



Garlic Mustard (*Alliaria petiolata*) Monitoring at Effigy Mounds National Monument

2006-2015

Natural Resource Report NPS/HTLN/NRR—2017/1451



ON THE COVER

Autumn forest at Effigy Mounds National Monument.
NPS file photo.

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Abstract

Although garlic mustard abundance has fluctuated greatly since survey inception in 2006, the 2015 abundance estimate was the lowest observed (2,150 m²) compared to the high observed in 2012 (13,250 m²). Garlic mustard frequency, however, has remained relatively constant across all survey years from a low estimate of 43.0% in 2010 to a high of 48.5% in 2012. In addition, the percent overlap of transects containing garlic mustard is relatively similar when comparing any two surveys – further illustrating the relative stability of the plant distribution across the park landscape. Garlic mustard was always absent from 37.5% of transects and always present in 21.3% of transects. Given garlic mustard’s persistence on the park, management efforts may be most effective in areas where plant abundance and year-to-year recurrence are low.

Introduction

Although the exact period of garlic mustard (*Alliaria petiolata* (Bieb.) Cavara & Grande) naturalization in Effigy Mounds National Monument (EFMO), Macgregor, Iowa, remains unknown, observations were noted as early as 1993 (Rovang, personal communication). Since that time, garlic mustard has spread throughout the park's forest understory. Garlic mustard is of particular interest to resource managers and park staff as this species may pose deleterious impacts to native vegetation communities, including displacing native plant species (Daehler 2003), altering fire regimes (Evans et al. 2001), disrupting nutrient cycling (Rodgers et al. 2008), and changing ecosystem structure and function (Vitousek et al. 1997).

National Parks are directed to manage exotic plant species that, among other criteria, 1) “interfere with natural processes and the perpetuation of natural features, native species or natural habitats” or 2) “disrupt the accurate presentation of a cultural landscape” (NPS 2006). In light of the park's unique natural and cultural resources, garlic mustard impacts on the landscape may warrant management.

Management actions to control garlic mustard have continued since as early as 2000 when hand pulling was initially employed. Beginning in 2011, efforts to manage garlic mustard were substantially elevated with the use of large work crews employing spot foliar application of herbicide to individual plants. Since 2011 EFMO in conjunction with the Heartland Inventory and Monitoring Network (HTLN) Exotic Plant Management Team has annually managed garlic mustard.

HTLN began park-wide monitoring on fixed transects in 2006 with the intent of monitoring on a 4-year return interval. The monitoring schedule was altered, however, in order to evaluate garlic mustard response to previous management activities. Such understanding is important evaluative information given the investment toward garlic mustard control. Subsequent monitoring periods occurred in 2010, 2012 and, most recently, 2015. For an evaluation of changes in garlic mustard abundance and frequency between 2006 and 2010, see Bell et al. (2012). This report extends those data to include data captured during 2012 and 2015.

Methods

Field Methods

In order to assess the abundance and frequency of garlic mustard, a grid of 272 transects was established that spanned the entire park and was oriented at an azimuth of 82.25°. These transects were 200-m in length unless clipped by the park boundary. Seven transects were 0 to 50-m in length, 25 were 50 to 100-m in length, 15 were 100 to 150-m in length, and 225 transects were 150 to 200-m in length (Figure 1). Transects were contiguous (i.e., joined end to end) in the west-to-east direction and separated by 200-m in the north-to-south direction.

In order to estimate its abundance, garlic mustard cover was recorded in 10 m² increments (i.e., minimum mapping unit = 10 m²), while walking along each transect. Surveys were conducted in late fall to maximize detection of garlic mustard. Navigation files on Trimble GeoXT or GeoXH GPS units were used in order to follow transects. Some error in following transects likely occurred due to terrain and the need for surveyors to focus on plant identification while walking. In order to maximize detection, garlic mustard was observed in as wide a belt as possible. The maximum observable belt width naturally varied based on terrain and other factors affecting visual distance. In 2006, 222 transects were surveyed, while 272 transects were surveyed in 2010, 2012 and 2015. Eleven of the 50 transects excluded in 2006 were found to support garlic mustard in 2010, 2012 or 2015.

In order to provide a finer resolution of cover estimation than that of the entire 200-m transect, GPS points were collected along each transect to represent the approximate locations of garlic mustard plants. Each GPS point represented the location from where an observation was made, but usually did not represent the exact location of those plants. Spatial analyses were not conducted using these point data.

