Continued monitoring of vegetative succession along the *Volney-Marcy South* right-of-way, summer 2003

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ABSTRACT

This report constitutes a review of the fifth year of continued monitoring of vegetative succession in two belt transects on the *Volney-Marcy South* Right-of-Way (ROW). Each of the study transects consists of 17 quadrats (10x3 m). The presence of each vascular plant species was recorded for each quadrat, and the percent cover for each species within each quadrat was estimated. In 2003, there was a slight decrease in the number of species observed on each transect (from 2002 to 2003 Transect A declined from 69 species to 65 while Transect B declined from 88 species to 84). Dominant species in Transect A were *Viburnum dentatum* (Northern Arrowwood) (25.9% cover) and *Rubus allegheniensis* (Blackberry) (11.3%), and the dominant family was Rosaceae (51% of total cover). Transect B's highest-cover species were *Rubus allegheniensis* (Blackberry) (13.8%) and *Rubus idaeus* (Red Raspberry) (13.7%), and the dominant families were Asteraceae and Rosaceae (combining for 52% of total cover). Transect B was managed in 1998 with mechanical removal of unwanted species, as well as stump-treatment applications of herbicides. Vegetation on Transect A has not been managed since 1988.

INTRODUCTION

The *Volney-Marcy South* Right-of-Way is a 200-mile long, 345-kV power line that runs from Marcy to East Fishkill, New York. The ROW is owned and maintained by the Power Authority of the State of New York (PASNY), and passes through the Greenwoods Conservancy in Burlington, New York. The ROW runs from the southwest to the northeast through the 1200-acre Conservancy, which is protected by a conservation easement through the Otsego Land Trust. While the corridor created by the ROW crosses many ecosystem types within the Conservancy, including wetlands, the habitat directly adjacent to the ROW is primarily young-growth eastern deciduous forest.

Vegetation management is important to PASNY because of the potential for problems caused by trees and tall shrubs that get too near the uninsulated transmission lines, which hang as low as 30 feet above ground level. Line-to-ground faults, or "flashovers," can occur when vegetation grows too close to the transmission lines, and electricity jumps from the lines, via the vegetation, to the ground (Fickbohm 2001). On 14ugust 2003, a line-to-ground fault shorted out a power line as part of a long chain of events that left 50 million people in the northeastern United States without power (Walters 2003). Undesirable tree species that enter the "security

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zone" (the area within 15 feet of current-carrying transmission lines) pose a safety problem, and can also jeopardize the dependable transmission of electricity. Generally, a tree or shrub species is considered "undesirable" on the ROW if it matures at a height of at least 20 feet.

Prior to recent changes in attitudes about vegetation management, the vegetation on a ROW would be maintained every three or four years (Tedesco 2003). Since the 1950's, these maintenance practices have generally consisted of clear-cutting and the application of large volumes of indiscriminant herbicides from the ground or air (Tedesco 2003) and focused on the elimination of undesirable trees species. However, since 1980, the primary goal of ROW maintenance has changed to the promotion of desirable plant species that would help to limit the growth of undesirable species (Tedesco 2003). Increased shade under desirable species would prevent germination of many undesirable species' seeds. The encouragement of a relatively stable, early-successional community of low, dense vegetative cover would help slow the growth of undesirable species. Maintaining a community of desirable plants that slows the growth of undesirable species would mean less frequent maintenance along the ROW and economic savings.

