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Plant Community Monitoring Baseline Report, George Washington Carver National Monument

Natural Resource Technical Report NPS/HTLN/NRTR—2009/190

ON THE COVER
Restored prairie at George Washington Carver National Monument
Heartland I&M Network photograph.

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Executive Summary

Plant community monitoring at George Washington Carver National Monument of America (GWCA) is designed to detect and describe changes in the prairie community. This is accomplished by quantifying species composition, structure, and diversity of the prairie community. Restoration of the prairie is a focus of natural resource management at GWCA.

This report defines the baseline range of conditions for Heartland Inventory and Monitoring Network (HTLN) monitoring sites. Here “baseline” refers to the sample period of 2004-2008 in which monitoring data were collected to determine the amount of existing natural variability in the restored prairie. Defining a baseline range assumes no directional change for a condition between sample events. All monitoring data were analyzed for the presence of any significant change during the sample period. Once a baseline range has been established, future monitoring data will be analyzed for any significant departures from the baseline.

Monitoring data collected from all seven sites during 2004, 2005 and 2008 did not show any statistically significant directional change during the five year sample period. Therefore data collected during this period was summarized together in order to provide a range of natural variability for each measure.

Baseline conditions, as determined at the plant community monitoring site level, indicate a prairie that is composed a subset of native species occurring in greater abundance than most species in the restoration area. It is a species rich plant community with a distribution pattern composed of core and satellite species. This distribution pattern of species reflects a prairie that is in varying stages of restoration, with numerous species patchily distributed.

Non-native species are a noticeable component in the monitoring sites. However, only a single non-native species had a high enough frequency to qualify as a core species. The large baseline range for non-native foliar cover reflects both the varying degree of abundance and patchy distribution of non-native species among the sample sites and sample years

Introduction

Plant community monitoring at George Washington Carver National Monument (GWCA) is designed to detect and describe changes in the restored prairie community. This is accomplished by quantifying species composition, structure, and diversity of the prairie community. Moreover, monitoring data are used to determine temporal changes in the species composition, structure, and diversity of this community. A goal of long term monitoring is to estimate the rate of temporal change for measures of diversity, specifically as related to management efforts in the restoration of prairie habitats. Heartland Inventory and Monitoring Program (HTLN) plant community monitoring objectives compliment park management objectives to restore the historic scene to that of the Moses Carver farm of the 1860's and 1870's (Palmer 1983).

The National Monument was established in 1943 to honor the life and achievements of George Washington Carver. Many of his achievements are rooted in botanical exploration that began in the prairies and woodlands found on and around the 240 acres of the original farm. The goals of the park's cultural and natural resource management program are as follows (National Park Service, 1999):

- To study the park's flora, fauna, and natural systems to provide baseline data;
- To protect natural and cultural resources by identifying and mitigating threats to them; and,
- To restore the natural and cultural resources that are damaged, lacking, or absent due to past operations and activities of humans.

This report defines the baseline range of conditions for HTLN monitoring sites. Here "baseline" refers to the sample period of 2004-2008 in which monitoring data were collected to determine the amount of existing natural variability in the restored prairie. Defining a baseline range assumes no directional change for a condition between sample events. All monitoring data were analyzed for the presence of any significant change during the sample period. Once a baseline range has been established, future monitoring data will be analyzed for any significant departures from the baseline.

Plant community data has been collected three times since 2004 as part of the Heartland Inventory and Monitoring Program. The HTLN plant community sites are part of a long term monitoring program for the park and focus on the prairie restoration. Long term monitoring data collected from the prairie restoration can be used to address issues ranging from invasive exotic species guilds to change in community function and integrity through time. This report establishes a baseline summary of the prairie community at GWCA based on HTLN plant community monitoring efforts.

Methods

Field methods

The Heartland Inventory and Monitoring Network implemented monitoring at GWCA in 2004 to provide analyses of baseline conditions and to assess future change in floral communities (see DeBacker *et al.* 2004 for detailed information on monitoring protocol). Seven prairie sites (consisting of ten $10m^2$ plots at each site) were sampled in late spring and early fall during 2004, 2005, and late spring in 2008 (Fig. 1).