HTLN employees Craig Young and Tyler Cribbs conducted the first survey during October 23-27, 2006. The survey methods followed those outlined in Young et al. (2007). Jordan Bell, Ashley Dunkle, Chad Gross, and Craig Young, all affiliated with HTLN, conducted the second survey during November 9-11, 2010. Jordan Bell, Chris Kopek, Adam Throckmorton, and Craig Young, all with HTLN, and Candace LaRussa and Kat Busse with EFMO completed the third survey during November 6-8, 2012. Finally, Craig Young and Jordan Bell, along with Conservation Corps of Iowa staff Jeff Williams, Caleb Thyer, Rachelle Pollock and Audrey Menninga completed the fourth survey during November 19-21, 2015.

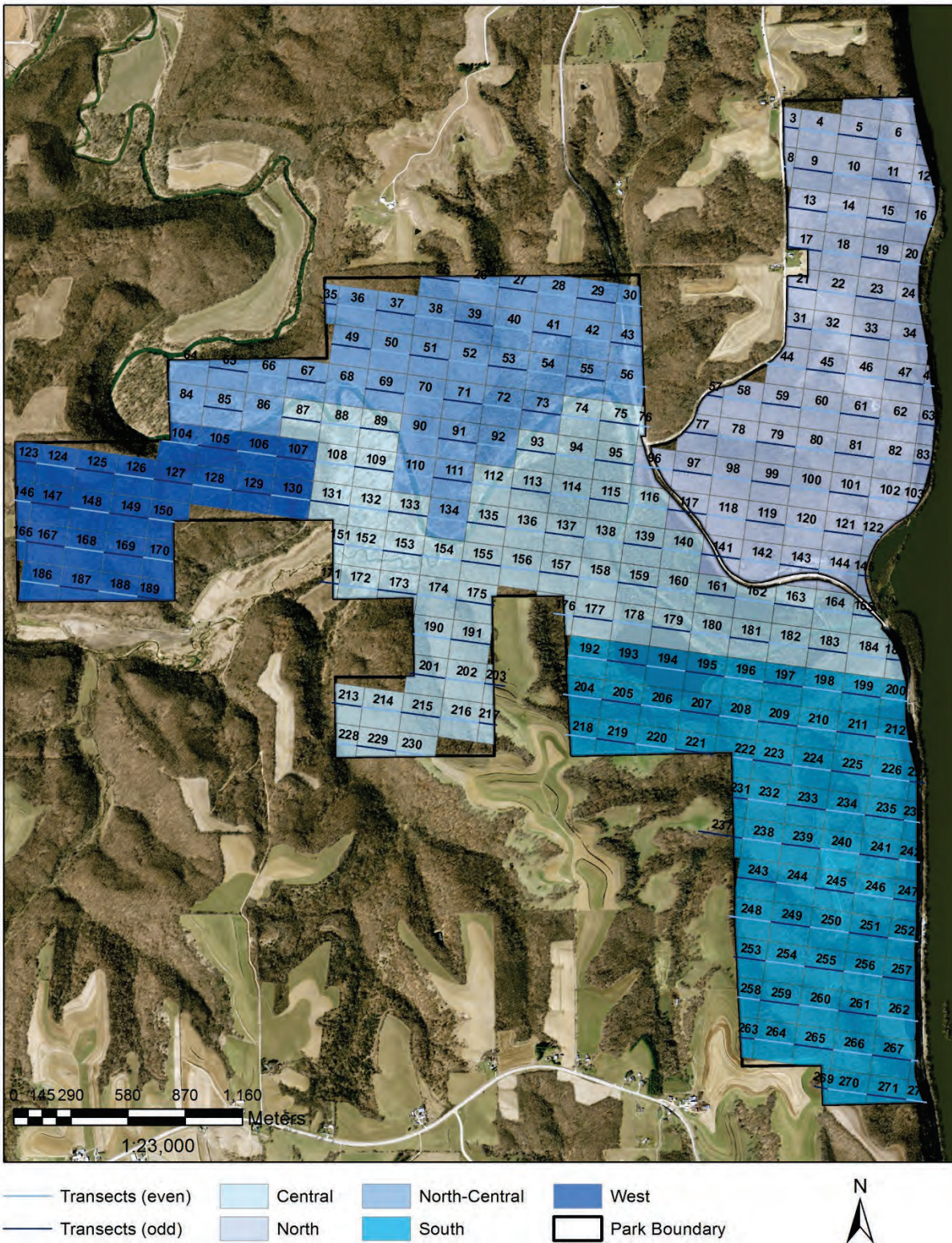


Figure 1: Location of 200-m transects at Effigy Mounds National Monument overlaid on assessment areas used to identify abundance trends in more localized areas of the park.

