE pHS MEASURED BY THE ADIRONDACK LAKES SURVEY



Maps from Gallagher and Baker, "Current status of fish communities in Adirondack lakes," in Baker et al., *Adirondack Lakes Survey: An Interpretive Analysis of Fish Communities and Water Chemistry, 1984–1987,* 1990. Most of the low-pH lakes are in the west and north; the lakes in the Champlain Valley are mostly circumneutral, with pHs of 6.0 or higher. The blue lines are watershed boundaries.

*Near the summits of Skagerack, Discovery, and Raven.

about a quarter of the rate in the heavily impacted southwestern Adirondacks and High Peaks. The current deposition rate of nitrate is estimated to be 1.7–2.5 kg N per hectare per year, again about a quarter of the rate in the southwestern Adirondacks and High Peaks.* The low deposition rates and calcareous bedrock are reflected in low rates of lake acidification. Almost no lakes in the Champlain Valley, and very few lakes in the whole Champlain watershed, are seriously acidified.

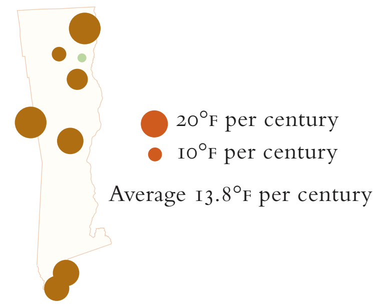
Climate Change. Climate change is now an ecological fact. The current winter warming rate in the Champlain Valley is about 14°F per century. It now seems possible that northern New York will warm over 10°F in the next century, giving it a climate like that of the mid-Atlantic states rather than the Northeast. It is likely that this will be accompanied by changes in rainfall, but as yet there is no clear trend in rainfall, and no certainty about what the trend will be when it does appear.

The ecological effects of this warming are uncertain. It seems likely that it will stress the white pines and northern hardwoods and allow the hemlock adelgid to spread further north. In theory this will benefit the oaks and hickories and allow the oak-hickory community to spread. But recall that the oak-hickory community is a mosaic community of northern and southern and calciphile and acidophile species. The northern species may be disadvantaged by climate change, and it is possible that the calciphile species may have difficulty spreading onto the relatively acid soils that were formerly occupied by northern hardwoods. So we may see an expansion of the oak-hickory community, but in a low diversity form.

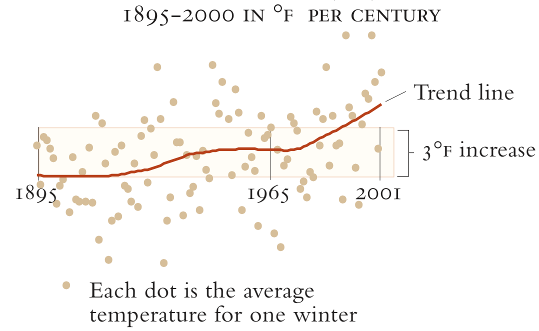
This would be consistent with much short-term vegetation change that I have observed in the field. Post-disturbance communities—drained waterbodies, woods after fire and disease, fallow fields—are usually colonized by a few opportunistic species with good dispersal and reproduction. Even when they are adjacent to high-diversity communities they are usually not highly diverse themselves. High diversity seems to require time and special conditions, and most rapid change seems to lower community diversity.

Deer. Deer eat young oaks, and growing deer populations in the Champlain Valley threaten the oak-hickory communities here. We have very little good information on the effects of deer, and so I can say very little. Elsewhere, there is clear evidence that deer suppress oak regeneration. Deer populations were quite low for the first half of the 20th century, reflecting both snowy winters and hunting pressure, and both red and white oaks seem to have reproduced well at that time. Deer populations have climbed rapidly in ex-

RECENT (1966–2001) WINTER TEMPERATURE TRENDS AT INDIVIDUAL STATIONS IN THE CHAMPLAIN VALLEY CLIMATE DIVISION



REGIONAL TRENDS IN WINTER (DJF) TEMPERATURE, 1895–2000 IN °F PER CENTURY



Winter temperature trends in the Champlain Valley, from National Weather Service data. Graphic from Jenkins, J. 2004. *The Adirondack Atlas: A Geographic Portrait of the Adirondack Park* (Syracuse University Press, 2004). Climate models predict that global warming will first increase winter temperatures and then summer temperatures. Currently we are seeing a strong, statistically significant increase in winter temperatures throughout northern New York. The increase began about 1970 and has thus far resulted in a 3° F winter warming in the Champlain Valley, for an average warming rate of over 10° F per century for 1970-2001. If this rate continues, the Champlain Valley could have the winter temperature of Washington, D.C., in 50 years.