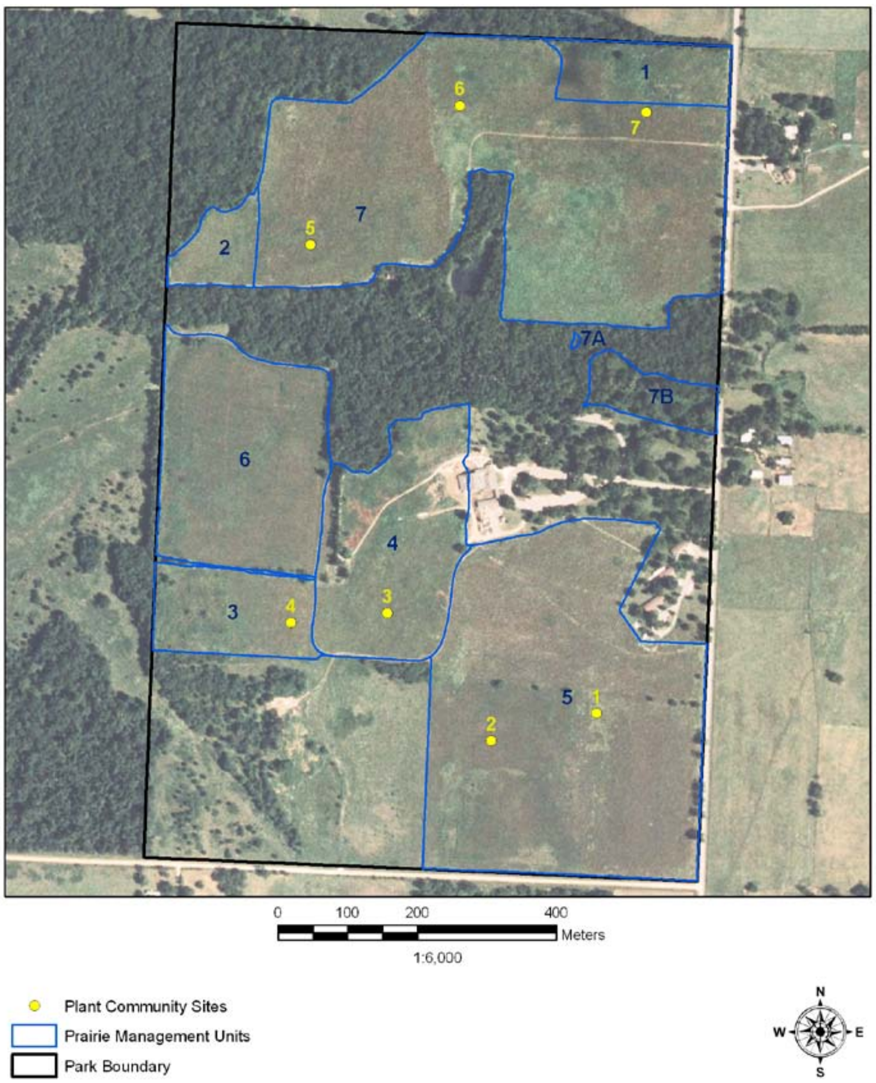

Figure 1. Map of George Washington Carver National Monument displaying Heartland Inventory and Monitoring Network plant community monitoring sites and prairie management units.

Management, specifically prescribed fire, of the restored prairie at GWCA has been minimal over the last few years. Recent prescribed fires affected HTLN plant community sample sites 3, 5, 6, and 7 in April of 2005. In the spring of 2008, the management unit that includes sites 1 and 2 was burned. These were the only two prescribed burns in the restored prairie since 2000.

HTLN plant community monitoring sample sites consist of randomly located, permanent, paired transects 50 meters in length and 20 meters apart with five circular $10m^2$ plots systematically spaced along each transect (Fig. 2).

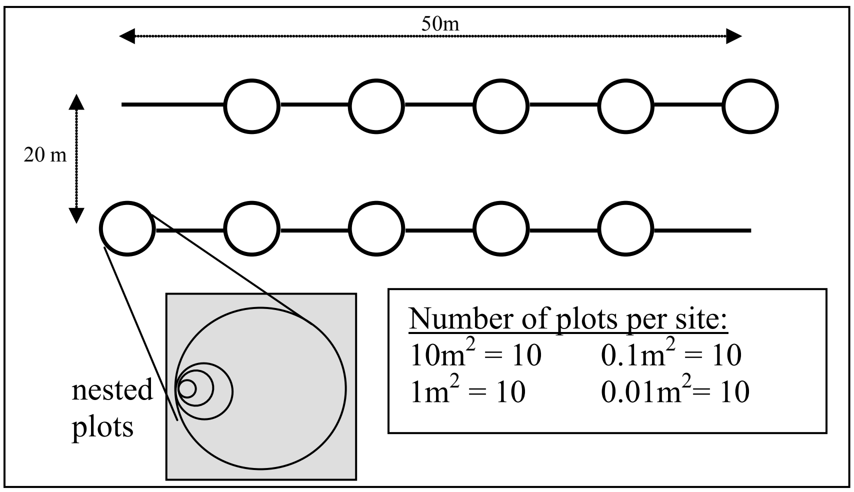

Figure 2. HTLN plant community monitoring sample site showing transects and plots including nested plots.

The primary sample unit is the site, and the $10m^2$ circular plots along each transect are secondary sample units. Each $10m^2$ plot also includes nested subplots of $1m^2$, $0.1m^2$ and $0.01m^2$ for frequency estimates at multiple scales. Working systematically from the smallest subplot ($0.01m^2$) to the largest ($10m^2$), all species are identified and foliar cover is estimated. Prairie vegetation is sampled in this manner.

Analytical methods

For analyses, the site was the unit of replication, and plots were pooled or averaged to produce a single parameter estimate for each site. Once estimates for all parameters were obtained for each site, averages and a measure of variability (standard deviation) were calculated among sample sites, to provide an estimate at the park level.