Analytical Methods

To determine changes in garlic mustard abundance, frequency and spatial distribution across the park data were analyzed in several ways. Two maps represented garlic mustard abundance on each transect during 2012 and 2015, respectively, for simple visualization (Figure 2 and 3). Next, annual abundance was calculated as the sum of garlic mustard cover over all transects, while frequency was calculated as the percentage of occupied transects (Figure 4). To determine if changes in abundance were localized or a park-wide phenomenon, survey transects were divided into 5 assessment areas (Figure 1 and 4) with high abundance of garlic mustard and where management actions have varied over time. The cumulative incidence of occurrence was determined for each transect as the number of surveys (0 to 4) in which garlic mustard was detected (Figure 6) and the incidence of occurrence was then summarized across all transects (Figure 6, Table 1). The percent overlap in transects containing garlic mustard when comparing any two surveys was evaluated (Table 2). Finally, to evaluate the amount of fluctuation in the abundance of garlic mustard in the park, the absolute change in cover from a previous year to the next for each transect across all survey periods was calculated using the following formula:

$$\text{Cumulative Absolute Cover Change} = \text{Abs}(2006 - 2010) + \text{Abs}(2010 - 2012) + \text{Abs}(2012 - 2015)$$

In this case, a zero value may either indicate that a transect has never supported garlic mustard or that the transect has always supported the exact same estimated abundance (i.e., no observed cover change) (Figure 5).

Measurement Uncertainty and Natural Variability

In total, three sources of error may affect abundance estimates including: 1) measurement error (including inter-observer error) resulting from the use of cover estimates, a minimum mapping unit, and variable belt widths, 2) spatial error associated with following transects (i.e., veering away from original transect accidentally or intentionally due to terrain), and 3) rarely ($n < 5$), differences in exclusion criteria between observers based on their assessment of field safety. Compounding this measurement uncertainty, garlic mustard abundance is well known to naturally fluctuate drastically from one year to the next (Van Riper et al. 2010; Pardini et al. 2009). Also, garlic mustard density has been documented to actually increase in response to management actions due to over-compensatory recruitment (Zipkin et al. 2009). The intersection of observer error, natural abundance fluctuations and management induced abundance changes precluded careful evaluation of measurement error or clear attribution of causation.

In contrast to abundance measures, frequency and distribution analyses are less prone to observer error as these measures are based on the presence or absence of a single garlic mustard plant on a single transect. Frequency and distribution data, however, ignore dramatic abundance fluctuations of garlic mustard. This is important to recognize as some non-manipulated garlic mustard populations studied in 1m²- plots have been known to be completely absent some years while being present in others (Nuzzo 1999). Overall, frequency and distribution data are less rich, but likely more accurate than abundance estimates.

Results and Discussion

Garlic Mustard Abundance

Since survey inception mean garlic mustard abundance per transect has been 31.8 m², 13.3 m², 48.7 m² and 7.9 m² for 2006, 2010, 2012 and 2015, respectively. The most dramatic increase in garlic mustard abundance between two surveys occurred between 2010 and 2012: 3,620 m² in 2010 to 13,250 m² in 2012 (Figure 4). The dramatic increase in abundance in 2012 was not the result of localized areas impacting park-wide abundance estimates, rather the increase was experienced park-wide (Figure 4). A simple visual assessment revealed that garlic mustard abundance fluctuated most in areas supporting large amounts of garlic mustard compared to other park areas possessing less garlic mustard (Figure 5). The precise reason for the sharp increase in garlic mustard abundance in 2012 is not well understood. The dynamic nature of garlic mustard populations has been of interest to researchers who have discovered several plausible factors responsible for these changes in abundance. For an extended discussion on the demographic difficulties involved in interpreting changes in garlic mustard abundance, see Bell et al. (2012). Fortunately, this sharp increase in abundance did not continue. The 2015 survey documented the lowest garlic mustard abundance with an estimate of 2,150 m², an 84% decrease from 2012 (Figure 3 and 4).

