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Vegetation development in old fields at the UWM Field Station

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Abstract

We studied abandoned fields at the UW-Milwaukee Field Station in 1990 to determine how previous cropping history and management practices have influenced present vegetation composition. Eleven fields were sampled for herbaceous species presence and coverage, and species compositions were analyzed by Detrended Correspondence Analysis ordination. Nearly all the fields were abandoned in the mid-1960's. Standing crop biomass of the herbaceous vegetation peaked in late July. Fields with very recent management (last 5 years) in the form of mowing or burning differed in species composition from fields without recent management and fields that have been unmanaged since abandonment. Species such as *Poa* spp., *Bromus inermis*, and *Solidago altissima* were common to nearly all the fields. However, recently managed fields were distinguished by the presence of a group of weedy, exotic species in contrast to the presence of many perennial native species in fields without recent management. Crop history, soil type, and field proximity did not have strong influences on species composition.

Introduction

Site histories are known to influence the pattern of vegetation succession on abandoned agricultural fields. Farming practices, the nature of last crop, and time of year of abandonment, can have persistent effects on species composition (Keever 1950, Beckwith 1954, Myster and Pickett 1990). Disturbances after abandonment also affect successional trajectories (Beckwith 1954, Connell and Slatyer 1977, Miller 1982).

The UWM Field Station has a number of successional old fields. Most of these were cultivated until 1964, and were abandoned from agriculture in 1965 when the University acquired the property. Some fields have been left virtually undisturbed since that time. Others have received various types of management (mowing or burning) in order to maintain old-field habitats at the Station. The purpose of this study was to collect some baseline data on the vegetation composition of these fields, compile their site histories, and determine how previous treatment may have influenced present species composition.

Methods

To determine patterns of old field biomass production, two abandoned fields of different successional status were sampled monthly from May through August 1990. Field 1 (Fig. 1), a small low field, had been planted in 1978 to alfalfa and brome grass with a cover crop of oats; it has been mowed yearly for hay since 1986, and thus receives repeated disturbance. Field 2 (Fig. 1), a drier field, is believed to have been planted in corn or small grains, then abandoned in the mid to late 1960's. It was never cut for hay, and has had no other management since it was abandoned. Vegetation samples of these two fields were taken near the end of each month, and consisted of five 0.25 m^2 randomly-placed quadrats per field. All vegetation in each quadrat was clipped just above ground level; the shoots were sorted by species, dried at 100°C for at least 24 hours, then weighed. Monthly biomass totals were calculated to determine when each field reached its peak biomass.

In late August 1990, 11 fields (including 1 and 2) were non-destructively sampled for herbaceous-layer species presence and coverage (Fig. 1). All are upland fields on areas above the 870' elevation contour (areas below this contour support marsh vegetation or swamps). All of the fields had been abandoned in the mid-late 1960's (except Field 1 - see above). Samples again consisted of 0.25 m^2 randomly-placed quadrats; the number of samples taken per field varied from 5-10, depending mainly on field size. Species cover was visually estimated with an index scale ranging from 0.5-5, based on Braun-Blanquet cover classes (0.5 = <1%, 1 = 1-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, and 5 = 76-100%; see Goldsmith, et al. 1986).

The cover class values were averaged for each species in each field, and these mean values were analyzed by Detrended Correspondence Analysis (DCA) ordination using the DECORANA program (Hill 1979, Hill and Gauch 1980). This technique represents compositional similarities among sites by graphical array in two dimensions. The full DCA ordination weights all species equally in determining relative similarities among sites. For comparison, the DCA was repeated with reduced weighting for rarer species; a polar ordination (Bray and Curtis 1957), which also deemphasizes rare species, was performed as well, using pairwise site similarities (Sorensen's Index, weighted by cover).

We analyzed the ordinations with respect to several site characteristics. A soil survey map of Ozaukee County (USDA Soil Conservation Service, 1970) was used to determine soil types of the fields. We compiled site histories from records and information supplied by current Field Station manager James Reinartz and previous manager Paul Matthiae (see Table 1 for summary histories; Appendix 1 contains more complete information). Fields were characterized with respect to two factors. The first was whether they were abandoned from perennial hay crops (Fields 1,3,6,7,9,11) or from annual crops such as corn or small grains (Fields 2,4,5,8,10).