After the 1988 establishment of the ROW through Greenwoods Conservancy, all maintenance of the ROW has been identified as "integrated vegetation management," which can incorporate mechanical, chemical, biological and cultural means of vegetation control (Daar et al. 1991) to help prevent flashovers. Mechanical means (hand-cutting with a chainsaw or brush-hog) and chemical means (spot applications of herbicides on tree stumps, or low-volume herbicide sprays) are the most often used methods in IVM. Biological means (such as herbivory and allelopathy) and cultural means (for example, promoting the use of ROW lands as snowmobile trails, grazing lands or apple orchards) (Daar et al. 1991) are not as common, and are not used on this section of the ROW. Initial establishment of the ROW consisted of clear-cutting in both of our study transects. Transect A has not been maintained in the 15 years since the creation of the ROW while Transect B was treated in 1998 using IVM techniques that included hand-cutting the undesirable tree species and spot applications of a triclorpyr-based herbicide to the stumps of these trees (McLoughlin 2003). Because many undesirable species will re-grow more stems that grow faster after being cut down, herbicide application to tree stumps is an important part of ROW vegetation management. The eventual goal of IVM on the *Volney-Marcy South* ROW is to promote a relatively stable community of low, dense vegetative growth characterized by large ground cover of shade-producing species such as *Rubus* spp. (blackberries and raspberries) and *Spiraea latifolia* (meadowsweet).

METHODS

Two belt transects were established in 1999 (Austin 2000) as annual study sites to monitor the vegetative succession along the *Volney-Marcy South* ROW as it passes through the Greenwoods Conservancy in Burlington, NY. Transect A is located 100 meters southwest of Zackow Road, and has a west-facing aspect with 25% slope; Transect B is located 300 meters southwest of Zackow Road, and faces east with a 20% slope (Austin 2000). Both transects traverse the ROW perpendicular to the power lines. Each transect measures 50 meters (width of the ROW) by 10 meters, and is divided into 17 study quadrats. Each quadrat, our sampling unit, measures 10 by approximately 3 meters. In both transects, Quadrat 1 is on the northwest border of the ROW and Quadrat 17 is on the southeast border (see Figure 1).

Between the first week of June and the first week of August, data were collected by a census survey of vascular plant species in every quadrat. As per Fickbohm (2001), each quadrat was roped off at its four corners; species diversity was recorded by identifying each plant species present in the quadrat. In August, after identifying all vascular plant species in all quadrats of both transects, each species was placed in a "cover class" for each quadrat in which it was present. Methodology for determining cover classes was adapted from Mueller-Dombois (1974), using the *Braun-Blanquet Cover-Abundance Scale*. Percent cover was determined by approximating the percent of each quadrat with aerial or ground cover by the foliage of each species. Once a species was placed in a cover class, the midpoint of that cover class was used as the "percent cover" within the quadrat (see Table 1). For instance, a species with approximately 40% ground or aerial cover within a quadrat would be assigned the cover value of 37.5% for that quadrat.

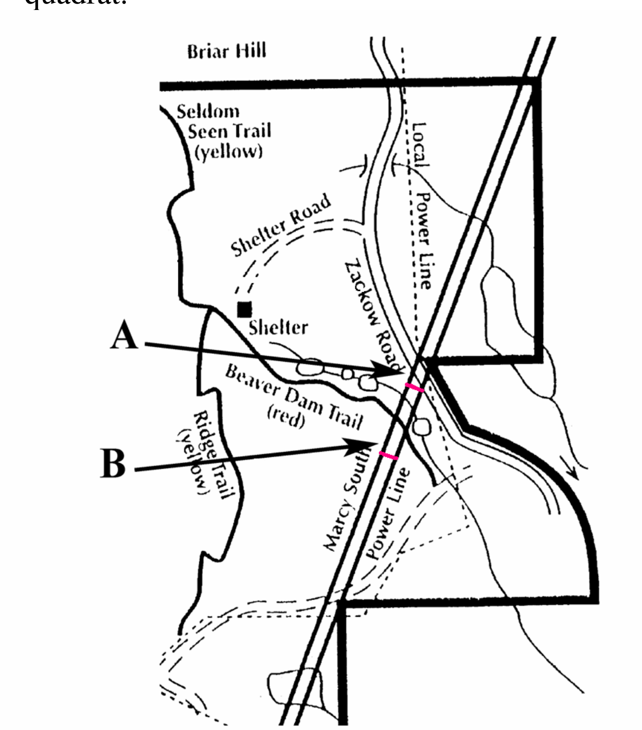

Fig 1. Map of Greenwoods Conservancy, showing the ROW and Transects A and B.