Garlic Mustard Frequency and Distribution

While garlic mustard abundance has fluctuated greatly over the four surveys, garlic mustard frequency has remained relatively stable. The frequency for each survey year was similar to all others, with only a 5.5% difference between the least and most frequently observed years: 43.0% in 2010 and 48.5% in 2012 (Figure 4). The cumulative incidence of occurrence showed that 37.5% of transects never supported garlic mustard in any survey period (Table 1, Figure 6). On the other hand, the next most frequent incidence class on Table 1 was 21.3% of transects supporting garlic mustard during every survey.

The highest incidence of reoccurrence was found between 2010 and 2012 with, 83.7% of transects supporting garlic mustard in 2010 found to also support garlic mustard in 2012. The relatively high values in Table 2 for any two-year comparison, indicated a high probability of garlic mustard reoccurring on each infested transect. Given the relatively unchanging park-wide frequency of garlic mustard along with its high percentage of reoccurrence, the distribution of garlic mustard was relatively stable during the survey period.

Management Implications

Given the natural variability in garlic mustard abundance and uncertainty in the data, final conclusions cannot be definitive. The 2015 abundance data, however, indicate a strong decrease in garlic mustard in EFMO. The 6x reduction between 2012 and 2015 is so great as to almost certainly rule out measurement error alone as the source of the difference. On the other hand, the North unit, which has received some of the most concerted control efforts, continues to show infestation levels similar to those observed in 2006 and 2010.

The frequency and re-occurrence analyses indicate little change in the distribution of garlic mustard over time. If control efforts were leading to local eradication, greater decreases in this metric should

be observed. Such a result may not be surprising as garlic mustard has been shown to persist for several years even in intensively managed sites because of the seed bank (Drayton and Primack 1999). Consequently, the prospect that garlic mustard is moving towards extinction in local sites cannot be ruled out.

Given garlic mustard's tendency to persist in already established transects, we recommend attention to transects where garlic mustard cover is low or infrequently observed as the best chance for successful eradication. This scenario characterizes the park's south unit where its presence is increasing steadily since 2006 going from 1 to 2 to 8 to 9 transects occupied over the study period. Targeted control of these localized populations, which may involve multiple annual treatments, may serve as a rapid response to what appears to be an early detection of a spreading garlic mustard population.

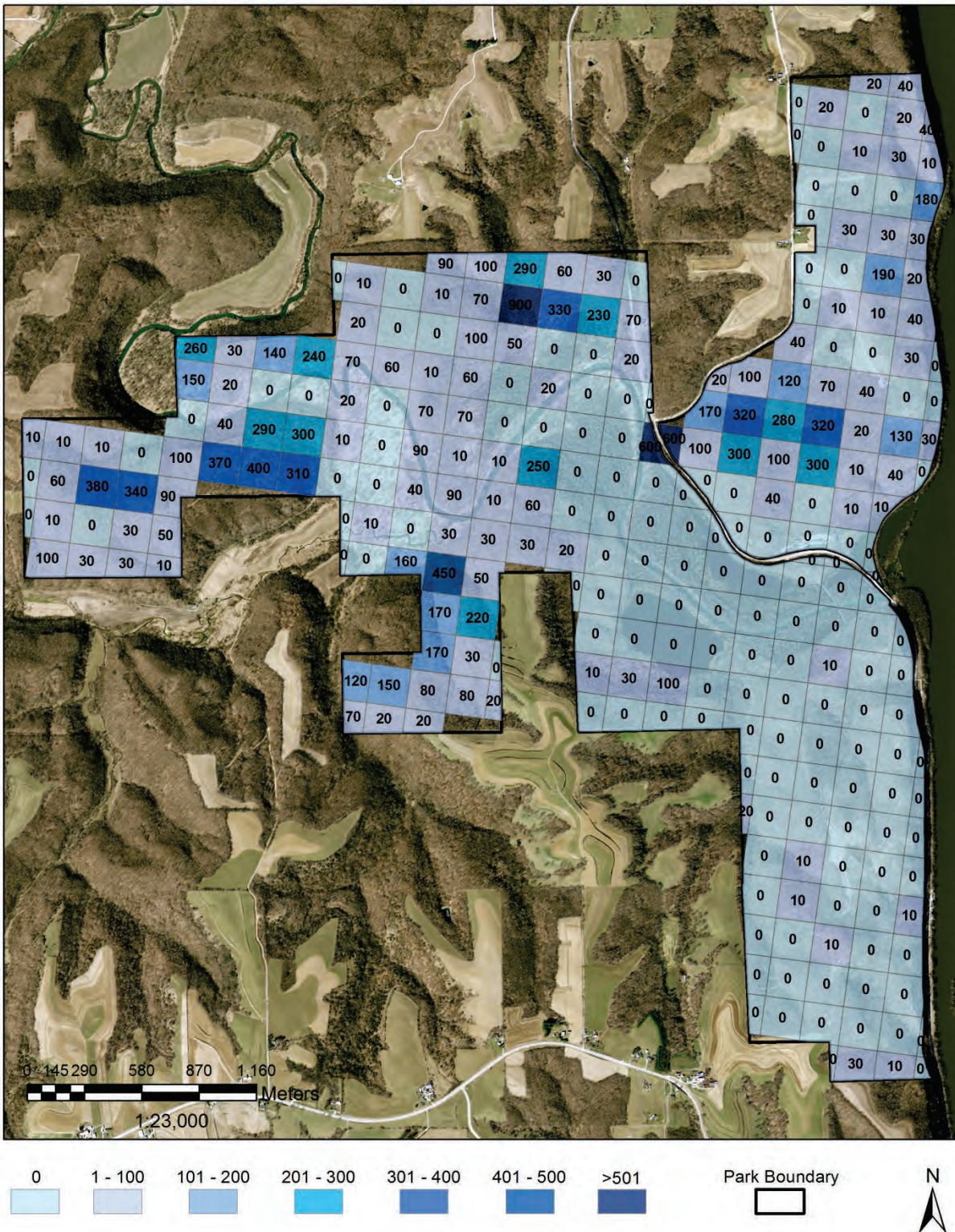


Figure 2: Distribution of garlic mustard (*Alliaria petiolata*) along with abundance estimates (m²) shown in grid cells as recorded during the 2012 survey for Effigy Mounds National Monument.

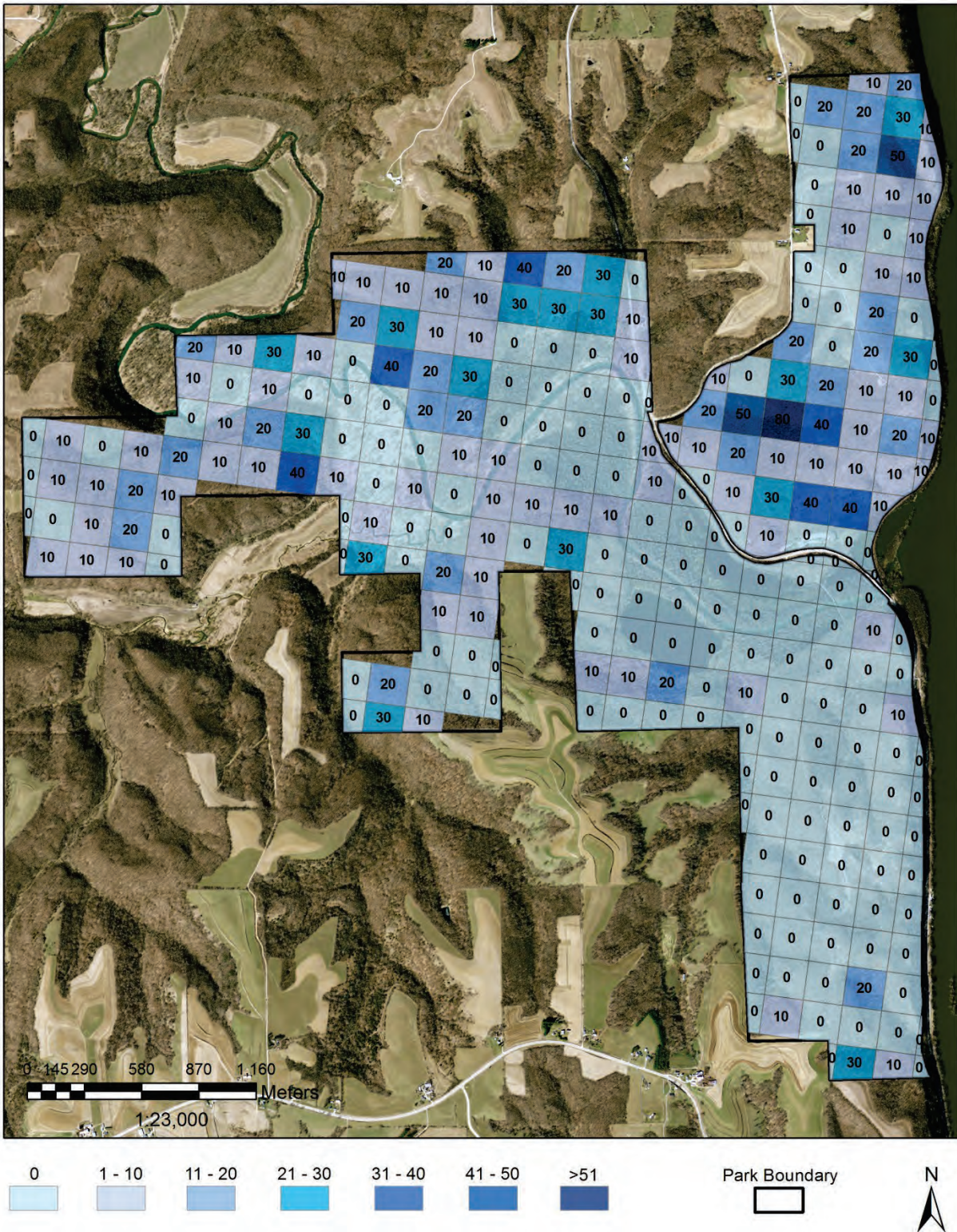


Figure 3: Distribution of garlic mustard (*Alliaria petiolata*) along with abundance estimates (m^2) shown in grid cells as recorded during the 2015 survey for Effigy Mounds National Monument.

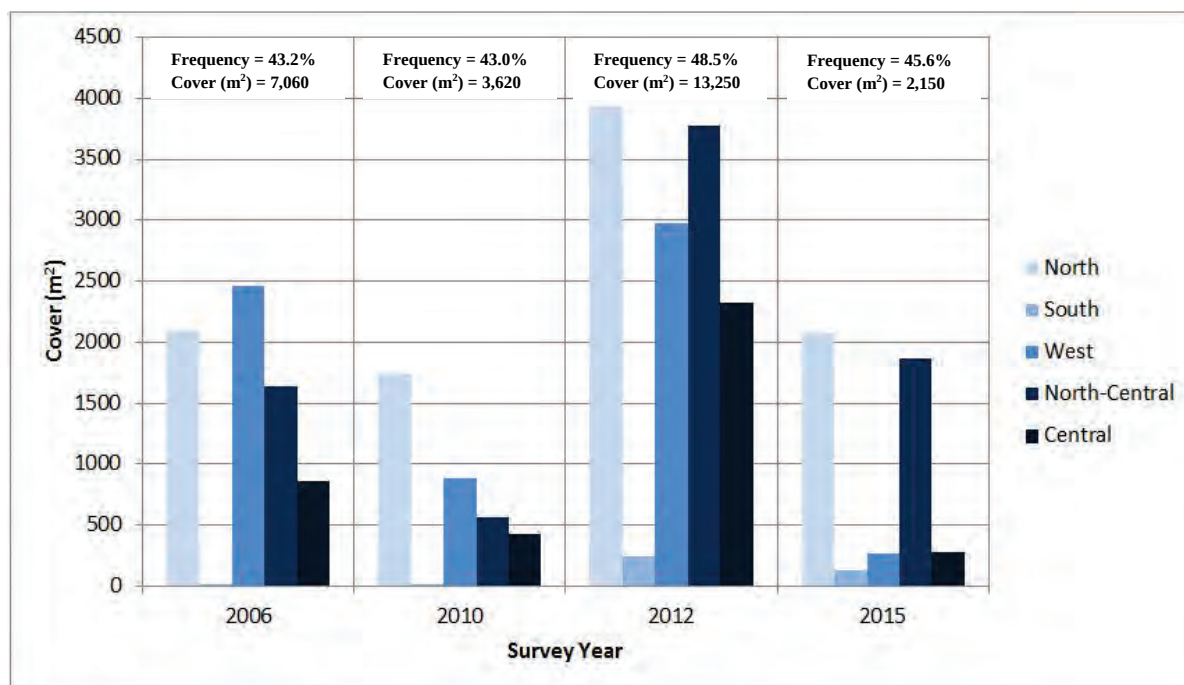


Figure 4: Chart illustrating the abundance of garlic mustard (*Alliaria petiolata*) per assessment area during each survey year.

Table 1: Incidence of occurrence (n = 222 in 2006, n = 272 in 2010, 2012 and 2015) as determined by the number of positive findings of garlic mustard (*Alliaria petiolata*) on transects for all four surveys.

Incidence of Occurrence	# of Transects	Percent of Transects
0	102	37.5%
1	31	11.4%
2	37	13.6%
3	44	16.2%
4	58	21.3%

Table 2: Pair-wise incidence of reoccurrence of garlic mustard (*Alliaria petiolata*) in previously occupied transects.

Year	2006 (n=96)	2010 (n=117)	2012 (n=132)	2015 (n=124)
2006	-	-	-	-
2010	81.3%	-	-	-
2012	81.3%	83.7%	-	-
2015	78.1%	76.9%	74.2%	-

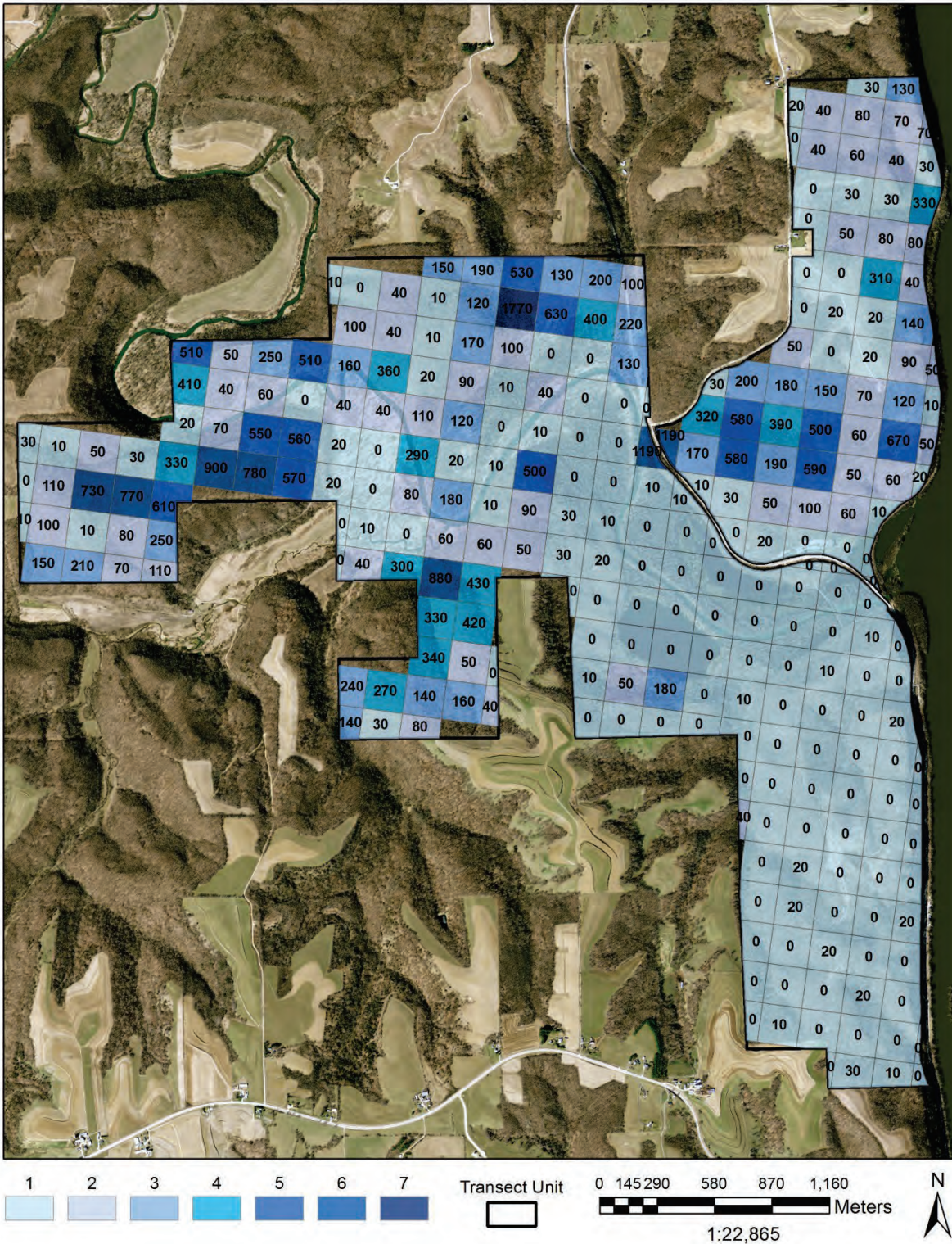


Figure 5: Cumulative absolute cover change in garlic mustard (*Alliaria petiolata*) cover as recorded in each transect during four surveys (2006, 2010, 2012, 2015). Change classes are as follows: 1=0-30 m², 2=31-110 m², 3=111-220 m², 4=221-340 m², 5=341-430 m², 6=431-670 m², 7≥671 m².

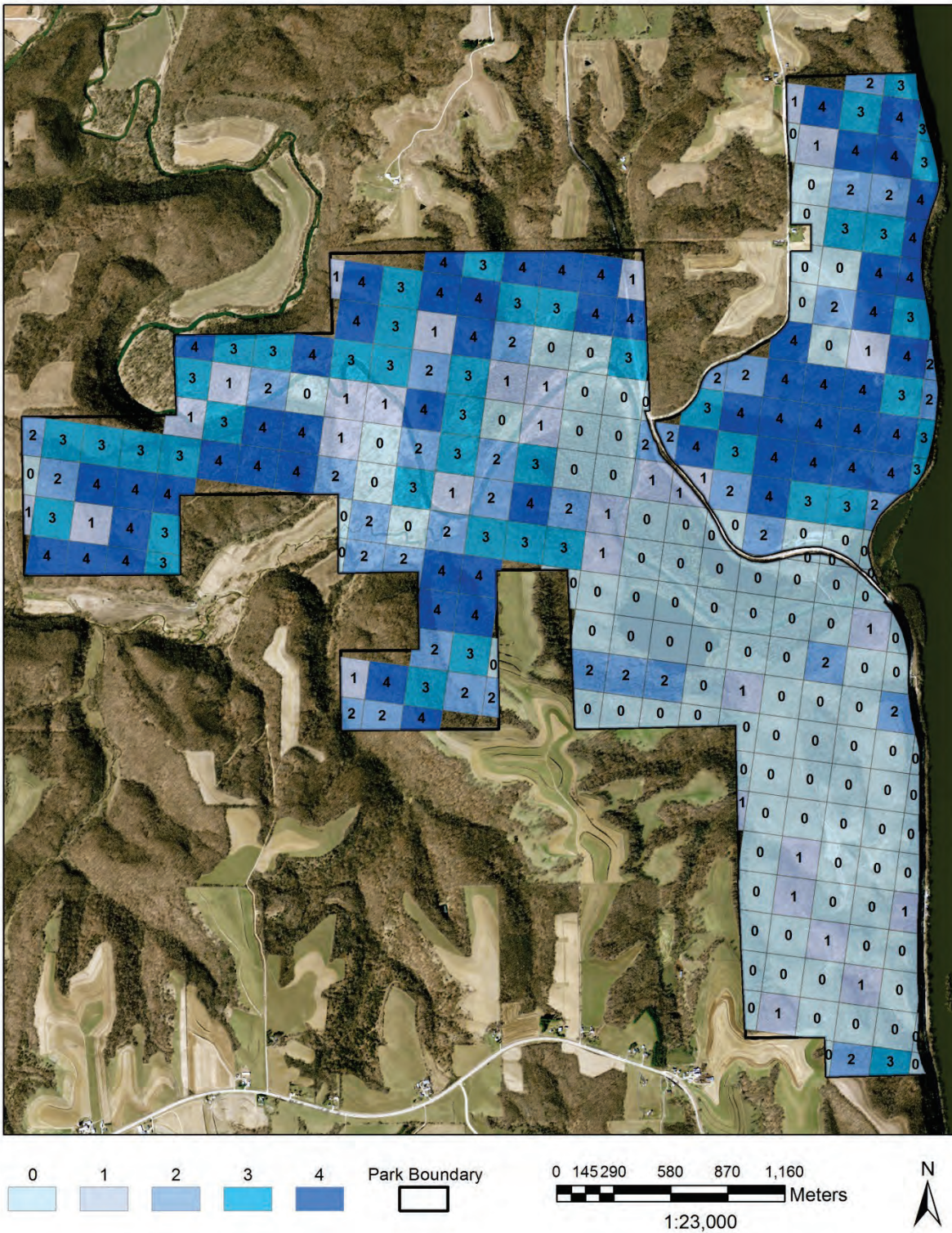


Figure 6: Location of transects along with incidence of garlic mustard (*Alliaria petiolata*) occurrence across four surveys (2006, 2010, 2012, 2015) identified on each transect.

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