National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Invasive Exotic Plant Monitoring at Hopewell Culture National Historical Park: Year 1 (2008)

Natural Resource Technical Report NPS/HTLN/NRTR—2008/148
NPS D-60

ON THE COVER. Early Spring view of the Scioto River at Hopewell Culture National Historical Park. Photo from Heartland Network Files.

Invasive Exotic Plant Monitoring at Hopewell Culture National Historical Park: Year 1 (2008)

Natural Resource Technical Report NPS/HTLN/NRTR—2008/148

Craig C. Young, Jennifer L. Haack, and Melanie S. Weber
National Park Service, Heartland I&M Network
Wilson's Creek National Battlefield, 6424 West Farm Road 182, Republic, MO 65738

December 2008

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The Natural Resource Publication series addresses natural resource topics that are of interest and applicability to a broad readership in the National Park Service and to others in the management of natural resources, including the scientific community, the public, and the NPS conservation and environmental constituencies. Manuscripts are peer-reviewed to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and is designed and published in a professional manner.

The Natural Resource Technical Report series is used to disseminate the peer-reviewed results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service's mission. The reports provide contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations. Current examples of such reports include the results of research that addresses natural resource management issues; natural resource inventory and monitoring activities; resource assessment reports; scientific literature reviews; and peer reviewed proceedings of technical workshops, conferences, or symposia.

Views, statements, findings, conclusions, recommendations and data in this report are solely those of the author(s) and do not necessarily reflect views and policies of the U.S. Department of the Interior, National Park Service. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

Printed copies of reports in these series may be produced in a limited quantity and they are only available as long as the supply lasts. This report is also available from the Heartland I&M Network and NRPM websites (http://www.nature.nps.gov/im/units/HTLN and http://www.nature.nps.gov/publications/NRPM/index.cfm, respectively) on the internet, or by sending a request to the address on the back cover.

Please cite this publication as:

Young, C.C., J.L. Haack, and M.S. Weber. 2008. Invasive exotic plant monitoring at Hopewell Culture National Historical Park: Year 1 (2008). Natural Resource Technical Report NPS/HTLN/NRTR—2008/148. National Park Service, Fort Collins, Colorado.

NPS D-60, December 2008

Contents

Executive Summary iv

Acknowledgements v

Introduction 1

Methods 3

Results and Discussion 4

Literature Cited 5

Executive Summary

In summary, this report provides information on invasive exotic plant abundance and distribution, as well as their ecological impacts and management difficulty to assist park natural resource managers in planning invasive exotic plant management on Hopewell Culture National Historical Park. During surveys in 2008, Davey Resource Group documented 34 high priority invasive plant species on Hopewell Culture National Historical Park. Three of these plant species were not previously documented as occurring on the park based on NPSpecies, the service-wide database for plant information. Japanese honeysuckle, the most abundant invasive plant on Hopewell Culture National Historical Park, covered between 0.75 and 10.4 acres in the forests and restored prairies. Of the 34 invasive plant species, 26 occurred in fewer than 25% of transects and occupied less than 1 acre. The relatively low cover of these species is encouraging and suggests that eradication or at least successful control may be a viable management option for some species.

Acknowledgements

Davey Resource Group conducted all field work associated with this project. We thank project manager Dave Riddell and GIS supervisor Deborah Sheeler for management of this project. We thank Kristen Bates for covering transects through some dense forests in search of high priority invasive plants on Hopewell Culture National Historical Park.

Introduction

Author's note. In this report, we use the term invasive exotic plant to refer to plants that are not native to the park and that are presumed to pose environmental harm to native plant populations or communities based on a review of numerous state and regional invasive exotic plant lists. The great majority of the introductory text was taken from Welch and Geissler (2007) with slight modification.

Scope of invasive exotic plant problem for National Parks

Globalization of commerce, transportation, human migration, and recreation in recent history has introduced invasive exotic species to new areas at an unprecedented rate. Biogeographical barriers that once restricted the location and expansion of species have been circumvented, culminating in the homogenization of the Earth's biota. Although only 10% of introduced species become established and only 1% become problematic (Williamson 1993, Williamson and Fitter 1996) or invasive, nonnative species have profound impacts worldwide on the environment, economies, and human health. Invasive species have been directly linked to the replacement of dominant native species (Tilman 1999), the loss of rare species (King 1985), changes in ecosystem structure, alteration of nutrient cycles and soil chemistry (Ehrenfeld 2003), shifts in community productivity (Vitousek 1990), reduced agricultural productivity, and changes in water availability (D'Antonio and Mahall 1991). Often the damage caused by these species to natural resources is irreparable and our understanding of the consequences incomplete. Invasive species are second only to habitat destruction as a threat to wildland biodiversity (Wilcove et al. 1998). Consequently, the dynamic relationships among plants, animals, soil, and water established over many thousands of years are at risk of being destroyed in a relatively brief period.

For the National Park Service (NPS), the consequences of these invasions present a significant challenge to the management of the agency's natural resources "unimpaired for the enjoyment of future generations." National Parks, like other land management organizations, are deluged by new exotic species arriving through predictable (e.g., road, trail, and riparian corridors), sudden (e.g., long-distance dispersal through cargo containers and air freight), and unexpected anthropogenic pathways (e.g., weed seeds in restoration planting mixes). Nonnative plants claim an estimated 4,600 acres of public lands each year in the United States (Asher and Harmon 1995), significantly altering local flora. For example, exotic plants comprise an estimated 43% and 36% of the flora of the states of Hawaii and New York, respectively (Rejmanek and Randall 1994). Invasive plants infest an estimated 2.6 million acres of the 83 million acres managed by the NPS.

More NPS lands are infested daily despite diligent efforts to curtail the problem. Impacts from invasive species have been realized in most parks, resulting in an expressed need to control existing infestations and restore affected ecosystems. Additionally, there is a growing urgency to be proactive—to protect resources not yet impacted by current and future invasive species (Marler 1998). Invasive exotic species most certainly will continue to be a management priority for the National Parks well into the 21st Century. Invasive exotic plants have been consistently ranked as a top vital sign for long term monitoring as part of the NPS Inventory & Monitoring (I&M) Program. During this process, invasive exotic plant monitoring was recognized across all network parks as the most important shared monitoring need.

Prevention and early detection as keys to invasive exotic plant management

Prevention and early detection are the principal strategies for successful invasive exotic plant management. While there is a need for long-term suppression programs to address very high-impact species, eradication efforts are most successful for infestations less than one hectare in size (Rejmanek and Pitcairn 2002). Eradication of infestations larger than 100 hectares is largely unsuccessful, costly, and unsustainable (Rejmanek and Pitcairn 2002). Costs, or impacts, to ecosystem components and processes resulting from invasion also increase dramatically over time, making ecosystem restoration improbable in the later stages of invasion. Further, in their detailed review of the nonnative species problem in the United States, the US Congress, Office of Technology Assessment (1993) stated that the environmental and economic benefits of supporting prevention and early detection initiatives significantly outweigh any incurred costs, with the median benefit-to-cost ratio being 17:1 in favor of being proactive.

Although preventing the introduction of invasive exotic plants is the most successful and preferred strategy for resource managers, the realities of globalization, tight fiscal constraints, and limited staff time guarantee that invaders will get through park borders. Fortunately, invasive exotic plants quite often undergo a lag period between introduction and subsequent colonization of new areas. Managers, then, can take advantage of early detection monitoring to make certain invasive exotic species are found and successfully eradicated before populations become well established.

This strategy requires resource managers to: (1) detect invasive exotic species early (i.e., find a new species or an incipient population of an existing species while the infestation is small (less than 1 hectare), and (2) respond rapidly (i.e., implement appropriate management techniques to eliminate the invasive plant and all of its associated regenerative material).

Invasive exotic plant management on Hopewell Culture National Historical Park

While a complete history of park invasive exotic plant management issues is beyond the scope of this report, a few important highlights are given:

1. Hopewell Culture National Historical Park encompasses lands subject to exotic plant invasion. The park has a long history of agricultural land-use and lies in an area of increasing exurban development in the vicinity of Chillicothe, Ohio.

2. The park consists of open fields that protect archaeologically significant lands. The park protects numerous mounds associated with Native American cultures during the period 200 B.C.E. to 500 C.E. Park managers have restored some old fields to a mixture of native warm season grasses and forbs. Forests are found along stream corridors and in areas with steeper topography adjacent to the old fields. The restored prairies and forests are known to support several invasive exotic plants.

3. Controlling invasive exotic plants on Hopewell Culture National Historical Park stands as an ongoing challenge for park natural resource managers.

Methods

Target species

The invasive exotic plants on two watch lists were the high priority species sought during monitoring (Table 1). Invasive exotic plants not known to occur on the park based on NPSpecies (the national NPS database for plant occurrence registration) constitute the early detection watch list. Invasive exotic plants known to occur on the park based on NPSpecies constitute the park-established watch list. While aquatic species are listed on the watch lists, terrestrial plants were the focus of this survey. Aquatic plants were documented occasionally.

Field methods

Invasive exotic plant species on designated watch lists (Table 1) were sought in forests and restored prairies on Hopewell Culture National Historical Park (Figure 1). An observer from Davey Resource Group made three equidistant passes through search units using a Trimble GPS unit; entire polygons were not fully searched. Search units were approximately 2 acres in size. On each pass, the observer identified invasive exotic plants in a 3- to 12-m belt, using the widest belt possible given site conditions. The observer attributed a coarse cover value to each species in each search unit: 0=0, 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2. A total of 107 search units encompassing 224 acres were surveyed on Hopewell Culture National Historical Park.

Analytical methods

Occupied search units were highlighted on maps for each invasive exotic plant encountered (Figures 2 – 35). We also calculated plant frequency and cover. The frame-wide frequency of invasive exotic plants was calculated as the percentage of occupied search units. A frame-wide cover range was calculated to estimate the abundance of each invasive exotic plant species identified using estimates of the park fraction observed:

$$\textit{fraction of park observed} = \frac{\textit{mean transect length} * \textit{number of search units} * \textit{belt width}}{\textit{reference frame area}}$$

The reference frame consisted of the total area included in search units. To calculate the minimum frame-wide cover for each species, the lower endpoints of the cover class values assigned to a species along each transect search were summed and divided by the fraction of park observed assuming that a 12-m belt was surveyed. Maximum cover was calculated using the upper endpoints of the cover values in each search unit and assumed that a 3-m belt was surveyed.

Invasiveness ranks

In order to provide additional information on the ecological impact and feasibility of control, the ecological impact and general management difficulty sub-ranks that constitute the invasiveness rank (I-rank), as determined by NatureServe (Morse et al. 2004), were listed when available. The ecological impact characterizes the effect of the plant on ecosystem processes, community composition and structure, native plant and animal populations, and the conservation significance of threatened biodiversity. General management difficulty ranks are assigned based on the resources and time generally required to control a plant, the non-target effects of control

on native populations, and the accessibility of invaded sites. Sub-ranks are given as high (H), medium (M), low (L), insignificant (I), unknown (U), or a combination of ranks.

Results and Discussion

In 2008, a total of 34 invasive exotic plant taxa were found during the survey on Hopewell Culture National Historical Park (Table 2). Of these plants, 31 taxa (91.1%) were known to occur on the park based on the NPSpecies database. Autumn olive (*Elaeagnus umbellata*), burningbush (*Euonymus alata*), and reed canarygrass (*Phalaris arundinacea*) were not previously included on the park-established watch list. These species will be entered in NPSpecies and should subsequently be included on the park-established watch list.

The distribution and abundance of the invasive exotic plant species on Hopewell Culture National Historical Park varied. The invasive species were widespread with 4 species (11.8%) found in over half of all search units and 8 species (23.5%) found in over a quarter of all search units. Few species, however, were highly abundant. The most abundant species were garlic mustard (*Alliaria petiolata*), Japanese honeysuckle (*Lonicera japonica*), Amur honeysuckle (*Lonicera maackii*), and multiflora rose (*Rosa multiflora*). Twelve species occupied a maximum of 0.1 acres or less. The relatively low cover of these species is encouraging and suggests that eradication or at least successful control may be a viable management option.

Three species were noted as having unambiguously high ecological impact: reed canarygrass, autumn olive, and cheatgrass (*bromus tectorum*). Ten species were characterized as having high-medium, high-low, or medium ecological impact. The remaining species had ambiguous medium-low ecological impacts or less, including nine species with low or insignificant impacts. The feasibility of control often strongly influences decisions regarding invasive exotic plant management. Autumn olive, for example, has high ecological impacts but low management difficulty. Controlling this species will likely provide a relatively large benefit for the management costs. Cheatgrass and reed canarygrass pose greater management challenges. Reed canarygrass, however, occupies relatively little area on Hopewell Culture National Historical Park, which also offers an opportunity for early control that may limit future spread.

Literature Cited

Asher, J. A., and D. W. Harmon. 1995. Invasive exotic plants are destroying the naturalness of U.S. Wilderness areas. International Journal of Wilderness 1:35-37.

D'Antonio, C. M., and B. E. Mahall. 1991. Root profiles and competition between the invasive, exotic perennial, *Carpobrotus edulis*, and two native shrub species in California coastal scrub. American Journal of Botany 78:885-894.

DeBacker, M.D., C.C. Young (editor), P. Adams, L. Morrison, D. Peitz, G.A. Rowell, M. Williams, and D. Bowles. 2005. Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program Vital Signs Monitoring Plan. National Park Service, Heartland Inventory and Monitoring Network and Prairie Cluster Prototype Monitoring Program, Wilson's Creek National Battlefield, Republic, Missouri. 104 pp. plus appendices.

Ehrenfeld, J.G. 2003. The effects of exotic plant invasions on soil nutrient cycling processes. Ecosystems 6:503-523.

King, W. B. 1985. Island birds: will the future repeat the past? Pages 3-15 *in* P. J. Moors, editor. Conservation of Island Birds. International Council for Bird Preservation. Cambridge University Press, Cambridge, UK.

Marler, M. 1998. Exotic plant invasions of federal Wilderness areas: current status and future directions. The Aldo Leopold Wilderness Research Institute. Rocky Mountain Research Station, Missoula, Montana, USA.

Office of Technology Assessment. 1993. Harmful non-indigenous species in the United States. OTA-F-565. U.S. Congress, Government Printing Office, Washington, D.C., USA.

Rejmanek, M., and M. J. Pitcairn. 2002. When is eradication of exotic pest plants a realistic goal? Pages 249-253 in C. R. Veitch and M. N. Clout, editors. Turning the Tide: the Eradication of Invasive Species. IUCN SSC Invasive Species Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Rejmanek, M., and J. M. Randall. 1994. Invasive alien plants in California: 1993 summary and comparison with other areas in North America. Madrono 41:161–177.

Tilman, D. 1999. The ecological consequences of changes in biodiversity: a search for general principles. Ecology 80:1455-1474.

Vitousek, P. M. 1990. Biological invasions and ecosystem processes: towards an integration of population biology and ecosystem studies. Oikos 57:7-13.

Welch, B.A. and P.H. Geissler. 2007. Early detection of invasive plants: a handbook. United States Geological Survey draft. http://www.pwrc.usgs.gov/brd/invasiveHandbook.cfm.

Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. Bioscience 48:607–615.

Williamson, M. 1993. Invaders, weeds and risk from genetically modified organisms. Experientia 49:219–224.

Williamson, M. and A. Fitter. 1996. The varying success of invaders. Ecology 77:1661–1666.

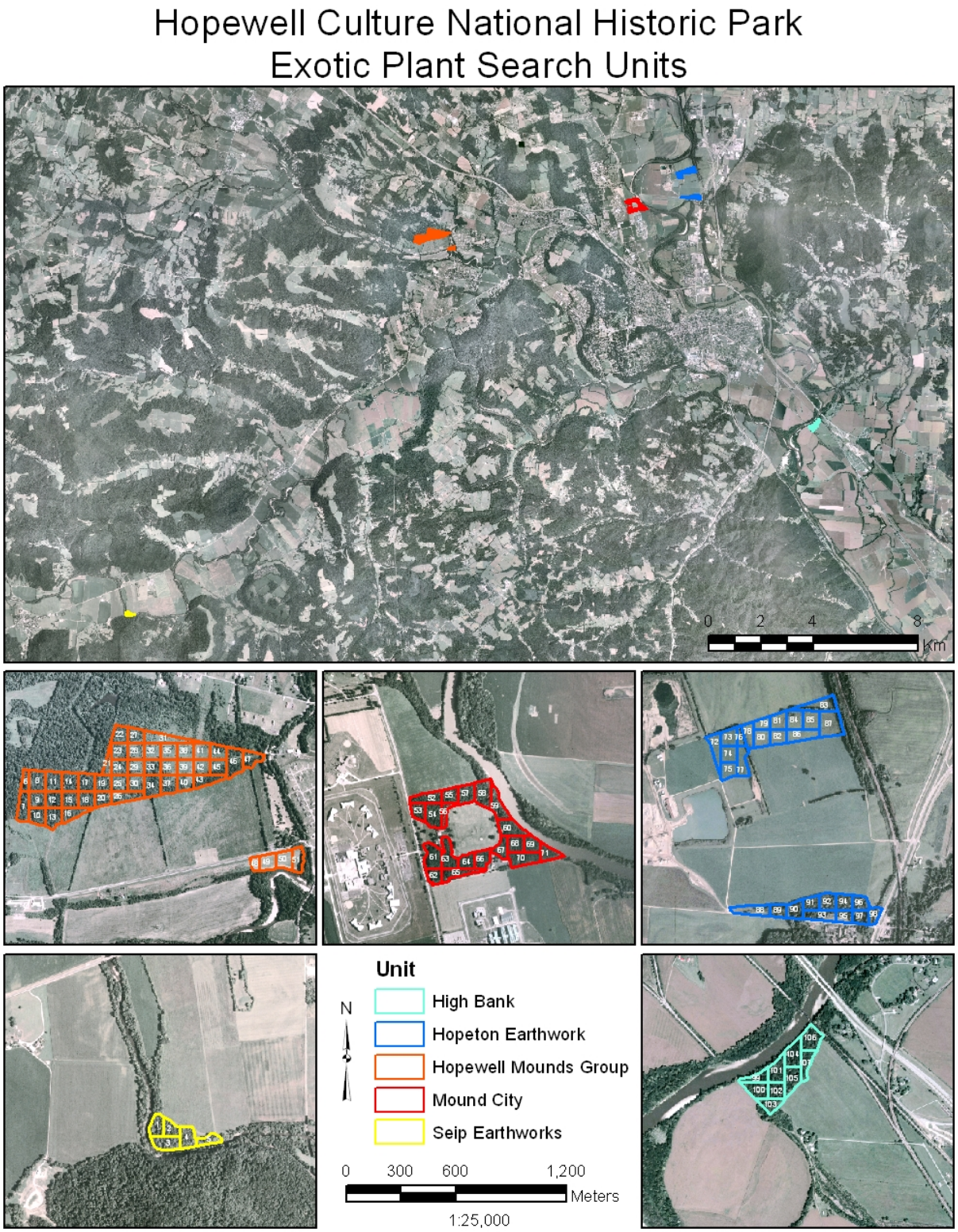

Figure 1. Invasive plant search units (n=107) on Hopewell Culture National Historical Park. Search units focused on restored prairies and intact forests on the park.

Table 1. Watch lists for Hopewell Culture National Historical Park.