Class	Cover Range (%)	Mid-point
1	0-5	2.5
2	5-25	15
3	25-50	37.5
4	50-75	62.5
5	75-95	85
6	95-100	97.5

Table 1. Cover Classes and their midpoints.

In each quadrat of both transects, tree specimens that exceeded 3.0 m (10 ft) were tallied, and the presence of non-native species (according to Mitchell (1997)) was recorded. When determining plant diversity in each transect, plants were only counted if they were identified to the species level. Specimens with overhanging coverage but no stems in a particular quadrat are counted towards that species' percent coverage in that quadrat, but do not contribute to the total count of species diversity. Proportions of vegetative cover were calculated by dividing the total percentage of a species (or group of species as with undesirable species) in a quadrat by the total percent cover of the quadrat.

To detect significant differences ($p < 0.05$) in the "proportion of undesirable species' cover" between transects, a two-way analysis of variance (ANOVA) with an interaction term, and with the quadrats nested within their transect, was conducted on the dependent variable (SAS, see Appendix 1). Significant differences ($p < 0.05$) in average percent cover for dominant species between transects in 2003 were detected using a two-sample t-test (see Appendix 2).

RESULTS AND DISCUSSION

After reviewing the results from the 1999 study, an decision was made to apply all analyses only to the 2000-2003 data. The 1999 study should be considered as a preliminary pilot study. Low species diversity counts for both transects suggest that the study was not a completely successful census survey of vascular plant species. In Transect A, an increase from 45 to 64 species from 1999 to 2000 is reason for concern; note that Transect A had not been managed for more than 10 years prior to the initial survey, making the large jump in species diversity all the more suspect. In addition, prior ANOVA results analyzing all five years of data showed a highly disproportionate number of outliers in the 1999 data compared to other years. Rather than risk applying analyses to a larger, potentially weaker set of five years of data (1999-2003), all analyses and plots utilize only the more reliable (but smaller) set of four years of data (2000-2003).

Because many observed species have very small (< 1%) cover within a quadrat, using 2.5% (the midpoint of Cover Class 1) as the percent coverage for many species within a quadrat can sometimes result in total percent cover of greater than 100% for a given quadrat (especially in quadrats with very numerous low-cover species). Overlapping layers of cover from different species could have the same effect.

Overview

Percent cover per quadrat for 2003 and annual averages for all species observed on Transect A and B are given in Appendix 3 and 4. In Transect A, the total number of species declined slightly from 68 in 2002 to 65 in 2003 (Figure 2), but included 2 species observed for the first time. Total average percent cover in Transect A was 123% (up from 121% in 2002). The dominant family was Rosaceae, with 51% cover (see Figure 3). The top species (in terms of % cover) were *Viburnum dentatum* (Northern Arrowwood) (25.9%), *Rubus allegheniensis* (Blackberry) (11.3%), *Spiraea latifolia* (Meadow Sweet) (9.1%), and *Prunus serotina* (Black Cherry) (6.5%). The largest increase in cover was for *Prunus serotina* (Black Cherry), which increased 2.6% from 2002 to 2003. Although the dominant species in Transect A, *Viburnum dentatum* (Northern Arrowwood) also had the largest decrease of 6.8% from 2002 to 2003.

