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<http://www.google.com/search?hl=en&lr=&safe=off&q=%22Comparison+of+fire%2C+herbicide%2C+and+sod+removal+to+control+exotic+vegetation%22>)

Restoring Native Vegetation on Indiana Dunes Razed Residential Sites

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Editor's note: See the reference *Choi and Pavlovic 1994* for a more thorough write-up of exotics control.

Sand dunes of the Lake Michigan shoreline within Indiana Dunes National Lakeshore are home to over 1,000 native plant species and more than 100 Indiana endangered and threatened plant taxa (Wilhelm 1990). This 40 km (25 mi) long dune and swale complex is also home to unusual plant combinations, like prickly pear cactus (*Opuntia humifusa*) and arctic bearberry (*Arctostaphylos uva-ursi coactilis*), that led early botanist Henry Cowles (1899) to develop important principles of local plant succession. Unfortunately, human activities have disturbed much of this flora (Hiebert 1990a). Bowles et al. (1990) noted that these activities, including home construction and subsequent abandonment, disturbed 35 of 81 Indiana endangered and threatened plants studied.

Park resource managers have prioritized that native vegetation be restored to more than 800 abandoned residential sites located within the park. However, extensive exotic plant infestation is a major obstacle that must be overcome in accomplishing the restoration goals (Hiebert 1990b). To find the best feasible ways of eradicating exotic species and restoring native species, we compared the effects of fire, herbicide, and sod removal on native vegetation restoration in xeric (dry) razed residential sites (fig. 1).

Figure 1 [photo]. Successful establishment of the planted native species, represented by horsetweed (*Mornarda punctata*) and black-eyed Susan (*Ruderbeckia serotina*), in a herbicide plot (Plate A) and a sod removal plot (Plate B) where exotic grasses were eradicated. Plates C and D show a fire plot and a control plot, respectively, where exotic grasses, represented by blue grass (*Poa pratensis*) and quackgrass (*Agropyron repens*), still dominate.

Methods

In May 1993, we established 24 experimental plots with four treatment groups (control, herbicide application, sod removal and prescribed burning) in three razed residential sites within the park. We then used a rotary seed broadcaster in each plot to sow a mixture of seeds (627 g) consisting of nine native species (table 1).

Table 1. Three categories of plant species sampled in experimental restoration plots in three razed residential sites within Indiana Dunes National Lakeshore.

Category	Genus & Species	Common Name
Planted Native	<i>Andropogon scoparius</i>	little blue stem
	<i>Elymus canadensis</i>	Canada rye grass

<i>Koeleria cristata</i>	junegrass
<i>Oenothera biennis</i>	evening primrose
<i>Panicum virgatum</i>	switch grass
<i>Monarda punctata</i>	horseweed
<i>Rudbeckia serotina</i>	black-eyed Susan
<i>Stipa spartea</i>	porcupine grass
<i>Sorghastrum nutans</i>	Indian grass

Voluntary Native

<i>Aster</i> sp. (footnote 1)	aster
<i>Cyperus</i> spp. (footnote 2)	umbrella sedges
<i>Erigeron annuus</i>	horseweed
<i>Eragrostis</i> spp. (footnote 3)	lovegrass
<i>Paspalum stramineum</i>	hairy lens grass
<i>Sporobolus cryptandrus</i>	sand dropseed
<i>Solidago canadensis</i>	Canada goldenrod
<i>Tradescantia ohiensis</i>	spiderwort
<i>Verbascum thapsus</i>	common mullein

Exotic

<i>Agropyron repens</i>	quackgrass
<i>Ambrosia artemisiifolia</i>	ragweed
<i>Bromus tectorum</i>	downy chess grass
<i>Digitaria sanguinalis</i>	crabgrass
<i>Festuca</i> sp. (footnote 4)	fescue grass
<i>Galium</i> spp. (footnote 5)	bedstraws
<i>Lepidum campestre</i>	field peppergrass
<i>Melilotus</i> spp. (footnote 6)	sweet clovers
<i>Physalis heterophylla</i>	clammy groundcherry
<i>Plantago lanceolata</i>	English plantain
<i>Poa pratensis</i>	blue grass
<i>Rumex acetosella</i>	field sorrel
<i>Saponaria officinalis</i>	soapwort
<i>Solanum carolinense</i>	horse nettle
<i>Stellaria media</i>	common chickweed