Early Detection Watch List		**Park-Established Watch List**	
Acer ginnala	Amur maple	*Ailanthus altissima*	Tree of heaven
Acer platanoides	Norway maple	*Albizia julibrissin*	Silktree
Aegopodium podagraria	Bishop's goutweed	*Alliaria petiolata*	Garlic mustard
Alnus glutinosa	European alder	*Arctium minus*	Lesser burdock
Ampelopsis brevipedunculata	Amur peppervine	*Berberis thunbergii*	Japanese barberry
Bromus sterilis	Poverty brome	*Bromus inermis*	Smooth Brome
Butomus umbellatus	Flowering rush	*Bromus tectorum*	Cheatgrass
Celastrus orbiculatus	Oriental bittersweet	*Carduus nutans*	Nodding plumeless thistle
Centaurea biebersteinii	Spotted knapweed	*Cirsium arvense*	Canada thistle
Centaurea solstitialis	Yellow star-thistle	*Cirsium vulgare*	Bull thistle
Coronilla varia	Crownvetch	*Daucus carota*	Queen Anne's lace
Cynanchum louiseae	Louise's swallow-wort	*Dipsacus fullonum*	Fuller's teasel
Dioscorea oppositifolia	Chinese yam	*Elaeagnus angustifolia*	Russian olive
Dipsacus laciniatus	Cutleaf teasel	*Glechoma hederacea*	Ground ivy
Egeria densa	Brazilian waterweed	*Hemerocallis fulva*	Orange daylily
Elaeagnus umbellata	Autumn olive	*Hesperis matronalis*	Dames rocket
Elymus repens	Quackgrass	*Hypericum perforatum*	Common St. Johnswort
Euonymus alata	Burningbush	*Leonurus cardiaca*	Common motherwort
Euonymus fortunei	Winter creeper	*Ligustrum vulgare*	European privet
Euphorbia cyparissias	Cypress spurge	*Lonicera japonica*	Japanese honeysuckle
Euphorbia esula	Leafy spurge	*Lonicera maackii*	Amur honeysuckle
Frangula alnus	Glossy buckthorn	*Lonicera tatarica*	Tatarian honeysuckle
Hedera helix	English ivy	*Lysimachia nummularia*	Creeping jenny
Holcus lanatus	Common velvetgrass	*Melilotus officinalis*	Sweetclover
Humulus japonicus	Japanese hop	*Morus alba*	White mulberry
Iris pseudacorus	Paleyellow iris	*Pastinaca sativa*	Wild parsnip
Lespedeza bicolor	Shrub lespedeza	*Paulownia tomentosa*	Princesstree
Lespedeza cuneata	Sericea lespedeza	*Poa pratensis*	Kentucky bluegrass
Ligustrum obtusifolium	Border privet	*Potentilla recta*	Sulphur cinquefoil
Linaria vulgaris	Butter and eggs	*Prunus mahaleb*	Mahaleb cherry
Lolium arundinaceum	Tall fescue	*Robinia pseudoacacia*	Black locust
Lolium pratense	Meadow fescue	*Rosa multiflora*	Multiflora rose
Lolium spp	Ryegrass	*Rumex acetosella*	Common sheep sorrel

Table 1 (cont.). Watch lists for Hopewell Culture National Historical Park.			
Early Detection Watch List		**Park-Established Watch List**	
Lonicera morrowii	Morrow's honeysuckle	*Rumex crispus*	Rumex crispus
Lonicera X bella	Showy fly honeysuckle	*Saponaria officinalis*	Bouncingbet
Lotus corniculatus	Bird's-foot trefoil	*Sorghum halepense*	Johnsongrass
Lotus tenuis	Narrow-leaf bird's-food trefoil	*Torilis arvensis*	Spreading hedgeparsley
Lythrum salicaria	Purple loosestrife	*Ulmus pumila*	Siberian elm
Microstegium vimineum	Nepalese browntop	*Verbascum thapsus*	Common mullein
Miscanthus sinensis	Chinese silvergrass	*Vinca minor*	Common periwinkle
Myosotis scorpioides	True forget-me-not		
Myriophyllum aquaticum	Parrot feather watermilfoil		
Myriophyllum spicatum	Eurasian watermilfoil		
Najas minor	Brittle waternymph		
Onopordum acanthium	Scotch cottonthistle		
Phalaris arundinacea	Reed canarygrass		
Phragmites australis	Common reed		
Poa compressa	Canada bluegrass		
Polygonum cuspidatum	Japanese knotweed		
Polygonum perfoliatum	Asiatic tearthumb		
Polygonum sachalinense	Giant knotweed		
Populus alba	White poplar		
Potamogeton crispus	Curly pondweed		
Pueraria montana var. lobata	Kudzu		
Pyrus calleryana	Callery pear		
Rhamnus cathartica	Common buckthorn		
Rorippa nasturtium-aquaticum			
Sonchus arvensis	Field sowthistle		
Spiraea japonica	Japanese meadowsweet		
Tanacetum vulgare	Common tansy		
Torilis japonica	Erect hedgeparsley		
Typha angustifolia	Narrowleaf cattail		
Typha X glauca			
Viburnum opulus	European cranberrybush		
Wisteria floribunda	Japanese wisteria		

Table 2. Overview of invasive exotic plants found on Hopewell Culture National Historical Park. Ecological impact and general management difficulty ratings are based on NatureServe I-Rank subranks (Morse et al. 2004). Subranks are given as high (H), medium (M), low (L), insignigicant (I), unknown (U), or not available (--).

Scientific Name	Common Name	Watch List	Frame-wide coverage (acres)	Frequency (percent)	Ecological impact	Management difficulty
Alliaria petiolata	Garlic mustard	Park-established	0.5 – 8.9	52.3	ML	M
Arctium minus	Lesser burdock	Park-established	0.0007 – 0.03	1.9	LI	MI
Berberis thunbergii	Japanese barberry	Park-established	0.003 – 0.1	4.7	HM	I
Bromus inermis	Smooth brome	Park-established	0.02 – 0.53	12.1	M	ML
Bromus tectorum	Cheatgrass	Park-established	0.03 – 0.8	18.7	H	HM
Cirsium arvense	Canada thistle	Park-established	0.04 – 0.9	19.6	ML	HM
Cirsium vulgare	Bull thistle	Park-established	0.0008 – 0.03	3.7	ML	ML
Daucus carota	Queen Anne's lace	Park-established	0.04 – 1.2	44.9	I	I
Dipsacus fullonum	Fuller's teasel	Park-established	0.002 – 0.08	3.7	L	ML
Eleagnus umbellata	Autumn olive	Early Detection	0.2 – 3.1	30.8	H	L
Euonymus alatus	Burningbush	Early Detection	0.003 – 0.1	7.5	LI	L
Glechoma hederacea	Ground ivy	Park-established	0.3 – 4.9	32.7	MI	U
Hemerocallis fulva	Orange daylily	Park-established	0.004 – 0.1	5.6	MI	L
Hesperis matronalis	Dames rocket	Park-established	0.003 – 0.1	4.7	MI	HL
Leonurus cardiaca	Common motherwort	Park-established	0.00006 – 0.002	0.9	--	--
Ligustrum vulgare	European privet	Park-established	0.004 – 0.16	8.4	HL	HM
Lonicera japonica	Japanese honeysuckle	Park-established	0.8 – 10.4	59.8	M	HM
Lonicera maackii	Amur honeysuckle	Park-established	0.4 – 6.1	63.6	HM	M
Lonicera tatarica	Tatarian honeysuckle	Park-established	0.03 – 0.9	25.2	M	M
Lysimachia nummularia	Creeping jenny	Park-established	0.01 – 0.6	21.5	L	L
Melilotus officinalis	Sweetclover	Park-established	0.008 – 0.3	16.8	M	M
Morus alba	White mulberry	Park-established	0.04 – 0.9	15.9	ML	ML
Pastinaca sativa	Wild parsnip	Park-established	0.002 – 0.09	10.3	LI	L
Phalaris arundinacea	Reed canarygrass	Early Detection	0.003 – 0.1	5.6	H	HM
Poa pratensis	Kentucky bluegrass	Park-established	0.02 – 0.7	24.3	M	ML
Potentilla recta	Sulphur cinquefoil	Park-established	0.002 – 0.09	9.3	HL	ML
Prunus mahaleb	Mahaleb cherry	Park-established	0.0006 – 0.02	0.9	LI	U
Rosa multiflora	Multifora rose	Park-established	0.4 – 4.9	60.7	L	L
Robinia pseudoacacia	Black locust	Park-established	0.1 – 2.2	23.4	HM	M

Table 2 (cont.). O Overview of invasive exotic plants found on Hopewell Culture National Historical Park. Ecological impact and general management difficulty ratings are based on NatureServe I-Rank subranks (Morse et al. 2004). Subranks are given as high (H), medium (M), low (L), insignigicant (I), unknown (U), or not available (--).

Scientific Name	Common Name	Watch List	Frame-wide coverage (acres)	Frequency (percent)	Ecological impact	Management difficulty
Rumex crispus	Curly dock	Park-established	0.006 – 0.2	18.7	HM	M
Sorghum halepense	Johnsongrass	Park-established	0.007 – 0.3	12.1	ML	HM
Torilis arvensis	Spreading hedgeparsley	Park-established	0.01 – 0.5	18.7	--	--
Verbascum thapsus	Common mullein	Park-established	0.0001 – 0.005	1.9	ML	L
Vinca minor	Common periwinkle	Park-established	0.05 – 0.7	6.5	I	U

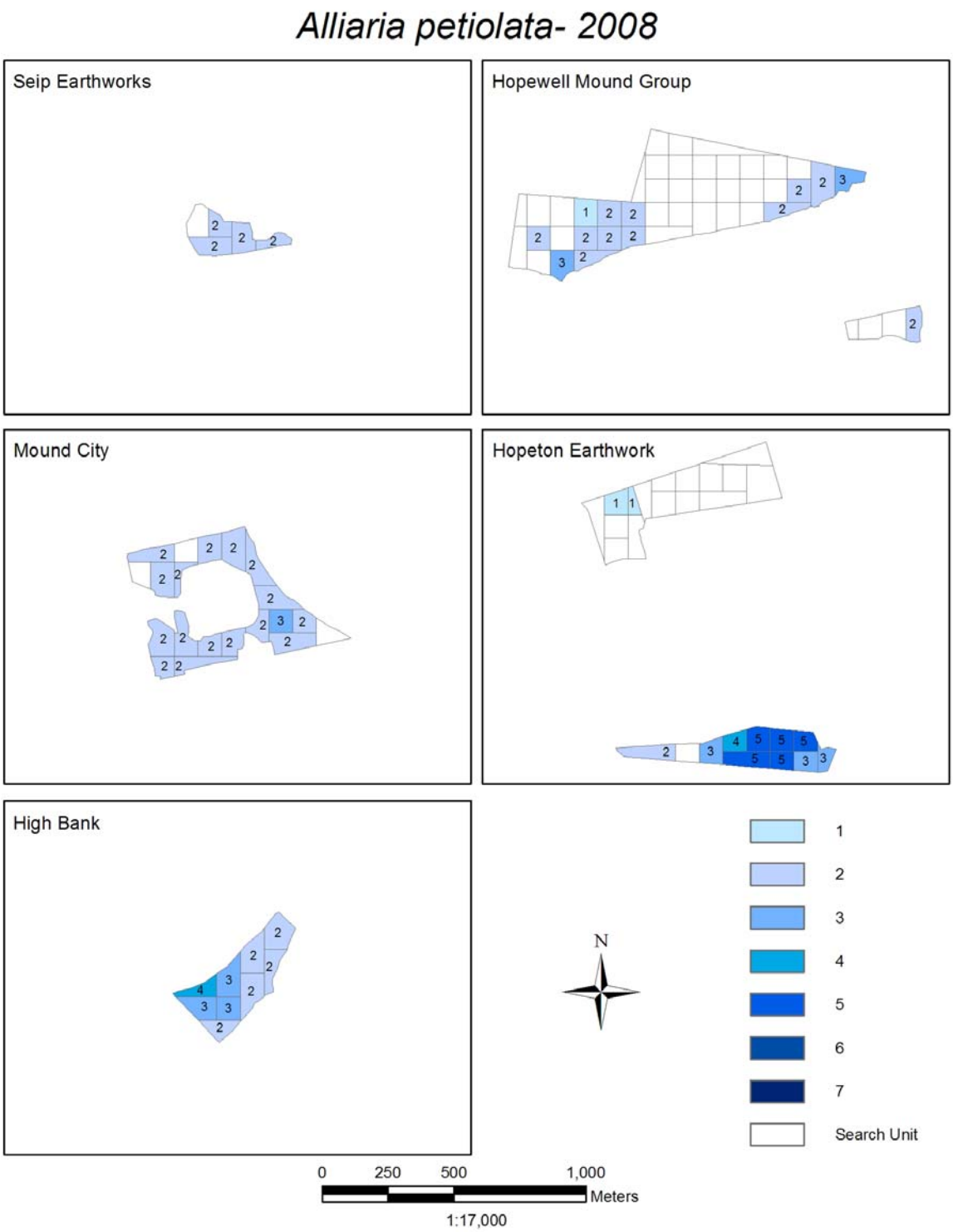

Figure 2. Abundance and distribution of *Alliaria petiolata* (garlic mustard) on Hopewell Culture National Historical Park, 2008 Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

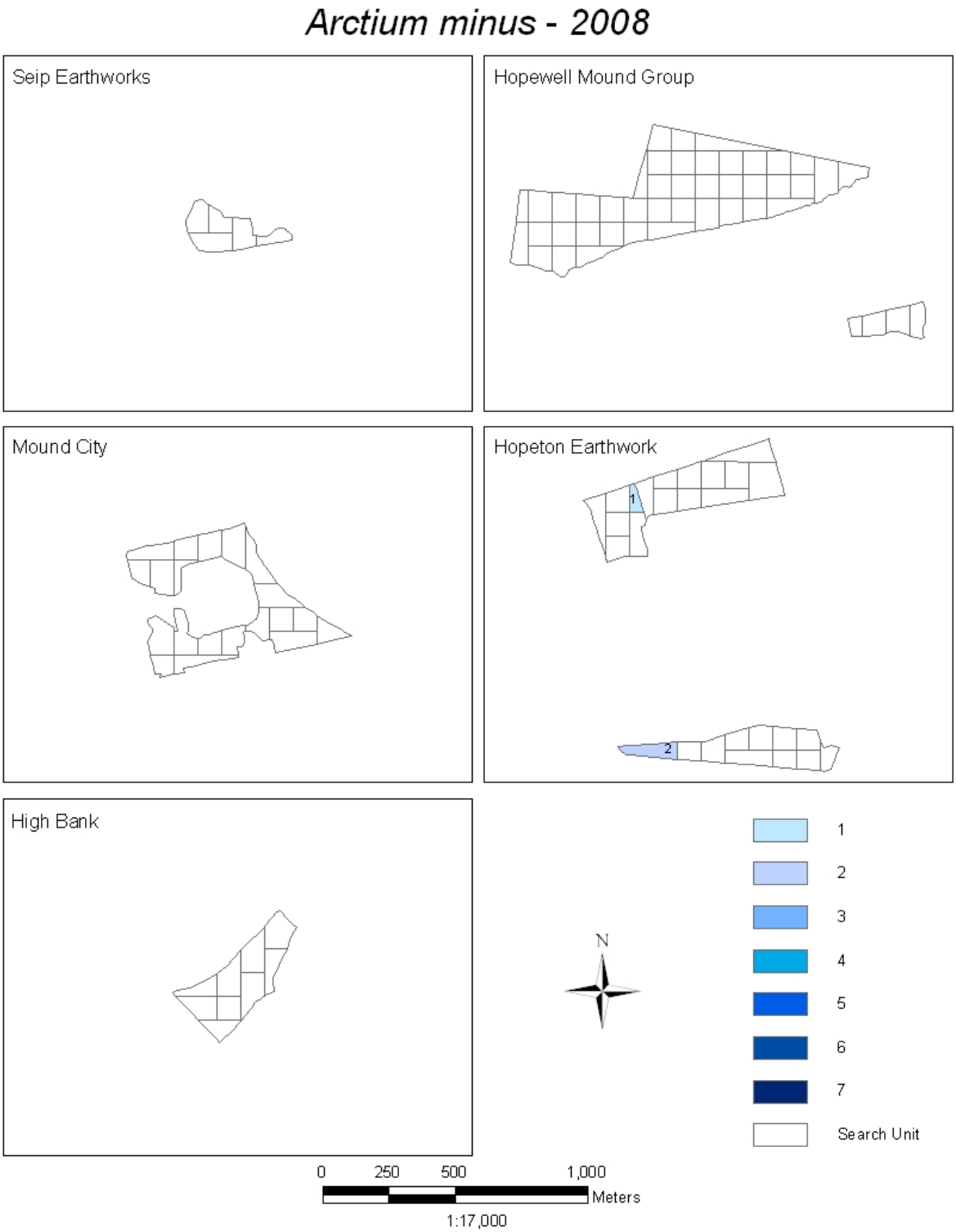

Figure 3. Abundance and distribution of *Arctium minus* (lesser burdock) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

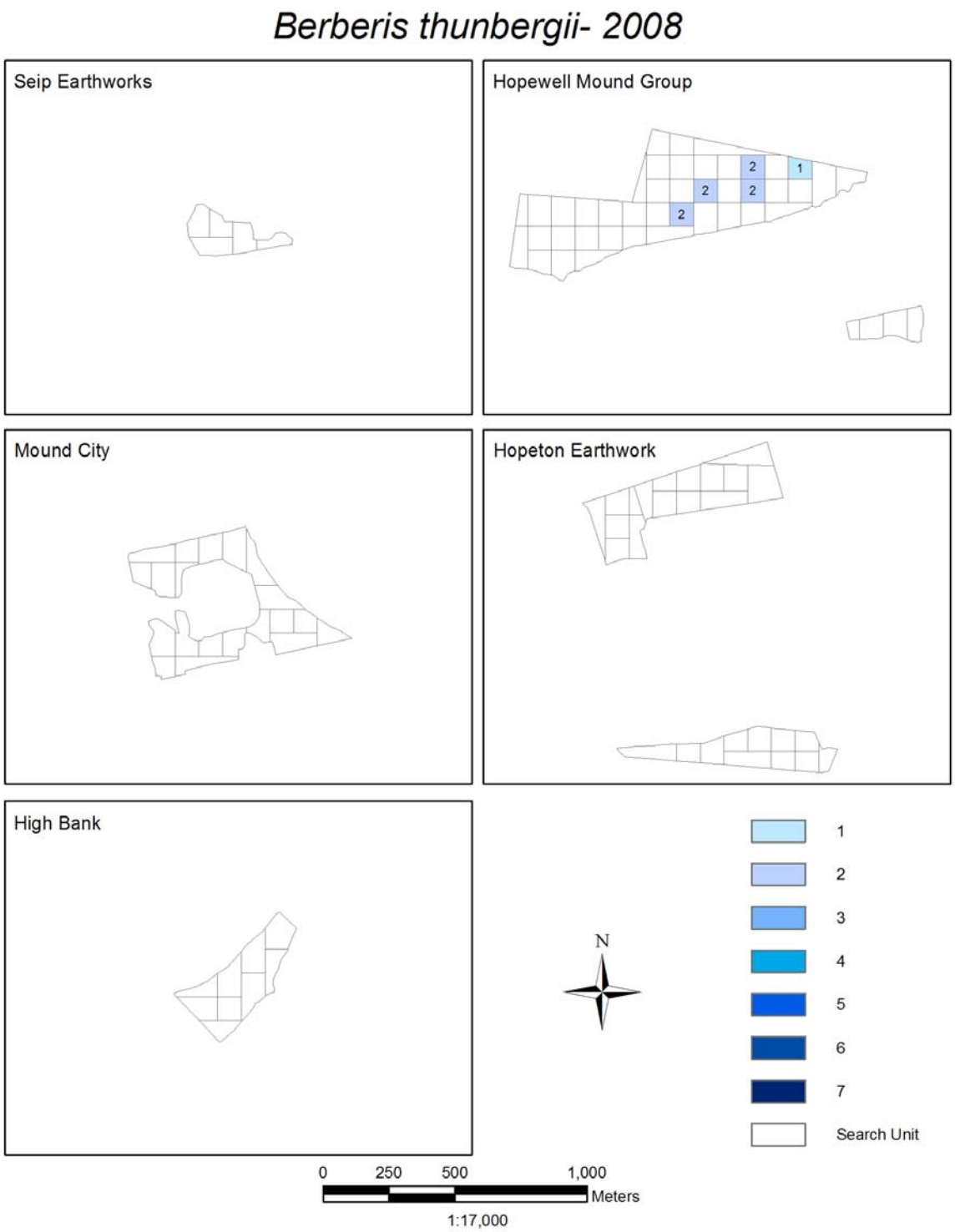

Figure 4. Abundance and distribution of *Berberis thunbergii* (eastern baccharis) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

