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Vegetation Community Monitoring at Wilson's Creek National Battlefield, Missouri

2008 - 2011

Natural Resource Data Series NPS/HTLN/NRDS—2012/234

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Introduction

Vegetation inventory and monitoring of four permanent sampling sites has been ongoing in the park's restored tallgrass prairie/savanna since 2008. Plant community monitoring is designed to detect and describe changes over time. This is accomplished by quantifying species composition, structure and diversity of the prairie/savanna community before and after prescribed burns. Restoration of the prairie/savanna community is a focus of natural resource management, which includes prescribed fire and mowing. Prescribed burns occurred in 2008 and 2010. This report summarizes findings from three years of vegetation community monitoring efforts by the Heartland Inventory and Monitoring Network.

Methods

Data collection

The Heartland Inventory and Monitoring Network (HTLN) augmented ongoing monitoring at WICR in 2008 to assess changes in the prairie/savanna community (see James et al, 2009 for detailed information on monitoring protocol). Monitoring of the four restored tallgrass prairie/savanna sites occurred in May of 2008, 2009, and 2011 (Fig. 1).

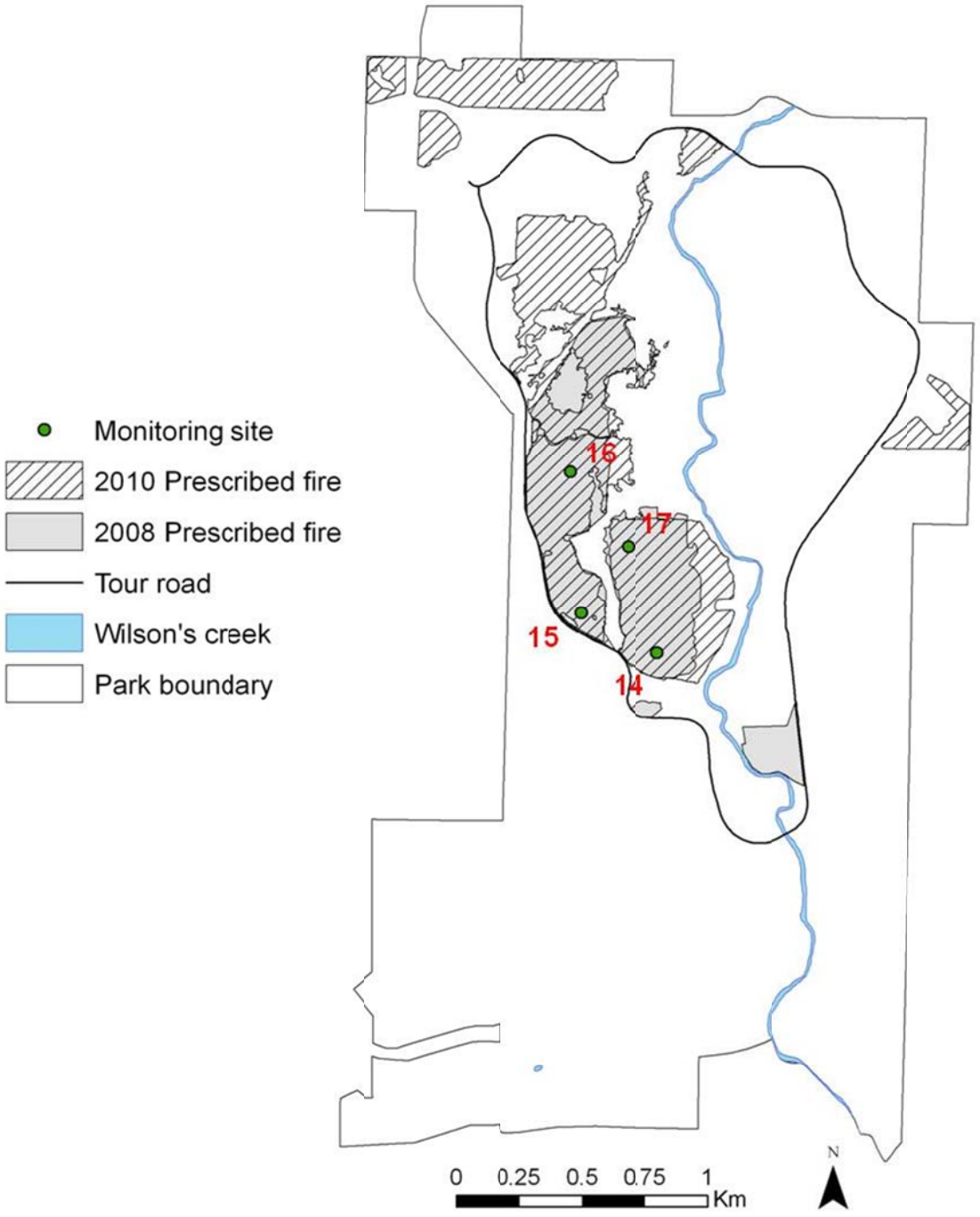


Figure 1. Location of Heartland Inventory and Monitoring Network vegetation monitoring sites (n=4) at Wilson's Creek National Battlefield, Missouri.