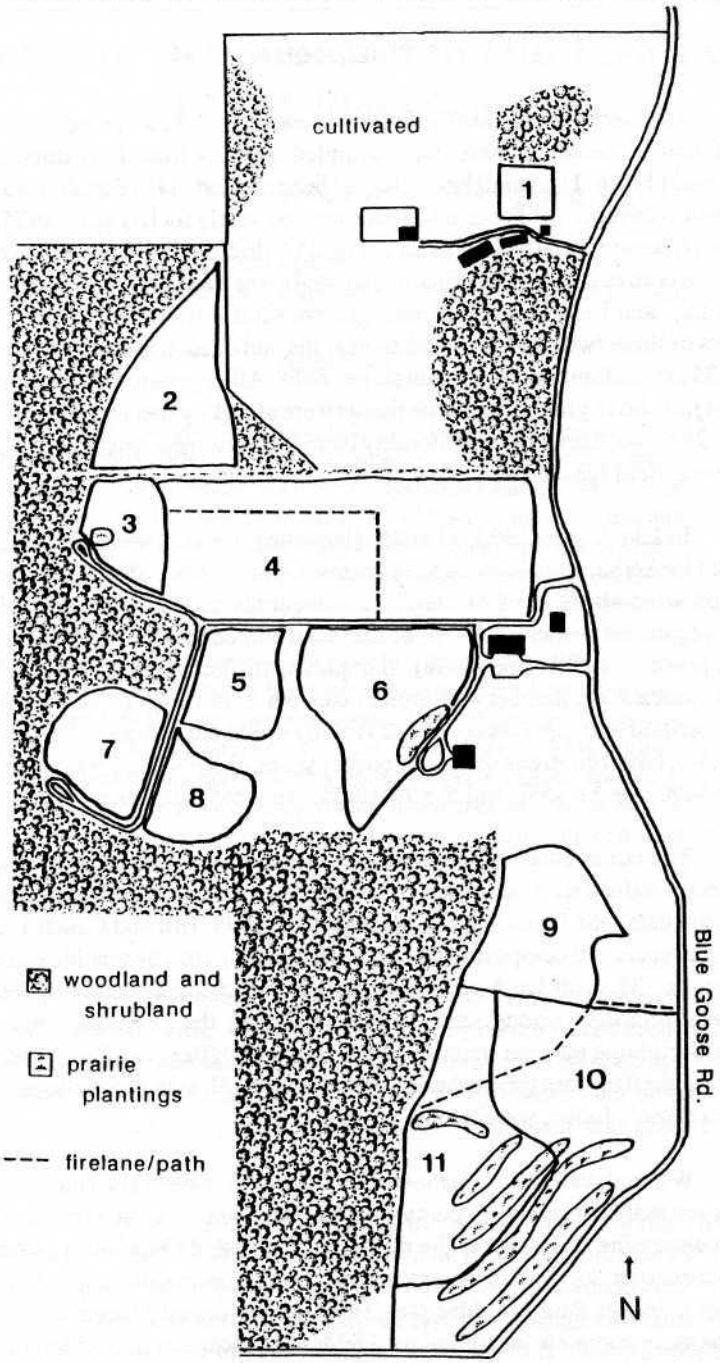

Figure 1. Map of the upland old fields at the UW-Milwaukee Field Station.

Table 1. Brief histories and soil types of the sampled field sites.

Field	Date Abandoned	Soil	Last Crop	Treatment Since Abandoned
1	still farmed	Casco loam	alfalfa/ brome hay	last planted 1978; not cut 1979-85; cut yearly 1986-1989[a]
2	late 60's?	Casco loam	corn(?) or small grains	none
3	1965	Casco loam, Casco-Rodman complex	timothy/ brome hay	burned in 1970's and 1990
4	1965	Casco loam	corn	burned in 1970's; woody spp. cut 1983-1984;mowed in1985; burned & mowed-1990
5	1964?	Casco-Rodman complex	corn	none
6	1965	Casco loam	timothy/ brome hay	burned once in 1970's(small section mowed in 1990)
7	1965	Fox Sandy loam	timothy/ brome hay	none
8	1964?	Fox Sandy loam, Casco-Rodman complex	wheat or oats	none
9	1965	Casco-Rodman complex	alfalfa/ brome hay	none
10	1964 or 1965	Casco & Hochheim loam	corn	burned & mowed regularly,to 1986[b]; none, 1987-1990
11	1965	Hochheim loam	alfalfa/ brome hay	same as Field 10