1. This could not be identified at the species level, but is presumed to be native.

2. *Cyperus filicumulis*, *C. schewinitzii*, and *C. strigosus*
3. *Eragrostis hypnoides* and *E. spectabilis*
4. *Festuca elatior*, *F. ovina*, and *F. rubra*
5. *Galium aparine* and *G. mollugo*
6. *Melilotus alba* and *M. officinalis*

In September 1994, two growing seasons after site preparation and seeding, we collected vegetation data. We grouped all identified plant species into three categories: (1) planted native-native species seeded in 1993, (2) voluntary native-native species occurring voluntarily (i.e., without being planted in 1993), and (3) exotic-(table 1). Using a point contact frame we also estimated vegetative covers and, using the paired t-test, compared these data with pretreatment data from August 1992 (table 2).

Table 2. Changes in cover of restored native, nonrestored native, and exotic species from 1992 (pretreatment year) to 1994 (posttreatment year) in the experimental restoration plots

Category/Treatment (footnote 2)	Cover (Mean + or - SE (footnote 1))		
	1992	1994	p
Exotic			
Control	83.0+11.8	78.8+18.4	
0.85			
Fire	94.5+9.0	98.8+14.7	
0.93			
Herbicide	81.8+14.6	24.6+7.1	
0.01			
Sod Removal	85.2+6.5	11.7+1.7	
<0.01			
Voluntary Native			
Control	16.2+8.4	17.3+7.6	
0.92			
Fire	27.0+13.8	25.5+9.7	
0.93			
Herbicide	28.6+13.0	35.2+7.8	
0.68			
Sod Removal	20.3+6.4	26.5+3.6	
0.42			
Planted Native			
Control	8.5+2.6	17.5+6.6	
0.23			
Fire	2.7+1.6	16.0+4.0	
0.01			
Herbicide	3.6+1.7	48.6+4.4	
<0.01			
Sod Removal	13.3+4.6	55.2+3.8	
<0.01			

1. Standard error of mean.

2. Probability of type I error from the paired t-test.

Results and Discussion--Fire

Although prescribed fire has been widely used elsewhere to control exotic species (Olson 1975, Apfelbaum and Rouffa 1983, Cole 1991), we found that fire did not successfully eradicate exotic species (e.g., blue grass--*Poa pratensis* and quickgrass--*Agropyron repens*). Voluntary native species coverage (e.g., hairy lens grass--*Paspalum stramineum* and umbrella sedges--*Cyperus* spp.) did not change significantly. Conversely, planted native species, represented by little blue stem (*Andropogon scoparius*), increased significantly from 2.7% to 16.0%. This increase, however, was not much different from the control plots, and it was not as significant as we found in the herbicide or sod removal plots (table 2).

These results clearly demonstrate that fire was not effective to control the fire-adaptive grasses in our study plots. In extreme cases, these exotic grasses reclaimed dominance quickly and reestablished ground cover to the prefire level within 2 weeks after the fire. Repeated fires and growing-season fires may be considered as

alternatives. Further study is needed to investigate the effects of these alternatives and to determine the timing and frequencies of fires for maximum benefits.

Herbicide

We noted that the herbicide Round-up successfully controlled exotic grasses, and similar studies (e.g., Bingham et al. 1980, Marquis et al. 1984, Nuzzo 1991) support herbicide use for this purpose. Planted native species, including little blue stem, Indian grass (*Sorghastrum nutans*), horseweed (*Monarda punctata*) black-eyed Susan (*Rudbeckia serotina*), and Canada rye grass (*Elymus canadensis*), have established 49% ground cover in our herbicide plots where we removed most exotic species. Herbicide treatment did not affect voluntary native species (e.g., lover grasses--*Eragostis* spp. and umbrella sedges) as shown in table 2.

Despite its success in eradicating exotic species, herbicide application still remains questionable; some roots, seeds, and other exotic species propagules are probably viable in the topsoil implicating a potential competition with native species for resources and space. A seed bank study or a longer vegetation change monitoring study may provide useful information to answer this question.

Sod Removal

Mechanical removal of exotic sods and topsoils can benefit native species by (1) providing a sandy and relatively infertile substrate--a natural characteristic of the Lake Michigan sand dune ecosystems--and (2) avoiding potential competition with existing exotic species. This method caused a response similar to the herbicide treatment. Exotic species cover, mostly blue grass and quackgrass, decreased significantly, whereas planted native species cover (little blue stem, Indian grass, horseweed, black-eyed susan, and evening primrose (*Oenothera biennis*) increased to 55%. Voluntary native species cover (e.g., love grasses and umbrella sedges) did not change significantly (table 2). Although the entire removal of sod may pose a potential risk of losing existing native species seed banks, it has proven to be very effective in preparing the sites for native vegetation reestablishment.