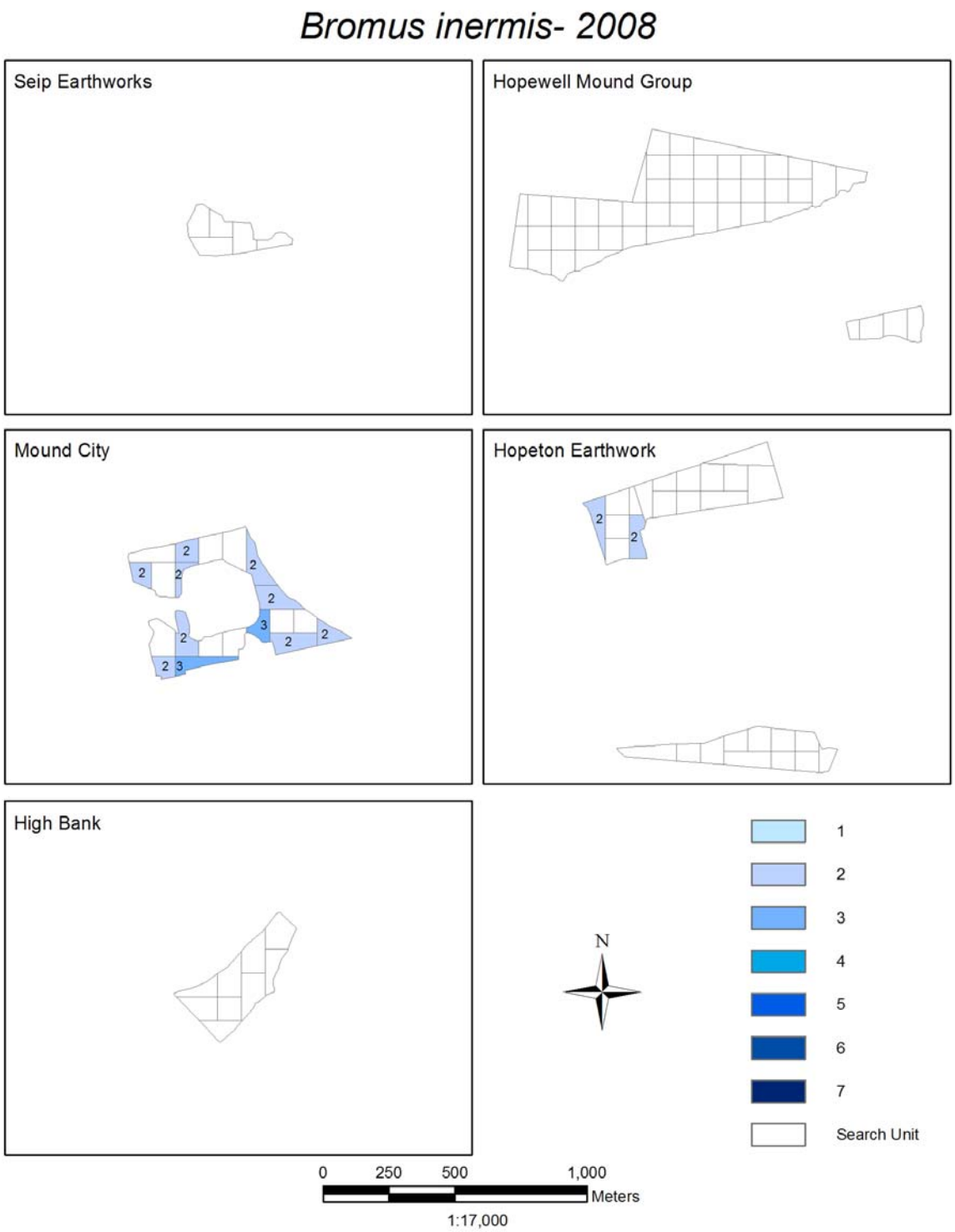

Figure 5. Abundance and distribution of *Bromus inermis* (smooth brome) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

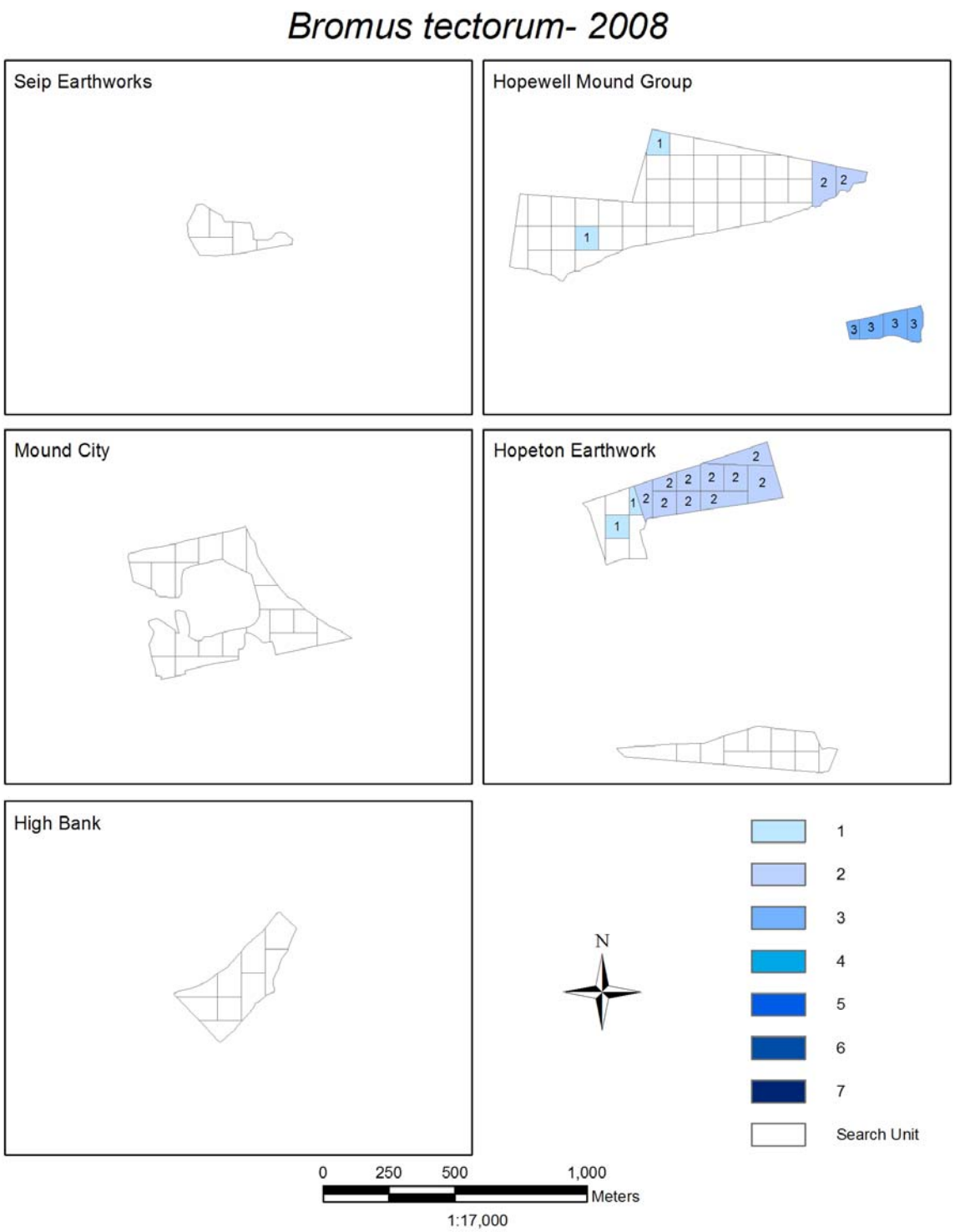

Figure 6. Abundance and distribution of *Bromus tectorum* (cheatgrass) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

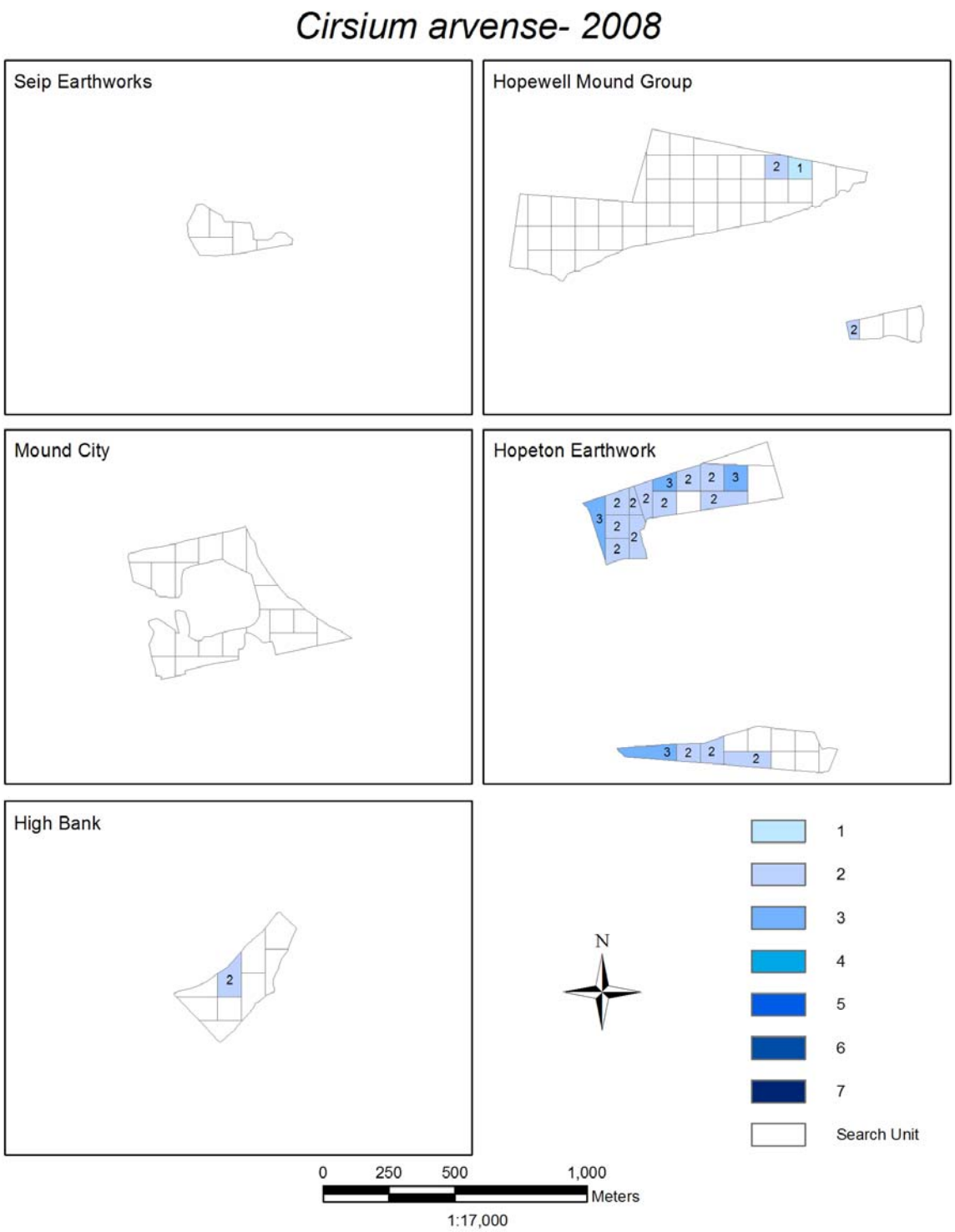

Figure 7. Abundance and distribution of *Cirsium arvense* (Canada thistle) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

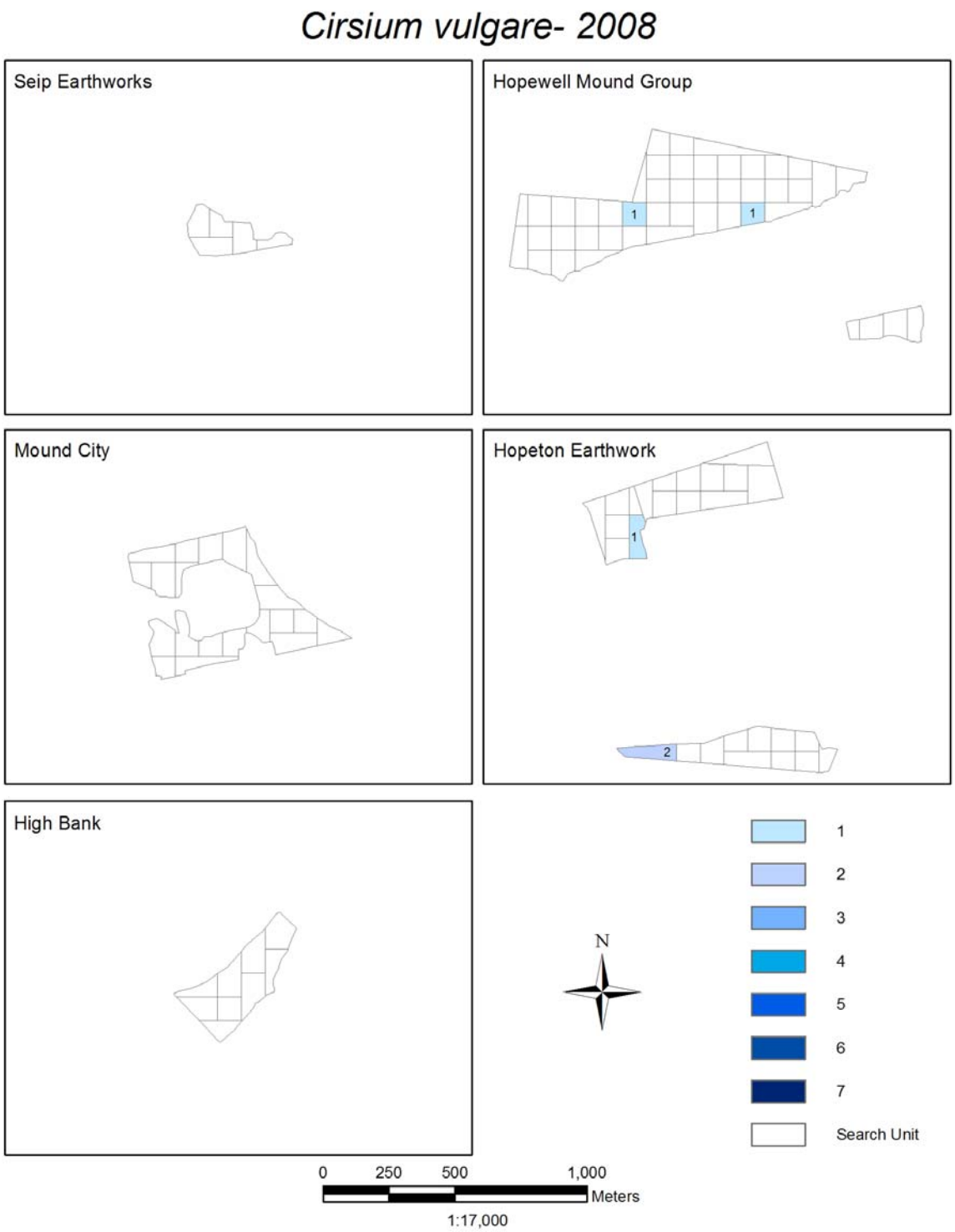

Figure 8. Abundance and distribution of *Cirsium vulgare* (bull thistle) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

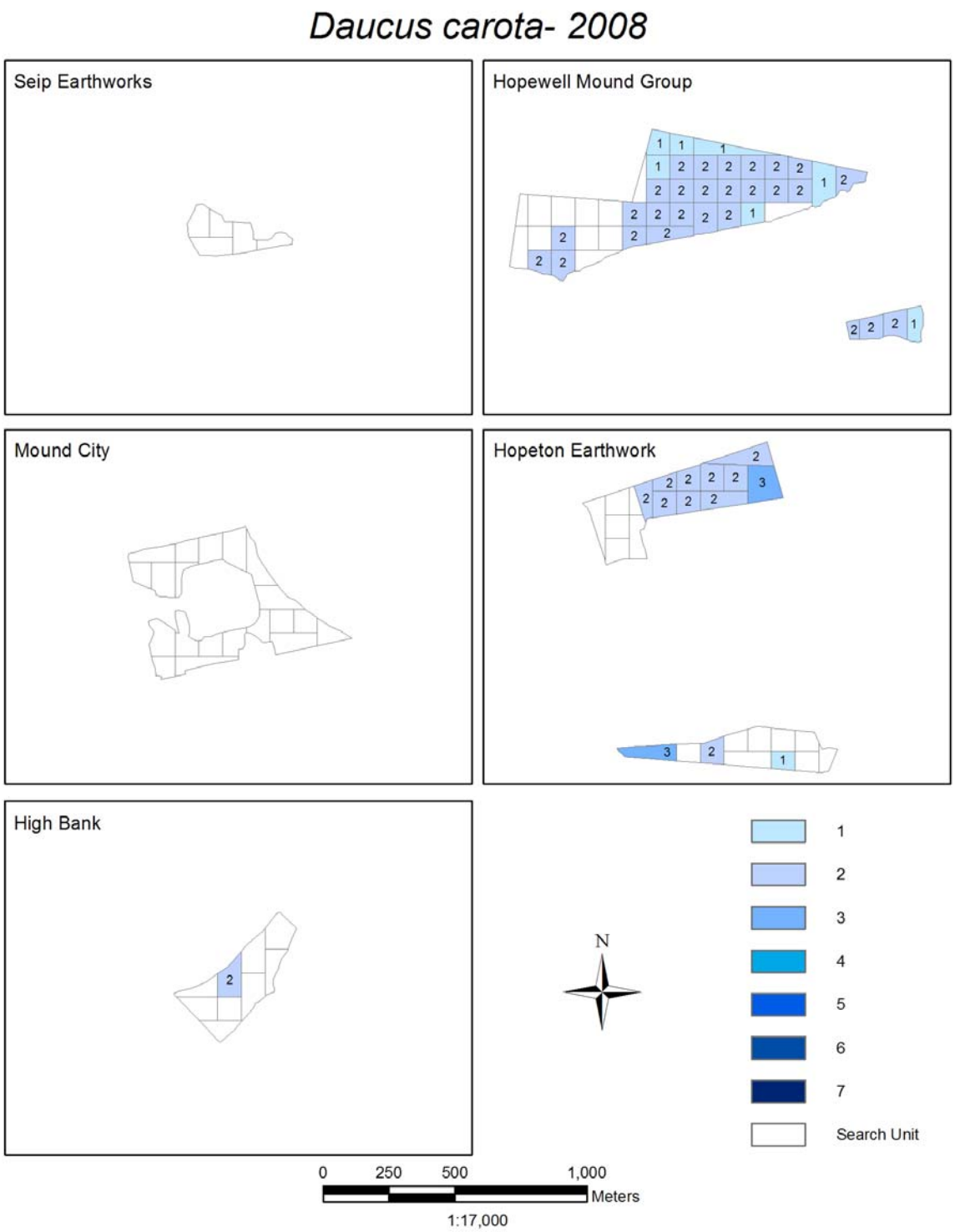

Figure 9. Abundance and distribution of *Daucus carota* (Queen Anne's lace) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