[a], not mowed in 1990, the year of this study

[b], except the region north of the firelane/path, which has had no management

The second was whether fields have been unmanaged (Fields 2,5,7,8,9) or managed (mowed or burned) (Fields 1,3,4,6,10,11) since abandonment. The latter could be distinguished further based on whether management had occurred within the past five years ("recent") or much earlier (15 or more years).

Results

Based on the monthly clipped quadrats, Field 1 (disturbed and "younger") had higher biomass totals than Field 2 (undisturbed and "older"); both fields reached their peak biomass in the late July sample (Fig. 2). Maximum species richness for Field 1 occurred in late June, while the maximum for Field 2 occurred in late August (Table 2). Over the growing season, 28 species were sampled in Field 1 and 27 species in Field 2; of these, only 10 species were found in both fields. In general, Field 2 had fewer "weedy" non-native perennials, and more native perennial herbs and woody species than Field 1.

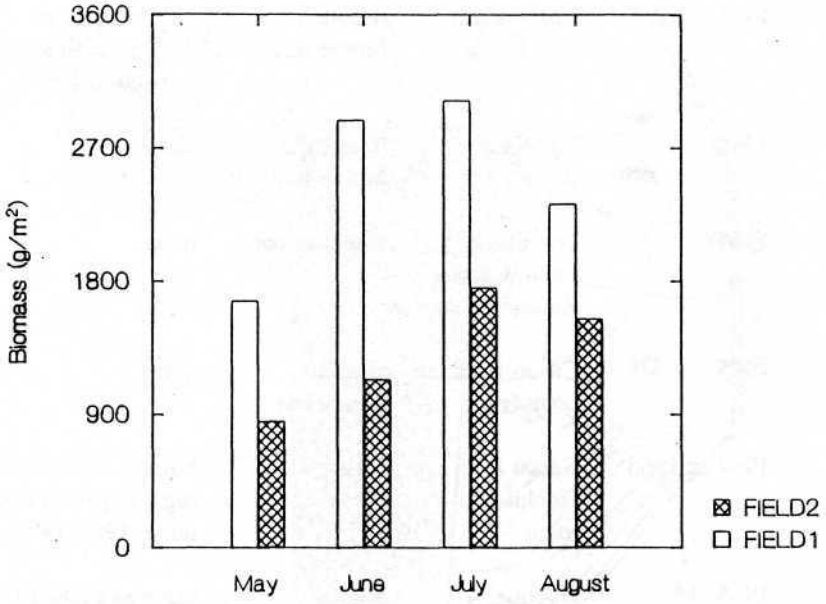

Figure 2. Shoot biomass totals for the 1990 growing season, for two fields of different successional stages.

Table 2. Total number of species found in the monthly biomass samples of Fields 1 and 2 at the UWM Field Station.

	No. of Species	
	Field 1	Field 2
May	16	9
June	18	16
July	16	14
August	13	18

Figure 3 presents the DCA ordination of all 11 fields sampled for cover in August, with site history information indicated. Field 1, with the most distinctive history and species composition, dissociates from the other fields along the first ordination axis. Management history appears to separate fields along the second ordination axis. Fields which have had management within the last five years array on the lower half of the axis, with Fields 1, 3, and 4, which have been burned or mowed the most recently (1990), showing the greatest divergence from the other fields. Fields without management for 15-25 years cluster together on the upper half of the second axis. Crop history shows no relationship to position on either axis.

Results of the DCA with rarer species downweighted and of the polar ordination were generally similar to the unweighted DCA, except that the separation according to management history was less dramatic. This indicates that the less common species were important in defining the compositional differences between managed and unmanaged fields.

Ordination patterns are only partially explained by the physical proximity of fields to each other. Fields 5-8 are similar in composition and are adjacent. However, Fields 2, 3 and 4 are adjacent to each other, yet Field 2 does not array near the other two in the ordination analysis. Fields 9-11 are contiguous, and while they are closely arrayed on the first ordination axis, they are moderately divergent along the second axis.