*Ito, M., Mitchell, M.J., and Driscoll, C.T. 2002. "Spatial patterns of precipitation quantity and chemistry and air temperature in the Adirondack region of New York." *Atmospheric Environment* 36: 1051–1062.

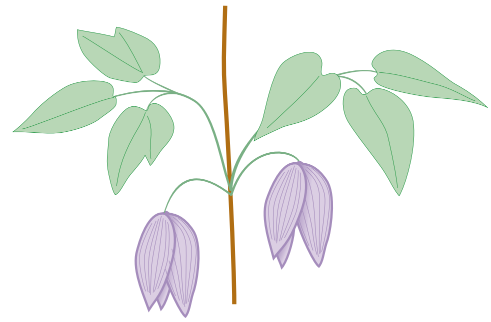
agricultural lands to the south of the Champlain Valley since 1970, and are currently rising in the Champlain Valley as well. Where I live (Washington County, in the Taconics) deer populations are currently quite high, and though I see abundant oak seedlings after good acorn years, I see very little establishment of young oaks. In my Champlain field work I was not looking specifically at forest regeneration, but still I noted much deer browse on shrubs and little oak regeneration. I regard deer impacts, both on oak forests and on other communities as potentially of great importance to forest conservation, and as meriting much more study than they thus far have received.

13 CONSERVATION VALUES

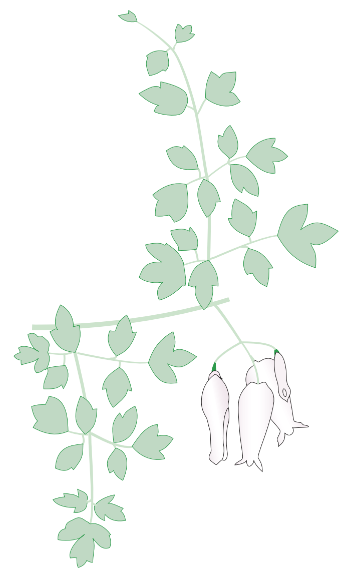
The West Champlain Hills, separately or in aggregate, seem to me to have high conservation value, and to merit more protection than they have thus far received. The case is a simple one. The West Champlain Hills are:

> Extremely beautiful, with dramatic rocks, lovely views, and fascinating opportunities for hiking and scrambling. I know of only one other place in the eastern United States—Mt. Desert Island in Maine—where you can stand on rocky open summits and have long views of a large body of water. And I know of no place in the eastern United States where you can then turn around and look at range after range of high mountains behind you.
>
> Unusual in their rockiness and their open summits. While the High Peaks have much bare rock, open cliffs and summits are surprisingly rare in many of the mid-elevation mountains in the park. Their size not withstanding, the West Champlain Hills are, overall, some of the rockiest mountains in the park, and indeed perhaps the rockiest that I have seen in the Northeast.
>
> Home, on southern summits and slopes, to many examples of dry calcareous oak forests, an unusual and unusually diverse community that is highly regarded by botanists wherever it occurs. This community is uncommon in Vermont and Massachusetts and probably in New York as well; it is possible, but not proven, that the West Champlain Hills contain a significant proportion of the New York and New England occurrences.
>
> Also home to perhaps 70 plants which are uncommon or rare in northern New York, most of them adapted to dry calcareous soils. These include not only some botanical arcanities like Back's sedge and the small-flowered bittercress, but some special woodland beauties, among which I would include the purple clematis and Allegheny vine shown at right.