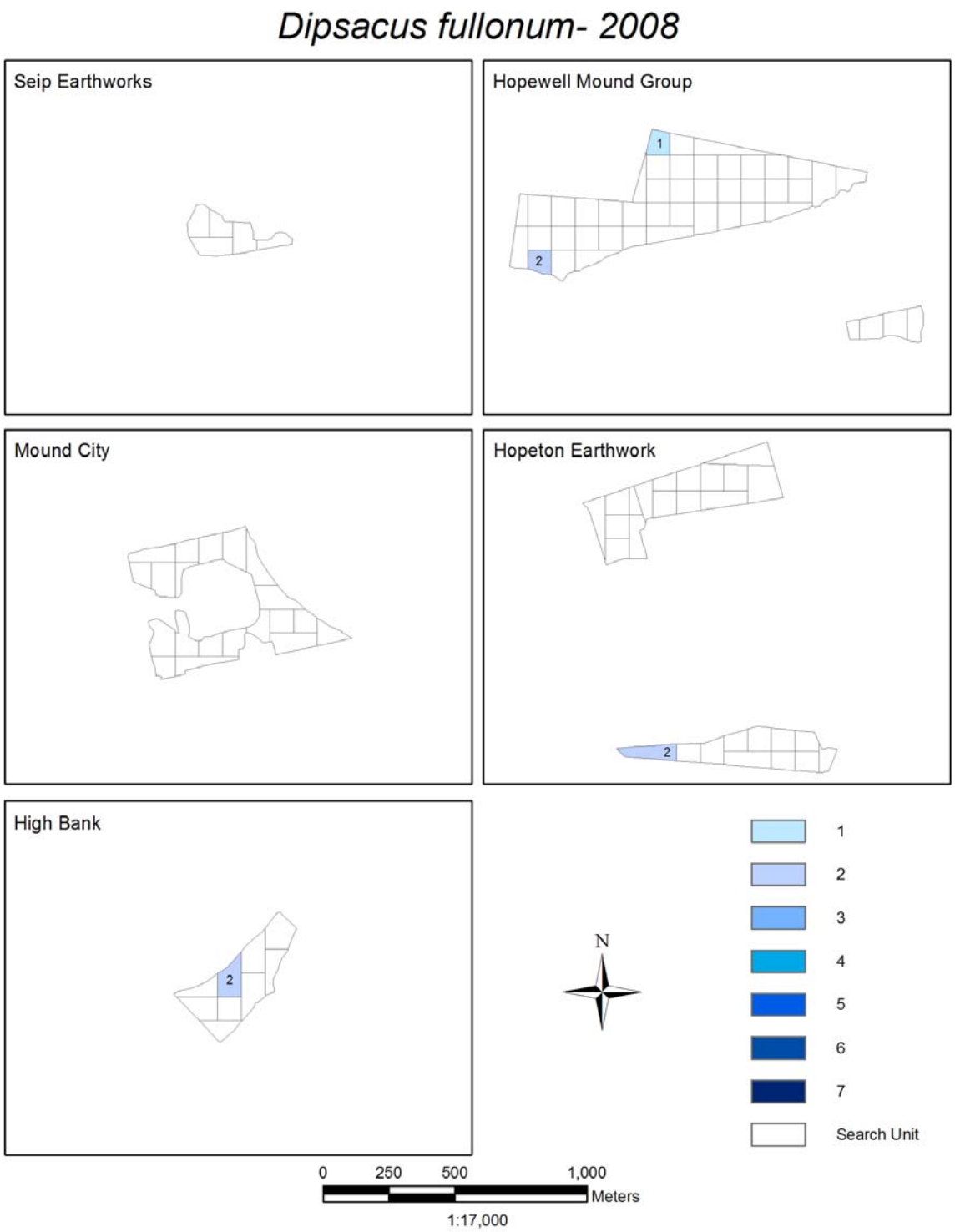

Figure 10. Abundance and distribution of *Dipsacus fullonum* (Fuller's teasel) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

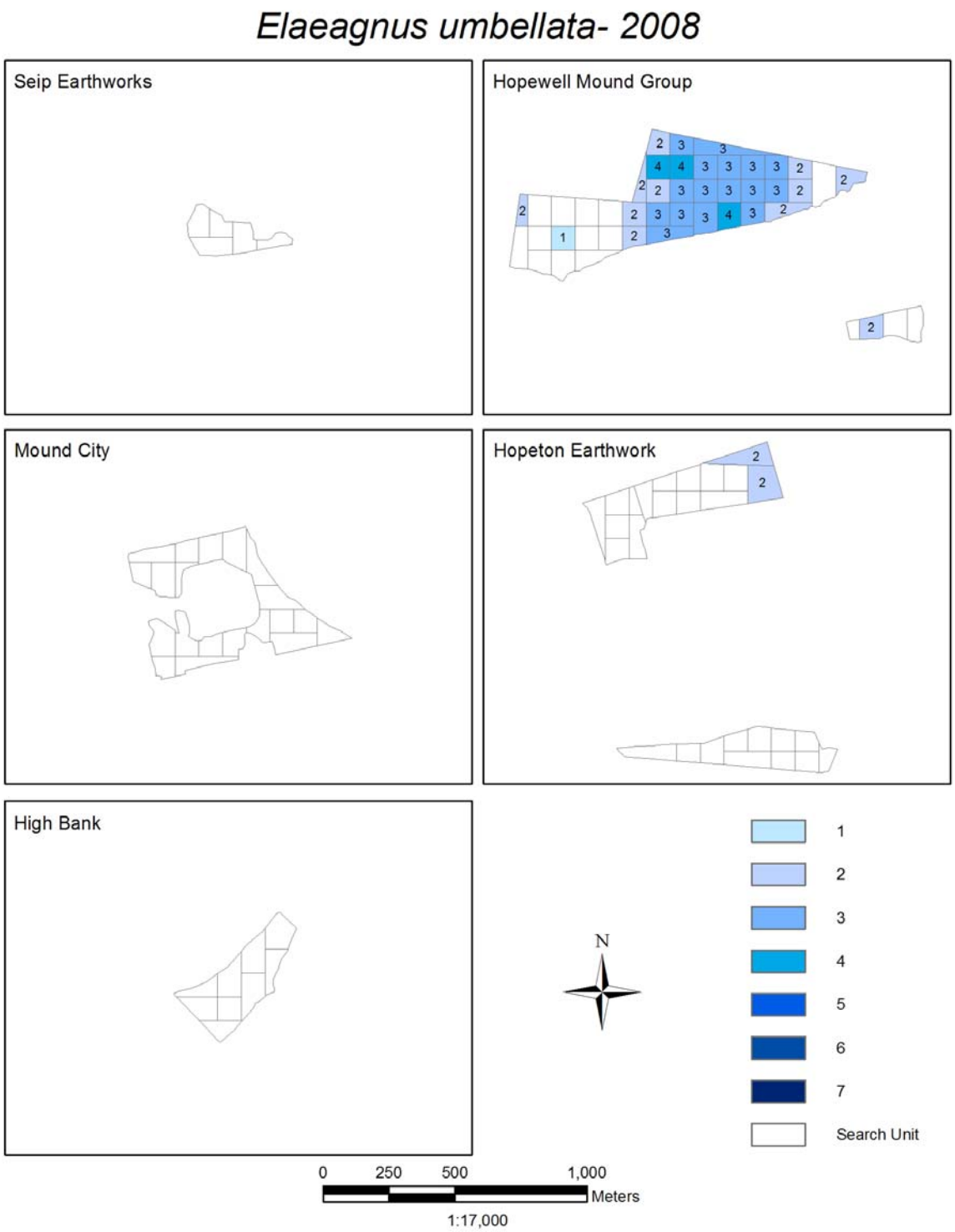

Figure 11. Abundance and distribution of *Elaeagnus umbellata* (autumn olive) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

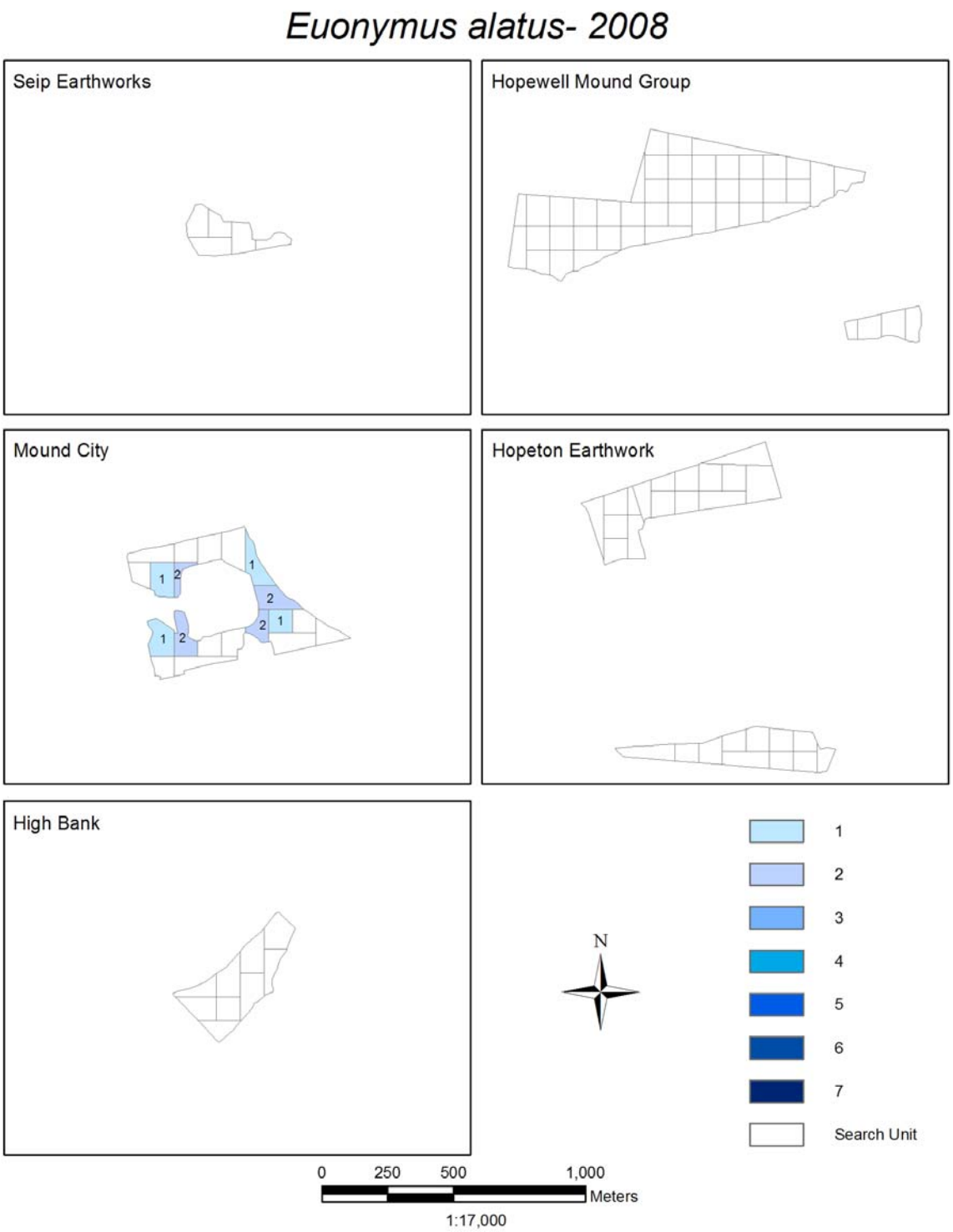

Figure 12. Abundance and distribution of *Euonymus alatus* (burningbush) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

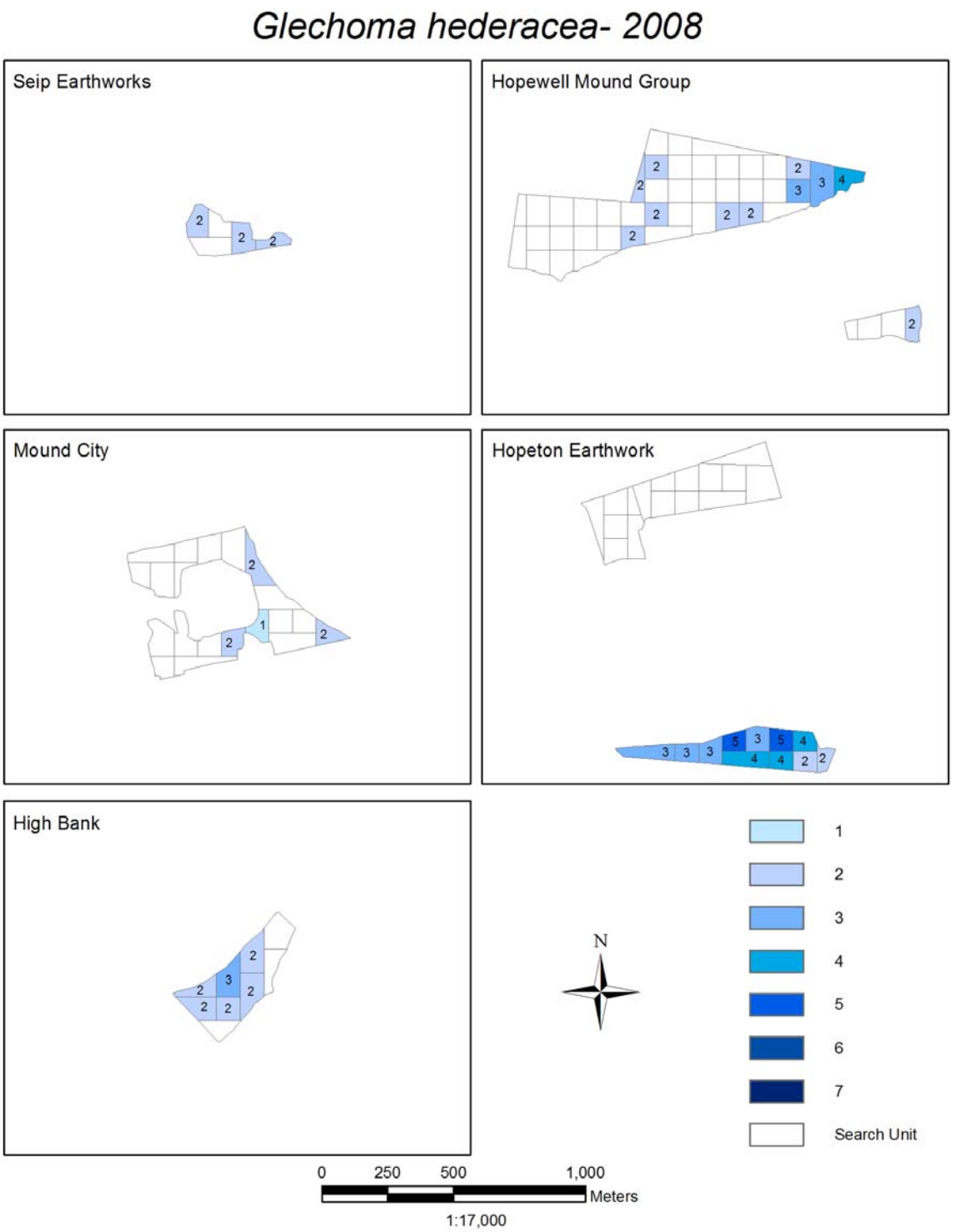

Figure 13. Abundance and distribution of *Glechoma hederacea* (ground ivy) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

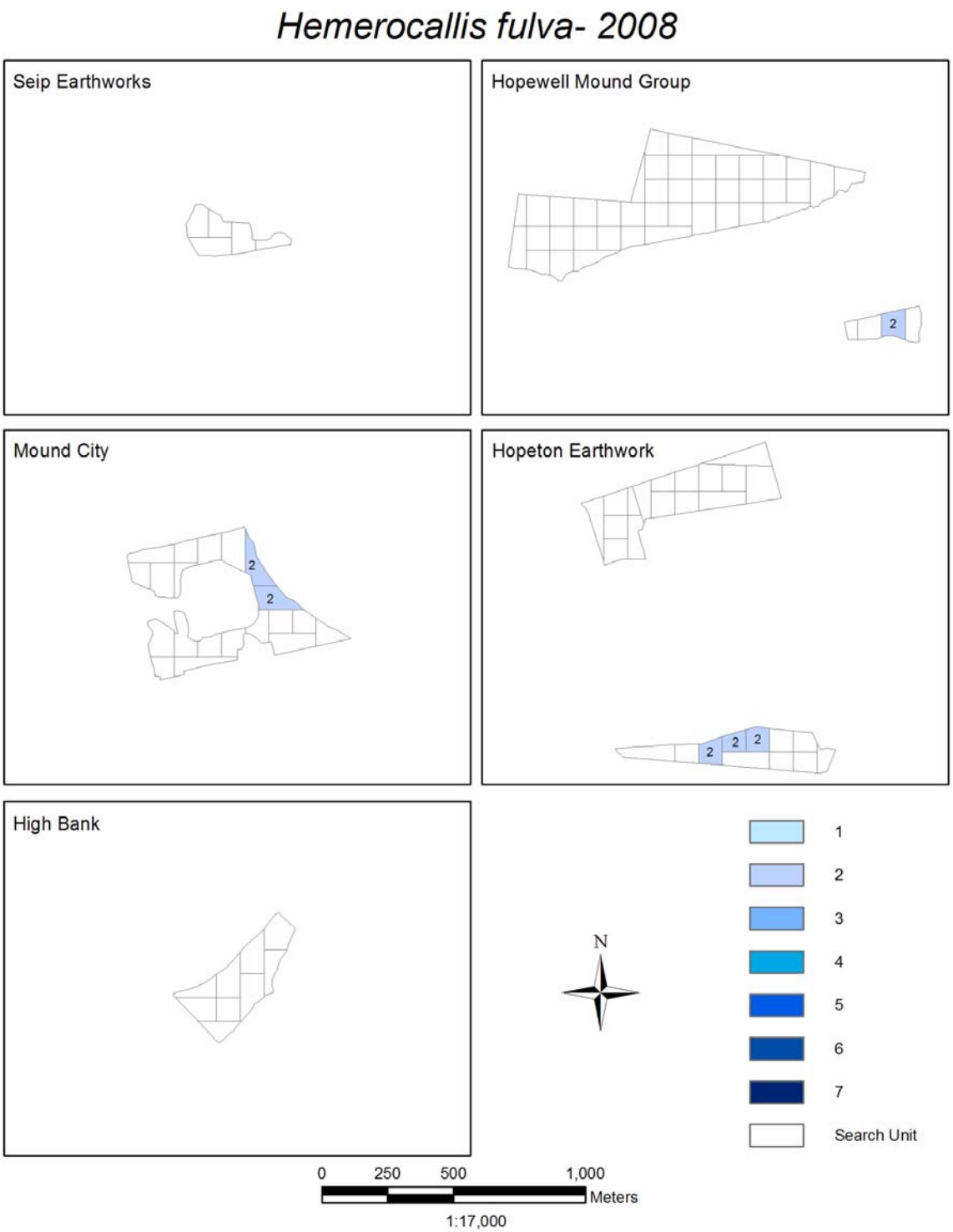

Figure 14. Abundance and distribution of *Hemerocallis fulva* (orange daylily) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

