Regeneration in a Heavily Browsed Northern Hardwood Stand Twelve Years After Scarification and Fencing

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Introduction

Most northern hardwood forests in the Lake States were established after extensive logging that took place about 100 years ago and tend to be single-aged. They are routinely managed using selection silviculture where partial cutting is used to establish additional age cohorts and maintain species diversity. Foresters depend on the older trees to produce seedlings (either prior to or immediately following harvesting) that will form these new cohorts. Success in this endeavor demands careful attention to the silvics of the species involved and an understanding of how to create conditions that favor regeneration of desirable species.

Foresters have found that their efforts to maintain species diversity and to improve the age structure in these northern hardwood forests have been thwarted in areas with an over-abundance of white-tailed deer. The preferential browsing of these animals seems to be responsible for the low rates of recruitment of important species like sugar maple, yellow birch, red oak, and others.

This study was established to quantify the effect of over-browsing on woody plant regeneration in a northern hardwood stand on Michigan State University's Upper Peninsula Tree Improvement Center in Escanaba, Michigan. The 35-acre stand chosen for the study was like many in the area. The overstory was dominated by mature sugar maple and American beech with associates like ironwood, basswood, American elm, yellow birch, and occasional butternut and black cherry. There was practically no advanced regeneration of woody plants other than ironwood anywhere in the stand. Portions of the stand had developed a continuous sedge groundcover. A sizeable deer herd (50 to 70 per square mile) routinely used the stand during the entire year, except in the winter when deep snow limited access to them. It was assumed that over-browsing had excluded the development of woody plants and forbs, thus allowing the sedges to become so abundantly established.

Following a thinning, scarification treatments were applied to break the dominance of the sedges and fences were erected to exclude deer from portions of the stand. The effect of these treatments on forb and woody plant regeneration was monitored and the results are reported here.

Methods

An initial inventory of standing timber in the study area was made in 1990. This inventory showed that the stand had an average basal area of 100 square feet, composed of 80% sugar maple, 11% American beech, and 9% associated species – primarily ironwood. Timber volumes averaged 8 thousand board feet per acre and 5 cords per acre. Stand density and timber volume varied from place to place. A thinning was done in February of 1992 when the ground was frozen. An attempt was made to increase stand uniformity and to obtain an average basal area of about 60 square feet per acre. Ironwood in the understory was preferentially removed. Logging slash was skidded out of the stand in order to facilitate subsequent scarification treatments and fence building.

The experiment was constructed using a split-plot, randomized block design with three blocks, two fencing treatments (the main-plots) and three scarification treatments (the sub-plots) yielding 18 treatment plots. Treatments were applied during the summer of 1992. Three scarification treatments were employed to break the competitive advantage of the sedges. Treatments included no scarification (controls), mechanical scarification, and chemical scarification. Mechanical scarification was achieved using a combination of a crawler-mounted brush blade and agricultural discs. Chemical scarification was accomplished using the broad-spectrum herbicide, glyphosate. Ten-wire, six-foot-tall electric fences were erected around half of these scarification treatment plots to form the main-plots.

We observed that mechanically scarified plots produced a flush of extremely vigorous agricultural weed growth during the first two years following treatment. This weed growth diminished after the second year. Deer were observed inside the fences from time to time throughout the course of the study. This type of fence does not commonly exclude deer completely, but our experience in other areas suggests that browsing by the deer that penetrate the fences is curtailed. For example, we have successfully grown highly favored browse species like white pine, aspen, and Douglas-fir inside nearby fences of similar design.

The first inventory of groundcover was made in July of 1996 (mid-way through the fifth growing season following the thinning). Sixty mill-hectare (1 meter square) observation plots were randomly located throughout the stand. Because of the random location of these observation plots, an unequal number fell in each of the various sub-plots. The error introduced by this sampling method became a problem during the analysis when trying to isolate the relatively small treatment differences. The purpose of this inventory was to look for striking differences among treatments. No such differences were found in 1996 so the data were filed away for use at a later time.