All sites are monitored according to the revised 2009 protocol and are comprised of two parallel transects, each containing five nested sample plots (Fig. 2). Species composition and foliar cover estimates are collected from each plot and values are summarized to the individual site.

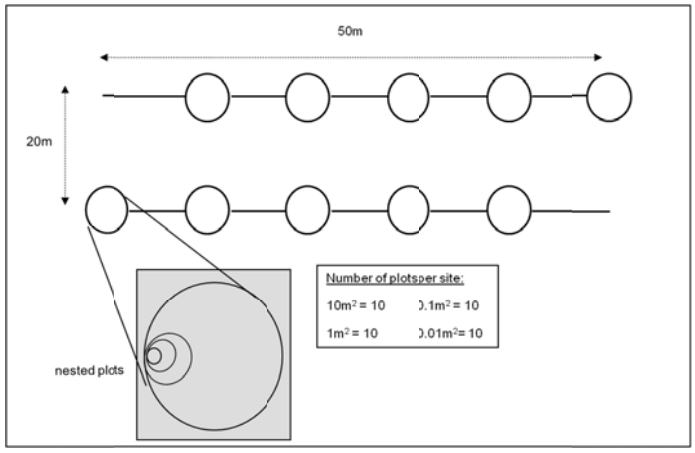


Figure 2. Heartland Inventory and Monitoring Network vegetation community sample design showing transects and plots including nested plots.

Foliar cover serves as an estimate of abundance for herbaceous species. Cover class intervals are converted to median values to estimate percent cover for each herbaceous and shrub species. Mean percent cover is then calculated as the species percent cover for a site, averaged for all ten plots within the site.

Data Summary and Analysis

Data collected from all plots within a site are summarized by species to the site level. Mean site values along with a measure of among site variability (± 1 standard error of the mean) are presented for the community. Foliar cover estimates collected for each species within a plot are the basis of field data used in all subsequent analysis.

Prairie/savanna community diversity

Three measures of diversity were calculated among all sites within the restored prairie/savanna. Alpha diversity (i.e., site level diversity) was calculated as the average species richness per site; gamma diversity (i.e., community level diversity) was estimated as the total number of species across all sites (McCune and Grace 2002). Each measure of diversity was summarized for the restored prairie/savanna. Beta diversity, as a measure of the heterogeneity in the data, was calculated as (Whittaker 1972):

$$\beta_w = (S_c / S) - 1$$

where:

β_w = beta diversity,
S_c = the number of species in the prairie,
S = the average species richness in the sample sites.

As a rule of thumb, values of $\beta_w < 1$ are rather low and $\beta_w > 5$ are considered high beta diversity (McCune and Grace 2002). If $\beta_w = 0$, then all species are found within each site. The one is subtracted to make zero beta diversity correspond to zero variation in species presence. While this measure does not have any formal units, the result could be thought of in approximate units as the "number of distinct communities" (McCune and Grace 2002).

Prairie species diversity

For each site within the community, species richness (S) along with the effective number of species derived from both Shannon diversity index (Shannon number or H_e) and Simpson's diversity index (Simpson's number or D_e) was calculated. Foliar cover estimates for each species in a site are used to determine each measure of species diversity in PC-ORD (McCune and Medford 1999).

Initial plant diversity for each site was calculated using the Shannon diversity index:

$$H' = - \sum_{i=1}^{n} p_i \ln p_i$$

where p*i* is the relative cover of species *i* (Shannon 1948). Simpson's index of diversity for an infinite population (D) was calculated by site (McCune and Grace 2002). It is the likelihood that two randomly chosen individuals from a site will be different species and emphasizes common species (McCune and Grace 2002). It is calculated by site using the complement of Simpson's original index of dominance:

$$\text{Simpson's index} = 1 - \sum_{i}^{n} p_i^2$$

Shannon and Simpson's index values were converted into effective number of species for each community (H_e and D_e, respectively). This allowed for both diversity measures to be compared directly to species richness of the sites (S) within and among sample years based on counts of distinct species in the community (Jost 2006). Shannon index was converted into effective number of species (H_e) using the following formula:

$$H_e = \exp^{(H)}$$

where H was the Shannon index value. The effective number of species based on Simpson's index (D_e) was the inverse of the index value or:

$$D_e = 1/(1-D)$$

where D was the Simpson's index value.

As S, H_e and D_e approach the same number, species begin to be equally abundant in the prairie/savanna while large differences in the number of species between each measure reflect an increasing number of less abundant species and decreasing number of more abundant species. See Jost (2006) and James et al (2009) for a complete explanation and implementation of species diversity measures, respectively.