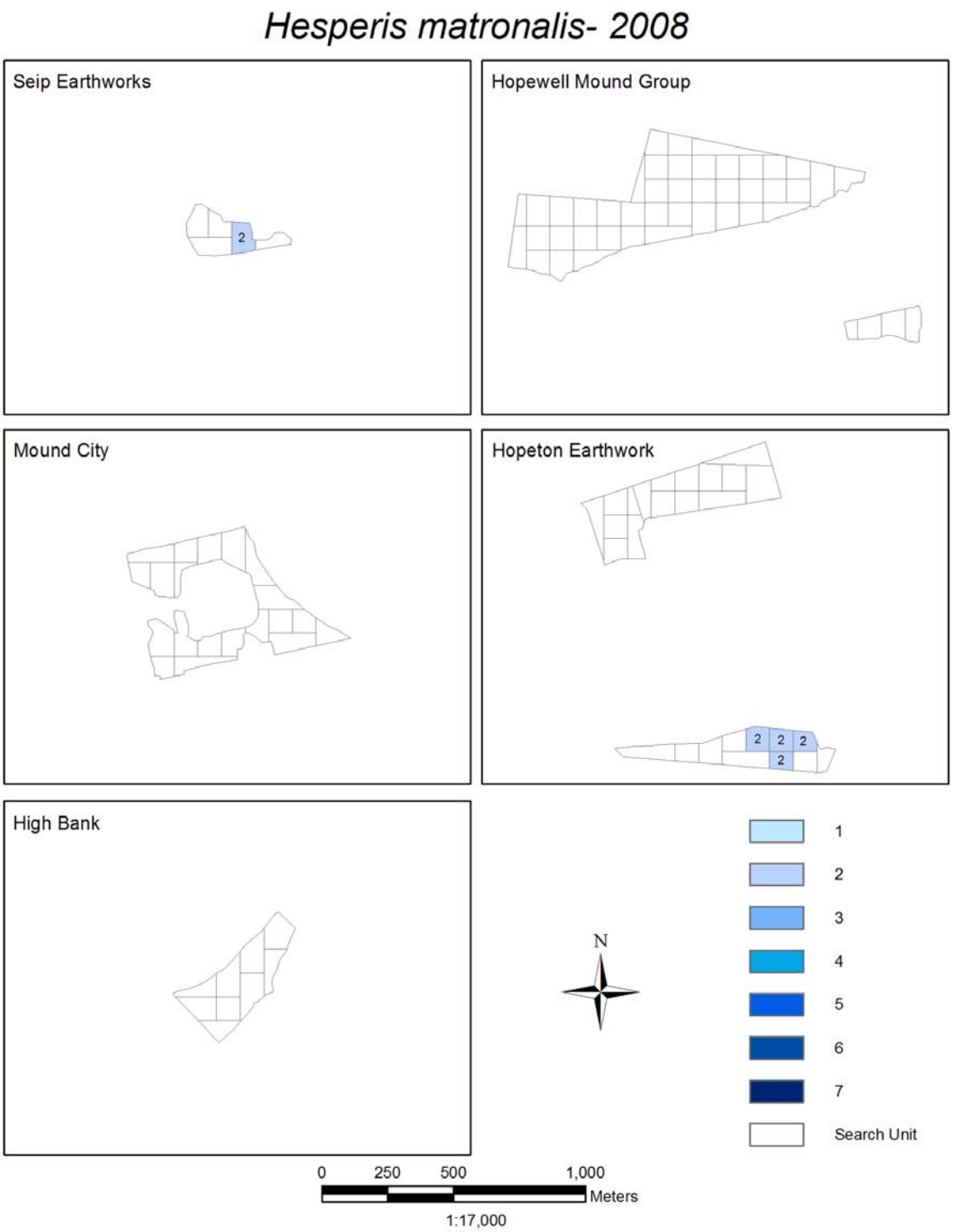

Figure 15. Abundance and distribution of *Hesperis matronalis* (dames rocket) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

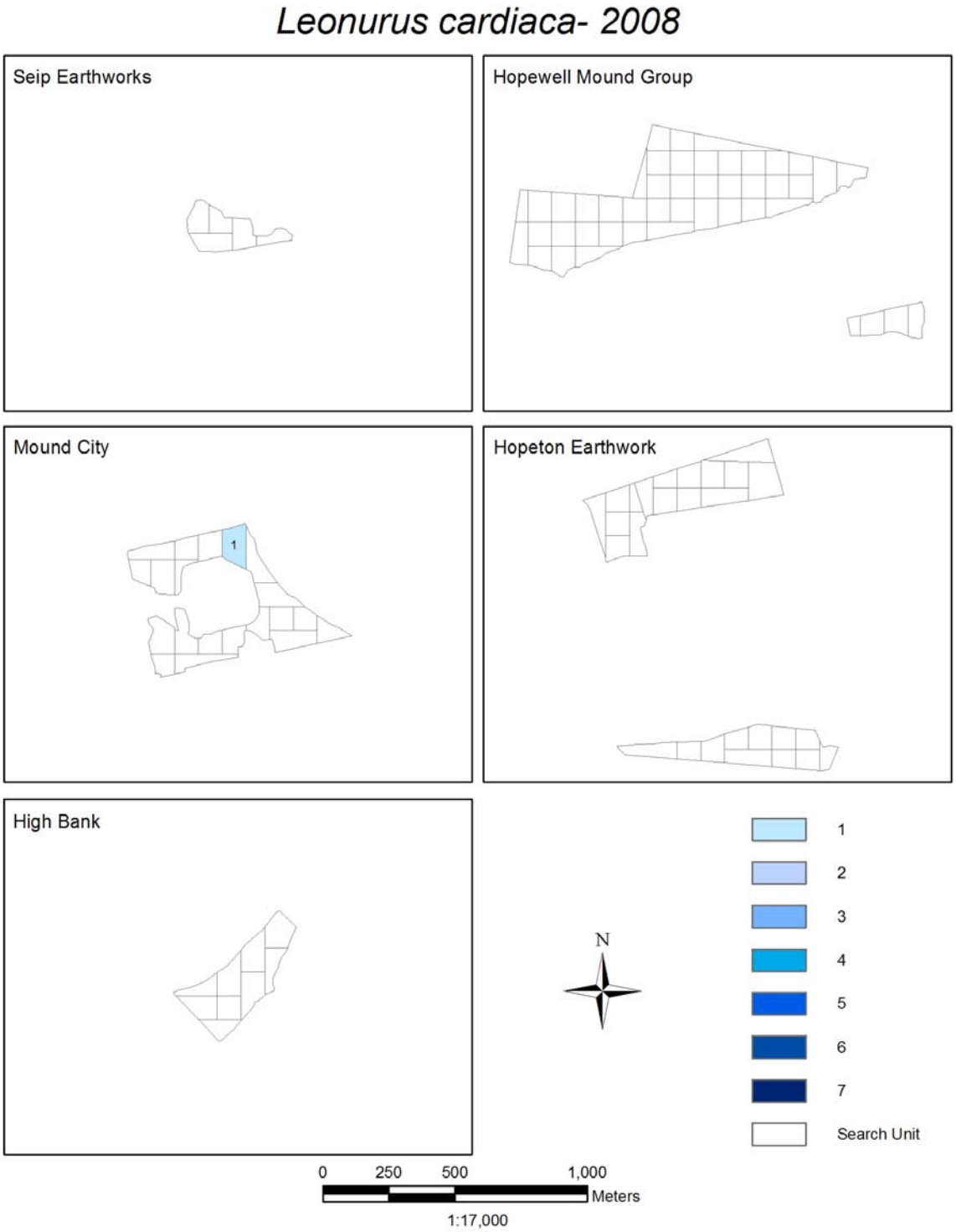

Figure 16. Abundance and distribution of *Leonurus cardiaca* (common motherwort) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

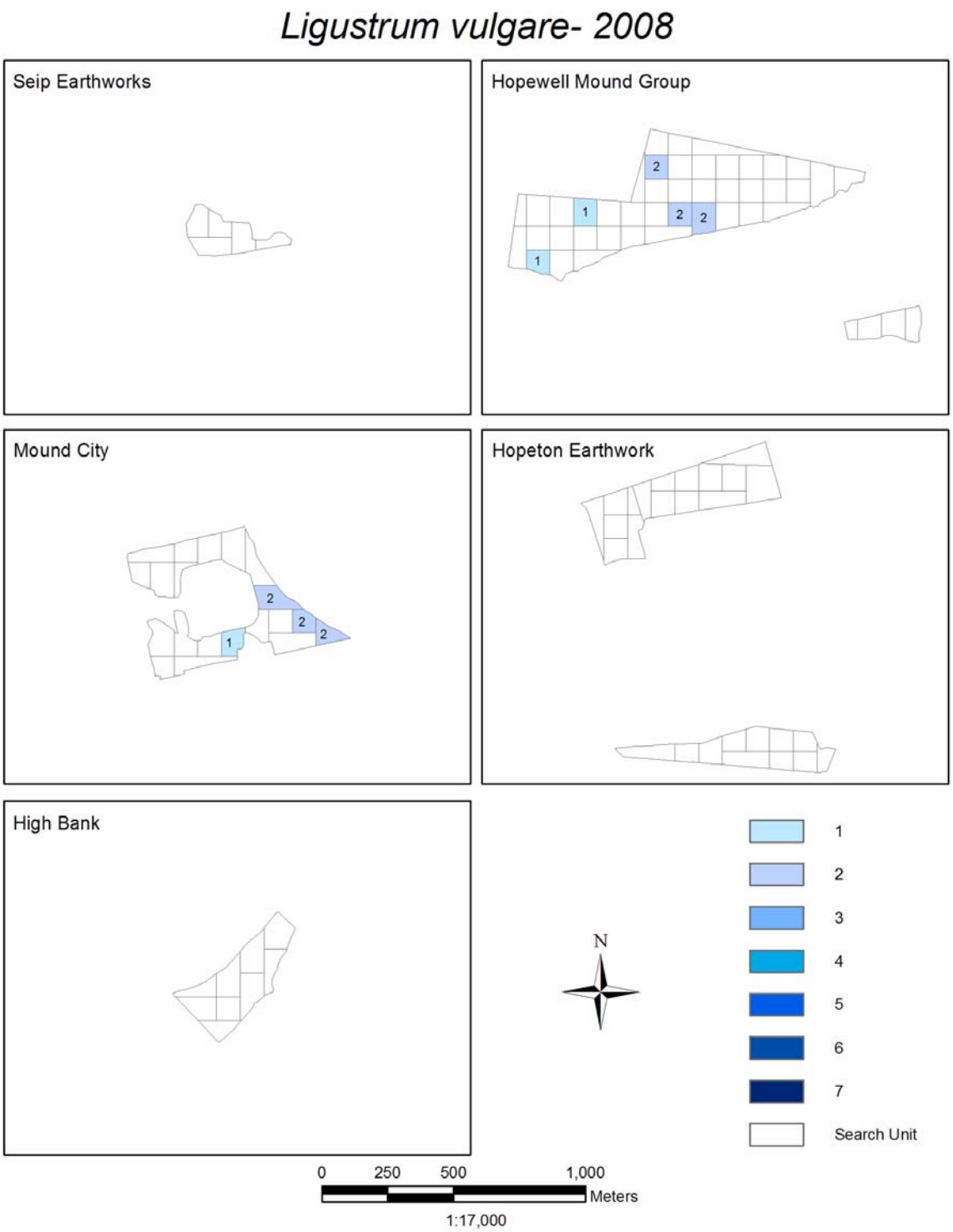

Figure 17. Abundance and distribution of *Ligustrum vulgare* (European privet) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

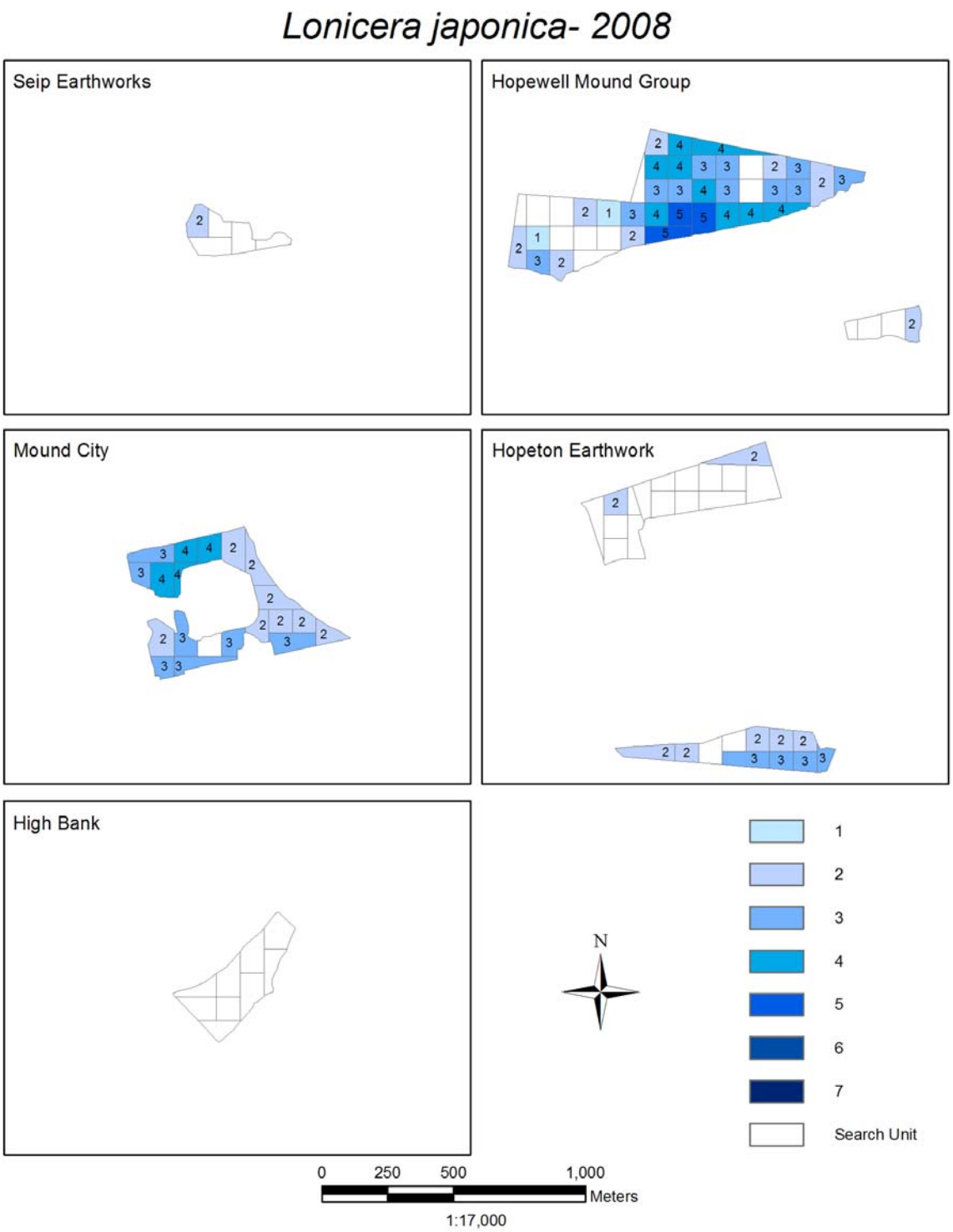

Figure 18. Abundance and distribution of *Lonicera japonica (*Japanese honeysuckle) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

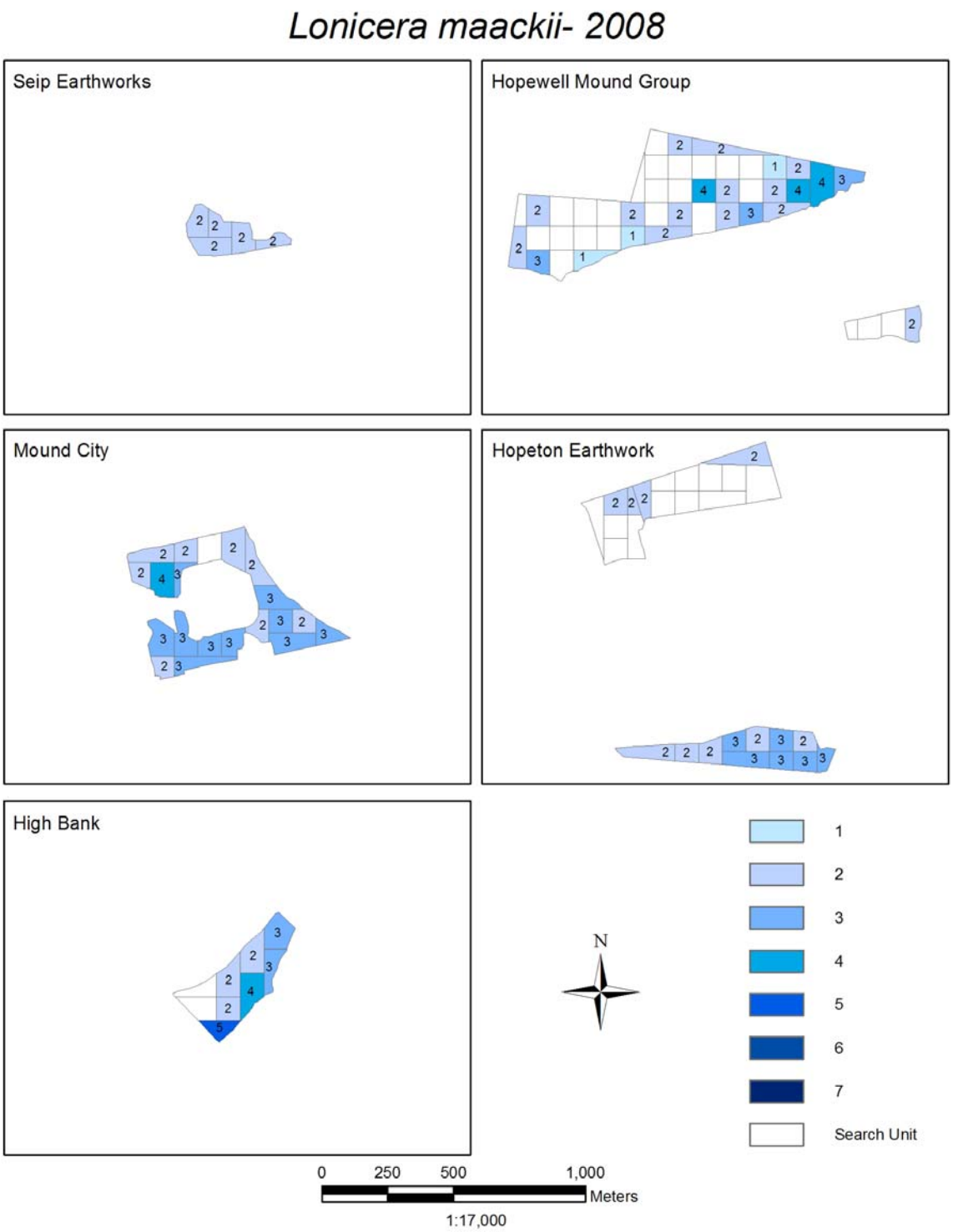

Figure 19. Abundance and distribution of *Lonicera maackii* (Amur honeysuckle) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