Individual species abundances and frequencies

Individual species frequency and percent foliar cover were calculated for each site. With the site as the replicate, species frequency was reported as the proportion (or percentage) of plots in which the species occurred within each site.

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

Species frequency within sites and among years was used to identify core species for each sample year. Core species were defined as those species occurring with ≥ 90% frequency in the community (among all sites within the restored prairie) (Collins and Glenn 1990). Core and satellite species, due to different patterns of abundance and distribution, respond differently to stochastic variability and therefore when analyzed separately can aid in understanding changes in community structure and local density.

To track the change in species frequency within and among sites across years, the optimal plot frame size for detecting a change in frequency is determined for each species. The primary use of frequency data in long term monitoring studies is to act as a surrogate for plant density. That is, the optimal plot size from which to obtain frequency data decreases as spatial structure (local density) of the population increases. Population simulation work demonstrated a plot frame size that returned a mean frequency close to 50% is nearly optimal for detecting changes in species over time across a broad range of spatial structure (Heywood and DeBacker 2007). Here the nested plot frame size that returns a mean frequency value for the site between 20-50% is defined as the optimal plot frame size. Focusing on the low side of the optimal 50% provides both a range for ascribing the optimal plot frame size and allows for species density to fluctuate without being reclassified into a smaller optimal plot frame. The plot frame size that returns a frequency value for each species within the optimal range is identified as the individual species optimal plot frame for detecting a change in its frequency (optimized frequency) over time.

The optimized frequency is determined for all core species at each site for each year. Changes in density of individual core species can be inferred spatially and temporally by reporting the optimized frequency at the site level for each year. It is this ability to detect a shift in optimized frequency across a range of frame sizes for all sampled species that is the strength of the nested sampling design.

Plant species richness, diversity and evenness

Plant diversity for each site was calculated using the **Shannon index**:

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

where p*i* was the relative cover of species *i* (Shannon 1948). Species distribution **evenness** was calculated by site using Pielou (1977)(J'):

$$J' = H' / H_{max}$$

where H' was the Shannon index and H_{max} was the maximum possible diversity for a given number of species if all species were present in equal numbers ((ln(species richness)). J' is a measure of distribution of species within a community as compared to equal distribution and maximum diversity (Pielou 1969). **Species richness** was determined as the total number of plant taxa recorded per site. Species richness was calculated with all species (native and exotic) included in the estimate. **Simpson's index** of diversity for an infinite population (D) was calculated by site (McCune and Grace 2002). It was the likelihood that two randomly chosen individuals from a site would be different species and emphasized common species (McCune and Grace 2002). It was 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 (Joust 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.

When measuring diversity in a single community, it is best to use species richness, Shannon index and Simpson's index to most accurately reflect diversity (Joust 2006). At the most basic level of species diversity, species richness provides a total number of distinct species sampled per unit area. Richness is insensitive to species abundance. Therefore a single individual species occurring only once in a community is treated the same as a species with thousands of individuals in the community. This measure is an indicator of species diversity but does not provide any information about the composition of species within the community. The Shannon index weights species by the natural log of their abundance. It is intermediate between species richness and Simpson's index in its sensitivity to rare species. Therefore this diversity measure provides information on both the count of unique species and their abundance in the community. Simpson's index goes one step further by disproportionately favoring dominant species based on species abundance and is little affected by gain or loss of rare species.

Dominance takes into account species abundance and evenness of distribution in the community. The degree of species abundance and dominance in the community is reflected by the degree to which $S > H_e > D_e$ when evenness (E) remains constant in a single community. The difference in number of species between the diversity measures reflects the presence of uncommon species and how species diversity is partitioned within the community. If all species occur in equal abundance in the community within and among sample years, then $S = H_e = D_e$. Effective number of species for each diversity measure reflects the number of species found in a similar community when all species occur in equal abundance. That is to say if $S = 100$ and $D_e = 20$, then the community is dominated by 20 species and 80 species occur in low abundance. Such a community would be equivalent to a community with just 20 species all occurring in equal abundance.

Alpha, beta and gamma diversity

Analyzing patterns in species richness at both the site and prairie scale allowed three kinds of diversity to be calculated (Whittaker 1972). Alpha diversity (i.e., local level diversity) was calculated as the average species richness per site; gamma diversity (i.e., landscape 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. 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 sample units have all of the species. The one is subtracted to make zero beta diversity correspond to zero variation in species presence. Beta diversity could be interpreted as an indicator of heterogeneity for the area of interest. 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 plant guild and exotic species summary

Average cover and associated standard deviation from the mean are also calculated for 10 plant guilds: warm-season grasses, cool-season grasses, annuals and biennials, perennial forbs, woody species (including shrubs) and grass-like species. Ecological prairie plant guilds are composed of species with significant overlap in niche requirements, and that occupy similar positions along a resource gradient in a community (Kindscher and Wells 1995). Guilds simplify the array of species into groups making ecosystem processes and functions more easily understood (Kindscher 1994).

Non-native species form a different type of species guild, specific to species intentionally or unintentionally introduced into an area outside of their natural range. Non-native species can influence ecological processes including trophic level relationships, interspecific competition, primary and secondary succession, nutrient cycling, and ecosystem productivity, diversity, and stability (Bratton 1982). Percent foliar cover for non-native species was calculated for each site. For a park-wide review of non-native species at GWCA see Cribbs et al. (2007).