A second inventory of groundcover in Block 2 was made in June of 2002 (the beginning of the 11th growing season). Block 2 was chosen because it displayed the greatest difference in groundcover between the fenced and unfenced treatments. Forty mill-hectare observation plots were located on a systematic grid so that an equal number fell inside and outside the fence throughout Block 2. The location of the observation plots relative to scarification treatments was not recorded. The purpose of this inventory was to provide data for Meghan Johnson's senior research project. She analyzed the data and prepared a report of her results.

A third inventory of larger woody regeneration (five-years and older) was made in September of 2003 (at the end of the 12th growing season) throughout the entire stand. Sixteen 1/500th-acre (5.2' radius) observation plots were arranged systematically within each of the sub-plots. This resulted in a total of 288 observation plots that were uniformly distributed among all treatments and blocks. This inventory was conducted to provide an assessment of the scarification and fencing treatments on this site.

These three inventories differed in their design and purpose. The 5th-year and 11th-year inventories sampled all vegetation but in a limited number of plots. The 5th-year inventory did not sample all treatments equally and the 11th-year inventory sampled only fencing effects in block two. The 12th-year inventory sampled all treatments and blocks systematically but only tallied larger woody regeneration (five-years and older). Comparisons among these inventories must only be done with these differences in mind.

Several indices were calculated to describe the plant community within each treatment. Each index contributes a slightly different description of the conditions observed throughout the site. They include *community density*, *richness*, *diversity*, and *dominance* as well as *taxa prevalence* and *dominance*.

Community Indices

1. (SPA) – *Community* <u>density</u>. This commonly used measure of the total number of stems per acre was computed from the average of all observation plots within a particular treatment. Obviously treatments with high SPA are densely populated while those with low SPA are sparsely populated.

2. (S) – the number of taxa present. This is widely used in the literature as a simple index of *community* <u>*richness*</u>. The average number of taxa present can be easily compared to establish whether richness varies among treatments.

3. (H) – the Shannon-Weaver Index. This is a measure of *community* <u>*diversity*</u> that accounts for both the number of unique taxa as well as the number of individuals within each of these taxa. The index ranges from a value of 0 for communities with only a single taxon (*i.e.*, monocultures) to higher values for communities with many, equally-represented taxa (*i.e.*, having smooth distributions). Communities with a few dominant taxa and numerous other rare taxa (*i.e.*, having lumpy distributions) have low H index values. A footnote is included with each table in this document to indicate the maximum possible value for H for that inventory.

$$H = -\sum_{i=1}^{s} \frac{n_i}{n_t} \ln\left(\frac{n_i}{n_t}\right)$$

Where:

H	=	Shannon-Weaver Index
n_i	=	number of individuals of a particular taxa
s	=	number of taxa in plot
n_t	=	total number of individuals in plot

4. (D) – Dominance Index. This, as its name implies, is a measure of *community <u>dominance</u>*. It ranges from a value near 0 when all taxa are equally represented to 1 when one taxon completely dominates the community.

$$D = \sum_{i=1}^{s} \left(\frac{n_i}{n_t}\right)^2$$

Where:

D	=	Dominance Index
n_i	=	number of individuals of a particular taxa
s	=	number of taxa in plot
n_t	=	total number of individuals in plot

Taxa Indices

5. (TP) – This index describes *taxa <u>prevalence</u>* or, how commonly a taxon was found within a particular treatment. It was computed for each taxa within a treatment and is the ratio of the number of plots in which a taxon occurred to the total number of plots in a treatment, expressed as a percent. Taxa with values of 100% occur in all treatment plots while those with a value of 0% are absent from that treatment.

6. (TD) – This describes *taxa <u>dominance</u>* and is equivalent to the Berger-Parker Dominance Index. It reflects the degree to which any taxon dominates the sites where it is present. It was calculated for each observation plot as the simple ratio of the number of individuals of a particular taxon and the total number of individuals in that plot. When expressed as a percent, values range from 100% (for a taxon that completely dominates an observation plot) to 0% (for a taxon that is missing from an observation plot). Index values presented in the following tables are the averages of all plots within a treatment where the TD value was greater than zero. Columns do not add to 100% as they would within a single observation plot.