*** "Both herbicide application and sod removal are equally effective in controlling the exotic grasses." ***

Management Implications

As discussed, prescribed fire did not control the exotic grasses in our study plots. Meanwhile, herbicide application and sod removal were very effective for this purpose. Herbicide treatment costs approximately \$50 per acre. Treating 800 razed residential sites (approximately 400-1,600 acres in total [162-648 ha]) using this method would cost approximately \$20,000-\$80,000 and seems to be affordable if spread over several years. Nevertheless, massive application of the herbicide Round-up, despite its relatively short half-life (about 60 days) and lower toxicity than the other commercial herbicide brands, conflicts with park policy. This is due to the potential for soil and water contamination by herbicide residue.

Sod removal is better accepted by park managers, because it is pollution-free. However, this option is much more labor-intensive and expensive than the herbicide option. Using two or three crews to remove

trees, shrubs, and sod for each razed residential site, this option would take approximately 800 work days (a day per site). Total cost would depend on labor costs, but can be based on a total of 12,800-19,200 crew hours. Typical NBS seasonal staff wages at Indiana Dunes are \$10 per hour, making the total cost of the sod removal option \$64,000-\$192,000. This option costs three to six times more than the herbicide option and seems prohibitively expensive. However, this cost can be reduced by using a park volunteer work force.

Recommendations

Based on our 3-year study, we recommend that prescribed fire not be used to eradicate the exotic grasses in the razed residential sites. Both herbicide application and sod removal are equally effective and preferable in controlling the exotic grasses. Herbicide application is less laborious and expensive than sod removal; however, the latter option is better suited to the park policy of avoiding chemical use. Sod removal is also more feasible than herbicide application if labor costs are subsidized significantly by a volunteer work force.

Literature Cited

- Apfelbaum, S.I. and A.S. Rouffa. 1983. James Woodworth Prairie Preserve: a case history of the ecological monitoring programs. Pages 27-30 in Proceedings of the Eighth North American Prairie Conference, Kalamazoo, Michigan.
- Bingham, S.W., J. Segura, and C.L. Foy. 1980. Susceptibility of several grasses to phosphate. *Weed Science* 28:579-585.
- Bowles, M.L., M.M. DeMauro, N.B. Pavlovic, and R.D. Hiebert. 1990. Effects of anthropogenic disturbances and endangered plants at the Indiana Dunes National Lakeshore. 10:187-200.
- Choi, Y.D. and N.B. Pavlovic. 1994. Comparison of fire, herbicide, and sod removal to control exotic vegetation. *Natural Areas Journal* 14:217-218.
- Cole, M.A.R. 1991. Vegetation management guideline: leafy spurge (*Euphorbia esula* L.). *Natural Areas Journal* 11:171-172.
- Cowles, H.C. 1899. The ecological relations of the vegetation on the sand dunes of Lake Michigan. *Botanical Gazette* 27:95-117, 167-202, 281-308, 361-391.
- Hiebert, R.D. 1990a. Restoration and protection of Great Lakes coastal ecosystems. *Natural Areas Journal* 10:173-175.
- Hiebert, R.D. 1990b. An ecological restoration model: application to razed residential sites. *Natural Areas Journal* 10:173-175.
- Marquis, L.Y., R.D. Comes, and C. Yang. 1984. Relative tolerance of desert salt grass (*Distichlis stricta*) and reed canary grass (*Phalaris arundinacea*) to boron. *Weed Science* 32:534-538.
- Nuzzo, V.A. 1991. Experimental control of garlic mustard (*Alliaria petiolata* [Bieb.] Cavara & Grande) in northern Illinois using fire, herbicide, and cutting. *Natural Areas Journal* 11:158-167.

Olson, W.W. 1975. Effects of controlled burning on grassland within the Tewaikon National Wildlife Refuge. M.S. thesis, North Dakota State University, Fargo, North Dakota. 137 pp.

Wilhelm, G.S. 1990. Special vegetation of the Indiana Dunes National Lakeshore. Indiana Dunes National Lakeshore Research Program Report 90-02. 373 pp.

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