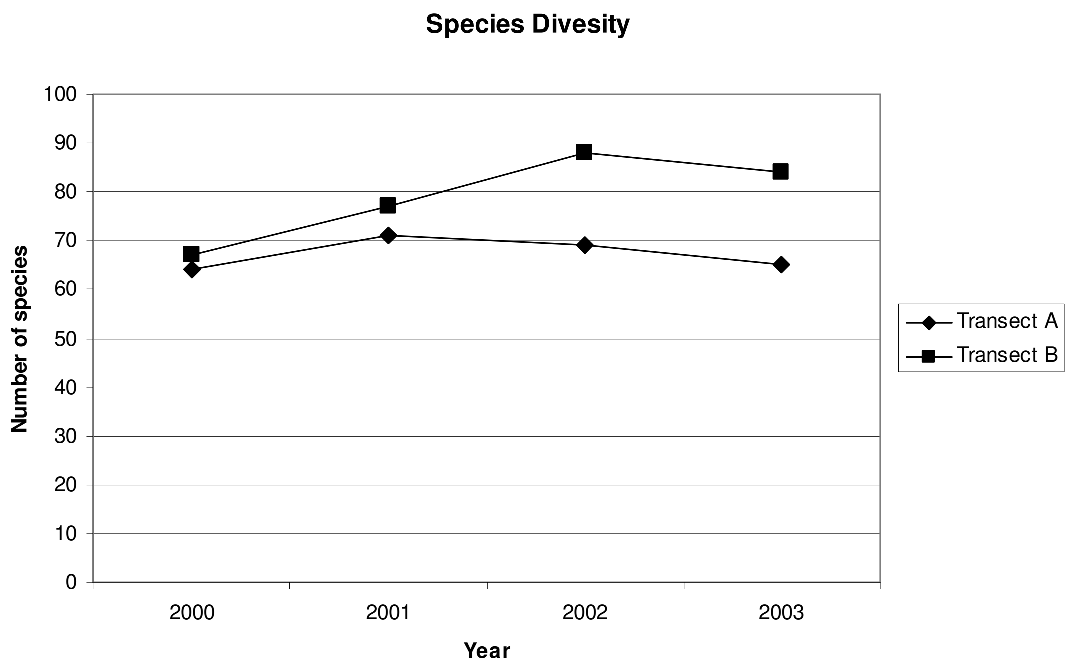

Figure 2. Species diversity of each transect, 2000-2003.

In Transect B, 84 species were observed in 2003 (down from 88 in 2002). Two of these 84 species were observed for the first time in 2003. Total average percent cover peaked in 2003 at 161% (up from 141% in 2002). The dominant families were Asteraceae and Rosaceae, accounting for 52% of the total cover (see Figure 2). The most dominant fully-identified species (in terms of cover) were *Rubus allegheniensis* (Blackberry) (13.8%), *Rubus idaeus* (Red Raspberry) (13.7%), *Fraxinus americana* (White Ash) (11.6%), *Impatiens capensis* (Jewel Weed) (9.0%), *Euthamia graminifolia* (Flat-Top Goldenrod) (8.0%), and *Solidago rugosa* (Rough-Stemmed Goldenrod) (6.8%). The largest increase in cover was for *Impatiens capensis* (Jewel Weed), which increased 6.0% from 2002 to 2003. *Fragaria virginiana* (Common Strawberry) saw the biggest loss, going down 2.9% between 2002 and 2003.

Especially because of the limited time frame of the available data, temporal variations in growing conditions can suggest non-existent trends in vegetative succession, cover, and diversity. For instance, Transect B saw a sudden increase in cover of *Impatiens capensis* (Jewel Weed), from 2.95% in 2002 to 8.97% in 2003 (this cover value ranks 5th out of all species from Transect B in 2003). This was most likely due to favorable (very wet) conditions for this species in 2003; one result of this increased cover is increased shade in some quadrats, leading to very little ground cover by species other than *I. capensis*.

Comparing Transect A to Transect B in 2003 can give a useful picture of how the transects differ during a given year. For the dominant species (with the highest relative frequency for each transect), average percent cover was compared between the two transects, using a two-sample t-test. The results of the t-tests are seen in Table 3.