Data Transformation and First Difference of Time Series

In order to test for any directional change within a monitoring site through time, data were transformed to ensure independence of each sample event. Species abundance data obtained from fixed monitoring sites repeatedly sampled over time were analyzed as differences rather than cover values.

The difference in species abundance within a site was calculated between two sample years:

$$d_{ij} = x_{ij2} - x_{ij1}$$

where x_{ij} is the abundance of species *j* in site *i* at sample year 1 and 2. For each species within a site the difference is the change in abundance through time. This "first difference" refers to the first derivative in a time series curve (Allen et al. 1977) and is the continuous equivalent of the discrete difference described above. The dataset of first differences in species abundance between two sampling events represents the changes in species composition within and among sites. Determining the difference in species abundance with each successive sampling event is indicative of the rate of compositional change across all sample years. Here, the transformed dataset represents the amount of difference calculated between 2004 and 2005, then again between 2005 and 2008 for each monitoring variable.

A paired t-test was used to test for any statistically significant changes between the first (2004-2005) and second (2005-2008) differences for each variable at each site. A non-significant t-test result ($p > 0.05$) indicates no directional change for that variable between 2004 and 2008. For each variable with a non-significant result, a baseline range was defined as the mean value ± one standard deviation as calculated from all of the site data (seven sites sampled during three years, n=21). Therefore baseline ranges of each variable are for the monitoring site.

Results

A total of 199 unique species were sampled between 2004 and 2008 in the seven HTLN monitoring sites (Appendix 1). The average number of unique species sampled among sites (gamma diversity) across three sample years was 140.7 ± 5.9 species (mean ± 1 standard deviation). The average number of species sampled per site (alpha diversity) was 45.8 ± 9.1 species. Therefore a site contained on average 42% of the total species richness for the baseline period (2004 – 2008). Average beta diversity for the preserve for all three years was 1.4 ± 0.1. Beta values indicated low species heterogeneity in the restored prairie for each sample year, such that all seven HTLN sites could be considered as representing a single prairie community.

Paired t-tests performed for each species diversity measurement among native and non-native species groups did not yield any significant directional changes among the three sample periods (Table 1 and 2.)

Table 1. Native species diversity measure t-test results (p-value) and baseline range (mean ± standard deviation) as calculated from all sample sites (n=21).

Native species	p-value	Baseline range
Species richness (S)	0.86	45.9 (9.1)
Shannon diversity (H_e)	0.89	42.3 (8.4)
Simpson's diversity (D_e)	0.99	37.9 (7.8)

Comparison of native species evenness (J') differences did not result in any significant directional changes among sample years ($p = 0.74$). Baseline native evenness was defined as 0.979 ± 0.004 for the site.

Table 2. Non-native species diversity measure t-test results (p-value) and baseline range (mean ± standard deviation) as calculated from all sample sites (n=21).

Non-native species	p-value	Baseline range
Species richness (S)	0.14	13.8 (5.9)
Shannon diversity (H_e)	0.13	13.2 (5.5)
Simpson's diversity (D_e)	0.13	12.6 (5.1)

Non-native species evenness baseline range (0.939 ± 0.215) was broader than the range for native species. Despite the uneven distribution of non-native species among sites, no significant directional change through time was detected ($p = 0.34$).

Of the 199 species detected among all sample periods, only eleven core species were identified (bold typeface, Table 2). Ten core species were native while Sulphur five-finger (*Potentilla recta*) was the only non-native core species. Thirty-one species (30 native, one non-native) had an optimum plot frame size of $10m^2$ or less (Table 3). Most species (n=168) occurred in lower frequency, such that a plot frame size larger than $10m^2$ would be required to define an optimum plot frame size and subsequent optimized frequency.

The optimum plot frame was used to infer population density for a single species. Plot frame sizes corresponded to the four nested plot frame sizes used in the sampling scheme. Smaller plot frame sizes were indicative of greater population densities than larger plot frame sizes. For each species, the optimized frequency range was calculated from frequency measures collected at the optimum plot frame size for that species (Table 3).

Table 3. Species with their associated optimum plot frame size and optimized frequency (mean ± standard deviation) at the monitoring site scale. Core species (n=11) are in bold typeface. Only species with an optimum plot frame size ≤ $10m^2$ are presented (n=31), all other species have an optimum plot frame size ≥ $10m^2$ (n=168) for a monitoring site. * = non-native species.

Scientific name	Optimum plot (m^2)	Optimized frequency
Acalypha virginica	0.01	2.7 (2.4)
Andropogon gerardii	0.01	4.1 (1.8)
Sorghastrum nutans	0.01	2.0 (1.9)
***Carex* spp**	0.1	2.7 (1.6)
***Oxalis* spp**	0.1	3.8 (2.0)
***Rubus* spp**	0.1	2.4 (2.6)
Schizachyrium scoparium	0.1	2.7 (1.6)
Agrostis hyemalis	1	3.9 (2.7)
Ambrosia artemisiifolia	1	3.2 (3.6)
Andropogon virginicus	1	2.8 (2.3)
Bouteloua curtipendula	1	2.9 (2.9)
Dichanthelium spp	1	3.9 (1.5)
Panicum virgatum	1	2.2 (1.6)
Rhus copallinum	1	4.3 (3.5)
Solanum carolinense	1	4.2 (2.7)
Strophostyles leiosperma	1	2.8 (3.4)
Valerianella radiata	1	2.9 (3.2)
Cirsium altissimum	10	5.7 (3.3)
Conyza canadensis	10	4.0 (3.0)
Erigeron strigosus	10	3.7 (3.0)
Geranium carolinianum	10	4.2 (2.9)
Hordeum pusillum	10	2.8 (2.1)
Juncus interior	10	3.7 (2.7)
Myosotis verna	10	5.1 (3.1)
Physalis heterophylla	10	3.4 (2.3)
Plantago virginica	10	5.9 (2.3)
Potentilla recta*	10	2.7 (2.6)
Rudbeckia hirta	10	3.6 (2.4)
Tragia betonicifolia	10	4.4 (4.0)
Tridens flavus	10	4.9 (3.5)
Vulpia octoflora	10	4.8 (2.8)

Functional guild types with foliar cover estimates greater than one percent for each site were included in the analysis (grass-like guild type did not meet this threshold and was excluded). For those guilds analyzed, no significant directional change was detected among sample years at the $p<0.05$ level (Table 4). Again, cover data for each guild type was summarized together to define the baseline range of foliar cover for the monitoring site.

Table 4. Guild foliar cover t-test results (p-value) and baseline range (mean ± standard deviation) for cover estimates at a monitoring site.

Guild	p-value	Baseline range
warm-season grass	0.57	47.5 (17.0)
woody species	0.82	23.8 (18.0)
non-native species	0.47	22.6 (22.5)
perennial forbs	0.66	18.5 (16.3)
annual/biennial forbs	0.43	15.2 (11.4)
cool-season grass	0.83	4.1 (3.7)

When differences in ground cover type values were compared among sample years, no significant directional change was found (Table 5.). Of the ground cover types, grass litter and bare soil had the most cover for a site.

Table 5. Ground cover t-test results (p-value) and baseline range (mean ± standard deviation) for cover estimates at a monitoring site.

Ground cover	p-value	Baseline range
grass litter	0.44	40.9 (25.3)
bare soil	0.31	29.7 (21.4)
rock	0.2	0.7 (0.5)
woody debris	0.21	0.6 (0.2)

Baseline ranges for the monitoring site were defined for all species abundance variables. Further optimum plot frame sizes and optimized frequency ranges were identified for all species sampled between 2004 and 2008.

Discussion

Plant community monitoring data, collected by HTLN at GWCA, were used to define baseline conditions in species richness, diversity and composition during three sample events over a five year period. Monitoring data collected from all seven sites during 2004, 2005 and 2008 did not show any statistically significant directional change for all variables and measures during the five year sample period. Therefore data collected during this period were summarized together in order to provide a range of natural variability for each measure. The prairie restoration sites are not scheduled to be monitored again until 2011. Those data could then be compared against the baseline range to determine if any significant changes have occurred in the time since last monitored. Furthermore, using the difference between sample events rather than the actual value for each sample event at a site provides the foundation for building a long term dataset from fixed monitoring sites to which time series analysis can be performed (McCune and Grace 2002).

Baseline conditions as determined at the plant community monitoring site level indicate a prairie that is composed of a subset of native species occurring in greater abundance than most species in the restoration area. It is a species rich plant community with a distribution pattern composed of core and satellite species (Hanski 1982). This distribution pattern of species reflects a prairie that is in varying stages of restoration, with numerous species patchily distributed (Grubb 1986). The overlap in baseline ranges of all native diversity measures demonstrates that, for native species within a site, the species are occurring in nearly equal proportions as measured by foliar cover estimates ($S \approx H_e \approx D_e$) . Even though there are only ten native core species (occurring with high frequency in every site during all years), the native species have similar foliar cover regardless of their frequency within a site. This is evident when looking at the baseline ranges for foliar cover estimates of the native guilds; native grass guild is similar to the other native guilds combined.

Non-native species are a noticeable component in the monitoring sites. However, only a single non-native species had a high enough frequency to qualify as a core species. The broad baseline range for non-native foliar cover reflects both the varying degree of abundance and patchy distribution of non-native species among the sample sites and sample years.

This report provides baseline ranges for future comparisons of plant community data collected as part of the long-term monitoring efforts at George Washington Carver National Monument.

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Appendix

Appendix 1. Species list for George Washington Carver National Monument compiled from seven Heartland Inventory & Monitoring Network plant community sites sampled during 2004, 2005 and 2008. Origin reflects if the species is native or non-native. Guild is the guild type functional group, non-native species are considered as a single guild with no additional guild type designated.