TWO FLOWERING VINES OF DRY CALCAREOUS WOODS



PURPLE CLEMATIS, *Clematis occidentalis*



ALLEGHENY VINE, *Adlumia fungosa*

Two vines with pendent flowers from old Arcto-Tertiary families. Purple clematis, from the Buttercup Family, is a northern species that reaches the Gaspe Peninsula and southern tip of James Bay. It is a woody perennial that often grows in very exposed sites. I have thus seen it only at a single site in the West Champlain Hills. Allegheny vine, from the Fumitory Family, is an uncommon and somewhat fugitive species of the northeastern United States and southern Canada. It is a high-climbing biennial herb that often grows on somewhat moist, rocky taluses. I saw it at four sites in this study, always very locally, and always in small amounts.

Also home to a significant number of other plants of moist fertile woods which seem to be more abundant in the West Champlain Hills than elsewhere in the Adirondack Park.

Distinguished by their possession of these species and others, which make them both more diverse than any other forests in the Adirondacks and, as best I can determine, richer in rare and uncommon species than any other community in the Adirondack Park.

Also distinguished because they afford multiple examples of dry-rich woods, a largely unstudied and poorly documented community and so raise fascinating questions about ecological history and ecological processes.

In fairly good condition, having survived logging and storms, being little affected by weeds, and apparently either tolerating or requiring occasional fires.

Of great potential value as reservoirs of southern species that may expand their ranges as the climate warms.

Almost all privately owned, and hence not protected against injurious logging, and without any long-term provisions for public access.

14 SUMMARY

1 This report deals with a belt of hills and small mountains along the west shore of Lake Champlain. Its theses are that these hills are important to Adirondack conservation because of an uncommon plant community they contain and interesting to science because this community exhibits an unusual type of diversity that is supported by unusual processes.

2 These findings were anticipated by surveys at several sites in New York and Vermont during the 1980s and 1990s which found rich floras on igneous bedrock. Because we assumed that most rich sites were on carbonate rocks—dolomite, limestone and marble—I and other botanists assumed to that these sites were anomalous, and did not see them as part of a widespread pattern.

3 About 46 days of field work between 2002 and 2007, and 2005, on over 30 dry-rich hills, has shown that the earlier results were not anomalous, and that high diversity floras occur regularly within calcareous oak-hickory communities on the west shore of Lake Champlain.

4 The hills where they occur, which we are calling the West Champlain Hills, are the eastern foothills of the Adirondacks. They

begin just south of the Ausable River and extend south, sometimes continuously and sometimes interrupted by farm land, to the south end of Lake Champlain and beyond. They are low, steep, cliffy, and very scenic. They extend to the lake shore in a number of places and create a dramatic contrast between the low-lying, agricultural Vermont shores and the steep and forested New York ones.

5 Geologically, the West Champlain Hills are igneous hills that have been steepened on their southern and eastern sides by glacial erosion. The rocks are granites and gneisses of Grenville age, generally hard and low in calcium, but made softer and richer in a number of places by gabbro and anorthosite. The bedrock is covered by glacial tills on the northern and western sides and outcrops extensively on the southern and eastern ones. It is on these bedrock outcrops—or, more precisely, on pans of shallow, dry, calcareous soils among them—that the oak-hickory communities occur.

6 Biologically, the West Champlain Hills belong to the northeastern province of the eastern deciduous forest. About 90% of their area is covered with a mixture of northern hardwoods, particularly beech, sugar maple, and yellow and white birches, and "transitional" conifers, particularly hemlock and white pine. The remaining 10% consists of open ledges and summits with low-diversity communities of common acidiphilic species and, somewhat incongruously, grassy oak-hickory forests with high-diversity communities containing many uncommon calciphiles.

7 The Lake Champlain basin as a whole is largely in private ownership, and the same is true for the West Champlain Hills. The largest tracts of New York State Forest Preserve land within the West Champlain Hills are the Split Rock and Poke-o-Moonshine Wild Forests and the portion of the Lake George Wild Forest that approaches Lake Champlain. The largest tracts of land held by private non-profit organizations in the West Champlain Hills are the Fort Ticonderoga Association's land at Mt. Defiance and the Nature Conservancy's preserve at Coon Mountain.

8 This survey found about 450 species of woodland, cliff, and summit plants, a high number when you consider that no species wetlands or disturbed areas were included. About 58% of these are common and widespread species of moist acid woods and acid rocks. The remainder—170 species, or about 37% of the flora—are ecologically specialized in the sense that they require dry soils (109 species, 24% of the flora), limy soils (135 species, 30%), or both (74 species, 16%). Many of these plants are also geographically specialized: 137 species (30% of the flora) reach their northern range limits

in the Champlain Valley. Many of these are near their altitudinal limits as well and are absent from the higher Adirondacks.

9 Because many of the West Champlain Hills species require dry or limy soils and are near their latitudinal and altitudinal limits here, the rocky southern slopes of the West Champlain Hills are in effect ecological islands of dry calcareous vegetation within a sea of wet, acid, northern hardwood forest. At least 70 Adirondack species are largely restricted to these islands, and a significant (but not evaluatable) number of others are probably commoner here than elsewhere in the Adirondacks.

10 While many of the West Champlain Hills plants occur regularly wherever their habitat occurs, many others are rarer than their habitat. My current survey data, which are admittedly incomplete, suggest that at least 70 West Champlain Hills species are uncommon or rare in the Adirondack region. This number greatly exceeds the number of rare or uncommon species in the alpine zone (about 20 species), the lowland boreal (about 23 species), or the Lake Champlain shores (about 25 species). When it comes to plant diversity, a good southern community beats a good northern one almost every time.

11 A distinctive feature of the West Champlain Hills is that they are, more than most other communities, ecological and geographical mosaics, incorporating species with different ecological preferences and geographic ranges. The mixture of northern and southern and acidophilic and calciphilic species within the oak-hickory community is one expression of their mosaic character. The small but species-rich patches of moist-rich vegetation found at cliff bases and in ravines are another. Both contribute to the overall diversity of the West Champlain Hills communities and distinguish them from ordinary and far more homogenous hardwood forests around them.

12 I observed mosses and lichens in this study but only did systematic collecting and inventory on one hill. My overall sense was that although the *cover* of mosses and lichens was often high, their *diversity* was generally low and their species composition no different from that of acid northern hardwood forests. In particular, almost none of the calcium-indicating bryophytes that are common on limestone and marble outcrops elsewhere in the Champlain Valley were seen on the igneous rocks of the West Champlain Hills. This poses an ecological problem: why, if these rocks support a strongly calciphilic vascular plant flora, do they not support a similarly calciphilic bryophyte flora?

13 The West Champlain Hills support four principal vegetation types and three or four smaller types. The two of these that are richest and most interesting are the calcareous oak-hickory woods on the upper slopes of the hills and the pockets of moist-rich vegetation on lower slopes and in ravines.

14 The oak-hickory woods are a distinctive community associated with dry, south-facing, fire-prone rocky slopes and benches and calcium-rich bedrock. I call them the Champlain Hills rich-dry community. They are typically dominated by red and white oaks, shagbark hickory, and hop hornbeam. They have open, diverse, grassy-looking understories with a mixture of acidiphilic and calciphilic species. They often have red or white pines in the canopy, but when the pines become dominant the diversity goes down and the community loses its characteristic understory.

15 The pockets of moist-rich vegetation occur mostly in ravines and at cliff bases. They have many of the species of rich maple-basswood forests, but I resist calling them examples of that community because they are small and often surrounded by nonrich forests. Their area is usually much less than that of the oak-hickory forest, but because they are species-rich they contribute disproportionately to the total diversity and many of the West Champlain Hills have as many or more moist-rich indicators as dry-rich indicators.

16 Both the Champlain Hills community and the areas of moist-rich vegetation are related to wide-ranging northeastern communities. Calcareous oak-hickory forests similar to those in the Champlain Valley occur in Vermont, Massachusetts, and elsewhere in New York. They are found on both sedimentary and igneous rocks, and are apparently an uncommon community in the Northeast. They are esteemed for their high diversity (and considered distinct from the much commoner low-diversity oak-hickory forests on sandy soils) wherever they occur.

The pockets of moist-rich vegetation in the West Champlain Hills are the Adirondack representatives of the rich mesic woods of western New England, central New York, and much of the upper Midwest. This is also a high-diversity community. It is usually associated with sedimentary rocks and, in contrast to the calcareous oak-hickory community, common in many parts of New York and New England.