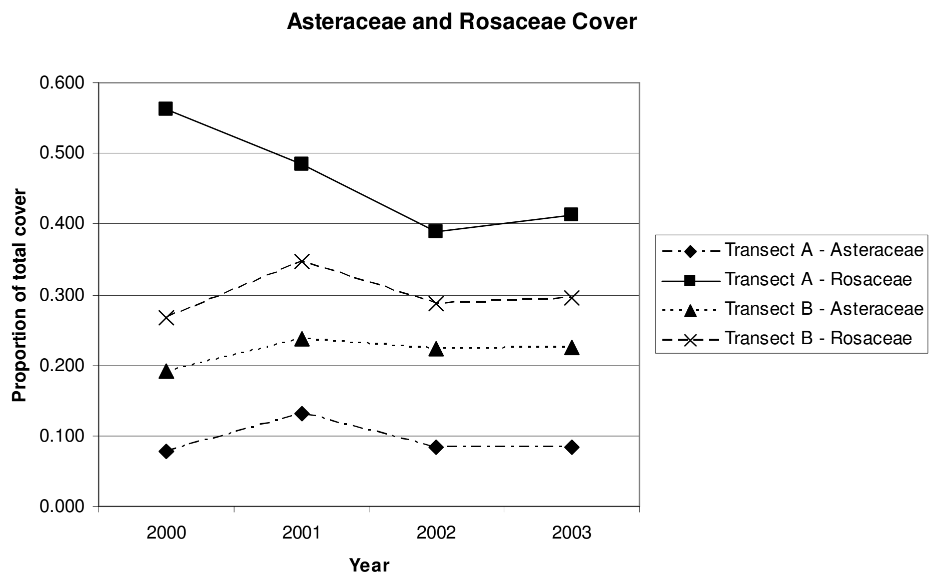

Figure 3. Asteraceae and Rosaceae cover (2000-2003).

The number of trees exceeding 3m in height increased in both Transect A and Transect B in 2003 (refer to Table 4). This is to be expected, as any tree exceeding this height in 2002 will again exceed this height in 2003 unless it is trimmed (this was not the case in 2003, since there was no vegetation management) or dies (this was also not observed in 2003).
The decisions involving establishment of the two study transects in 1999 were of the utmost importance to this study. Quadrat 17 of Transect B overlaps the bordering young-growth deciduous forest while Quadrat 17 in Transect A is within the corridor of the ROW. This is (in part) responsible for the relative dominance of *Fraxinus americana* (White Ash), and is also responsible for the large number of tree specimens with heights greater than 3m at the edge of Transect B. In Transect B, 49% of calculated White Ash cover is from Quadrat 17, and 60% of the tree specimens taller than 3m are White Ash specimens in Quadrat 17. While this has little effect on conclusions drawn about succession and undesirable cover in Transect B, it is an important consideration to keep in mind when making comparisons between the transects.

Overall species diversity has increased since 2000 in Transect B, but has remained relatively stable in Transect A (see Figure 4). Transect A has had 15 years of unfettered growth to reach a stable level of diversity; Transect B (having been managed just 5 years ago) has not yet reached a stable species count. This year, species diversity in both transects decreased slightly.

Presence of Undesirable Tree Species

Genus and Species	Common Name	Transect A 2002	Transect A 2003	Transect B 2002	Transect B 2003
Acer rubrum	Red Maple	x	x	x	x
Acer saccharum	Sugar Maple	x	x	x	x
Alnus incana	Speckled Alder	x	x	x	
Amelanchier sp.	Shadbush	x	x	x	x
Betula alleghaniensis	Yellow Birch			x	x
Fagus grandifolia	Beech	x		x	x
Fraxinus americana	White Ash	x	x	x	x
Malus pumila	Common Apple	x	x		
Picea rubens	Red Spruce	x	x	x	x
Pinus strobus	White Pine	x	x	x	
Populus tremuloides	Quaking Aspen	x	x	x	x
Prunus serotina	Black Cherry	x	x	x	x
Prunus virginiana	Choke Cherry	x	x	x	x
Quercus rubra	Red Oak	x	x	x	x
Sorbus americana	Mountain Ash	x			x
		14	12	13	12