Prairie guild abundance

Species are grouped into functional guilds and foliar cover estimates are presented at the guild level for the prairie. For each guild, foliar cover is totaled for each plot and then a mean site value is calculated from all ten plots. Guilds are first divided among native and nonnative groups

and then among grasses, forbs, sedges/rushes, ferns and woody species within each group. A complete species list along with guild assignment and origin is provided in Appendix A.

Results

Park management activities have occurred in the areas encompassing all four monitoring sites during the sample period. Most notable, prescribed fires were initiated in November 2008 and August 2010. In addition to prescribed fires, the area around sites 14, 15, and 16 was mowed in April 2011. For the purpose of this report, sample year 2008 is considered to reflect pre-management condition, sample year 2009 reflects the change following the November 2008 prescribed fire, and sample year 2011 reflects the change following the August 2010 prescribed fire and mowing.

Of the 140 species observed during the sample period, 110 were native species. Non-native and native species occurred in four different guild types (Fig. 3).

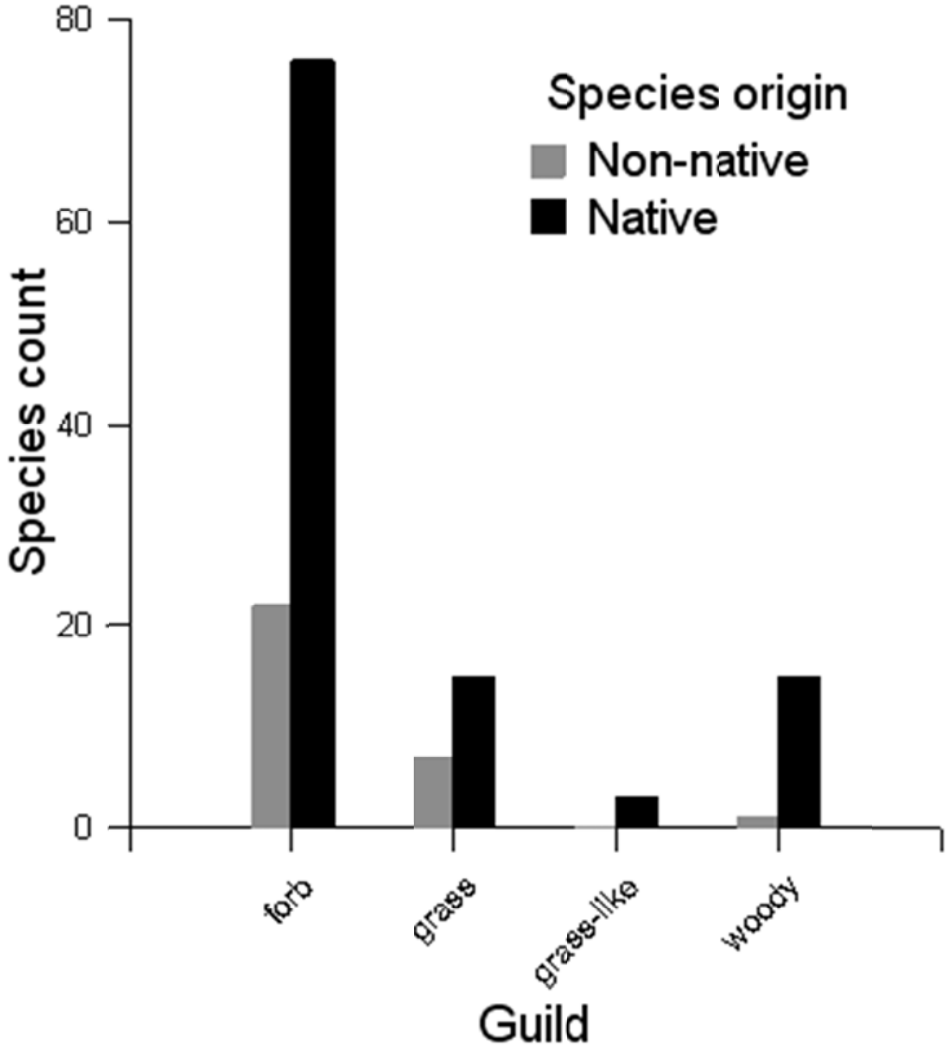


Figure 3. Total species richness for each guild type by species origin for the sample period 2008 – 2011 (N = 4 sites).

The forb guild, both native and non-native, had the highest species membership for the four sites during the sample period. The number of native grass species nearly equaled the number of native woody species observed.

Annual species richness in the restored tallgrass prairie/savanna differed by six species during the monitoring period (gamma diversity, Table 1). Alpha diversity (mean site species richness) fluctuated by five species among the three sample years. Both alpha and gamma diversity measures were highest in 2011, while beta diversity was greatest in 2008.

Table 1. Alpha, beta and gamma diversity for the restored prairie by sample year (N = 4 sites).