Finally, soil types do not appear to correlate well with the ordination patterns. Soil types of all the fields are similar. All are loams, with most in the Casco series, and a few from the Fox and Hochheim series (Table 1).

Table 3 lists the average cover class by field for the 58 species found in this study, organized into four main groups: 1) those species common in most of the fields; 2) those found predominantly in the fields with recent management; 3) those found mostly in the fields without recent management; and 4) rarer species of infrequent occurrence. Species common to most of the fields include *Asclepias syriaca*, *Bromus inermis*, *Hypericum perforatum*, *Poa* spp., and *Solidago altissima*. Species most common in fields with recent management include *Agropyron repens*, *Medicago*

sativa, Taraxacum officinale, and *Trifolium pratense*. *Lotus corniculatus* was a dominant species in Field 1, but was not sampled in any of the other fields. Species most common in fields without recent management include *Asclepias verticillata, Fraxinus americana, Melilotus officinalis,* and *Monarda fistulosa*. The group of species predominating in recently-managed fields were mostly non-native herbaceous perennials, whereas the group predominating in fields without recent management were mainly native herbaceous and woody perennials. Several unmanaged fields (2,5,7) also show some development of shrub and sapling layers, although these strata were not directly sampled.

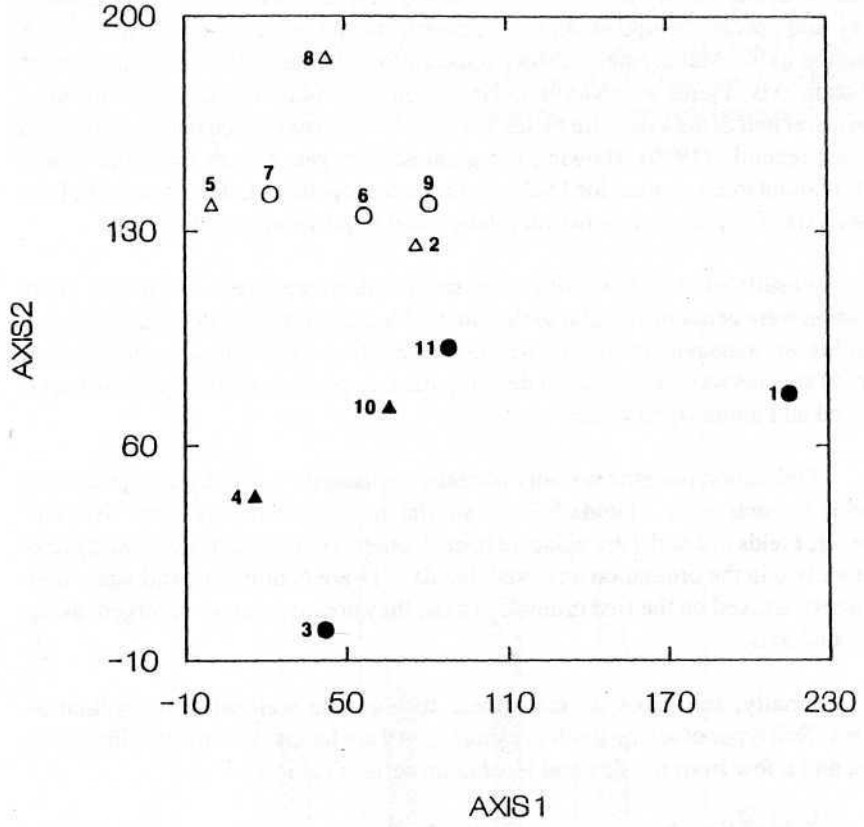

Figure 3. DCA ordination of 11 old fields at the UW-Milwaukee Field Station, based on species cover class data. Symbols refer to last crop and time since most recent management. Filled symbols = recent management (within the last five years); open symbols = no recent management. ○ = perennial hay crops; △ = annual cultivated crops.

Table 3. Average cover class values by field for species in 11 UWM Field Station fields, organized into four groups: those species common to most of the fields; those found predominantly in the fields with recent management (management within the last five years); those found mostly in the fields with no recent management (no management for the past 15-25 years); and less common species which are found in both groups. *, non-native species.

	Fields with Recent Management					Fields with No Recent Management					
Species	1	3	4	10	11	2	5	6	7	8	9
**Poa* spp.	2.2	1.1	2.2	2.7	2.4	2.8	2.0	2.5	2.5	1.7	2.4
**Bromus inermis*	3.4	1.3	0.4	0.7	2.4	2.8	1.2	1:8	1.0	2.0	2.2
Solidago altissima		0.4	0.4	0.5	0.2	2.2	0.2	1.2	0.4	0.7	0.8
Asclepias syriaca		0.3	0.3	0.3	0.6	0.4	0.4	0.5	0.2	0.2	0.2
**Hypericum perforatum*		0.6	0.4		0.2	0.5	0.9	0.3	0.6	0.6	0.2
**Daucus carota*		1.3	0.6				0.9	0.3	0.2		0.1
**Agropyron repens*	0.8	1.6	0.6	1.2	0.2	0.6			0.6		
**Medicago sativa*		1.5	1.8	0.3	0.4						
**Linaria vulgaris*			0.3	0.7		0.2				0.2	
**Taraxacum officinale*	0.5	0.6					0.1		0.1		
**Medicago lupulina*			0.4		0.2				0.1		
**Trifolium pratense*	1.0		0.4								
**Achillea millefolium*			0.1		0.2						
**Convolvulus arvensis*	0.1			0.2							

	Fields with Recent Management					Fields with No Recent Management					
Species	1	3	4	10	11	2	5	6	7	8	9
Asclepias verticillata				0.3			0.2	0.2	0.4	0.7	0.2
Vitis riparia			0.4	0.2			0.7	0.1	0.2	0.2	
Monarda fistulosa		0.1				0.2	0.2		0.5	0.3	0.1
**Melilotus officinalis*			0.6				0.4	0.3	0.1	0.3	
Fraxinus americana						0.2	0.2			0.2	
Parthenocissus quinquefolia							0.4		0.1		
Solidago graminifolia						0.4		0.3			
Physalis heterophylla						0.4			0.1		
Ulmus rubra			0.2							0.3	0.1
Equisetum sp.			0.1			0.1		0.2			
**Tragopogon pratensis*							0.1		0.1		
Aster sagittifolius		0.6				0.4					
Cornus stolonifera			0.4								0.2
**Dactylis glomerata*	0.2					0.3					
Phleum pratense	0.2					0.2					
Oxalis europaea		0.1							0.2		
Acer negundo	0.3										
Acer saccharum									0.1		
**Agrostis stolonifera*	0.4										
Ambrosia artemisiifolia										0.3	
Anaphalis margaritacea									0.1		

Anemone virginiana						0.1					
Aster pilosus		0.2									
Erigeron annuus									0.1		
**Festuca elatior*	0.2										
Gentiana quinquefolia						0.2					
**Glechoma hederacea*	0.3										
**Lotus corniculatus*	1.8										
**Lychnis alba*							0.1				
**Melilotus alba*				0.3							
**Plantago major*									0.1		
**Ranunculus acris*									0.1		
Ratibida pinnata		0.4									
**Rhamnus cathartica*											0.2
Rhus radicans									0.2		
Rubus sp. 1											0.1
Rubus sp. 2									0.2		
**Solanum dulcamara*		0.4									
Solidago canadensis			0.2								
Solidago gigantea							0.4				
Solidago ulmifolia					0.4						
Spiraea latifolia						0.4					
**Verbascum thapsus*									0.2		
Xanthoxylum americanum									0.1		
# Species/Field	13	15	18	11	10	18	16	11	26	13	12
# Samples/Field	5	5	5	7	5	5	5	7	10	7	8

Discussion

Previous studies (Keever 1950, Beckwith 1954, Myster and Pickett 1990) have shown that early successional stages are greatly influenced by the character of the last crop, and the time of year of abandonment (or last disturbance). Myster and Pickett (1990) found that the vegetation on abandoned fields converges toward increasing similarity over time, but that the last crop still influences successional pathways and composition of old fields. Later successional stages may also be influenced by soil type and by disturbances (Beckwith, 1954). Large disturbances (such as burning or mowing a large area) can favor colonizing species (Connell and Slatyer 1977, Miller 1982).

If time since initial abandonment were the only factor involved, the Field Station old fields should be quite similar and cluster together in the ordination, but they are not. One factor increasing the divergence of the fields in ordination is the presence of many uncommon species. Of the 58 species found, almost half of them occurred in only one field, and at relatively low abundances. Some of these less common species may be remnants of an earlier successional stage.

Vegetation composition seems to correlate best with the amount of time since the most recent management (i.e., disturbance). The fields which have been burned or mowed within a year of the sampling (Fields 1,3, and 4) are most different from the other fields, while the fields without recent management are relatively similar in composition. This supports the findings of Myster and Pickett (1990) if 'time since abandonment' is equated with 'time since disturbance'. Non-native herbaceous perennials were predominant in recently-managed fields, while native herbaceous and woody perennials were predominant in fields without recent management. Non-native species are often successful colonizers, characterized by high rates of reproduction, growth, and/or dispersal. This supports the findings of Connell and Slatyer (1977) and Miller (1982), that large disturbances favor colonizing species, and reduction of disturbance favors late-succession species, such as woody plants. Neither last crop nor soil type correlates well with the ordination.

One purpose of the biomass study was to determine the best time of year to sample the fields to obtain the best representation of their species composition. Although Fields 1 and 2 are of different successional stages, both had their peak biomass in the late July sample. If species richness is considered, Field 1, with the most recent management, had the highest number of species in the late June sample, when the majority of species also peaked in biomass (12 of 18 species present). However, the July sample was comparable to the June sample, both in species richness and composition. Species richness in Field 2 peaked in the late August sample; however, July and August were very similar in species composition. In Field 2, peak biomass occurred for 9 species in the July sample, and for 10 species in the

August sample. This difference in peak richness between Fields 1 and 2 may indicate that fields at an earlier successional stage should be sampled earlier in the year than fields of a later successional stage, due to differences in species' life histories. However, a reasonable representation of species composition, even for different-aged fields, can be obtained by sampling in July, if periodic sampling is not possible.

One of the management goals at the UWM Field Station is to maintain old-field habitats in a broad range of successional stages. The differences in species composition of these fields, which were almost all abandoned about the same time, would indicate that the management techniques are having the desired effects, particularly in reducing invasion of woody plants.

Acknowledgments

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Appendix I.

History of Agricultural and Old-Fields at the UWM Field Station, 1990 (See Figure 1 for indication of field numbers.)

Field #1.
Small section of low, hay field N. of manager's residence and S. of wet depression. Our recorded history of this field begins in 1977. Before 1978, the field was owned by Mr. J. Wright and cropped for hay by Mr. Marvin Hoffmann.
1977 - Planted in corn (may also have been corn in 1976).
1978 - Planted in oats as a cover crop for alfalfa/brome grass hay which was seeded in with the oats.
1979-1985 - Hay crop left as wildlife land. No cutting of hay.
1986-1989 - Hay crop cut once, or usually twice, per growing season.
1990 - Hay crop not cut.
From 1980 to 1985 a goat was tethered in the field during the growing season. The position of the tether stake was moved approximately weekly.

Field #2.
Old field in SW portion of land previously owned by Wright. Nothing (no burning, cutting, cropping, etc.) has been done to this field since 1977. In 1977 it was already an old-field and we have no record of when it was last used as an agricultural field. According to Paul Matthiae, Charles Stenzel, owner prior to Wright, attempted to crop this field in the mid-late 1960's but eventually abandoned the effort due to moist soils. Believes he was planting corn in the mid-60's and may have tried small grains as well. Does not recall the field being hay-cropped.

All of the remaining fields on Field Station property were in agriculture until 1964. They were abandoned from agriculture in 1965 when the University obtained the Field Station property and have received various management (or no management) since that time.

There was originally a management plan for some of the fields. Field #3 was to be maintained in a grass-forb structure with no woody vegetation. Field #4 was to be maintained at a young shrub carr successional level. Area east of Field #4 was to have succession allowed to the point where it attained a mature shrub carr with seedling and sapling trees to 2-3 inches diameter, then set back and allowed to attain this stage again. This plan was meant to produce three old field successional stages for education and research uses. The plan has not been fully implemented.