Table 2. Presence of undesirable tree species (2002 and 2003)

Genus and Species	Common Name	Difference in Transect Means	Std. Error of Difference	p-value	Higher Cover?
Prunus serotina	**Black Cherry**	**5.59**	**2.32**	**0.014**	**A**
Prunus virginiana	Choke Cherry	1.18	2.38	0.313	-
Rubus allegheniensis	Blackberry	2.5	4.37	0.287	-
Rubus idaeus	**Red Raspberry**	**9.71**	**3.68**	**0.008**	**B**
Spiraea latifolia	**Meadow Sweet**	**7.21**	**1.58**	**<0.001**	**A**
Rubus flagellaris	Dewberry	0.15	0.15	0.166	-
Acer rubrum	Red Maple	2.21	1.51	0.077	-
Fraxinus americana	**White Ash**	**10.44**	**5.81**	**0.046**	**B**
Viburnum dentatum	**Northern Arrowwood**	**19.26**	**4.67**	**<0.001**	**A**
Euthamia graminifolia	**Flat-Top Goldenrod**	**5.59**	**2.36**	**0.016**	**B**
Solidago rugosa	**Rough-Stemmed Goldenrod**	**4.41**	**1.53**	**0.006**	**B**

Table 3. Two-sample T-test results for specific species' cover (2003 data only). Species with significant differences between Transect A mean cover and Transect B mean cover are in bold.

2000-2003: Transect and Time effects

The proportion of vegetative cover by undesirable species is an important quantity to study. PASNY maintains a list of undesirable species (species that can reach heights that pose risks to safe and reliable electricity transmission), as seen in Table 2, which was used in determining the proportion of undesirable cover in each quadrat and transect. In addition to the species listed in Table 2, three species observed on our transects are also considered potentially undesirable because they can reach problem heights when growing under power lines. These species are *Crataegus* sp. (Hawthorn), *Viburnum lentago* (Nannyberry), and *Viburnum dentatum* (Northern Arrowwood). Thus, it is the sum of these three species' cover and the cover of the tree species from Table 2 that represent total undesirable cover. This value, as a proportion of the total cover, gives us the undesirable cover proportion."

Total number:

	2002	2003
Transect A	65	69
Transect B	30	34

		# specimens	
Transect	Quadrats	2002	2003
A	1 to 6	24	30
A	7 to 11	36	32
A	12 to 17	5	7
B	1 to 6	5	7
B	7 to 11	0	1
B	12 to 17	25	26

Table 4. Tree specimens over 3 m (10’) in height in 2002 (Tedesco 2003) and 2003.

Statistical analysis (ANOVA) shows a high degree of statistical significances for the proportion of undesirable species’ recorded. The difference between transects is significant ($p < 0.0001$). This tells us that the historical difference in management practices for our two transects plays an important role. Thus, the date of each transect’s last vegetation management has an effect on the amount of undesirable cover present in that transect (this is represented as the vertical difference between plots of Transect A and Transect B in Figure 4).

The difference over time within a transect is also significant ($p < 0.0001$). This tells us that the proportion of undesirable cover is changing. Woody, undesirable tree species constitute an increasing proportion of the vegetative cover on both transects. This phenomenon is represented in Figure 4 by the positive slope of the plots.

The nesting of quadrats within transects is also significant ($p < 0.0001$). This was introduced into our ANOVA model because of the differences in proportion of undesirable cover introduced by using quadrats as our sampling unit. The p-value for nesting is significant because of the geographic variation among quadrats within a transect (Sokal and Rohlf 1981). Quadrats are nested within transects because the transects are in different locations, so the patterns of vegetative growth across one transect are not the same as the patterns across the other.

More interestingly, the Transect*Year interaction term is significant ($p = 0.0018$), suggesting that the difference in the additive increase of the proportion of undesirable cover depends not only on the transect and the amount of time elapsed, but also on the combination of (transect*time elapsed). Note that the most important difference between the two transects is that Transect A has not been managed since 1988, while Transect B was managed in 1998. The 1988 treatment for both transects consisted of clear-cutting, while the 1998 treatment on Transect B consisted of mechanical cutting in conjunction with spot-applications of herbicides (McLoughlin 2003). Based on the ANOVA results, it can be hypothesized that the difference between the 1988 and 1998 treatments has an effect on the rate of succession of undesirable species. Thus, undesirable cover in Transect A is probably increasing faster than in Transect B (note the difference in slopes of the plots in Figure 4).

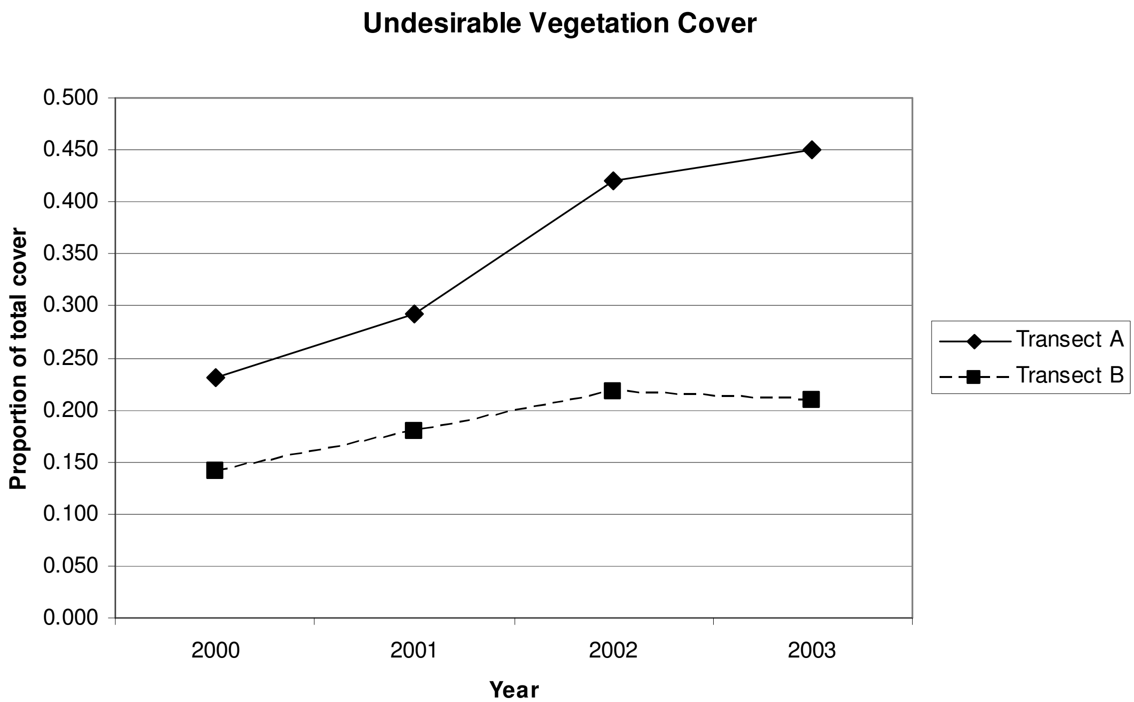

Figure 4. Undesirable vegetation cover as a proportion (2000-2003).

The data presented support the conclusion that IVM practices taken on Transect B in 1998 have had a significant impact on controlling undesirable species. Although relative proportions of these species are increasing on both transects and growth patterns between the transects are different, the rate at which the proportion of undesirable species are increasing in transect B in much lower than of increase in Transect A. Therefore, data presented here support the notion that spot removal of undesirable species, without disturbance of desirable species, will have lasting management value because competition with, and shading by, low-growing plants will reduce the necessary frequency of tall tree removal.