Origin	Guild	Scientific name	Common name
Native	annual-biennial forb	*Acalypha virginica*	Virginia copperleaf
Native	perennial forb	*Achillea millefolium*	Common yarrow
Native	perennial forb	*Ageratina altissima*	Tall ageratina
Native	cool-season grass	*Agrostis hyemalis*	Ticklegrass
Native	annual-biennial forb	*Ambrosia artemisiifolia*	Common ragweed
Native	annual-biennial forb	*Ambrosia bidentata*	Lanceleaf ragweed
Native	perennial forb	*Amphicarpa bracteata*	Hog-peanut
Native	warm-season grass	*Andropogon gerardii*	Big bluestem
Native	warm-season grass	*Andropogon virginicus*	Broom-sedge
Native	perennial forb	*Apocynum cannabinum*	Hemp dogbane
Native	perennial forb	*Artemisia ludoviciana*	White sage
Native	perennial forb	*Asclepias* spp	
Native	perennial forb	*Asclepias stenophylla*	Narrow-leaved milkweed
Native	perennial forb	*Asclepias syriaca*	Common milkweed
Native	perennial forb	*Asclepias verticillata*	Whorled milkweed
Native	perennial forb	*Asclepias viridiflora*	Green milkweed
Native	perennial forb	*Asclepias viridis*	Ozark milkweed
Native	perennial forb	*Aster ericoides*	Squarrose white wild aster
Native	perennial forb	*Aster pilosus*	Awl wild aster
Native	perennial forb	*Aster* spp	
Native	annual-biennial forb	*Bidens aristosa*	Bearded beggarticks
Native	annual-biennial forb	*Bidens* spp	
Native	warm-season grass	*Bouteloua curtipendula*	Side-oats grama-grass
Native	perennial forb	*Brickellia eupatorioides*	Aster
Native	perennial forb	*Calystegia sepium*	Hedge-bindweed
Native	woody	*Campsis radicans*	Trumpet creeper
Native	grass-like	*Carex bushii*	Bush's sedge
Native	grass-like	*Carex molesta*	Troublesome sedge
Native	grass-like	*Carex shortiana*	Short's sedge
Native	grass-like	*Carex* spp	
Native	annual-biennial forb	*Chaerophyllum tainturieri*	Southern chervil
Native	perennial forb	*Chamaecrista fasciculata*	Partridge-pea; locust-weed
Native	annual-biennial forb	*Chamaecrista nictitans*	Partridge pea
Native	annual-biennial forb	*Chenopodium album*	Lamb's quarters, pigweed
Native	annual-biennial forb	*Chenopodium* spp	
Native	annual-biennial forb	*Cirsium altissimum*	Tall thistle
Native	perennial forb	*Cirsium discolor*	Tall or roadside thistle
Native	perennial forb	*Cirsium* spp	
Native	annual-biennial forb	*Conyza canadensis*	Horseweed
Native	annual-biennial forb	*Croton capitatus*	Woolly croton

Native	annual-biennial forb	*Croton glandulosus*	Tooth-leaved croton
Native	annual-biennial forb	*Croton monanthogynus*	Prairie-tea
Native	grass-like	*Cyperus echinatus*	Globe flatsedge
Native	grass-like	*Cyperus lupulinus*	Great plains flatsedge
Native	grass-like	*Cyperus* spp	
Native	perennial forb	*Desmodium canadense*	Canadian tick-trefoil
Native	perennial forb	*Desmodium illinoense*	Prairie tick-trefoil
Native	perennial forb	*Desmodium nuttallii*	Nuttall's ticktrefoil
Native	perennial forb	*Desmodium paniculatum*	Tick-trefoil
Native	perennial forb	*Desmodium perplexum*	Perplexed ticktrefoil
Native	perennial forb	*Desmodium* spp	
Native	cool-season grass	*Dichanthelium* spp	
Native	cool-season grass	*Digitaria cognata*	Carolina crab grass
Native	annual-biennial forb	*Diodia teres*	Poorjoe
Native	perennial forb	*Echinacea pallida*	Pale purple coneflower
Native	cool-season grass	*Elymus virginicus*	Virginia wild rye
Native	warm-season grass	*Eragrostis spectabilis*	Purple lovegrass
Native	annual-biennial forb	*Erechtites hieraciifolia*	Fireweed
Native	annual-biennial forb	*Erigeron annuus*	Annual fleabane
Native	annual-biennial forb	*Erigeron* spp	Fleabane
Native	annual-biennial forb	*Erigeron strigosus*	Rough fleabane
Native	perennial forb	*Euphorbia corollata*	Flowering spurge
Native	annual-biennial forb	*Euphorbia cyathophora*	Fire-on-the-mountain
Native	annual-biennial forb	*Euphorbia dentata*	Toothed spurge
Native	annual-biennial forb	*Galium aparine*	Cleavers
Native	annual-biennial forb	*Gamochaeta purpurea*	Purple cudweed
Native	annual-biennial forb	*Geranium carolinianum*	Carolina crane's-bill
Native	perennial forb	*Glandularia canadensis*	Rose vervain
Native	annual-biennial forb	*Gnaphalium obtusifolium*	Fragrant cudweed
Native	perennial forb	*Hieracium longipilum*	Long-haired hawkweed
Native	cool-season grass	*Hordeum pusillum*	Little barley
Native	perennial forb	*Hypericum punctatum*	Spotted st. John's wort
Native	perennial forb	*Hypericum* spp	
Native	perennial forb	*Ipomoea pandurata*	Man of the earth
Native	grass-like	*Juncus interior*	Rush
Native	grass-like	*Juncus* spp	
Native	annual-biennial forb	*Krigia cespitosa*	Sunflower
Native	annual-biennial forb	*Lactuca canadensis*	Tall lettuce
Native	perennial forb	*Lactuca* spp	
Native	annual-biennial forb	*Lepidium densiflorum*	Prairie-pepperweed
Native	perennial forb	*Lespedeza capitata*	Bush-clover
Native	perennial forb	*Lespedeza procumbens*	Downy trailing lespedeza
Native	perennial forb	*Lespedeza violacea*	Violet lespedeza
Native	perennial forb	*Lespedeza virginica*	Virginia lespedeza
Native	annual-biennial forb	*Linum sulcatum*	Grooved yellow flax
Native	warm-season grass	*Muhlenbergia* spp	
Native	annual-biennial forb	*Myosotis verna*	Early scorpion grass
Native	annual-biennial forb	*Nuttallanthus texanus*	Texas toadflax
Native	perennial forb	*Oenothera laciniata*	Cutleaf evening primrose
Native	perennial forb	*Oenothera speciosa*	White evening-primrose