Field #3.
1965 - Timothy/brome hay field. Little if any alfalfa. Was always in a hay field with a heavy grass (condition in 64 and long thereafter).
1965-1970 - No management.
Early-mid 70's - Burned. First fire hot and fast on headwind. Probably burned twice, several years apart.
Mid 70's - 1989 - No management.
1990 - Burned 3/21/90. A good hot fire except for the center of the depression, a strip about 5 - 10 m wide along the southern edge (along road), and the extreme SW corner, which did not burn.

Field #3.
Area labeled as prairie plantings.
1965-1989 - Same as field #3.
1990 - Thistle (*Cirsium arvense*) found in this area. Flowerheads removed 7/25/90. Area sprayed with Roundup herbicide 7/31/90. Plowed mid-August. Area planted with prairie seed in Spring of 1991.

Field #4.
1965 - Abandoned corn field, corn stubble still standing.
1965 - '70's - No management.
Early-mid 70's - Burned. May have had second burn. Definitely had follow up flame torching to top kill brush because there was insufficient litter to carry fire and top kill with the first burn.
Mid 1970's - 1982 - No management.
1983-1984 - Cut all woody plants out of the area. Recorded their location, height, basal diameter, age, dry weight and species. These records are available at the Field Station.
1985 - Mowed with the bush hog and tractor.
1986-1989 - No management.
1990 - Burned, good hot fire, 3/21/90. Mowed sweet clover (*Melilotus* spp.) from the sections where it was dense (about 2/3 of the field) before it set fruit, 6/25/90.

Area east of Field #4.
Portion of original corn field, which was not sampled for this study.
1965 - Abandoned corn field, corn stubble still standing.
Early 70's - Burned once. Poor fire, ineffective woody plant removal.
Early 70's-present - No additional management.

Field #5.
1965 - Abandoned corn field. Not in corn the previous year, already a weedy, abandoned field.
1965-present - No management.

Field #6.
The management goal set in 1965 was to keep this field in an open grass meadow.
1965 - Hay field. Timothy/brome, dense grass sod, little alfalfa.
Early 70's - Burned once, good hot fire.
Early 70's-1989 - No additional management.
1990 - Mowed sweet clover in a small area in the N. central part of field (along road) 6/25/90.

Field #6.
Area labeled as prairie plantings.
1965-1984 - Same as field #6.
1985 - Prepared area for planting prairie. Applied Roundup herbicide and plowed.
1986 - Planted prairie (seed directly and plants started in greenhouse) in early spring. Flax as a cover crop, watered during first month. Records of species planted and seeded are available. Permanent plots have been established and sampled to describe the composition of the vegetation in the area.
1987-present - No management.

Field #7.
The management goal was to allow field to succeed to forest condition. Closure would expand forest land base naturally and allow successional studies in the process. Also would reduce the edge impact on the beech-maple forest.
1965 - Hay field. Timothy/brome - extremely dense sod. Succession was very slow. Elm seedlings were the most aggressive invader.
1965-present - No management.

Field #8.
The management goal set in 1965 was to allow succession processes to proceed naturally.
1965 - Abandoned (weedy) cultivated field. Last crop either wheat or oats.
1965-present - No management.

Field #9.
1965 - Hay field. Alfalfa/brome crop. As the alfalfa died out brome, other grasses dominated, maintained in a good dense sod.
1966 - Cedar trees planted in area below 870' contour line.
1968-present - No additional management.

Field #10.
1965 - Abandoned corn field.
Region north of the firelane/path has been unmanaged. The following management history applies only to the region south of the firelane.
1966 - Prairie planted in areas marked. Some records are available on planting methods and species planted.

1969 - Burned.
1971 - Burned.
1972 - Burned.
1973 - Prairie vegetation in the planted strips was sampled.
1974-1978 - Burned about every other year.
1980 - Burned, 4/19/80.
1981 - Mowed sweet clover before it set seed (June).
1985 - Burned 4/19/85.
1986 - Mowed sweet clover before it set seed (June).
1987-present - no management.

Field #11.
1965 - Alfalfa/brome hay field. Management history is the same as for Field #10