Year	Alpha	Beta	Gamma
2008	53.5	0.87	100
2009	57.7	0.79	103
2011	58.7	0.81	106

The native species component of the restored tallgrass prairie/savanna community is characterized by a larger number of species that are represented by a few individuals and/or low foliar cover (species richness, Fig. 4), and a small number of species that occur frequently in large abundance (Shannon and Simpson number, Fig. 4). This is consistent with the distribution patterns of species within a native prairie (Collins and Glenn, 1991).

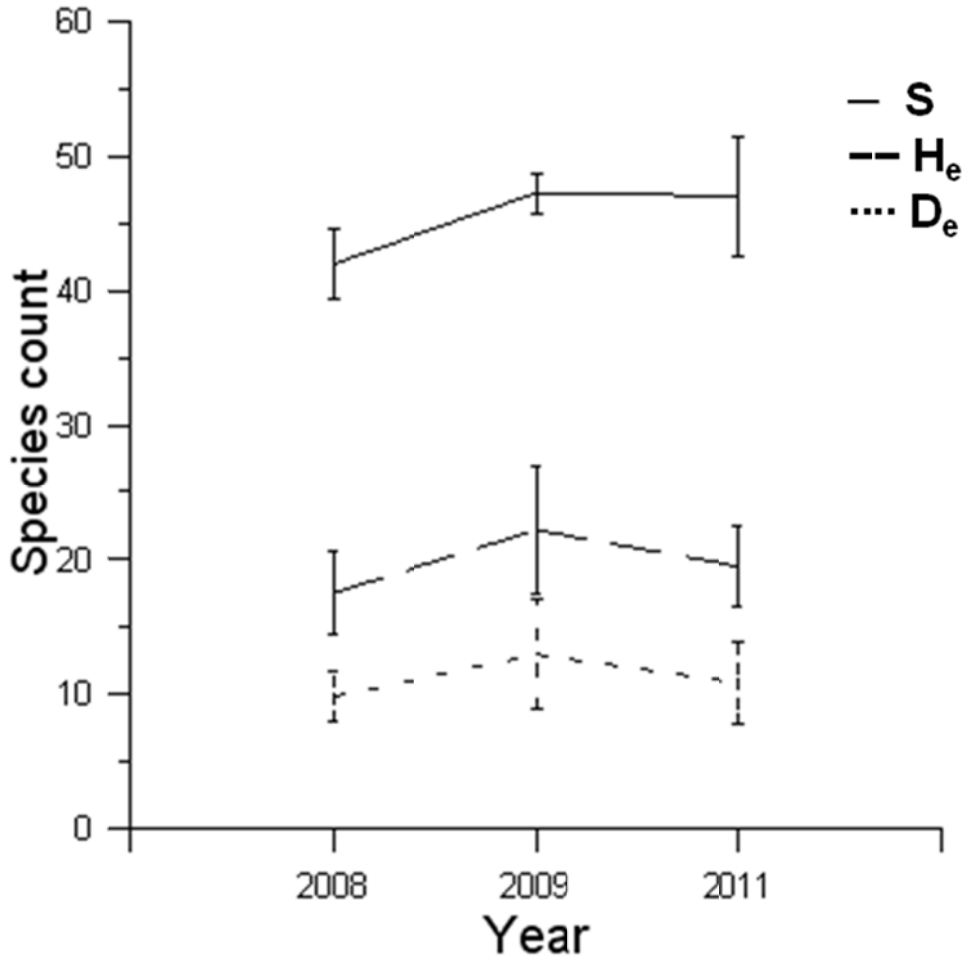


Figure 4. Mean number of native species within a site as measured by species richness (S) and effective number of species for two diversity measures (Shannon number, H_e; and Simpson's number, D_e) for prairie sites. Error bars are ± 1 standard error of the mean.

During each sample year, 23 non-native species were recorded among the four sites. Even though there are fewer non-native species in the community, they exhibit the same pattern in species diversity as observed for native speices (Fig. 5).