Native	perennial forb	*Oxalis* spp	Wood-sorrel
Native	perennial forb	*Oxalis violacea*	Violet wood-sorrel
Native	cool-season grass	*Panicum anceps*	Beaked panicgrass
Native	warm-season grass	*Panicum capillare*	Witch-grass
Native	warm-season grass	*Panicum* spp	Panicgrass
Native	warm-season grass	*Panicum virgatum*	Switchgrass
Native	woody	*Parthenocissus quinquefolia*	Virginia-creeper, woodbine
Native	cool-season grass	*Pascopyrum smithii*	Western wheatgrass
Native	warm-season grass	*Paspalum laeve*	Field paspalum
Native	cool-season grass	*Paspalum* spp	Crowngrass
Native	perennial forb	*Penstemon digitalis*	Talus slope penstemon
Native	perennial forb	*Physalis heterophylla*	Clammy ground cherry
Native	perennial forb	*Physalis longifolia*	Longflower ground cherry
Native	perennial forb	*Physalis virginiana*	Virginia ground cherry
Native	perennial forb	*Phytolacca americana*	Pokeweed, pokeberry
Native	perennial forb	*Plantago aristata*	Longbracted plantain
Native	annual-biennial forb	*Plantago virginica*	Plantain
Native	cool-season grass	*Poa arida*	Plains bluegrass
Native	annual-biennial forb	*Polygala sanguinea*	Purple milkwort
Native	annual-biennial forb	*Polygonum pensylvanicum*	Pennsylvania smartweed
Native	perennial forb	*Polygonum* spp	
Native	woody	*Prunus americana*	Wild plum
Native	annual-biennial forb	*Ptilimnium nuttallii*	Laceflower
Native	woody	*Rhus copallinum*	Shining sumac
Native	woody	*Rhus glabra*	Smooth sumac
Native	woody	*Rosa carolina*	Pasture rose
Native	woody	*Rubus* spp	
Native	perennial forb	*Rudbeckia hirta*	Black-eyed susan
Native	perennial forb	*Rudbeckia* spp	Coneflower
Native	perennial forb	*Ruellia humilis*	Fringeleaf ruellia
Native	perennial forb	*Sabatia angularis*	Rosepink
Native	perennial forb	*Salvia azurea*	Sage
Native	woody	*Sassafras albidum*	Sassafras
Native	warm-season grass	*Schizachyrium scoparium*	Little bluestem
Native	grass-like	*Schoenoplectus tabernaemontani*	Softstem bulrush
Native	perennial forb	*Schrankia nuttallii*	Sensitive brier
Native	perennial forb	*Scutellaria parvula*	Little skullcap
Native	annual-biennial forb	*Sida spinosa*	Prickly spinosa
Native	annual-biennial forb	*Silene antirrhina*	Catchfly, campion
Native	woody	*Smilax bona-nox*	Saw greenbrier
Native	annual-biennial forb	*Solanum americanum*	Nightshade
Native	perennial forb	*Solanum carolinense*	Horse-nettle
Native	perennial forb	*Solidago* spp	
Native	warm-season grass	*Sorghastrum nutans*	Indian grass
Native	cool-season grass	*Sphenopholis obtusata*	Wedge-grass
Native	perennial forb	*Spiranthes cernua*	Nodding ladies' tresses
Native	warm-season grass	*Sporobolus asper*	Tall dropseed
Native	perennial forb	*Strophostyles leiosperma*	Small-flowered woolly bean
Native	perennial forb	*Stylosanthes biflora*	Sidebeak pencilflower
Native	woody	*Symphoricarpos occidentalis*	Wolfberry