An example of how these indices are used to describe communities:

Suppose there are two communities, each represented by one 1/500th - acre plot. Each plot has five taxa and ten individuals. The first plot has one individual of each of four taxa and six individuals of the fifth taxa. The second plot has two individuals of all five taxa.

We can use <u>community indices</u> to describe each area as a whole. Both areas would have a *community density* (SPA) of 5,000 because there are ten individuals in each. Both areas would have a *community richness* (S) value of 5 because there are five taxa in each. *Community diversity* (H) would be 1.228 for the first and 1.609 for the second area. *Community dominance* (D) is 0.4 for the first area and 0.2 for the second. Together, these indices convey that the communities are equally *dense* and *rich* but the first community is less *diverse* and more *dominated* ("lumpier") than the second.

These community indices do not convey anything about: (a) which taxa are present, (b) how common they are, or (c) which are dominant. For this we can turn to a simple list of taxa found in the samples and to the <u>taxa indices</u>. These indices are computed for each plot and then averaged within each area.

Suppose that sugar maple has a *prevalence* (TP) value of 80 and a *dominance* (TD) value of 6 while ironwood has a *prevalence* (TP) value of 80 and a *dominance* (TD) value of 50 within a particular community. Both taxa are equally common (you will find them in 80% of both areas) but ironwood is proportionally more abundant (composing 50% of the stems where it occurs) than sugar maple (composing only 6% of the stems where it occurs). In other words, sugar maple is diffusely distributed throughout both areas while ironwood is fairly dominant everywhere.

Results and Discussion

Fifth-year Results (random samples of all groundcover)

A one-way analysis of variance suggested that there were significant, but slight differences in community structure among scarification treatments and between fencing treatments after five growing seasons. Unscarified (control) plots were *richer* (S), more *diverse* (H), and less *dominated* (D) than scarified plots. Plots treated with herbicide were *denser* (SPA) but the least *rich* (S) and *diverse* (H). Fenced plots were slightly more *dense* (SPA) and *dominated* (D) and slightly less *rich* (S) and *diverse* (H) than unfenced plots (Table 1).

Few of the 45 species found during this inventory (Appendix 1) could be said to be more *prevalent* (TP) or *dominant* (TD) in any of the treatments relative to the others. An exception was shield fern, which in control plots was two times more *prevalent* (TP) than in mechanically scarified and four times as *prevalent* (TP) as in herbicide scarified plots. This suggests that the fern was present at the time of treatment and was nearly eliminated as a consequence of scarification (Table 2 and 3).

Small sugar maple seedlings were found nearly everywhere regardless of treatment and composed 11-17% of all stems tallied. On the other hand, ironwood seedlings were found in only about half of the area and composed no more than 4% of the seedlings.

Table 1. Groundcover diversity five growing seasons after a thinning in a mixed northern hardwood stand in Escanaba, MI under various fencing and scarification treatments.

Treatment	SPA	S	H[a/]	D
Fencing Treatment				
Fence	244,034	8.8	1.62	0.28
No Fence	223,799	9.0	1.77	0.23
Scarification Treatment				
Herbicide	267,507	8.5	1.58	0.29
Mechanical	210,444	9.0	1.70	0.26
No Scarification	232,299	9.1	1.80	0.22

a/ - The Shannon-Wilcox Index theoretically ranges from a minimum of 0 (an empty plot) to a maximum of 3.81 (a plot with equal numbers of all 45 species found during this inventory). Actual plot values here ranged from 0.84 to 2.53.

Table 2. Prevalence and dominance of the six most common taxa present five growing seasons after three scarification treatments were applied in a thinned northern hardwood stand in Escanaba, MI.