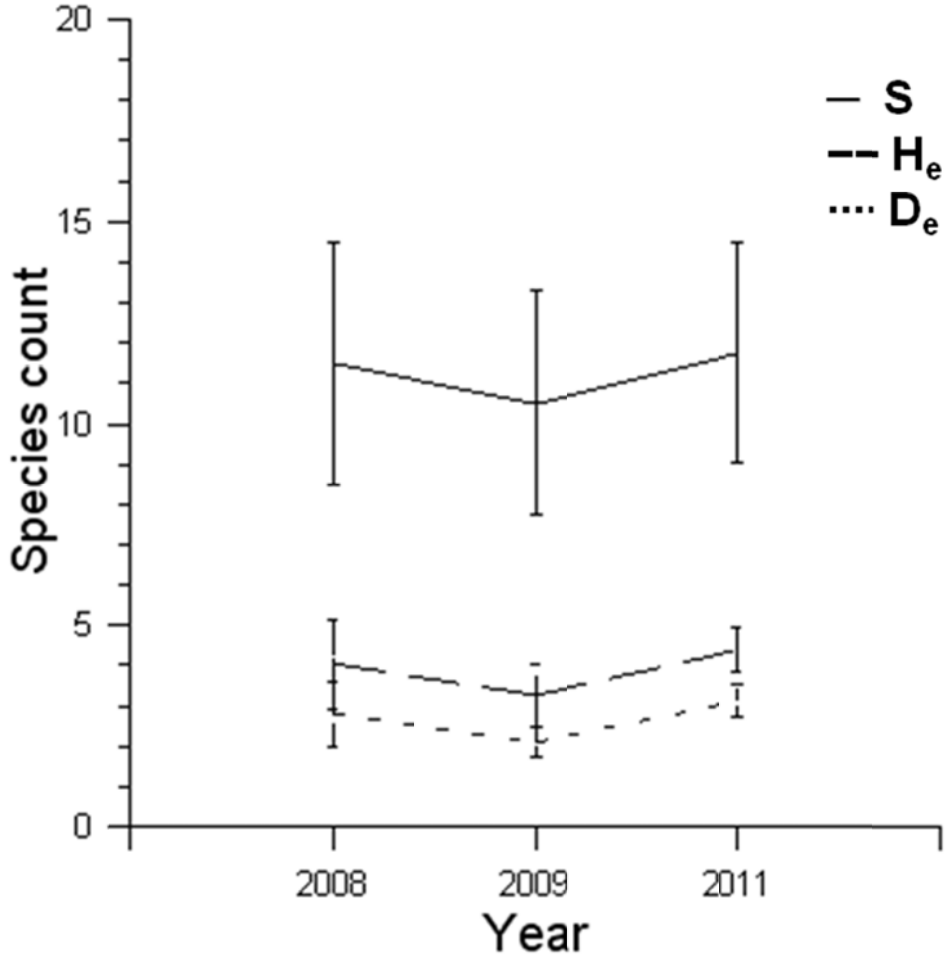


Figure 5. Mean number of non-native species within a site as measured by species richness (S) and effective number of species for two diversity measures (Shannon number, H_e; and Simpson's number, D_e) for prairie sites. Error bars are ± 1 standard error of the mean.

Of the non-native species, sericea lespedeza (*Lespedeza cuneata*) accounts for at least half of the total site foliar cover in each of the three sample years. No other non-native species exceeds ten percent mean site foliar cover in any sample year. This supports the difference between species richness and the other two site level diversity measures presented in Fig. 5.

Forbs (both native and non-native) and native grass guilds occurred in greatest abundance during all three sample years (Fig. 6).