Native	woody	*Symphoricarpos orbiculatus*	Coralberry
Native	perennial forb	*Tephrosia virginiana*	Virginiana tephrosia
Native	perennial forb	*Teucrium canadense*	American germander
Native	perennial forb	*Tragia betonicifolia*	Tragia
Native	warm-season grass	*Tridens flavus*	Purpletop
Native	perennial forb	*Trifolium arvense*	Rabbitfoot clover
Native	annual-biennial forb	*Triodanis perfoliata*	Round-leaved triodanis
Native	annual-biennial forb	*Valerianella radiata*	Corn salad
Native	perennial forb	*Verbascum blattaria*	Moth mullein
Native	perennial forb	*Verbena simplex*	Narrow-leaved vervain
Native	perennial forb	*Verbena stricta*	Hoary vervain
Native	perennial forb	*Vernonia baldwinii*	Western ironweed
Native	annual-biennial forb	*Viola bicolor*	Violet
Native	perennial forb	*Viola sororia*	Violet
Native	woody	*Vitis* spp	
Native	cool-season grass	*Vulpia octoflora*	Six-weeks fescue
Non-native		*Allium vineale*	Field-garlic, scallions
Non-native		*Annual bromus* spp	B. tectorum, B. japonicus
Non-native		*Barbarea vulgaris*	Yellow rocket
Non-native		*Bromus inermis*	Smooth brome
Non-native		*Carduus nutans*	Musk-thistle
Non-native		*Cirsium vulgare*	Bull thistle
Non-native		*Convolvulus arvensis*	Field-bindweed
Non-native		*Cruciata pedemontana*	Piedmont bedstraw
Non-native		*Daucus carota*	Queen anne's lace
Non-native		*Dianthus armeria*	Deptford pink
Non-native		*Digitaria sanguinalis*	Northern crab-grass
Non-native		*Euphorbia davidii*	David's spurge
Non-native		*Kummerowia stipulacea*	Korean clover
Non-native		*Lactuca serriola*	Prickly lettuce
Non-native		*Lespedeza cuneata*	Chinese lespedeza
Non-native		*Leucanthemum vulgare*	Ox-eye daisy
Non-native		*Lolium arundinaceum*	Tall fescue
Non-native		*Melilotus officinalis*	Yellow sweet clover
Non-native		*Melilotus* spp	
Non-native		*Phleum pratense*	Timothy
Non-native		*Plantago lanceolata*	Narrowleaf plantain
Non-native		*Poa compressa*	Canada bluegrass
Non-native		*Poa pratensis*	Kentucky bluegrass
Non-native		*Potentilla recta*	Sulphur five-fingers
Non-native		*Rumex acetosella*	Common sheep sorrel
Non-native		*Rumex crispus*	Curly dock
Non-native		*Rumex spp*	Dock
Non-native		*Saponaria officinalis*	Bouncingbet
Non-native		*Setaria faberi*	Nodding foxtail-grass
Non-native		*Setaria* spp	
Non-native		*Setaria viridis*	Green foxtail-grass
Non-native		*Sorghum halepense*	Johnsongrass
Non-native		*Stellaria media*	Common chickweed
Non-native		*Taraxacum officinale*	Common dandelion

Non-native	*Torilis japonica*	Japanese hedge-parsley
Non-native	*Tragopogon dubius*	Fistulous goat's beard
Non-native	*Trifolium campestre*	Pinnate hop-clover
Non-native	*Trifolium pratense*	Red clover
Non-native	*Trifolium repens*	White clover
Non-native	*Trifolium spp*	
Non-native	*Veronica arvensis*	Corn speedwell
Non-native	*Vicia sativa*	Garden vetch

The NPS has organized its parks with significant natural resources into 32 networks linked by geography and shared natural resource characteristics. HTLN is composed of 15 National Park Service (NPS) units in eight Midwestern states. These parks contain a wide variety of natural and cultural resources including sites focused on commemorating civil war battlefields, Native American heritage, westward expansion, and our U.S. Presidents. The Network is charged with creating inventories of its species and natural features as well as monitoring trends and issues in order to make sound management decisions. Critical inventories help park managers understand the natural resources in their care while monitoring programs help them understand meaningful change in natural systems and to respond accordingly. The Heartland Network helps to link natural and cultural resources by protecting the habitat of our history.

The I&M program bridges the gap between science and management with a third of its efforts aimed at making information accessible. Each network of parks, such as Heartland, has its own multi-disciplinary team of scientists, support personnel, and seasonal field technicians whose system of online databases and reports make information and research results available to all. Greater efficiency is achieved through shared staff and funding as these core groups of professionals augment work done by individual park staff. Through this type of integration and partnership, network parks are able to accomplish more than a single park could on its own.

The mission of the Heartland Network is to collaboratively develop and conduct scientifically credible inventories and long-term monitoring of park "vital signs" and to distribute this information for use by park staff, partners, and the public, thus enhancing understanding which leads to sound decision making in the preservation of natural resources and cultural history held in trust by the National Park Service.

www.nature.nps.gov/im/units/htln/

Heartland Network

Natural Resource Monitoring

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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U.S. Department of the Interior

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