17 If we compare the floristics and ecology of the calcareous oak-hickory and rich mesic forests, a number of striking contrasts emerge. The oak-hickory forests are dry, more convex, thinner-soiled, more fire-prone, more apt to be found on igneous rocks,

and less dependent on groundwater seepage and soil movement. Their plant diversity is highest above ledges and near summits, and involves a group of drought-adapted, late-developing, light-requiring species. The mesic forests are wetter, more concave, darker, less fire-prone, more common on sedimentary rocks, and strongly dependent on groundwater seepage and soil movement. Their diversity peaks in ravines and on lower slopes. Their indicator species, as a group, are remarkably distinct from those of the oak-hickory forests, and are more shade adapted, much less drought tolerant, and mostly early developing.

18 I call the contrasting geobotanical patterns of the oak-hickory woods and rich mesic woods *dry richness* and *moist richness* and hypothesize that they are sustained by different processes. Weathering, surface wash, root-zone weathering and nutrient cycling by woody plants are probably important in both communities. In moist-rich communities they are augmented by groundwater seepage and soil movement. In dry-rich communities they either have to stand on their own, or are perhaps augmented by the vertical transport of nutrients by evapotranspiration.

19 If my hypothesized mechanisms are correct, they can explain many of the differences between dry-rich and moist-rich communities:

> The moist-rich species are adapted to the high-calcium levels and permanently moist soils of the rich mesic forests. This in turn forces them to live under dense summer canopies and to develop early and have the characteristic architectures of early-season species.
>
> The dry-rich species have less calcium and moisture available and perhaps less shade tolerance as a result. They contain many late-season species that reach their best development on thin soils that allow for nutrient-cycling from the root zone, on convex rocky terrain where the canopy is patchy and much sunlight reaches the forest floor.
>
> Because calc-silicate igneous rocks weather less readily than metasedimentary carbonates, calcium is less available on igneous rock surfaces. This may explain why igneous rocks have few calcium-indicating mosses, and why sparsely vegetated igneous summits have so few calcium-indicating vascular plants.

20 These same hypotheses may also explain some of the differences between the rich communities on metasedimentary (carbonate) and igneous (calc-silicate rocks):

> Metasedimentary, white-rock, carbonate hills may, in some sense, be rich all over. They have calcium available on the bare rock surfaces for bryophytes and contact-rich vascular plants like some of the small ferns; calcium available at the bottom of the root zone that can be pumped to the surface by woody plants; and calcium available inside them and below them in groundwater that then surfaces and supports rich mesic forests on talus slopes and in ravines.
>
> Igneous, black-rock, siliceous hills seem to be rich only in particular places. Their calcium apparently needs to be concentrated by surface wash or pumped from the root zone by trees and shrubs, and so their calcium indicators congregate in shallow soils near the edge of outcrops. They have only limited amounts of internal groundwater flow and so, while they support almost as many moist-rich *species* as carbonate hills, can support only limited amounts of moist-rich vegetation.

21 The oak-hickory communities of the West Champlain Hills have at various times been subject to logging and fire, and are currently subject to acid deposition, climate change, the arrival of Eurasian weeds, and increased browsing by deer. We do not have, and may never have, the information we need to account for the effects of these disturbances. Data on deposition rates and lake acidification suggest that acid deposition is not a problem, and my observations in this study suggest that alien weeds, while well established, are thus far not abundant and not currently an ecological problem. My observations also suggest that some oak-hickory stands have been logged, but this only establishes that some stands can tolerate some amount of logging. It does not tell us whether other stands that did not tolerate it ceased to be oak-hickory stands and were converted to northern hardwoods.

The potential effects of deer, climate, and fire are yet more complex. Deer populations are increasing and deer eat oaks; oak reproduction appears to have been good fifty years ago and appears to be bad now, but how uniformly this is true has not been measured, and whether it is the result of deer has not been tested. Winter temperatures are increasing rapidly and summer temperatures are likely to begin increasing as well. In theory this will eventually result in an expansion of the oak-hickory community, but in the short-term it may reduce the average diversity of the community by eliminating northern species and creating large areas of new forests dominated by a few good colonists. And finally, while most or all of the oak-hickory woods have burned at one time or another, it is far from being clear that they need to burn. Interestingly, the three burns I examined were not regenerating oaks and had few calcareous ground-layer species. This raises that possibility that fires reorganize the oakwoods and that it may take some time—possibly even a forest generation—for them to return to their pre-fire composition.

22 The *conservation values* of the Champlain Hills are high, and their *conservation needs* are substantial. They are in many ways nearly ideal sites for conservation projects. They are fairly small, very attractive, locally esteemed sites that have recreational value, rarity value, diversity value, and scientific value. They are largely unprotected and so have definite conservation needs; and they have southern xeric communities which may be able to survive climate change and found larger communities in the next century.

APPENDIX 1: ECOLOGICALLY SPECIALIZED SPECIES

These are lists of what are called ecologically specialized species in this document, and indicator species in subsequent documents. An asterisk indicates that, in my estimation, the species is modal: within northern New York the species is either restricted to the West Champlain Hills or commoner there than elsewhere. The columns following the names give four measures of abundance. The first is my own estimate, based on its frequency in the western Champlain Valley relative to the frequency of its habitat. Here I call a species frequent (F) in the Adirondack region if its habitat is common and if it occurs frequently within it; uncommon (U) if the habitat is scarce and if it is found in half or fewer of the sites with proper habitat, and rare (R) if it is found in only a few of the sites with proper habitat, or if its proper habitats are themselves rare. The second column gives the number of West Champlain Hills sites it is known from; all records through 2007 are included. The third column gives the Vermont Natural Heritage Program rank, based on its abundance in Vermont. The fourth the New York Natural Heritage Program rank, based on its frequency in New York as a whole. For an explanation of these ranks see p. 22.

"Dry-Rich" Species: Plants Commonly Found in Dry Calcareous Soil

Anemone virginiana, virginia anemone*	F	15	
Antennaria plantaginifolia, plantain-leaved pussytoes	F	28	
Aquilegia canadensis, columbine	F	28	
Arabis canadensis, sicklepod mustard*	U	8	
Arabis drummondii, drummond's rockcress*	R	2	S1 S2
Arabis lyrata, lyre-leaved rockcress*	R	1	S1-2
Arabis missouriensis, missouri rockcress *	R	1	S1 S2
Asclepias quadrifolia, four-leaved milkweed*	U	14	S3S4
Asplenium platyneuron, ebony spleenwort*	U	12	
Aster undulatus, wavy aster*	U	10	
Bromus kalmii, kalm's bromegrass*	R	3	S2S3
Cardamine parviflora, small-flowered bittercress*	R	4	S2S3
Carex backii, back's sedge*	U	14	S3 S2
Carex hitchcockiana, hitchcock's sedge	R	1	S3
Carex peckii, peck's sedge*	R	1	
Carex sprenglii, long-beaked sedge*	R	2	
Carya ovata, shagbark hickory*	U	31	
Celtis occidentalis, hackberry	?U	3	
Cerastium arvense, field chickweed*	R	3	
Chenopodium simplex , large-seeded goosefoot*	R	3	
Clematis occidentalis, purple clematis*	R	3	S3
Conopholis americanus, squawroot	U	1	S2S3
Corallorhiza maculata, spotted coralroot	R	4	
Cornus rugosa, roundleaved dogwood*	F	16	
Cypripedium calceolus, yellow lady's slipper	R	1	S3
Desmodium glutinosum, tick-trefoil*	U	14	
Desmodium nudiflorum, tick-trefoil*	U	1	
Desmodium paniculatum, panicled tick-trefoil*	U	13	S3
Dichanthelium latifolium, broad-leaved panic grass*	U	14	
Dirca palustris, leatherwood*	U	11	
Elymus hysterix, bottle-brush grass*	F	20	
Festuca subverticillata, blunt fescue	F	14	
Galium circaezans, round-leaved wild liquorice*	F	20	
Galium lanceolatum, lance-leaved wild liquorice*	U	26	
Geranium bicknellii. bicknell's geranium*	R	3	S3
Geranium robertianum, robert's geranium	F	18	
Hackelia virginiana, virginia stickseed*	R	3	
Helianthus divaricatus, woodland sunflower*	U	28	
Hepatica americana, round-lobed hepatica*	U	27	
Juniperus virginiana, red cedar*	F	12	
Lespedeza intermedia, intermediate bush-clover*	R	5	
Lilium philadelphicum, wood lily*	R	6	S3
Lonicera dioica, limber honeysuckle*	U	13	
Lonicera hirsuta, hairy honeysuckle*	R	3	S2
Minuartia michauxii, stiff sandwort*	U	16	
Muhlenbergia glomerata	?	6	
Myosotis verna, spring forget-me-not	R	1	S1S2
Parietaria pensylvanica, pellitory*	R	3	
Penstemon hirsutus, hairy beardtongue*	R	3	S3
Phryma leptostachya, lopseed*	U	5	
Poa saltuensis	U	3	S2S3
Polygonum douglasii, douglas's knotweed*	U	7	S1 S2
Potentilla arguta, cut-leaved cinquefoil*	U	9	
Rhus aromatica, fragrant sumac*	U	11	S3
Ribes cynosbati, prickly gooseberry	F	12	
Ribes hirtellum, bristly gooseberry*	U	16	
Rosa carolina, carolina rose	?F	13	
Quercus alba, white oak*	U	26	
Saxifraga virginiensis, early saxifrage	F	24	
Schizachne purpurascens pirple melic*	U	13	
Shepherdia canadensis, buffalo berry*	R	1	
Solidago arguta, cut-leaved goldenrod	?F	13	
Solidago squarrosa, squarrose goldenrod*	3	1	S2S3
Solidago caesia, blue-stemmed goldenrod*	F	34	
Symphoricarpos albus, white snowberry*	R	4	S3S4
Triosteum auriantiacum, horse gentian*	R	3	S3
Ulmus rubra, slippery elm	U	2	
Uvularia grandiflora, large-flowered bellwort	F	12	
Uvularia perfoliata, perfoliate bellwort*	R	1	S2
Viburnum rafinesquianum, rafinesque's viburnum*	U	23	
Viola conspersa, dog violet	?	1	
Vitis aestivalis, summer grape	R	2	
Waldsteinia fragarioides, barren strawberry*	F	18	
Woodsia obtusa, blunt-lobed woodsia*	R	4	S3
Xanthoxylon americanum, prickly ash*	R	1	

“Moist-Rich” Species: Plants Commonly Found in Moist Calcareous Soil

Actaea pachypoda, white baneberry	F	8	
Actaea rubra, red baneberry	F	3	
Adiantum pedatum, maidenhair fern	F	18	
Adlumia fungiosa, allegheny vine*	U	2	S3
Allium tricoccum, wild leek	?	2	
Aquilegia canadensis, columbine	F	28	
Aralia racemosa, spikenard	?	2	
Arismaea triphyllum, jack-in-the-pulpit	F	9	
Asarum canadense, wild ginger	?	3	
Asclepias exaltata, poke milkweed	?	4	
Asplenium trichomanes, maidenhair spleenwort	F	12	
Botrychium virginianum, rattlesnake fern	?	5	
Bromus pubescens, hairy brome	?	13	
Carex albursina, white bear sedge	?	1	
Carex arctata, arching sedge	?	5	
Carex blanda	F	14	
Carex communis	F	23	
Carex deweyana, dewey’s sedge	F	5	
Carex digitalis,	F	6	
Carex gracillima	F	2	
Carex laxiculmis	?	12	
Carex laxiflora, loose flowered sedge	F	19	
Carex pedunculata, pedunculate sedge	F	8	
Carex plantaginea, plantain-leaved sedge	?	6	
Carex platyphylla, broadleaved sedge	F	29	
Carex rosea	?	2	
Carex sparganioides, bur-reed sedge	?	2	
Carex swannii, swann’s sedge	F	2	
Carex virescens	?	2	
Carya cordiformis, bitternut hickory	?	10	
Caulophyllum thalictroides, blue cohosh	?	8	
Cystopteris bulbifera, bulblet fern	?	1	
Cystopteris fragilis s. l., fragile fern	F	21	
Dentaria diphylla, toothwort	F	2	
Depraria acrostichoides, silvery spleenwort	F	2	
Dicentra cucullaria, dutchman’s britches	?	1	
Dryopteris goldiana, goldie’s fern	R	2	
Eupatorium rugosum, white snakeroot	F	15	
Galium triflorum, three-flowered bedstraw	F	19	
Geranium robertianum, robert’s geranium	F	18	
Hepatica acutiloba, sharplobed hepatica	?	5	
Juglans cinerea, butternut	F	9	
Laportea canadensis, wood nettle	?	1	
Millium effusum, dropseed	F	3	
Oryzopsis racemosa, broadleaved mountain-rice*	F	34	
Osmorhiza claytonii, sweet cicely	F	11	
Panax quinquefolius, ginseng	?U	1	S2S3
Phegopterix hexagonaptera, broad beech fern	U	2	
Ranunculus abortivus, dwarf buttercup	F	11	
Rubus occidentalis, black raspberry	F	16	
Rubus odoratus, purple-flowering raspberry	F	19	
Ribes cynosbati, prickly gooseberry	F	12	
Sambucus pubens, red elderberry	F	11	
Sanguinaria canadensis, bloodroot	?	2	
Sanicula marilandica, maryland sanicle	?	9	
Saxifraga virginiensis, early saxifrage	F	24	
Solidago flexicaulis, zigzag goldenrod	?	3	
Sphenopholis obtusata, widgeon grass	F?	4	
Staphylea trifolia, bladdernut	R	1	
Thalictrum dioicum, early meadow-rue	F	6	
Tilia americana, basswood	F	25	
Viola canadensis, canada violet	F	2	
Viola conspersa, dog violet	F	1	
Viola pubescens, tall yellow violet	F	6	
Viola rostrata, long-spurred violet	?	1	

Many of these species can occur in small amounts in pockets of fertile soil in otherwise ordinary woods; hence the regional frequencies of many species are uncertain. The boundaries between this group and the dry-rich species are also uncertain. Several species like *Adlumia fungiosa* and *Osmorhiza claytonii* are near the dividing line and could have been included in either group. Several others (*Aquilegia canadensis, Geranium robertianum, Saxifraga virginiensis, Viola conspersa*) occur regularly in both moist and dry habitats and have been included in both groups.

"Other-dry" Species: Plants of Dry, Exposed, Often Acid Sites

Amelanchier cf. sanguinea, small shadbush*	U	22	
Anaphalis margaritacea, pearly everlasting	F	4	
Andropogon scoparius, little bluestem	F	2	
Aralia hispida, bristly sarsaparilla	F	4	
Arctostaphylos uva-ursi, bearberry	?F	7	
Bulbostylis capillaris	?	4	
Campanula rotundifolia, harebell	F	28	
Carex cephalophora	?	3	
Carex merritt-fernaldii	?	1-2	S1S2
S2S3			
Carex siccata	R	2	S1
Carex umbellata group	F	18	
Ceanothus americanus, new jersey tea	U	8	
Comptonia peregrina, sweetfern	F	9	
Corydalis sempervirens, pale corydalis	F	19	
Dichanthelium cf. depauperatum		25	
Dichanthelium columbianum	?U	1	S3
Dichanthelium xanthophysum	?U	3	S3
Elymus trachycaulus*	F	25	
Gaylussacia baccata, black huckleberry	F	10	
Hieracium scabrum, rough hawkweed	F	2	
Juncus secundus, secund rush*	R	5	S1
Juniperus communis, common juniper	F	27	
Lechea intermedia, common pinweed*	F	22	
Oryzopsis pungens sharp-leaved mountain rice	U	6	S2
Polygala polygama, common milkwort	R	1	S2
Polygonum douglasii, douglas's knotweed*	U	7	S1
S2			
Potentilla tridentata, three-toothed cinquefoil	F	1	
Prunus pumila, sand cherry	?U	2	S2
Selaginella rupestris, rock spikemoss*	U	11	S3
Silene antirrihina, sleepy catchfly	?F	8	
Solidago bicolor, silverrod	F	22	
Solidago nemoralis, gray goldenrod	F	12	
Solidago puberula, downy goldenrod	F	13T	
Specularia perfoliata, venus's looking-glass*	U	9	
Woodsia ilvensis, rusty woodsia*	U	29	

The status of several of these species is unclear. *Campanula rotundifolia, Selaginella rupestris, and Specularia perfoliate* are common on calcareous sites and may be dry-rich species instead. *Polygonum douglasii* was treated as an overlap species and incleded both in this group and in the dry-rich species.