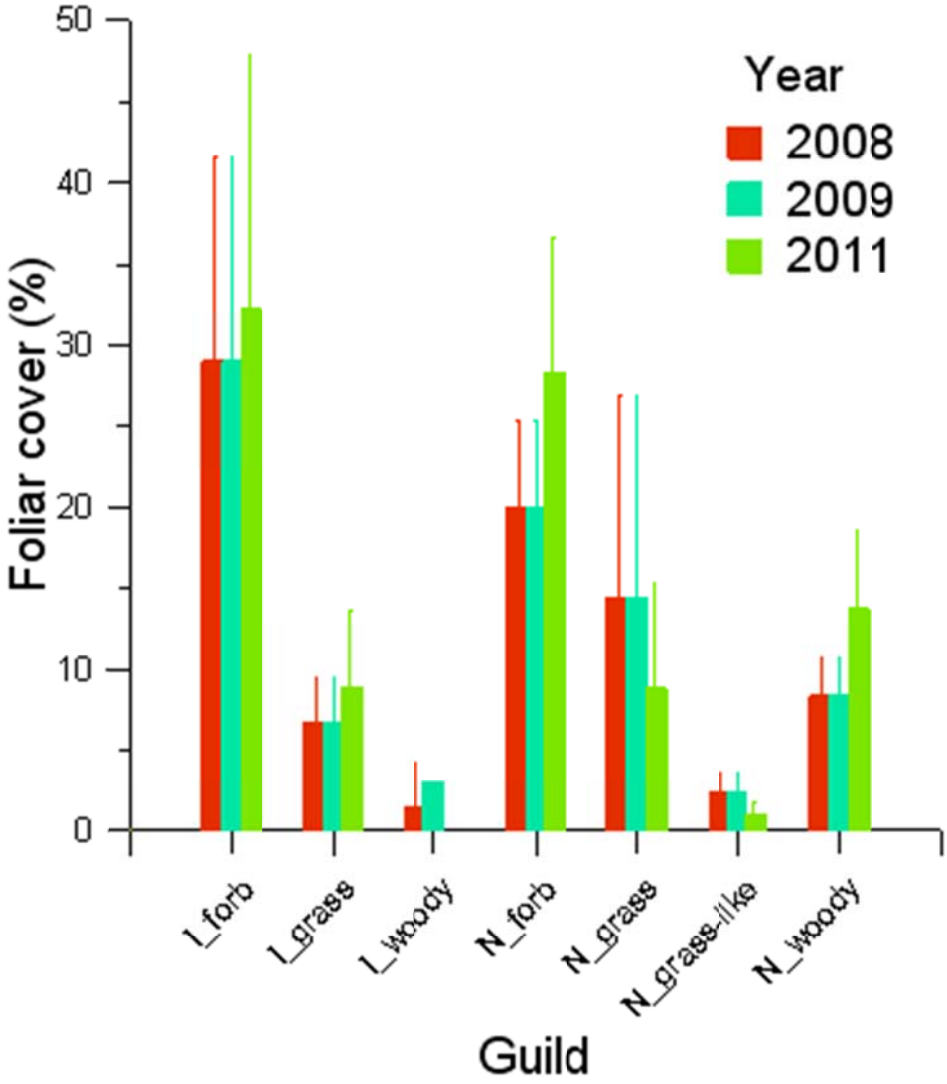


Figure 6. Mean foliar cover (± 1 standard error of the mean) for native (N) and non-native (I) plant guilds in the reconstructed tallgrass prairie (N = 4 sites). "I" = invasive or non-native plant guild, "N" = native species guild.

Of particular interest is the effect of management activities on sericea lespedeza. Change in abundance as measured by foliar cover estimates (%) are presented in Figure 7 for each monitoring site, by sample year.

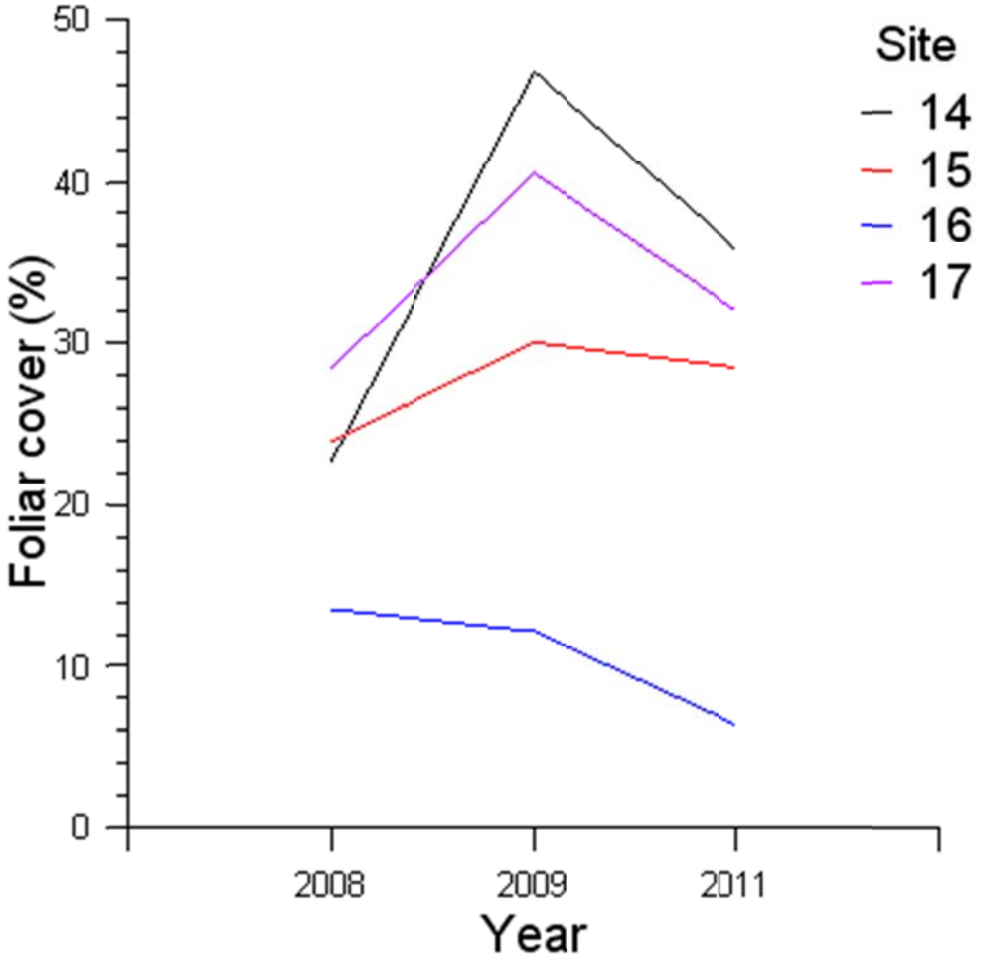


Figure 7. Foliar cover estimates (%) for sericea lespedeza (*Lespedeza cuneata*) in each monitoring site by sample year.

Sericea lespedeza was more abundant on three sites in 2011 than in 2008. Only site 16 showed a decrease after each year's management activities. In addition, those sites with more sericea lespedeza all showed a spike in foliar cover estimates in 2009, following the November 2008 prescribed fire. During the sample period, sericea lespedeza was observed in all but two plots within each site (site 16 in 2009 and site 14 in 2011). Even though there were observed changes in mean foliar cover within sites among years, the observed presence of sericea lespedeza within sites among years did not change.

Discussion

No directional trend was detected in community composition or structure at the end of the sample period as indicated by the overlap of error bars in Figs. 4-6. Of note is the absence of multiflora rose (*Rosa multiflora*) in 2011, as indicated by the non-native woody guild data (Fig. 6, I_woody). Again, foliar cover of sericea lespedeza increased between 2008 and 2011 in all but a single monitoring site. This single site was impacted by the April 2011 mowing and the reduction in sericea lespedeza at this site might reflect the short recovery time of the area between mowing and field sampling.

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Appendix

Appendix A. Species list compiled from four HTLN vegetation monitoring sites sampled between 2008 and 2011. Origin is 'N' for native species and 'I for non-native species.

Scientific name	Common name	Guild	Origin
Acalypha virginica	Virginia threeseed mercury	forb	N
Achillea millefolium	common yarrow	forb	N
Agrostis hyemalis	winter bentgrass	grass	N
Allium vineale	wild garlic	forb	I
Ambrosia artemisiifolia	annual ragweed	forb	N
Amphicarpaea bracteata	American hogpeanut	forb	N
Andropogon gerardii	big bluestem	grass	N
Andropogon virginicus	broomsedge bluestem	grass	N
Antennaria neglecta	field pussytoes	forb	N
Antennaria plantaginifolia	woman's tobacco	forb	N
Apocynum cannabinum	Indianhemp	forb	N
Asclepias amplexicaulis	clasping milkweed	forb	N
Asclepias syriaca	common milkweed	forb	N
Asclepias tuberosa	butterfly milkweed	forb	N
Asclepias viridiflora	green comet milkweed	forb	N
Baptisia alba	largeleaf wild indigo	forb	N
Barbarea vulgaris	garden yellowrocket	forb	I
Bouteloua curtipendula	sideoats grama	grass	N
Brickellia eupatorioides	false boneset	forb	N
Bromus	Brome	grass	I
Bromus inermis	smooth brome	forb	I
Carduus nutans	nodding plumeless thistle	forb	I
Carex	Sedge	grass-like	N
Celtis occidentalis	common hackberry	woody	N
Cerastium nutans	nodding chickweed	forb	N
Chaerophyllum procumbens	spreading chervil	forb	N
Chaerophyllum tainturieri	hairyfruit chervil	forb	N
Chenopodium album	Lambsquarters	forb	N
Chrysopsis pilosa	soft goldenaster	forb	N
Cirsium altissimum	tall thistle	forb	N
Conyza canadensis	Canadian horseweed	forb	N
Croton monanthogynus	prairie tea	forb	N
Cruciata pedemontana	piedmont bedstraw	forb	I
Cuscuta	Dodder	forb	N
Cyperus	Flatsedge	grass-like	N
Daucus carota	Queen Anne's lace	forb	I
Descurainia pinnata	western tansymustard	forb	N
Desmodium paniculatum	panicledleaf ticktrefoil	forb	N
Desmodium perplexum	perplexed ticktrefoil	forb	N
Desmodium sessilifolium	sessileleaf ticktrefoil	forb	N
Dianthus armeria	Deptford pink	forb	I
Dichanthelium	rosette grass	grass	N
Dichanthelium clandestinum	Deertongue	grass	N
Echinacea pallida	pale purple coneflower	forb	N

Appendix A. Species list compiled from four HTLN vegetation monitoring sites sampled between 2008 and 2011. Origin is 'N' for native species and 'I for non-native species (continued).

