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Oak Savanna Restoration: Problems and Possibilities

Abstract

A degraded oak savanna in southwestern Wisconsin is being restored using intensive cutting of undesirable shrubs (buckthorn, prickly ash, honeysuckle) and selective removal of trees that are crowding the open-grown bur and white oaks. Land use records and historic aerial photographs have been used to guide the restoration process. Slippery elm, black walnut, cherry, and black oak are being removed by cutting and burning, or by converting to fire wood. Hundreds of aspen have been killed by girdling with subsequent cutting and burning. Management involves controlled burns and extensive weed control. Removal of invasive shrubs and trees has exposed the groundlayer to higher light intensities and stimulated the growth of savanna forbs and grasses. A number of typical herbaceous savanna species have reappeared after clearing, or have been successfully introduced from local sources. However, bramble control and regrowth of buckthorn and honeysuckle remain principal problems. One savanna species endangered in Wisconsin, purple milkweed, was first seen in the savanna after a single controlled burn, and appears to be spreading. The red-headed woodpecker, a typical savanna bird, was first seen after shrub and canopy clearing in the savanna. Tree removal is a slow and expensive operation, and strategies for preventing damage to the groundlayer during tree removal had to be devised. Approximately 30 acres (12 hectares) of high-quality savanna have been restored during seven years.

Key words: oak, savanna, *Quercus macrocarpa*, *Quercus alba*, *Asclepias purpurascens*, red-headed woodpecker, buckthorn, honeysuckle, brambles, *Rubus*, *Juglans niger*, *Ulmus rubra*.

The oak savanna ecosystem was once a major vegetation type in midwest United States, but is now exceedingly rare. (Nuzzo, 1986) Definitions of oak savanna vary, but generally focus on the extent of tree canopy coverage (for instance, 10-50 percent tree cover), or the presence of open-grown oaks (oaks with large horizontal branches) (Leach and Givnish, 1996). The groundlayer plant composition of oak savannas seems to be unique, with a number of species that can probably be called “savanna specialists.” (Packard, 1988; Leach and Givnish, 1999)

Pleasant Valley Conservancy, a 140 acre natural area, is in the “Driftless Area” of southwestern Wisconsin. Surveyors’ notes, historic air photos, and tree surveys tell us that the dominant vegetation before settlement was oak savanna, with areas of dry prairie on the steepest south-facing slopes and wet to mesic prairie in the bottomlands. One of the oldest bur oak on the property has been dated by tree rings to 200 years but many oaks are over 150 years old.

The property was in general agricultural use from the 1880s through the 1950s with about 15 acres in cropland (now planted to prairie) and the rest in pasture, woodland, or wetland. Savanna areas that had probably been lightly pastured retained many remnant forbs and grasses in suppressed condition, with a number of characteristic savanna species present. Today, about 30% of the property is prairie, 40% oak savanna,

and 40% oak woods. Extensive restoration work began about 1997, and has involved clearing of invasive shrubs and trees, controlled burns, and planting with seeds collected from remnants on the property or nearby.

Overall approach to savanna restoration

The long-term goal of the restoration process is an unimpaired functioning ecosystem in which viable populations of native species are maintained (Healy and McShea, 2002). This includes not only oaks, but associated tree species, as well as an understory of native herbaceous savanna plants with occasional native shrubs. Also, a range of ages in the oaks is desirable, thus ensuring continued integrity of the savanna ecosystem.

Two types of oak savannas are present at Pleasant Valley Conservancy, one dominated by white-oak (*Quercus alba*) and the other by bur oak (*Quercus macrocarpa*). In general, the bur oak savannas are on the ridge tops (dolomite bedrock) and the white oak savannas are on the slopes (sandstone bedrock), although there is some intermixture. In both savannas, black oak (*Quercus velutina*), shagbark hickory (*Carya ovata*) and black cherry (*Prunus serotina*) are significant but minor components. Basswood (*Tilia americana*) and hackberry (*Celtis occidentalis*) are also occasionally present. Several native shrubs that would have been components of the original savanna are also present: hazelnut (*Corylus americana*), choke cherry (*Prunus virginiana*), nannyberry (*Viburnum lentago*), elderberry (*Sambucus canadensis*), and juneberry (*Amelanchier arborea*).

Although these shrubs are relatively fire-sensitive, they generally have the ability to resprout quickly, and in the original savanna would probably have remained as minor components (depending on the fire-return interval).

When restoration began, both savanna types contained large, typical open-grown oaks but were heavily degraded. The understory contained dense stands of invasive shrubs, primarily honeysuckle (*Lonicera sp.*), buckthorn (*Rhamnus cathartica*), and prickly ash (*Xanthoxylum americanum*). Two fire-sensitive tree species that would not have been part of the original savanna had often invaded, and in some areas were present in large populations: black walnut (*Juglans niger*) and slippery elm (*Ulmus ruber*).

A decision was made to remove all black walnut and slippery elm and to remove any black oak or shagbark hickory trees that were crowding open-grown bur or white oaks. Black cherry, basswood, and hackberry are not as invasive as walnut and elm and were only removed when they were crowding open-grown oaks or were present in larger amounts.

Brush removal

Much of the initial restoration work involved brush removal. All cut stumps were treated with herbicide, generally glyphosate (21% in water), to prevent resprouts. Herbicide used in this manner is effective at any time of year (Brock, 2004) This procedure was close to 100 percent effective but was most efficient when part of tree

removal activities on the same site. The cut brush provides an excellent base for the burn pile that is an essential part of the tree removal process.

Although cutting followed by herbicide treatment eliminated shrubs, there was always a seed bank in the soil. Despite annual burns, new seedlings of the invasive shrubs continued to appear. This problem was worse with buckthorn and honeysuckle than it was with prickly ash. Honeysuckle plants generally flower and set seed in their second year, so that it was essential to remove any new honeysuckle plants arising from the seed bank. New buckthorn plants do not flower and set seed until they are older, so that it takes some years after buckthorn are removed before new growth begins to again contribute to the seed bank.

With annual burns, competition from native herbaceous species should perhaps eventually eradicate these invasive shrubs. The principal effect of fire is to top-kill shrubs; the roots are not killed. After a burn, the above-ground plant parts may be dead, but in the next growing season new shoots quickly arise from the living roots. Another season of fire will kill these new shoots, but even after years of consecutive fire, invasive shrubs may remain a problem. To help suppress new woody growth, establishment of native herbaceous savanna vegetation to compete with the invasive shrubs should be done. (See below).

Because buckthorn is allelopathic (Seltzner and Eddy, 2003), it may be several years after a heavy buckthorn infestation has been removed before native species will

become established. Several of our savanna areas were essentially “buckthorn deserts” in the first two years after eradication, despite extensive seeding with native species, but a good groundcover was eventually established.

Tree removal

The goal of savanna restoration is to create an open tree canopy (10-50% cover). The goal of tree removal is not to generate trees for market, but to restore the land to its former state. Although it may be possible to have some economic return from the cut trees, this should only be done if it can be ensured that damage to the habitat will not occur. Loggers operate with a different rationale than restoration ecologists. Slash that a logger might leave is often not compatible with the restoration process and logging trucks and skidders may damage fragile topsoil layers.

Removal of woody plants is best done in the winter, preferably when there is snow on the ground. Selection of personnel is important. The workers should be able to identify the various tree species in winter and should be careful when felling trees to be certain that they will not damage nearby trees that are to remain. Although wheeled vehicles are essential for tree bole removal, they should only be permitted when the ground is frozen solid (preferably with some snow cover). If tree removal is not to occur, the logs must be cut in lengths short enough for a person to toss them on a fire. We prefer to have a manager on the site when tree cutting is being carried out. This person can be

treating cut stumps with herbicide or tending a burn pile while at the same time monitoring the tree-cutting personnel. Once a tree is cut it is gone forever!

Tree removal is a slow and expensive operation. As an example, a 2.1 acre savanna was cleared by six people in one week (240 hours). This is over 114 hours/acre, a not insignificant expense. The actual cost will depend upon the labor costs in the area under restoration. If the average hourly cost for labor is \$25, the total cost for this 2.1 acre parcel would be \$6000, or about \$2860 per acre. The cost per acre on a larger parcel could conceivably be less. Also, clearing on a level site should be faster than on a slope. The trees cut are summarized in Table 1. As seen, most of the trees cut were walnuts or elms. In addition to the tree cutting summarized in Table 1, there was a lot of honeysuckle and prickly ash on this site that was also removed at the same time. Twenty of the walnuts were large enough to be saw logs. Since these were on relatively level ground, and there was good snow cover, they were accessible and could be moved to the town road using a skidder installed on the back of a small tractor. These logs were donated to a nonprofit group and were hauled to a nearby mill for sawing into lumber. Most of the smaller cut logs were donated to neighbors, who cut them up and removed them for fire wood. Again, it is important to monitor those removing fire wood to ensure that they are not damaging the soil surface.

Use of fire

Fire plays an important role in the maintenance of the oak savanna ecosystem (Curtis, 1959; Dey, 2002)., Fire was used frequently even after European settlement. (According to personal communication from William Aeschlimann, a nearby retired dairy farmer, the hills in our area were burned every spring.) Historic photographs show that the south and west slopes of these hills were open (Jones, McGraw, Reiersen, Sorkin, and Wade, 1936). At present, all these open areas have become closed, either with red cedar or with invasive shrubs. Air photos from 1937, 1940, and 1949 (Soil Conservation Service) show that the south-facing slope of Pleasant Valley Conservancy was an open savanna, presumably because it was frequently burned.

Farming stopped at Pleasant Valley Conservancy about 1955, and subsequent air photos show the savanna areas gradually filling in with trees. By 1997, when we began restoration, the south-facing slope was almost completely wooded, except for a few isolated areas where some common prairie grasses and forbs still existed in scattered amounts. The lower slope had very few open-grown oaks, but the upper slope had trees typical of a savanna. Once the undesirable woody vegetation was removed, fire was introduced. In the first years, burns were very spotty, but hand-seeding and annual burning brought back prairie and savanna vegetation capable of carrying a fire. Since year four, burns have been very successful.

We have burned our oak savannas in both spring and fall, but the fall is often the best time. A lot depends upon rainfall and temperature, and since the leaf litter is the major fuel, on leaf fall. In our area, bur oaks begin to lose their leaves in mid October and

by the end of the month, or in early November, most of the leaves are on the ground. Leaves remain longer on white oaks, and some leaves stay on the tree through the winter. To do a fall burn in our white oak savanna areas, we wait until most of the white oak leaves are down, which is usually mid-November. The savanna fire is a low-intensity fire that moves slowly through the leaf litter.

Savanna burns are much more difficult to do than prairie burns, because there is a lot more preparation necessary before a burn can begin, and mop-up after the burn takes a lot more time. Once a prairie is burned, it takes very little time to ensure that the fire is out and it is safe to leave. A savanna almost always has standing dead trees that can easily catch fire. A standing dead tree can act as a chimney, carrying the fire from the ground into the upper parts of the tree. Such a “smoker” cannot be left to burn, even if there is nothing around to catch fire, because changes in wind may blow sparks into distant parts. (We leave our dead trees standing as habitat for wildlife.)

The best way to deal with a standing dead tree is to prevent it from catching fire in the first place. This means making a wide leaf- and stick-free zone around each tree. We first cut any vegetation next to each trunk with a gasoline-powered brush cutter, using a plastic blade (Stihl, Polycut) to prevent damage to the trunk. This is followed by a gasoline-operated leaf blower which creates a vegetation- and leaf-free zone. In addition to dead trees, we also remove flammable materials around the relatively fire-sensitive white oaks. The purpose is to lessen the chance of fire scarring, which could eventually

leave the tree susceptible to disease. It may take a whole day to “fire-proof” all trees on our ridge-top savanna.

Savannas often have a lot of dead branches or even whole logs on the ground. These logs can block the progress of fire. If the fire does not carry well through the unit, because of dead logs or other reasons, it is essential to walk into the unburned area with a drip torch and restart the fire (a technique called “stripping”). Often one has to strip the burn unit extensively, walking back and forth with the drip torch, igniting the unit over and over again. Again, this is in contrast to a prairie burn, where once the black lines are set and the head fire is started, it is usually possible to just stand back and watch.

Bramble control

A major problem in oak savanna restoration is the control of brambles (*Rubus spp.*, mainly raspberry and blackberry). Brambles are a minor component of the degraded savanna, but once the habitat is opened up and light reaches the forest floor, brambles can grow rampantly. Although our brambles are native, we still consider them undesirable because they tend to take over the savanna.

Brambles are biennials but have a perennial root system. The bramble plant is top-killed by fire, but the roots send up new shoots the next growing season. Since flowers only develop on the second year shoots, annual fire will keep brambles from setting seed, but we have not succeeded yet in eradicating brambles by annual burns. It is possible that

if annual burning is continued long enough, the bramble plant would eventually be eliminated, especially if herbaceous savanna species became established.

One additional procedure to aid in bramble control is to cut the plants in mid-summer, at flowering time. At this time of year, most of the nutrients are in the stems, and if these are severed the roots will be starved. We have found this procedure to be helpful, although it does not completely eliminate the brambles. Complete elimination of brambles from an area requires the use of herbicide. A successful approach is to cut every living bramble cane and treat the cut stem with 21 percent aqueous glyphosate. Although laborious, this procedure is quite effective and can be done any time of the year, including winter. We have used this approach primarily on areas of high priority or high visibility. A second approach is basal bark treatment of bramble canes with triclopyr (Garlon 4[®], 15% in a hydrocarbon oil; Diluent Blue[®]). A sponge-type applicator can be used. In order to avoid damage to other plants from the volatile triclopyr, this technique should only be done in the winter. To achieve eradication, every cane must be treated.

A third approach, which may be effective after a controlled burn, is an early spring treatment with fosamine (Krenite[®], 1.2% aqueous). In our area, by mid-May, bramble plants have formed rosettes of leaves adjacent to the fire-killed stems. These rosettes are killed quickly by the herbicide and disappear within a week or so. If sprayed carefully, damage to nearby desirable plants can be avoided. (The manufacturer's literature on Krenite[®] implies that the herbicide should be used only on fully grown plants in the late summer or early fall. However, we have found that small plants early

spring are very sensitive and die quickly.) Since brambles grow very rapidly in the early spring, the habitat must be carefully monitored and treatment carried out as soon as the rosettes have four or five leaves.

Rubus always has an extensive seed bank, so that effective bramble control requires reseeding with herbaceous savanna species, since competition from other plants is an important factor in keeping brambles from becoming reestablished.

Handweeding

An essential part of savanna restoration is careful handweeding of areas in the years immediately following clearing. Opening up an area to increased sunlight is virtually a guarantee that invasive plants will flourish. Many of these are the same plants encountered during prairie restoration, such as sweet clover (*Medicago spp.*), wild parsnip (*Pastinaca sativa*), mullein (*Verbascum thapsus*), and bull thistle (*Cirsium vulgare*). Although generally present in smaller numbers in savannas than in restored prairies, they still must be dealt with. Careful surveys at least weekly (preferably more often) during the growing season are necessary to discover and pull these weeds.

Savanna remnants

We were fortunate at Pleasant Valley Conservancy that a number of characteristic savanna species had maintained populations throughout the years (Table 2). Once the savanna was opened up, we were able to find them, either because they were now more

visible or because they had increased in population size. Several species of more than usual interest should be mentioned.

Dodecatheon meadii (shooting star) has developed in almost all of our cleared white-oak savannas. Most plants of this species also flower and set seed. Presumably, this species had been growing vegetatively in the deep shade and proliferated in the increased light.

Asclepias purpurascens (Purple milkweed) is on the State Endangered list. This handsome plant, a characteristic savanna species, was presumably present in the savanna but “hidden” among all the brush. Removing the brush and burning brought it out. We initially saw it in 1998 in one of our white oak savanna areas and as further areas were cleared, it was found elsewhere. It is never common, and some plants do not flower, making them particularly hard to find. Using permanent markers, plants have been followed over a number of years. Some years a plant does not appear, but then shows up again the following year. Some years flowers occur, but the next year only vegetative plants are present. Only in two years (2001 and 2004) have we obtained seed pod formation. In 2001 seeds were collected and seedlings raised which were set out the following year. Some of these plants have survived in the wild but have not yet grown to substantial size.

The related plant, poke milkweed (*Asclepias exaltata*), has also developed in our restored savannas. Uncommon, but more prevalent than *A. purpurascens*, its flowering is

never consistent, but we have had more success with seed set with this species than with *A. purpurascens*.

Eupatorium sessilifolium (Upland bonesetis listed as Threatened in Wisconsin. So far, we have found it growing in only one small area of one of our bur oak savannas. It generally flowers and sets seeds, but we have been so-far unsuccessful in attempting to raise plants.

Introduction of savanna species by seed

An important part of oak savanna restoration is the introduction of savanna forbs and grasses that would originally have been present but have disappeared over the years of neglect. All of our introductions have been with seed collected from nearby remnants, or from other Dane County sites within less than 20 miles of the Conservancy.

During our seed collecting work, we have kept careful records of seed collecting dates. These dates have been published (Brock and Brock, 2003). Although the dates are for the Dane County area, they should be useful throughout southern and southwestern Wisconsin, as well as Northern Illinois and eastern Iowa.

We preferably plant seed after controlled burning, either in the fall of the year it is collected, or, at latest, in the next spring, depending on when the burn was carried out. Burning creates open and bare areas where seeds can take root. Volunteers involved in

seed planting are instructed to plant primarily in these open areas. Seeding rates are based on the publication of Henderson (1998). (Although this publication concerns prairie restoration, many savanna species are included, especially for those targeted for mesic prairies.)

Successful Introductions

We have had excellent success with the establishment of various savanna grasses in newly cleared areas, especially *Elymus hystrix* (bottle brush grass), *Elymus villosus* (silky rye), *Elymus riparius* (woodland rye), and *Bromus pubescens* (woodland brome). The first two were already present in remnants on the property, and the third came from a nearby roadside. These cool-season (C3) grasses begin to develop earlier in the year than the C4 prairie grasses, and are usually in full flower by mid July. We collected seed and hand-planted them on other savanna areas as they were restored. We have continued to spread these grasses and they are now widespread on the Conservancy. Because they are moderately cool-season grasses, they get a head start over brambles and invasive shrub resprouts, thus helping us to keep these latter plants in check. They also help to carry fire during savanna burns.

In addition to the savanna species that were present at the time restoration began, we have also had considerable success in introducing new species that are characteristic of the oak savanna habitat. All of these species have been collected from nearby locations, primarily roadsides. A number of species were collected from the

approximately 2500 feet of roadside on Dane County Highway F which is owned by Pleasant Valley Conservancy. This roadside is actually a high-quality remnant. Most of the *Zizia aureus* (golden Alexander), *Aster sagittifolius* (arrow-leafed aster), and *Veronicocastrum virginicum* (culver's root) came from there. *Elymus riparius* (riverbank rye) and *Bromus pubescens* (woodland brome) came from a roadside about a mile away. *Agastache nepetoides* (giant yellow hyssop) and *Eupatorium purpureum* (woodland brome), both of which are now well established at Pleasant Valley Conservancy, came from Dane County sites about 20 miles away. *Agastache neptoides* (Giant yellow hyssop) is listed as Threatened in Wisconsin. It was not found on the Conservancy but was introduced from seeds collected elsewhere in Dane County. It has thrived well and is now quite common in all of our savanna areas. Another savanna species, *Aureolaria grandiflora*, has also been introduced. This plant is said to grow hemiparasitically on oaks, and was planted under the drip line of large oak trees. So far, we have only five locations where single plants of this species are growing, but we expect further development over the next few years.

Lists of species typical of oak savannas have been published (Bray, 1960; Leach and Ross, 1955; Bader, 2001). The Atlas published by Cochrane and Iltis (2000) is an excellent resource for assessing the significance of a particular species in a remnant.

A more detailed presentation of the restoration activities at Pleasant Valley Conservancy can be found at our web site: <http://www.savannaoak.org>.

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Table 1. Tree removal on a 2.1 acre (0.8 hectares) savanna (six people; 240 hours)				
Tree species removed	Number	Average diameter (inches)	Average diameter (centimeters)	Range (inches)
Birch (<i>Betula papyrifera</i>)	2	14	35	13.5-14
Black oak (<i>Quercus velutina</i>)	2	25	62.5	12-39
Cherry (<i>Prunus serotina</i>)	5	6.2	15.5	3.5-11
Elm (<i>Ulmus rubra</i>)	58	10.5	26.3	4.0-12.5
Hackberry (<i>Celtis occidentalis</i>)`	3	7.7	19.3	4.5-10
Red cedar (<i>Juniperus virginiana</i>)	1	4	10	
Walnut (<i>Juglans niger</i>)	99	10.8	27	3.5-32
Also removed were numerous honeysuckle and prickly ash shrubs				

Table 2. Savanna species present at Pleasant Valley Conservancy which were established or flourished after restoration began		
Latin name	Common name	Comments
<i>Actaea alba</i>	Doll's eyes	Very restricted
<i>Actaea rubra</i>	Red baneberry	Restricted areas
<i>Agrimonia gryposepala</i>	Tall agrimony	Common
<i>Anemone quinquefolia</i>	Wood anemone	Common
<i>Anemone virginiana</i>	Tall anemone	Common (scattered)
<i>Aquilegia canadensis</i>	Wild columbine	Widespread
<i>Arabis canadensis</i>	Sickle pod	Common (scattered)
<i>Aralia racemosa</i>	Spikenard	Restricted
<i>Asclepias exaltata</i>	Poke milkweed	Restricted
<i>Asclepias purpurascens</i>	Purple milkweed	Very restricted (State-endangered)
<i>Aster lateriflorus</i>	Calico aster	Widespread
<i>Aster pilosus</i>	Frost aster	Widespread
<i>Aster sagittifolius</i>	Arrow-leaf aster	Common (scattered)
<i>Bidens frondosus</i>	Beggar's ticks	common
<i>Carex pensylvanica</i>	Pennsylvania sedge	Widespread

<i>Circaea lutetiana canadensis</i>	Enchanter's nightshade	Widespread
<i>Cirsium discolor</i>	Old-field thistle	Restricted
<i>Coeloglossum viride</i>	Frog orchid	Very restricted
<i>Cryptotaenia canadensis</i>	Honewort	Common
<i>Cypripedium calceolus pubescens</i>	Large yellow lady-slipper	Restricted (mostly found in oak woods)
<i>Desmodium glutinosum</i>	Tick trefoil	Common
<i>Dodecatheon meadii</i>	Shooting star	Common
<i>Echinocystis lobata</i>	Wild cucumber	Restricted
<i>Elymus hystrix</i>	Bottlebrush grass	Originally restricted, now widespread
<i>Elymus villosus</i>	Silky rye	Originally restricted, now widespread
<i>Elymus virginicus</i>	Virginia wild rye	Common but localized
<i>Erechtites hieracifolia</i>	Burnweed	Common
<i>Erigeron spp.</i>	Fleabane	Very common
<i>Eupatorium altissimum</i>	Tall boneset	Relatively common
<i>Eupatorium rugosum</i>	White snakeroot	Widespread
<i>Eupatorium sessilifolium</i>	Upland boneset	Very restricted (State threatened)
<i>Fragaria virginiana</i>	Wild strawberry	Widespread
<i>Galium tinctorium</i>	Stiff bedstraw	Widespread
<i>Geranium maculatum</i>	Wild geranium	Widespread

<i>Geum canadense</i>	White avens	Common
<i>Goodyera pubescens</i>	Rattlesnake plantain	Restricted
<i>Hackelia virginiana</i>	Stickseed	Common
<i>Helianthus spp.</i>	Woodland sunflowers	Patchy in a few areas
<i>Hypericum punctatum</i>	Dotted St. John's wort	Restricted
<i>Lactuca spp.</i>	Wild lettuce	Common
<i>Laportea canadensis</i>	Wood nettle	Restricted
<i>Lobelia inflata</i>	Indian-tobacco	Restricted
<i>Lobelia siphilitica</i>	Great blue lobelia	Restricted
<i>Lysimachia ciliata</i>	Fringed loosestrife	Restricted
<i>Lysimachia quadrifolia</i>	Whorled loosestrife	Restricted areas but widespread in those areas
<i>Monarda fistulosa</i>	Bergamot	Common
<i>Osmorhiza claytoni</i>	Hairy sweet cicely	Moderately common
<i>Osmorhiza longistylis</i>	Smooth sweet cicely	Common
<i>Phryma leptostachya</i>	Lopseed	Common
<i>Podophyllum peltatum</i>	May apple	Restricted but forms large clones
<i>Polemonium reptans</i>	Jacob's ladder	Restricted
<i>Polygonatum biflorum</i>	Smooth Solomon's seal	Common
<i>Potentilla simplex</i>	Old-field cinquefoil	Widespread, potentially invasive?
<i>Prenanthes alba</i>	Lion's foot	Restricted

<i>Pyrola elliptica</i>	Shinleaf	Restricted
<i>Ranunculus abortivus</i>	Small-flowered buttercup	Common
<i>Ranunculus fascicularis</i>	Early buttercup	Widespread
<i>Sanicula marilandica</i>	Black snakeroot	Widespread
<i>Scrophularia lanceolata</i>	Figwort	Restricted
<i>Senecio pauperculus</i>	Balsam ragwort	Common
<i>Smilacina racemosa</i>	False Solomon's seal	Common
<i>Smilacina stellata</i>	Starry Solomon's seal	Restricted
<i>Solidago canadense</i>	Canada goldenrod	Widespread
<i>Solidago ulmifolia</i>	Elm-leaf goldrod	Restricted
<i>Taenidia integerrima</i>	Yellow pimpernel	Restricted
<i>Teucrium canadense</i>	Germander	Restricted, but forms large patches
<i>Thalictrum dasycarpum</i>	Tall meadow rue	Occasional
<i>Thalictrum dioicum</i>	Early meadow rue	Restricted
<i>Triosteum perfoliatum</i>	Early horse gentian	Widespread
<i>Uvularia grandiflora</i>	Bellwort	Restricted
<i>Veronicocastrum virginicum</i>	Culver's root	Restricted
<i>Viola soraria</i>	Dooryard violet	Common
<i>Zizia aurea</i>	Golden alexander	Common