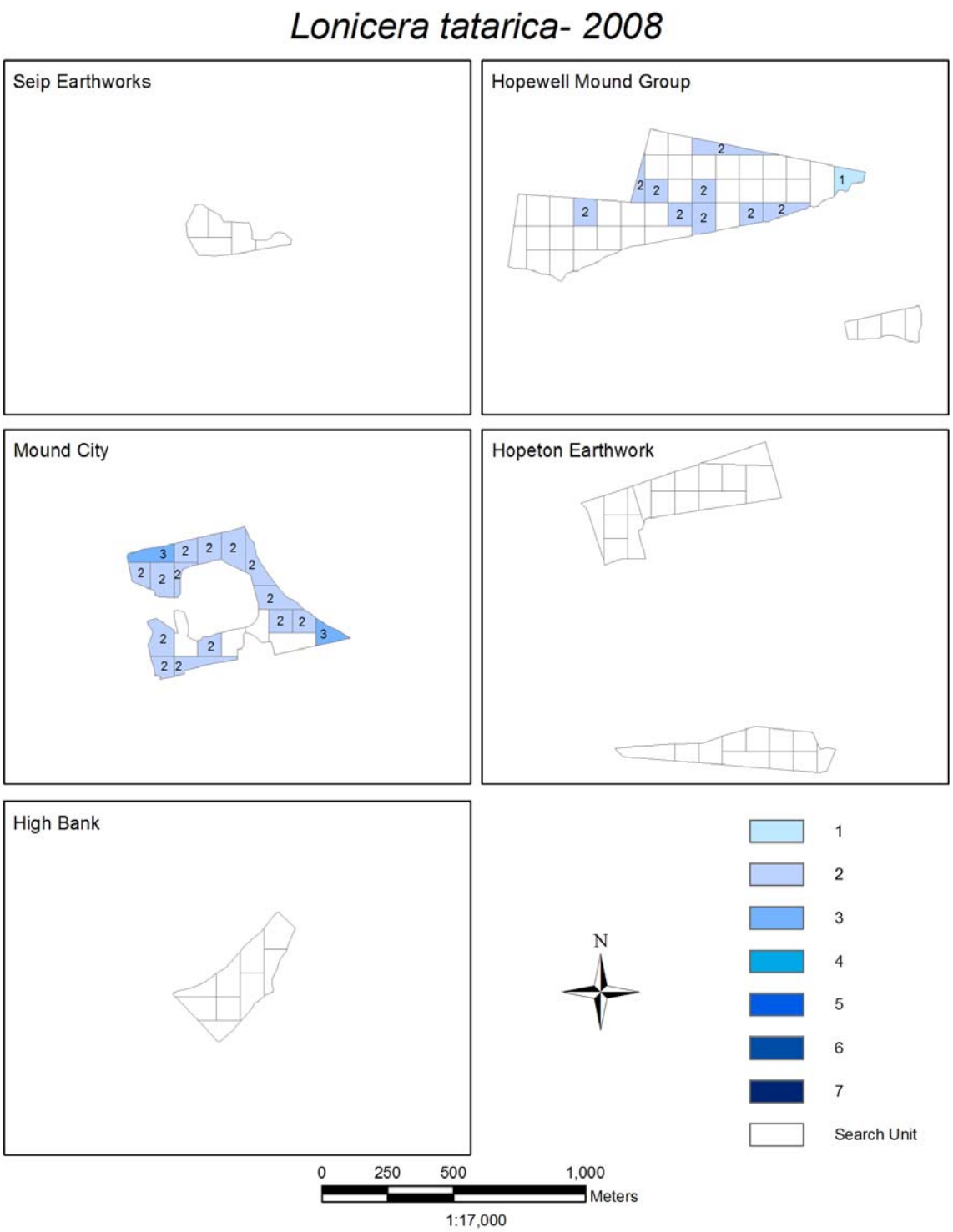

Figure 20. Abundance and distribution of *Lonicera tatarica* (Tatarian honeysuckle) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

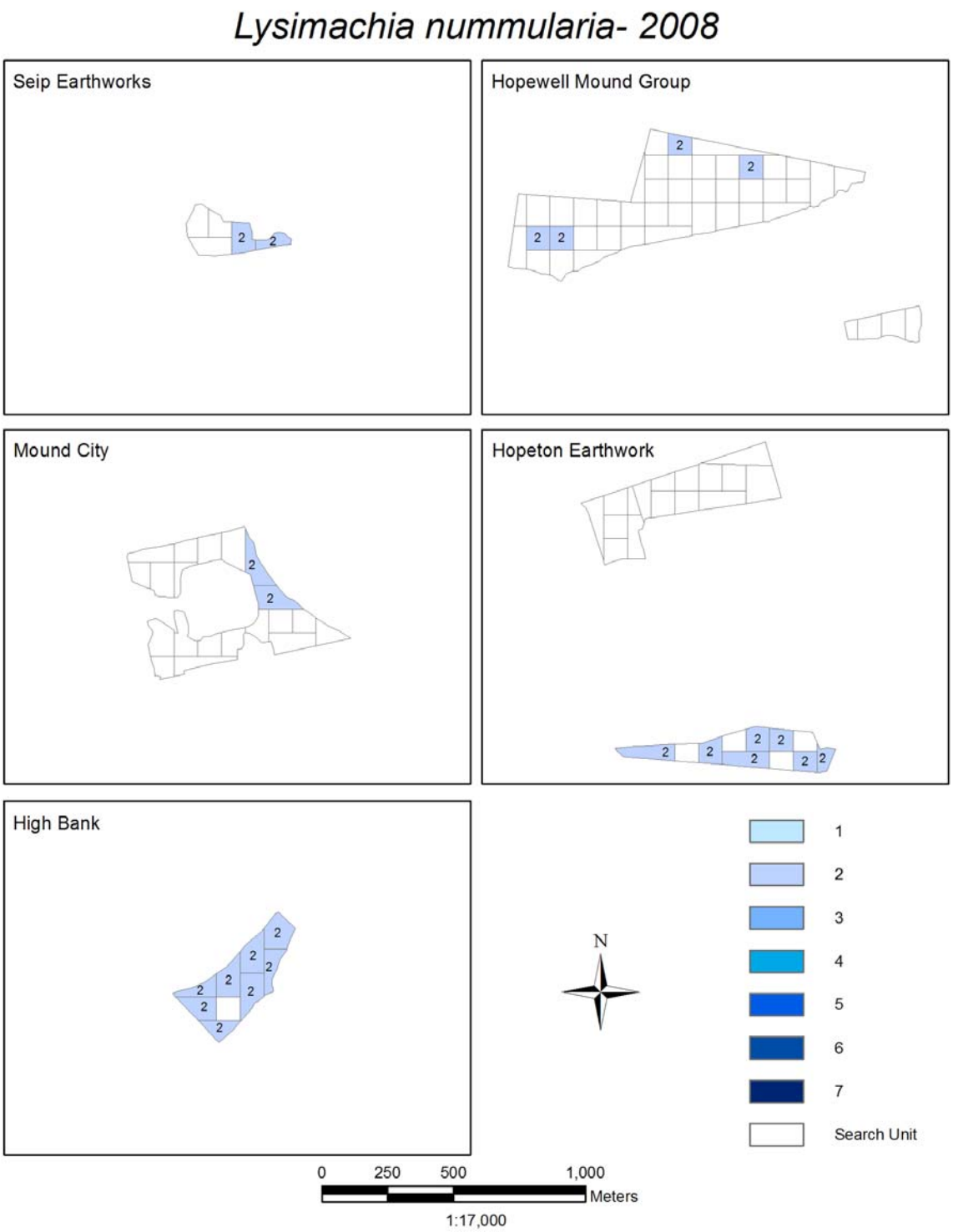

Figure 21. Abundance and distribution of *Lysimachia nummularia* (creeping jenny) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

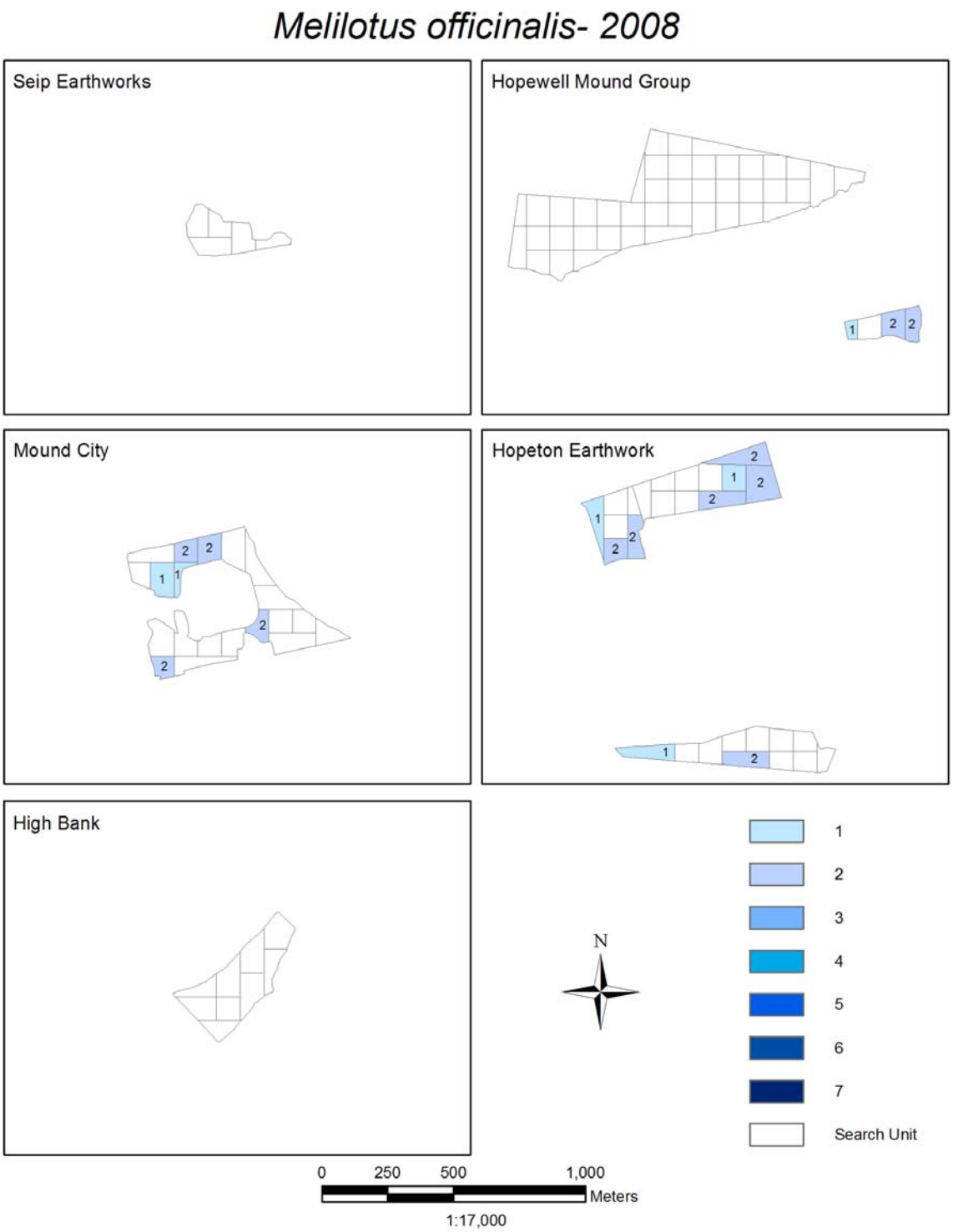

Figure 22. Abundance and distribution of *Melilotus officinalis* (yellow sweetclover) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

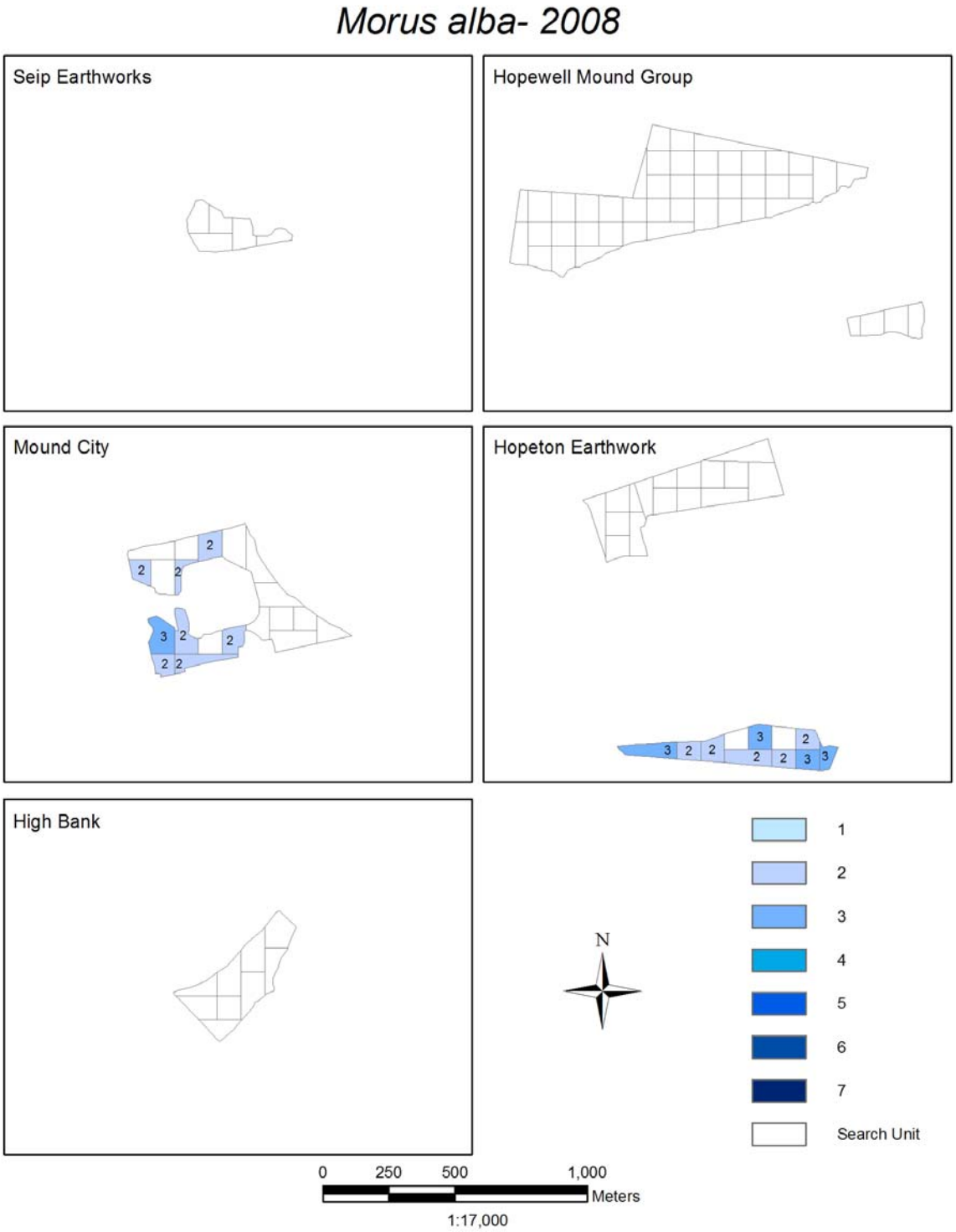

Figure 23. Abundance and distribution of *Morus alba* (white mulberry) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

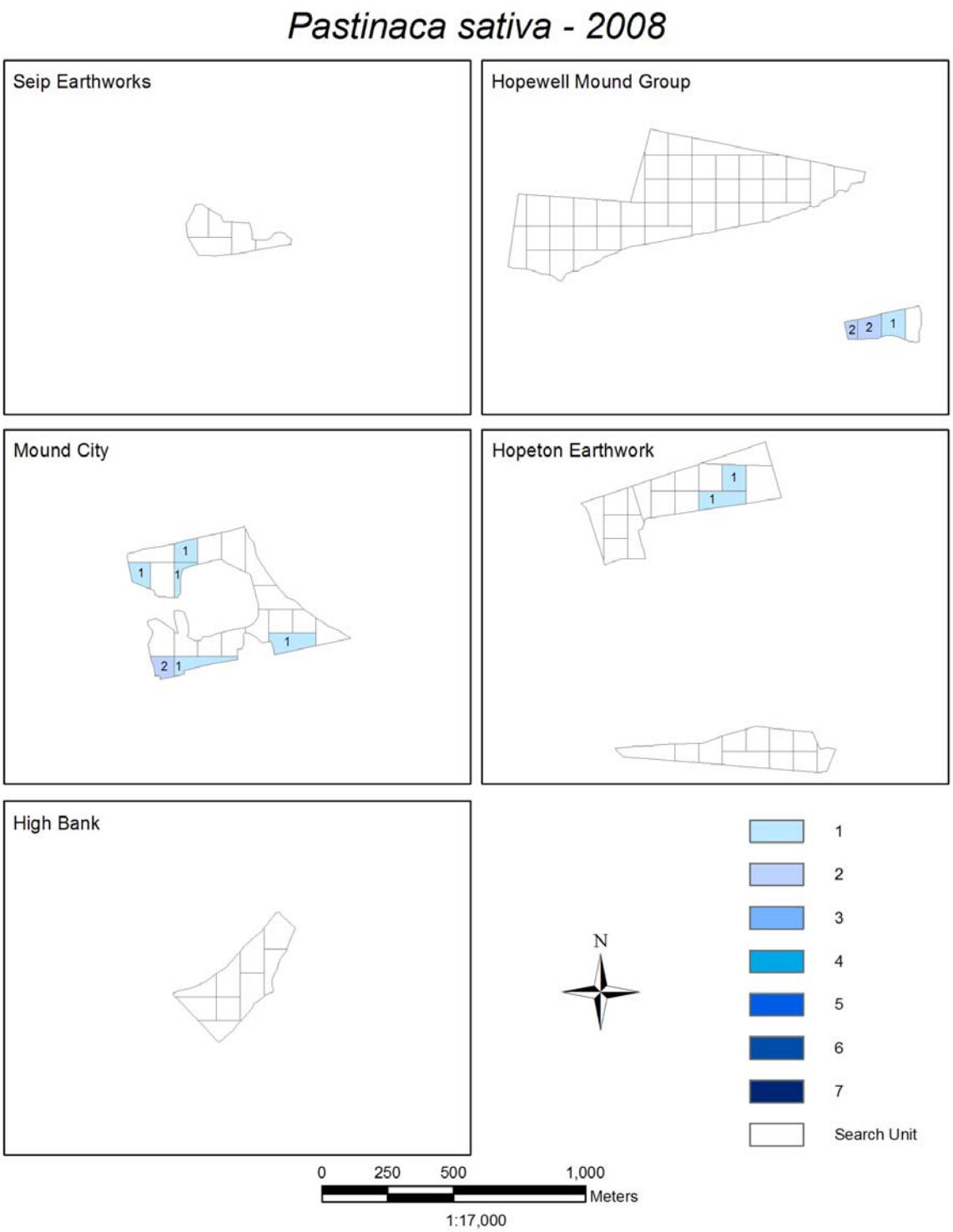

Figure 24. Abundance and distribution of *Pastinaca sativa* (wild parsnip) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

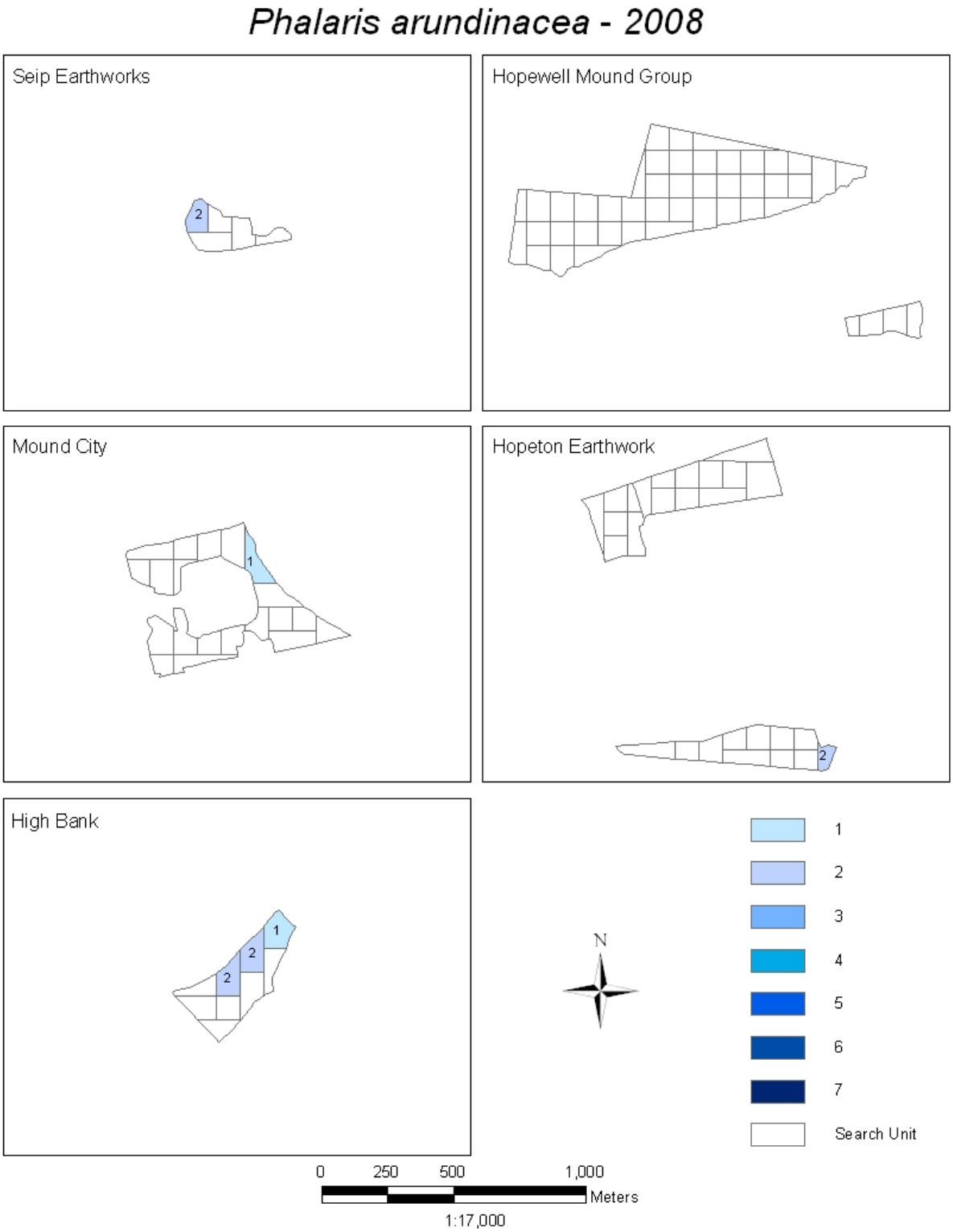

Figure 25. Abundance and distribution of *Phalaris arundinacea* (reed canarygrass) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