Scientific name	Common name	Guild	Origin
Elymus virginicus	Virginia wildrye	grass	N
Eragrostis spectabilis	purple lovegrass	grass	N
Erigeron annuus	eastern daisy fleabane	forb	N
Erigeron strigosus	prairie fleabane	forb	N
Eryngium yuccifolium	button eryngo	forb	N
Euphorbia corollata	flowering spurge	forb	N
Galium aparine	Stickywilly	forb	N
Geranium carolinianum	Carolina geranium	forb	N
Glandularia canadensis	rose mock vervain	forb	N
Gleditsia triacanthos	Honeylocust	woody	N
Hieracium longipilum	hairy hawkweed	forb	N
Hordeum pusillum	little barley	grass	N
Hypericum	St. Johnswort	forb	N
Hypericum punctatum	spotted St. Johnswort	forb	N
Juncus	Rush	grass-like	N
Kummerowia stipulacea	Korean clover	forb	I
Lactuca canadensis	Canada lettuce	forb	N
Lactuca serriola	prickly lettuce	forb	I
Lamium purpureum	purple deadnettle	forb	I
Lepidium densiflorum	common pepperweed	forb	N
Lespedeza capitata	roundhead lespedeza	forb	N
Lespedeza cuneata	sericea lespedeza	forb	I
Lespedeza procumbens	trailing lespedeza	forb	N
Lespedeza violacea	violet lespedeza	forb	N
Lespedeza virginica	slender lespedeza	forb	N
Leucanthemum vulgare	oxeye daisy	forb	I
Medicago lupulina	black medick	forb	I
Melilotus officinalis	yellow sweetclover	forb	I
Mirabilis nyctaginea	heartleaf four o'clock	forb	N
Monarda fistulosa	wild bergamot	forb	N
Myosotis verna	spring forget-me-not	forb	N
Oenothera biennis	common evening primrose	forb	N
Oenothera laciniata	cutleaf evening primrose	forb	N
Oligoneuron rigidum	Stiff goldenrod	forb	N
Oxalis	woodsorrel	forb	N
Oxalis violacea	violet woodsorrel	forb	N
Panicum virgatum	switchgrass	grass	N
Parthenium integrifolium	wild quinine	forb	N
Penstemon digitalis	talus slope penstemon	forb	N
Physalis heterophylla	clammy groundcherry	forb	N
Plantago virginica	Virginia plantain	forb	N
Poa compressa	Canada bluegrass	grass	I
Poa pratensis	Kentucky bluegrass	grass	I
Polygonum pensylvanicum	Pennsylvania smartweed	forb	N
Potentilla recta	sulphur cinquefoil	forb	I
Prunus	plum	woody	N
Pseudognaphalium obtusifolium	Fragrant cudweed	forb	N

Appendix A. Species list compiled from four HTLN vegetation monitoring sites sampled between 2008 and 2011. Origin is 'N' for native species and 'I for non-native species (continued).

Scientific name	Common name	Guild	Origin
Ratibida pinnata	pinnate prairie coneflower	forb	N
Rhus aromatica	fragrant sumac	woody	N
Rhus copallinum	winged sumac	woody	N
Rhus glabra	smooth sumac	woody	N
Rosa carolina	Carolina rose	woody	N
Rosa multiflora	multiflora rose	woody	I
Rosa setigera	climbing rose	woody	N
Rubus	blackberry	woody	N
Rudbeckia hirta	blackeyed Susan	forb	N
Ruellia humilis	fringeleaf wild petunia	forb	N
Rumex crispus	curly dock	forb	I
Salvia azurea	azure blue sage	forb	N
Sassafras albidum	sassafras	woody	N
Schedonorus phoenix	Tall Fescue	grass	I
Schizachyrium scoparium	little bluestem	grass	N
Setaria	bristlegrass	grass	I
Setaria faberi	Japanese bristlegrass	grass	I
Silene antirrhina	sleepy silene	forb	N
Silphium laciniatum	compassplant	forb	N
Solanum carolinense	Carolina horsenettle	forb	N
Solidago	goldenrod	forb	N
Solidago altissima	Canada goldenrod	forb	N
Sorghastrum nutans	Indiangrass	grass	N
Sorghum halepense	Johnsongrass	grass	I
Sporobolus compositus	Tall dropseed	grass	N
Stellaria media	common chickweed	forb	I
Stylosanthes biflora	sidebeak pencilflower	forb	N
Symphoricarpos orbiculatus	coralberry	woody	N
Taraxacum officinale	common dandelion	forb	I
Teucrium canadense	Canada germander	forb	N
Torilis japonica	erect hedgeparsley	forb	I
Toxicodendron radicans	eastern poison ivy	woody	N
Tragia betonicifolia	betonyleaf noseburn	forb	N
Tridens flavus	purpletop tridens	grass	N
Trifolium arvense	rabbitfoot clover	forb	N
Trifolium campestre	field clover	forb	I
Triodanis perfoliata	Venus' looking-glass	forb	N
Ulmus	elm	woody	N
Valerianella radiata	beaked cornsalad	forb	N
Verbascum thapsus	common mullein	forb	I
Verbena urticifolia	white vervain	forb	N
Vernonia baldwinii	Baldwin's ironweed	forb	N
Veronica arvensis	corn speedwell	forb	I
Viburnum prunifolium	blackhaw	woody	N
Viola bicolor	field pansy	forb	N
Viola sororia	common blue violet	forb	N
Vitis	grape	woody	N

Appendix A. Species list compiled from four HTLN vegetation monitoring sites sampled between 2008 and 2011. Origin is 'N' for native species and 'I for non-native species (continued).

Scientific name	Common name	Guild	Origin
Vulpia octoflora	sixweeks fescue	grass	N