Taxa	Control (no scarification)		Herbicide Scarification		Mechanical Scarification	
	TP (%)	TD (%)	TP (%)	TD (%)	TP (%)	TD (%)
Hepatica	90	16.9	80	20.4	70	20.6
Sugar maple	90	11.0	90	14.0	100	16.6
Ironwood	60	2.3	50	4.2	40	1.6
Sweet Cicely	60	6.8	70	6.3	60	7.1
Violet	60	6.3	50	7.0	40	2.9
Shield fern	40	5.7	10	0.0	20	2.8

"TP" is a measure of the proportion of samples in which a taxon was present. "TD" reflects the average dominance of a taxon relative to all plants.

Table 3. Prevalence and dominance of the six most common taxa present five growing seasons after two fencing treatments were applied in a thinned northern hardwood stand in Escanaba, MI.

Taxa	Inside Fences		Outside Fences	
	TP (%)	TD (%)	TP (%)	TD (%)
Sugar maple	90	14.3	90	13.9
Hepatica	80	22.8	70	16.0
Sweet Cicely	70	8.1	60	5.4
Ironwood	40	1.3	60	3.8
Alternate-leaved dogwood	50	2.6	30	3.1
Raspberry	50	7.2	40	4.3

"TP" is a measure of the proportion of samples in which a taxon was present. "TD" reflects the average dominance of a taxon relative to all plants.

Eleventh-year Results (systematic sample of all groundcover in block two)

A one-way analysis of variance suggested that significant differences in community structure existed between fenced and unfenced areas of Block 2. Fenced areas were nearly twice as *dense* (SPA) as unfenced areas in the eleventh year. Fenced areas were slightly *richer* (S) than unfenced areas but were more *dominated* (D) and less *diverse* (H), probably due to an uneven distribution of stems among taxa (Table 4). Community statistics were similar in year eleven to those computed in year five although *density* (SPA) had nearly doubled in fenced plots. If plants had an equal opportunity to become established everywhere in the stand, it would appear that fences provided the difference between survival and death for many young plants of most taxa between year five and year eleven.

Thirty-one species were found in the stand at the time of this inventory (Appendix 1). Sugar maple was the only woody plant that was commonly found in the area sampled by this inventory. It was three times as *prevalent* (TP) (90% vs. 30%) and more than seven times as *dominant* (TD) (4.5% vs. 0.6%) inside the fence as outside. Wild leek and trout lily were more *prevalent* (TP) and *dominant* (TD) outside the fences than inside, while bedstraw showed just the opposite trend (Table 5). This suggests that deer browsing reduces sugar maple and bedstraw and favors wild leek and trout lily. It is interesting to note that ironwood did not appear as one of the *prevalent* (TP) taxa in this inventory (appearing in less than 20% of the plots). This must be a sampling artifact because it appeared frequently in both the 5th-year and 12th-year inventories.

Table 4. Groundcover description eleven growing seasons after two fencing treatments were applied in a thinned northern hardwood stand in Escanaba, MI.

Treatment	SPA	S	H[a/]	D
Fence	600,575	8.9	1.63	0.26
No Fence	317,285	8.1	1.70	0.23

a/ - The Shannon-Wilcox index theoretically ranges from a minimum of 0 (an empty plot) to a maximum of 3.43 (a plot with equal numbers of all 31 species found during this inventory). Actual plot values here ranged from 0.75 to 2.12.

Table 5. Prevalence and dominance of the seven most prevalent taxa present eleven growing seasons after two fencing treatments were applied in a thinned northern hardwood stand in Escanaba, MI.

Taxa	Inside Fences		Outside Fences	
	TP (%)	TD (%)	TP (%)	TD (%)
Sweet cicely	100	23.0	70	7.8
Hepatica	90	14.0	90	13.2
Sugar maple	90	4.9	30	0.6
Trout lily	80	18.8	100	24.5
Bedstraw	80	14.0	40	5.8
Spring beauty	80	2.1	70	6.0
Wild leek	40	2.8	90	18.1

"TP" is a measure of the proportion of samples in which a taxon was present. "TD" reflects the average dominance of a taxon relative to all plants.

Twelfth-year Results (systematic sample of larger woody regeneration in all treatments and blocks)

The third inventory (larger woody regeneration) was the most complete and systematic of the three. These data could be analyzed using the original split-plot randomized block design of the experiment. This type of analysis of variance demonstrated moderately significant differences in community structure between fencing treatments and among scarification treatments. Unfortunately there were strong interactions between the treatment effects and the blocks – due mainly to unexplained irregularities in Block one. One-way analysis of variance among fencing and scarification treatments confirmed the differences suggested by the split-plot analysis. Based on these analyses it appears that fenced plots were three times as *dense* (SPA) as, and are more *rich* (S) and *diverse* (H) than, and less *dominated* (D) than unfenced plots. Mechanically scarified plots tended to be less *dense* (SPA), *rich* (S), and *diverse* (H) than and more *dominated* (D) than plots treated otherwise (Table 6).

Ten woody plant species were present in the stand at the time of this third inventory (Appendix 1). Sugar maple, ironwood, American beech, and buckthorn were the most *prevalent* (TP) among these – occurring in more than 20% of the stand. Sugar maple was *prevalent* (TP) in fenced plots (composing about 30% of the seedlings there) but was rarely found outside the fences. This is consistent with observations made for the 11th-year inventory. An equal *density* (TD) of ironwood was found everywhere in the stand – although it was slightly more *prevalent* (TP) inside the fences. Distribution of buckthorn and beech seemed to be unaffected by fencing treatments (Table 7).

Scarification treatment seemed to have little effect on most species with the exception of ironwood. Ironwood was more *prevalent* (TP) and *denser* (TD) in unscarified, control plots (Table 8).

Table 6. Woody plant regeneration (5-years and older) diversity twelve growing seasons after a thinning in a mixed northern hardwood stand in Escanaba, MI under various fencing and scarification treatments.

	SPA	S	H[a/]	D
Fencing Treatment				
Fence	7,101	1.77	0.44	0.74
No Fence	1,837	1.21	0.31	0.80
Scarification Treatment				
Herbicide	5,146	1.51	0.42	0.51
Mechanical	2,104	1.24	0.30	0.81
No Scarification	6.156	1.72	0.41	0.75

a/ - The Shannon-Wilcox index theoretically ranges from a minimum of 0 (an empty plot) to a maximum of 2.30 (a plot with equal numbers of all 10 woody plants found during this inventory). Actual plot values here ranged from 0 to 1.33.

Table 7. Prevalence and Dominance of woody plant regeneration (5-years and older) within fencing treatment plots, 12 years after treatment. Italic numbers indicate rarity while shaded numbers indicate commonness.

Taxa	Inside Fences		Outside Fences	
	TP (%)	TD (%)	TP (%)	TD (%)
Ironwood	**65**	**32.1**	**49**	**36.5**
Sugar Maple	**48**	**30.8**	*5*	*1.8*
Buckthorn	**29**	**10.9**	**30**	**17.1**
Beech	**17**	**6.7**	**20**	**9.9**
American Elm	*7*	*1.6*	*3*	*1.4*
Ash	*5*	*3.1*	*0*	*0*
Dogwood	*4*	*1.5*	*3*	*1.7*
Leatherwood	*1*	*0.2*	*6*	*3.3*
Serviceberry	*1*	*0*	*0*	*0*
Softwood	*0*	*0*	*6*	*0.5*

"TP" is a measure of the proportion of samples in which a taxon was present. "TD" reflects the average dominance of a taxon relative to all plants.

Table 8. Prevalence and Dominance of woody plant regeneration (5-years and older) in scarification treatments, 12 years after treatment. Italic numbers indicate rarity while shaded numbers indicate commonness.

Species	Control – no scarification		Herbicide Scarification		Mechanical Scarification	
	TP (%)	TD (%)	TP (%)	TD (%)	TP (%)	TD (%)
Ironwood	**70.8**	**41.9**	**55.2**	**30.0**	**43.8**	**31.0**
Buckthorn	**33.3**	**13.8**	**29.2**	**13.7**	**26.0**	**14.4**
Sugar Maple	**29.2**	**19.2**	**29.2**	**16.8**	**20.8**	**12.8**
Beech	**17.7**	**6.1**	**21.9**	**9.7**	**16.7**	**9.1**
American Elm	*10.4*	*2.5*	*3.1*	*1.4*	*2.1*	*0.6*
Dogwood	*3.1*	*1.3*	*4.2*	*1.5*	*3.1*	*2.0*
Leatherwood	*3.1*	*1.3*	*4.2*	*2.5*	*3.1*	*1.4*
Softwood	*3.1*	*0.4*	*3.1*	*0.2*	*2.1*	*0.2*
Ash	*1.0*	*0*	*1.0*	*0*	*5.2*	*4.6*
Serviceberry	*0*	*0*	*0*	*0*	*1.0*	*0.1*

"TP" is a measure of the proportion of samples in which a taxon was present. "TD" reflects the average dominance of a taxon relative to all plants.

Conclusions

Although differences among treatments took about a decade to develop, it seems clear that excluding white-tailed deer using electric fences can increase the *density*, *richness*, and *diversity* of forbs and woody plants in thinned northern hardwood stands like this one. Sugar maple regenerates well under all conditions but requires some type of protection from deer browsing to survive and be recruited into the overstory. In the absence of fencing, species like ironwood, buckthorn, and American beech (that are less desirable for both deer browse and timber production) *dominate*.

Sugar maple stands like this one may eventually disappear from the landscape if deer browsing is allowed to continue at present levels. The only species that will regenerate and survive are those that are not eaten by the deer, so future forests may likely be *dominated* by ironwood and beech. Groundcover in these future stands will also contain fewer species and be dramatically less *dense* than today's stands if heavy deer browsing continues.

We found that fencing of forest stands is expensive and cannot be expected to exclude all deer from the area. Fences like the ones we used can cost more than $2.00 per linear foot to build and require routine maintenance throughout the year to ensure that they remain effective. Fencing remains a poor option for low- to middle-value stands and for stands in remote locations. Perhaps another way could be found to limit the number of deer that feed in regenerating stands but this author is at a loss to think of one.

Mechanical scarification restricted the abundance and diversity of all taxa and is particularly detrimental to sugar maple regeneration. The flush of agricultural weeds that occurred during the first two years following mechanical scarification may have been responsible for the lower establishment rates of forbs and woody plants in these plots. Mechanical scarification is quite difficult and expensive to accomplish without damaging the trees that remain after a thinning. These data show that it would be better to do nothing than to mechanically scarify stands like this.

Scarification may reduce the prevalence of certain species that depend on advanced regeneration to survive disturbances. In this study, shield fern seemed to be an example of this problem. The abundance of other species that produce seed irregularly, like trillium, will be reduced by scarification treatments.

If maintaining or increasing the diversity and density of woody plants and forbs in the northern hardwood forests of the Upper Peninsula is desirable, methods will need to be developed to overcome the effects of both past and future over-browsing. The goal may be simple to establish but the methods to achieve it will most certainly be difficult and expensive.

Acknowledgements:

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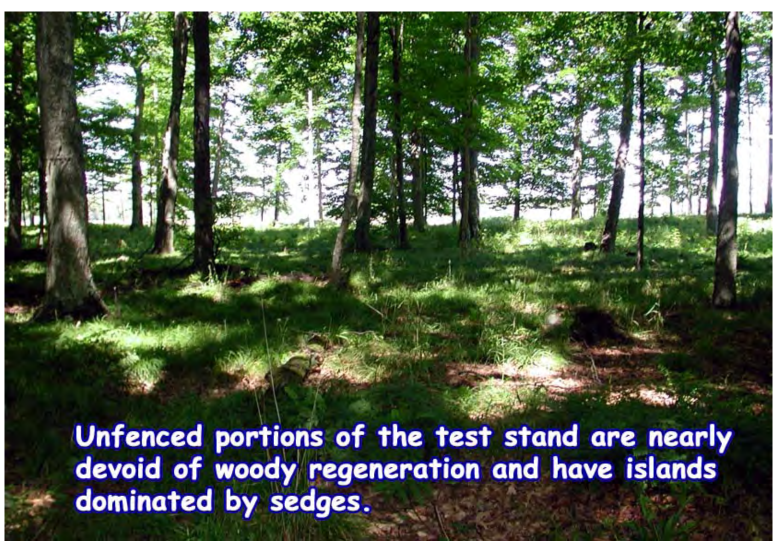
Appendix 1. Species identified in the three inventories of a thinned northern hardwood stand in Escanaba, MI.				
Common Name	***Scientific Name***	**Inventory**		
		1996	**2002**	**2003**
alternate-leaved dogwood	*Cornus alternifolia*	X		X
American beech	*Fagus grandifolia*	X	X	X
American elm	*Ulmus Americana*	X	X	X
aster	*Aster spp.*	X		
balsam fir	*Abies balsamea*	X		
bedstraw	*Galium boreale*	X	X	
black cherry	*Prunus serrotina*		X	
Bladder campion	*Silene cucubalus*	X		
blood root	*Sanguinaria canadensis*		X	
blue cohosh	*Caulophyllum thalictroides*	X		
bracken fern	*Pteridium aquilinum*		X	
buckthorn	*Rhamnus* spp.			X
burdock	*Arctium minus*	X	X	
cinnamon fern	*Osmunda cinnamomea*	X		
clover	*Trifolium repens*	X	X	
dandelion	*Taraxacum officinale*		X	
Dutchman's breeches	*Dicentra cucullaria*		X	
elderberry	*Sambucus canadensis*	X		
false miterwort	*Tiarella cordifolia*	X		
false nettle	*Boehmaria cylindrica*	X		
false solomon's-seal	*Smilacina racemosa*	X		
goldenrod	*Solidago* spp.	X		
goldthread	*Coptis groenlandica*		X	
hawk weed	*Hieracium aurantiacum*	X		
hepatica	*Hepatica americana*	X	X	
hooked buttercup	*Ranunculus recurvatus*	X		
horsetail	*Equisetum arvense*	X	X	
indian cucumber root	*Medeola virginiana*	X		
ironwood	*Ostrya virginiana*	X	X	X
Jack in the pulpit	*Arisaema triphyllum*	X	X	
lady fern	*Athyrium filix-femina*	X		
leatherleaf	*Chamaedaphne calyculata*	X	X	
leatherwood	*Dirca palustris*			X
lilly of the valley	*Maianthemum canadense*	X	X	
lopseed	*Phryma leptostachya*	X		
maidenhair fern	*Adiantum pedatum*	X		
miterwort	*Mitella diphylla*	X	X	
nightshade	*Solanum dulcamara*	X		
other		X	X	X
pigweed	*Amaranthus albus*	X		
primrose violet	*Viola x primulifolia*	X	X	
raspberry	*Rubus* spp.	X	X	
red osier dogwood	*Cornus stolonifera*	X		
serviceberry	*Amelanchier arborea*			X
shield fern	*Dryopteris spinulosa*	X		
smooth yellow violet	*Viola pensylvanica*	X	X	
spring beauty	*Claytonia virginica*		X	
squirrel corn	*Dicentra canadensis*		X	
stinging nettle	*Urtica dioica*	X		
strawberry	*Fragaria virginiana*	X	X	
sugar maple	*Acer saccharum*	X	X	X
sweet cicely	*Osmorhiza claytoni*	X	X	
thistle	*Cirsium* spp.	X		
trilium	*Trillium erectum*	X	X	
trout lily	*Erythronium americanum*		X	
white ash	*Fraxinus americana*	X		X
wild geranium	*Geranium maculatum*		X	
wild leek	*Allium tricoccum*	X	X	


A millhectare plot in a fenced portion the test stand


Fenced portions of the test stand show abundant woody regeneration.


Unfenced portions of the test stand are nearly devoid of woody regeneration and have islands dominated by sedges.