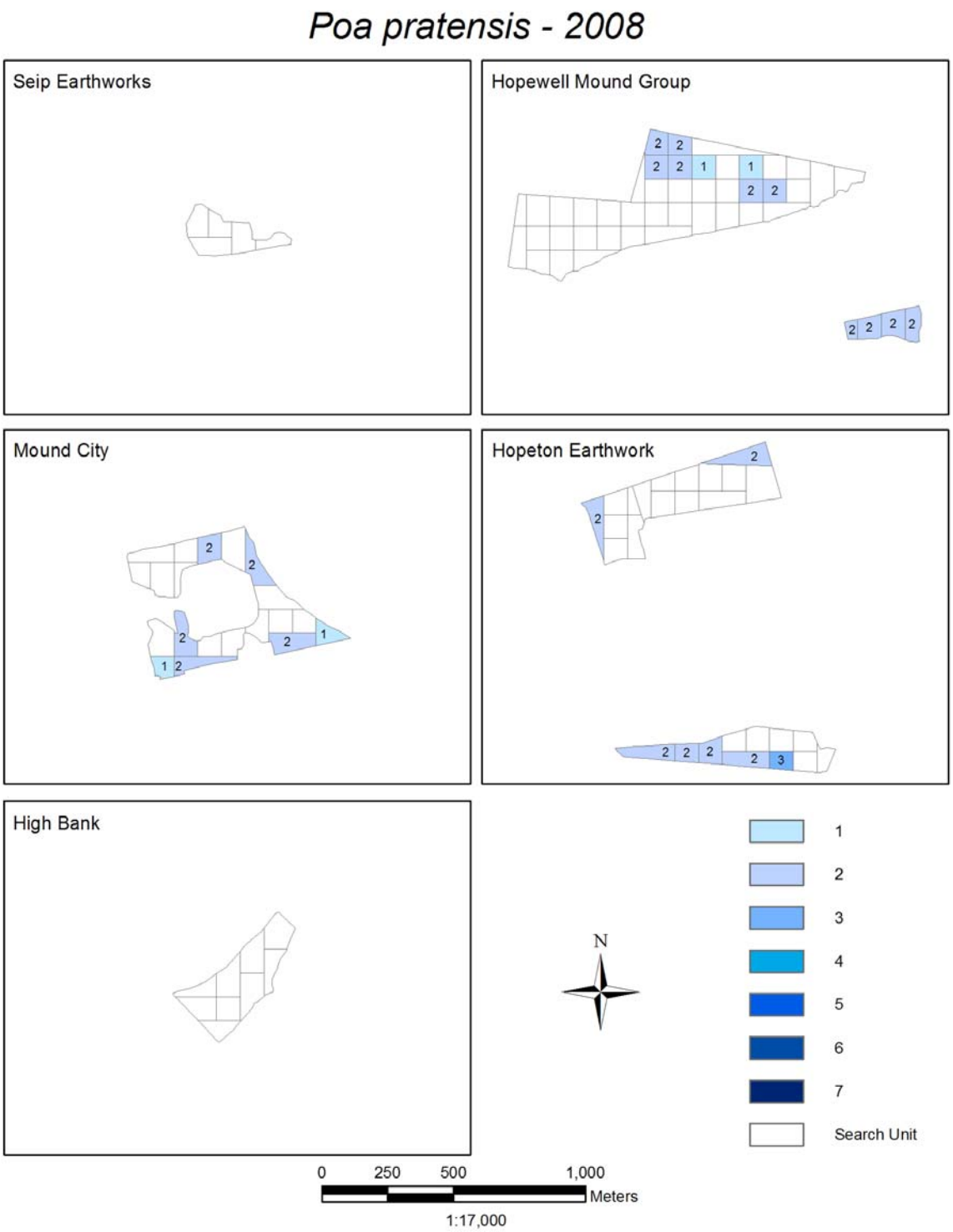

Figure 26. Abundance and distribution of *Poa pratensis* (Kentucky bluegrass) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

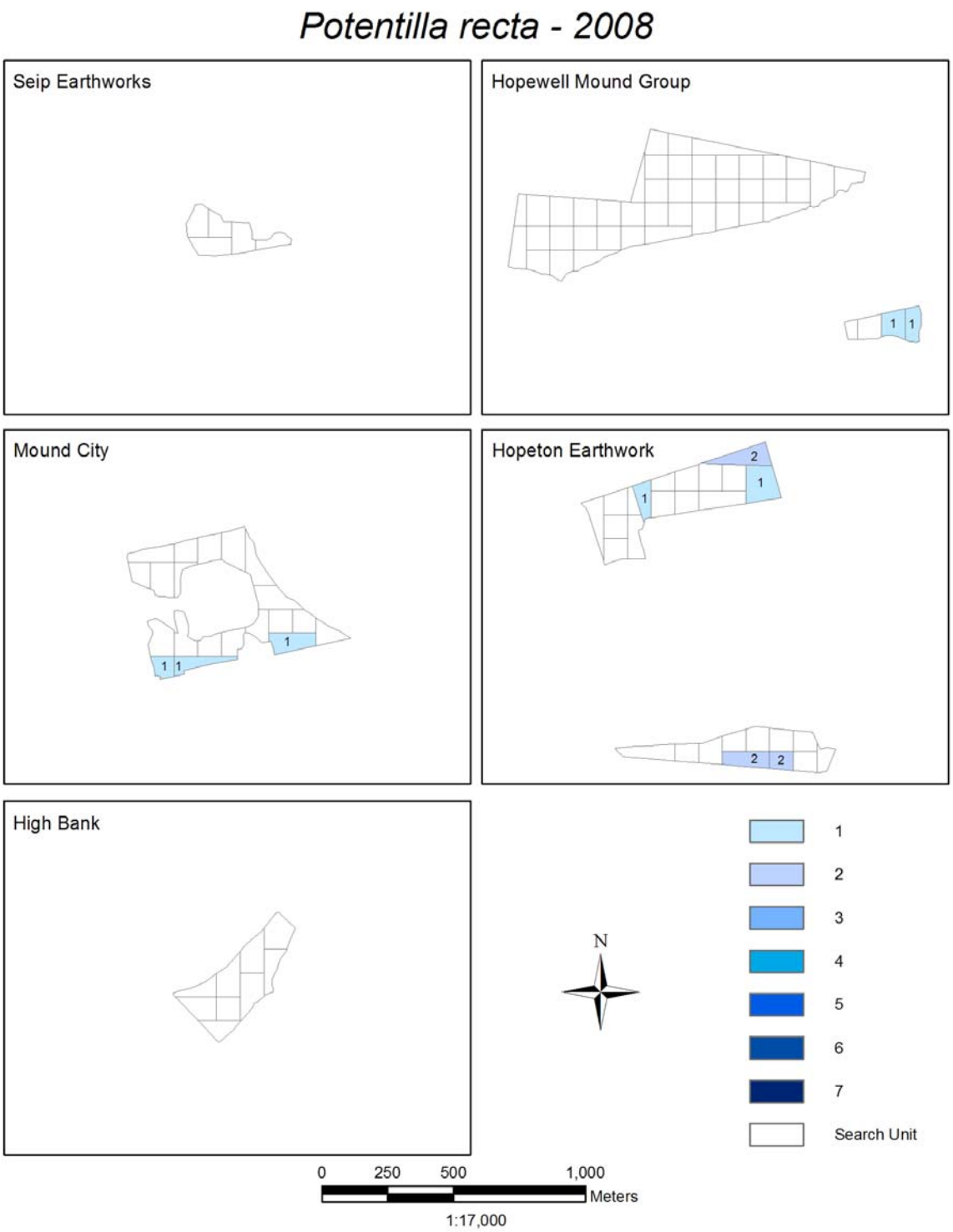

Figure 27. Abundance and distribution of *Potentilla recta* (sulphur cinquefoil) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

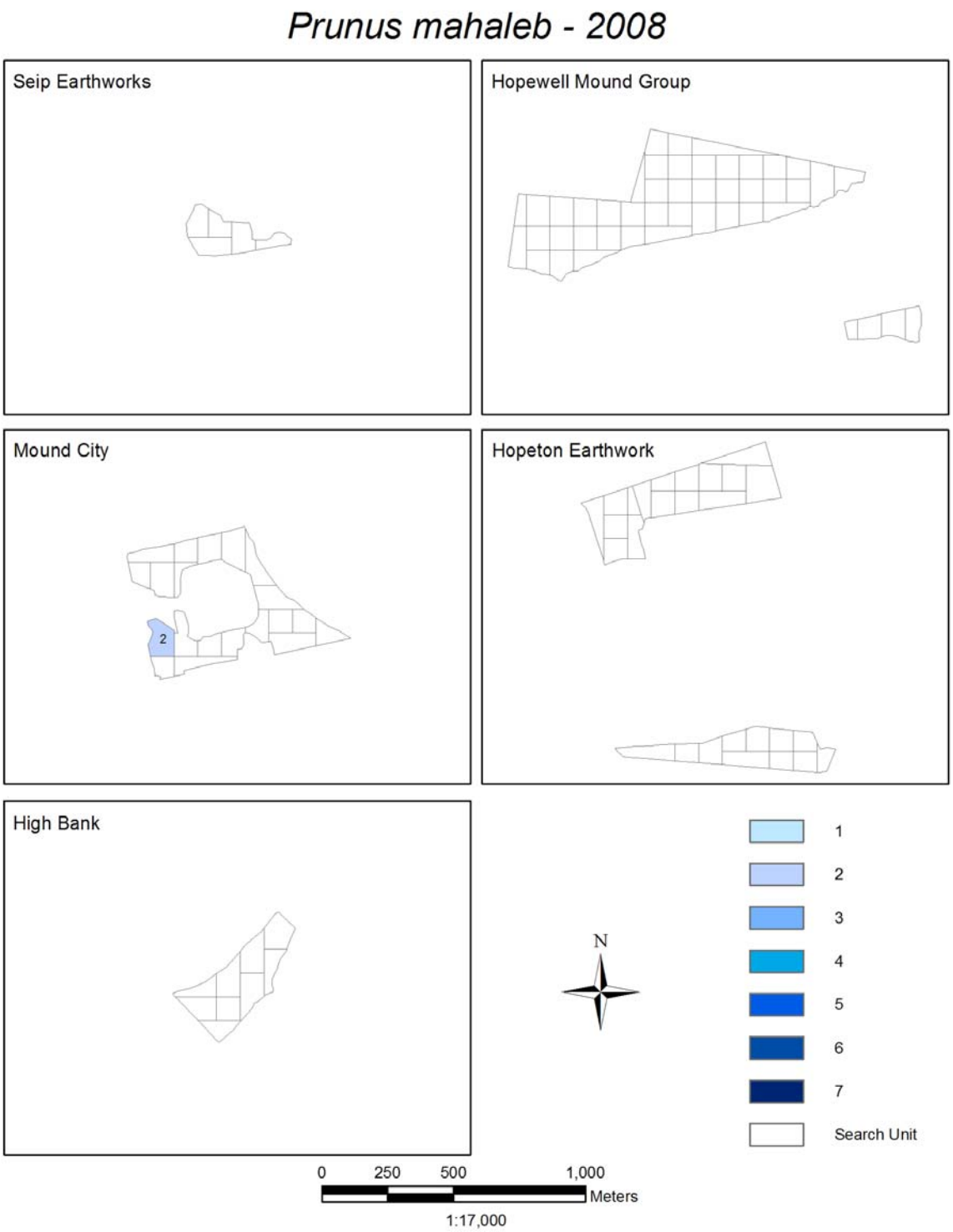

Figure 28. Abundance and distribution of *Prunus mahaleb* (Mahaleb cherry) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

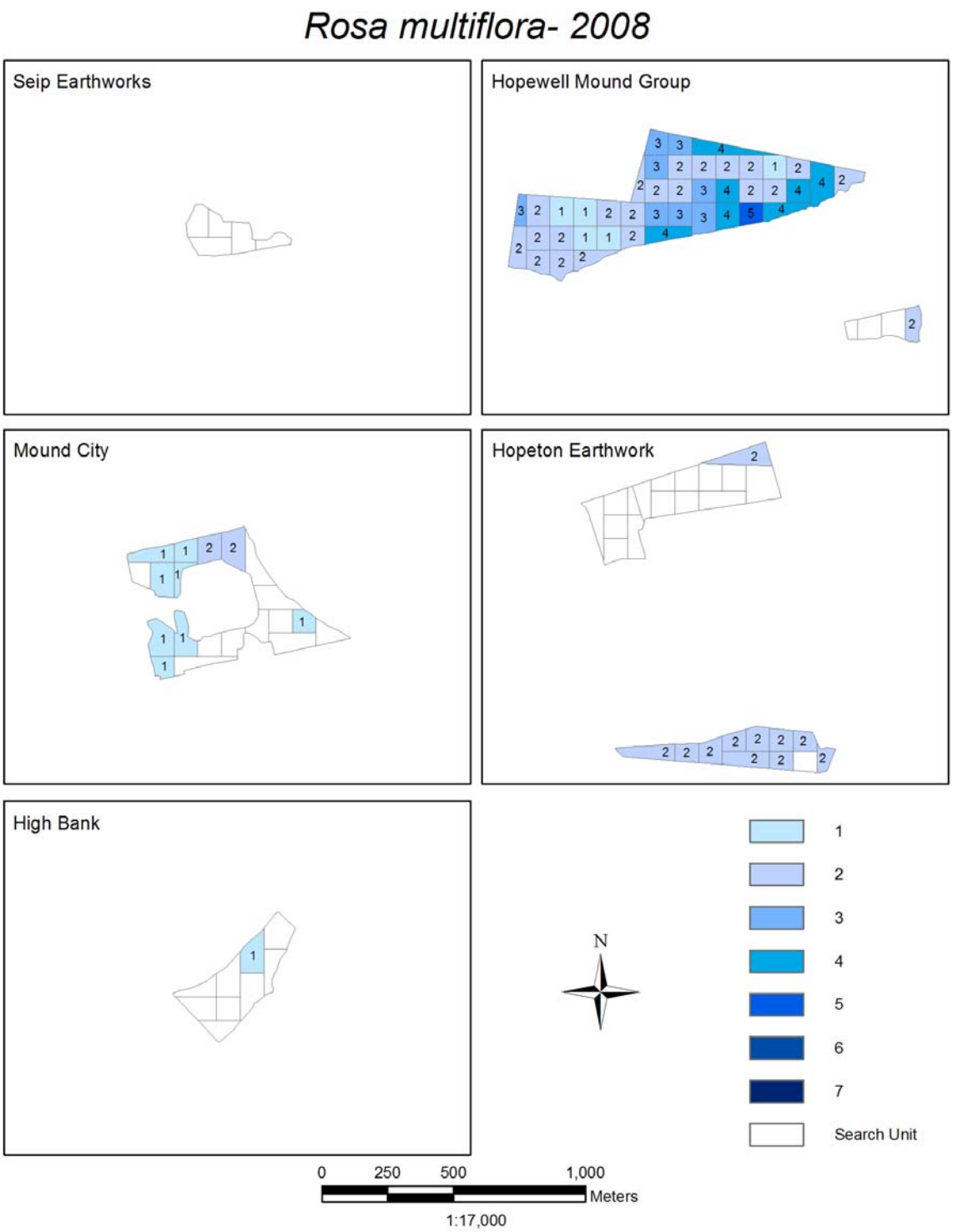

Figure 29. Abundance and distribution of *Rosa multiflora* (multiflora rose) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

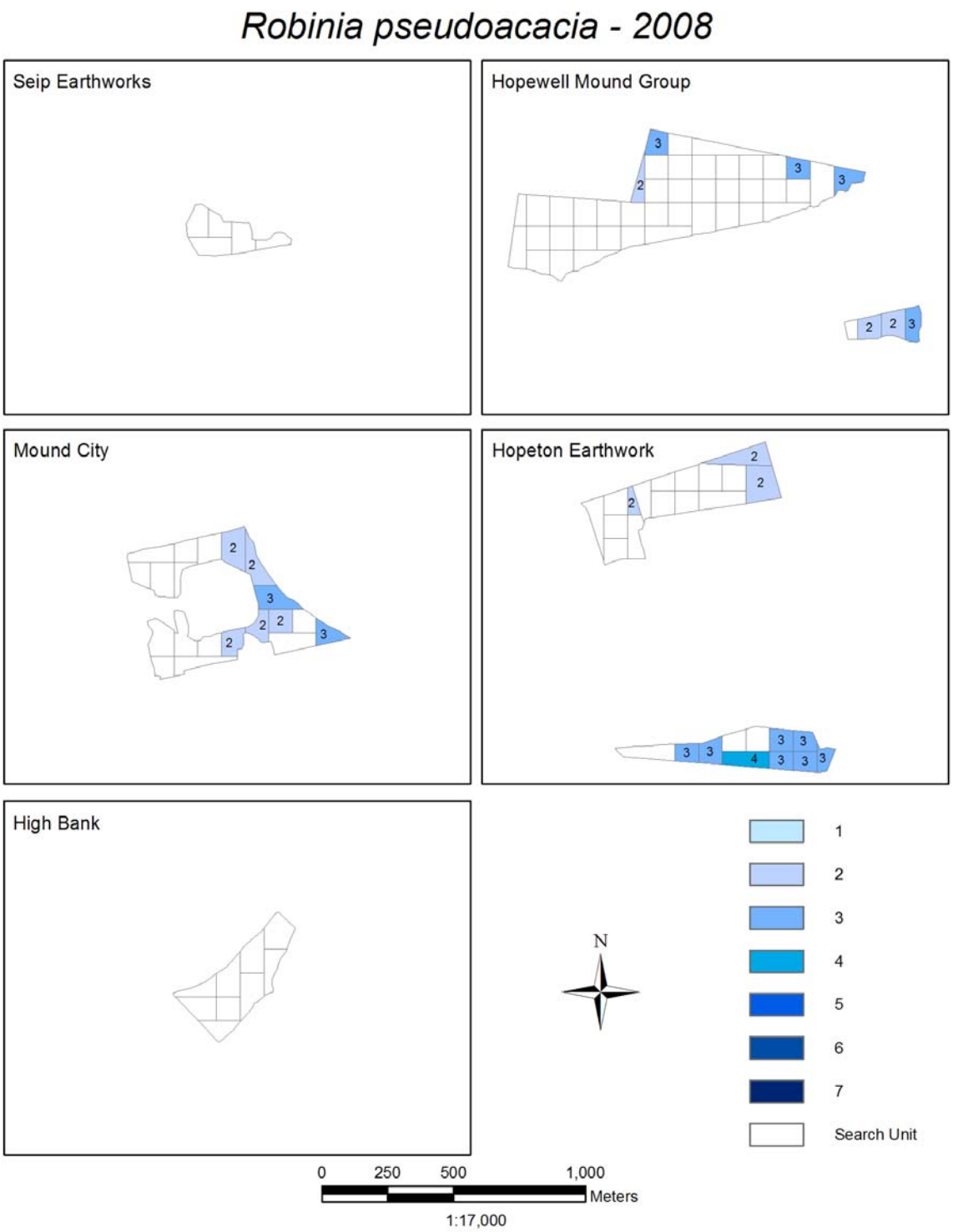

Figure 30. Abundance and distribution of *Robinia pseudoacacia* (black locust) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