APPENDICES

Appendix 1: ANOVA results

(Two-way ANOVA with an interaction term, with quadrats nested within their transect)

OUTPUT:

```
                    ANOVA For Undesirable Cover by Quadrat w/Nesting

                        Class Level Information
        Class          Levels    Values
        Quadrat            17    1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
        Transect            2    1 2
        Year                4    2000 2001 2002 2003
                                 Number of observations    136

Dependent Variable: Proportion
                                              Sum of
    Source                        DF         Squares     Mean Square    F Value    Pr > F
    Model                         39      4.64463222      0.11909313      23.89    <.0001
    Error                         96      0.47857936      0.00498520
    Corrected Total              135      5.12321158

                R-Square     Coeff Var      Root MSE    Proportion Mean
                0.906586      25.69943      0.070606           0.274738

    Source                        DF         Anova SS     Mean Square    F Value    Pr > F
    Transect                       1       0.99759981      0.99759981     200.11    <.0001
    Year                           3       0.24205975      0.08068658      16.19    <.0001
    Transect*Year                  3       0.08034953      0.02678318       5.37    0.0018
    Quadrat(Transect)             32       3.32462312      0.10389447      20.84    <.0001
```

LOG:

```
NOTE: PROCEDURE ANOVA used:
      real time           1:13.16


1548  DATA Undesirable Cover;
1549  INPUT Quadrat Transect Year Proportion;
1550  CARDS;

NOTE: The data set WORK.UNDESIRABLE has 136 observations and 4 variables.
NOTE: The data set WORK.COVER has 136 observations and 4 variables.
NOTE: DATA statement used:
      real time           0.05 seconds


1687  TITLE 'ANOVA For Undesirable Cover by Quadrat';
1688  PROC PRINT;

NOTE: There were 136 observations read from the data set WORK.COVER.
NOTE: PROCEDURE PRINT used:
      real time           0.00 seconds


1689  PROC SORT;
1690  BY transect;

NOTE: There were 136 observations read from the data set WORK.COVER.
NOTE: The data set WORK.COVER has 136 observations and 4 variables.
NOTE: PROCEDURE SORT used:
      real time           0.00 seconds


1691  PROC ANOVA;
1692     CLASS quadrat transect year;
1693     MODEL proportion = transect year transect*year quadrat(transect);
1694  RUN;
```

Appendix 2: Two-sample t-test calculations

No assumption of equal variances is made, so we consider the Behrens-Fisher problem where:

Our test statistic is: $t' = \dfrac{\bar{x}_1 - \bar{x}_2}{s'_{\bar{x}_1 - \bar{x}_2}}$

The standard error of the difference between means is: $s'_{\bar{x}_1 - \bar{x}_2} = \sqrt{\dfrac{s_1^2}{n_1} + \dfrac{s_2^2}{n_2}}$

And our degrees of freedom are found with:

$$v' = \frac{\left(\dfrac{s_1^2}{n_1} + \dfrac{s_2^2}{n_2}\right)^2}{\dfrac{\left(\dfrac{s_1^2}{n_1}\right)^2}{n_1 - 1} + \dfrac{\left(\dfrac{s_2^2}{n_2}\right)^2}{n_2 - 1}}$$

The following S-Plus script was used to calculate the probability that the difference between the two transect means for a particular species is significant:

```
v1<-var(cover$A)
v2<-var(cover$B)

n1<-length(cover$A)
n2<-length(cover$B)

SEdiff<-
sqrt((var(cover$A)/length(cover$A))+(var(cover$B)/length(cover$B)))

dff<-function(v1,v2,n1,n2){
   S21<-v1/n1
   S22<-v2/n2
   dfreedom<-trunc(((S21+S22)^2)/( (S21^2)/(n1-1) + (S22^2)/(n2-1) ))
   }

mean(cover$A)-mean(cover$B)

SEdiff

dfreedom

pt((mean(cover$A)-mean(cover$B))/SEdiff,dfreedom)
1- pt((mean(cover$A)-mean(cover$B))/SEdiff,dfreedom)
```

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