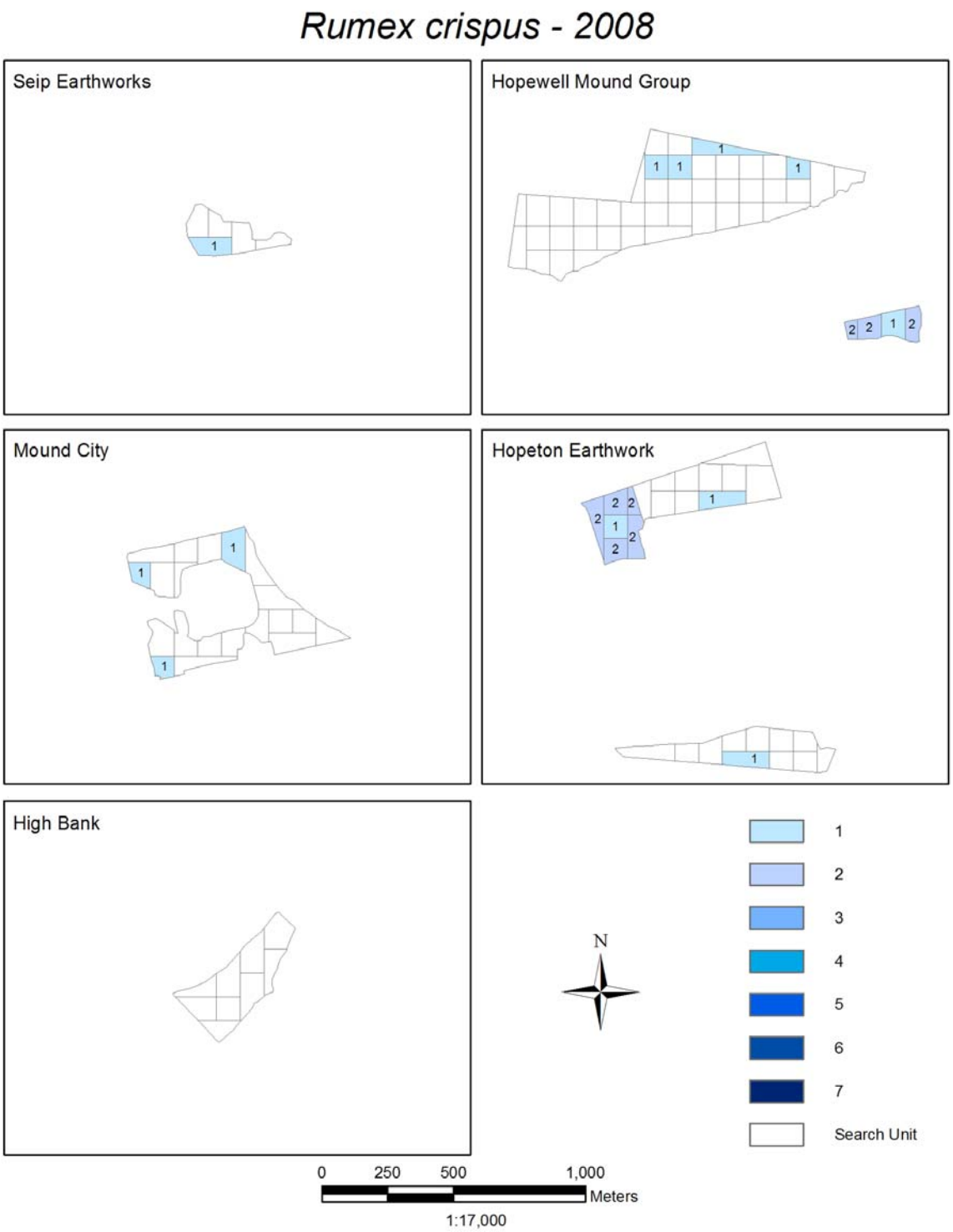

Figure 31. Abundance and distribution of *Rumex crispus* (curly dock) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

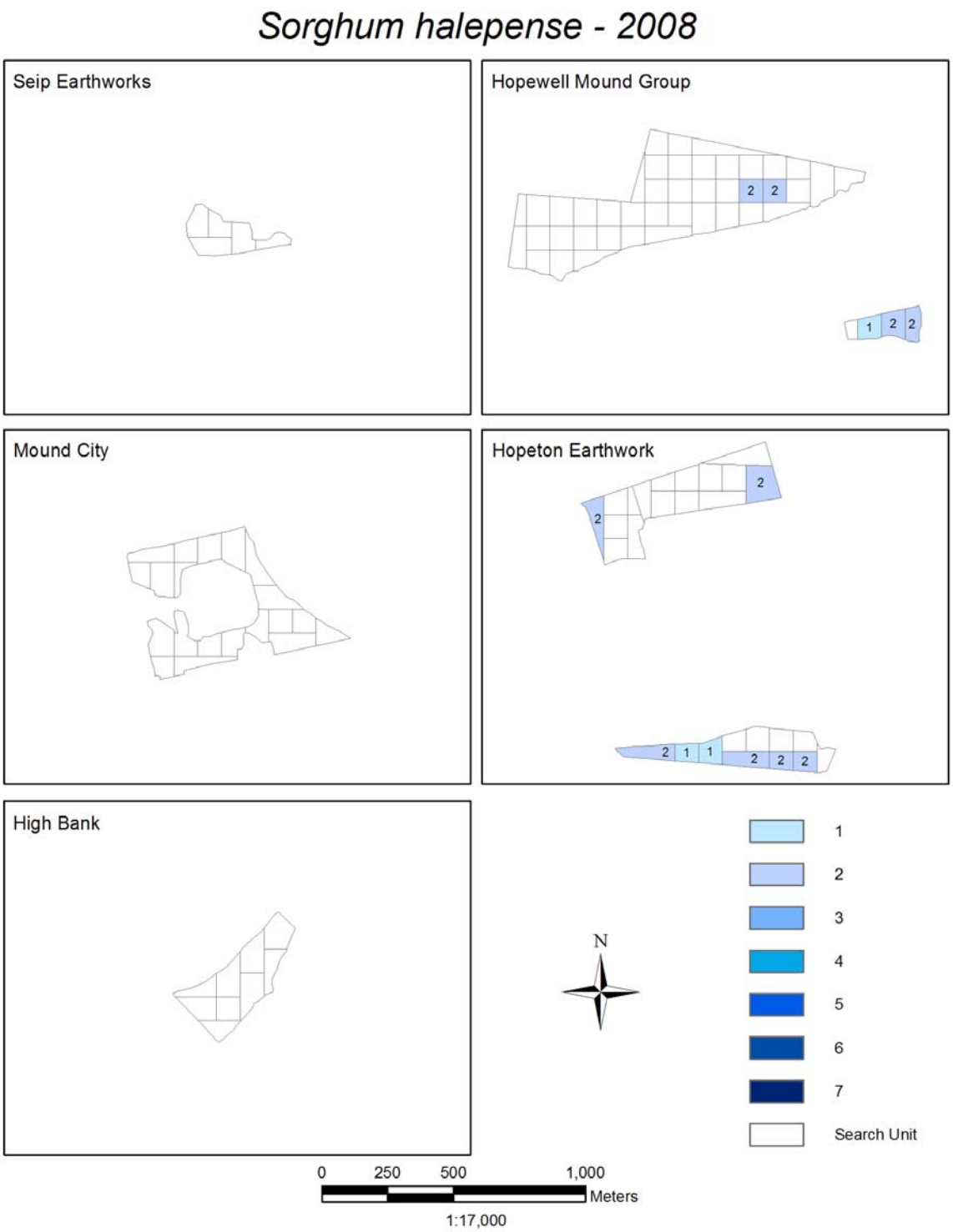

Figure 32. Abundance and distribution of *Sorghum halepense* (johnsongrass) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

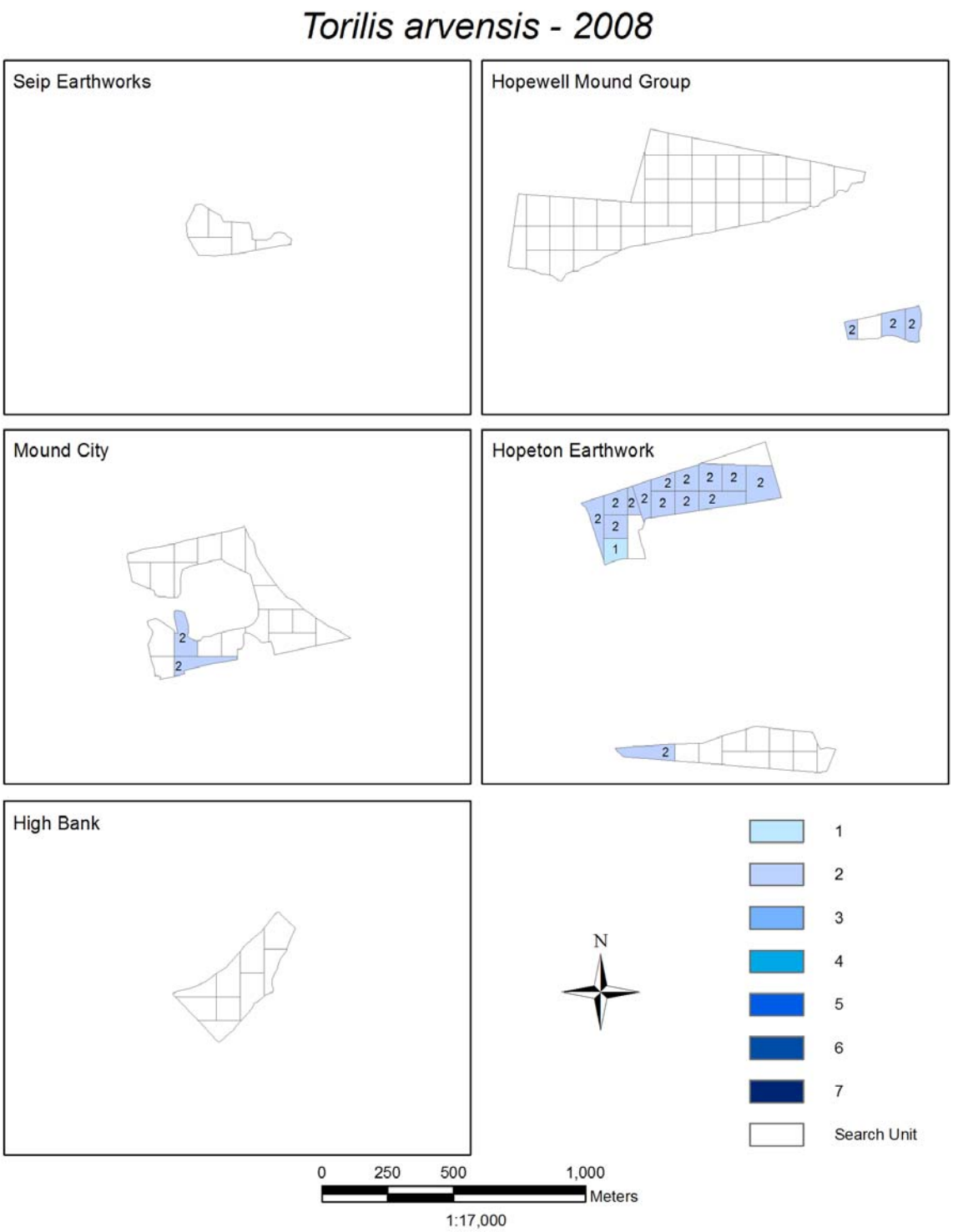

Figure 33. Abundance and distribution of *Torilis arvensis* (spreading hedgeparsley) on Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

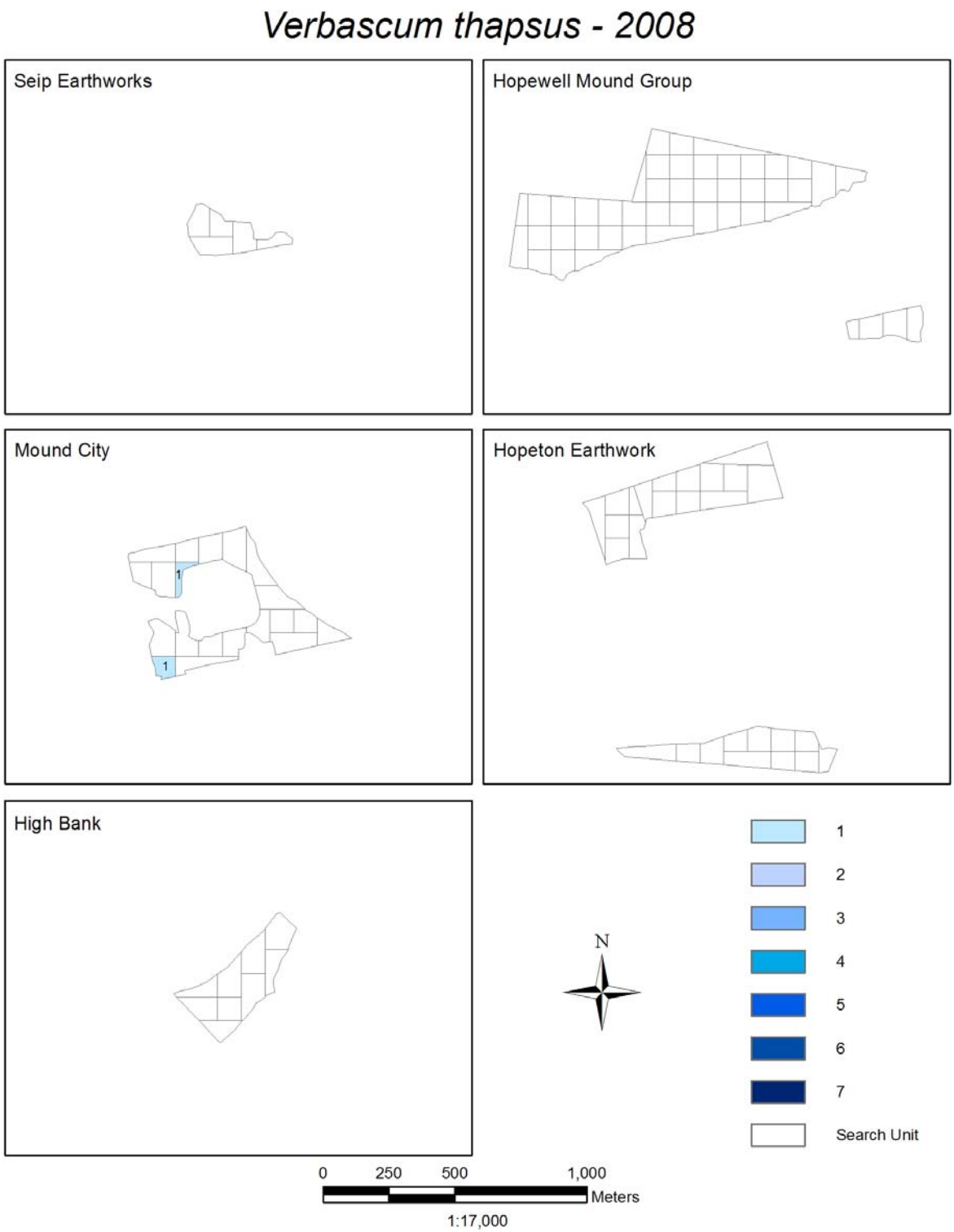

Figure 34. Abundance and distribution of *Verbascum thapsus* (common mullein) at Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

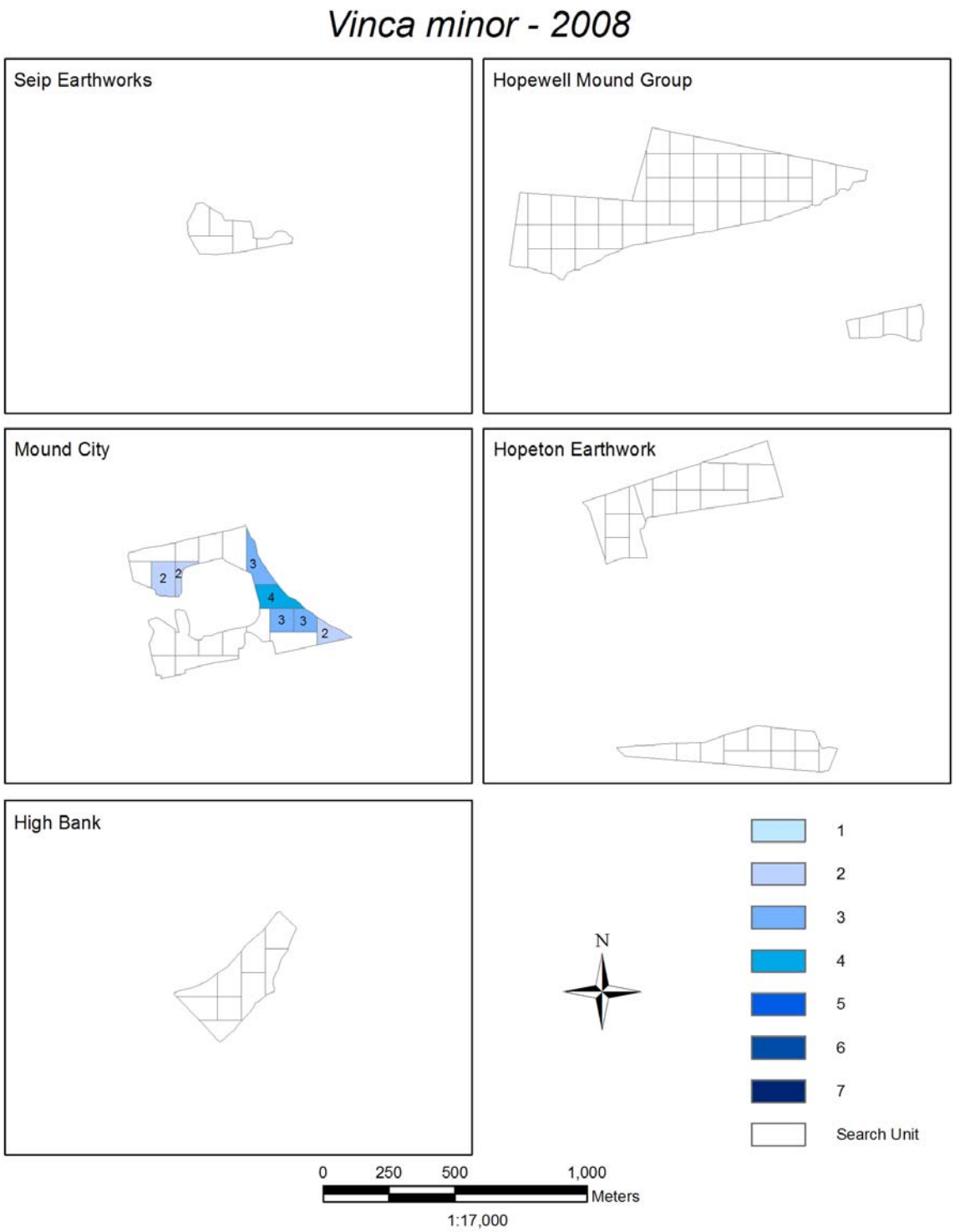

Figure 35. Abundance and distribution of *Vinca minor* (common periwinkle) at Hopewell Culture National Historical Park, 2008. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7=1,000-4,999.9 m^2.

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.

NPS D-148, December 2008

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA ™