National Park Service
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Natural Resource Program Center

Invasive Exotic Plant Monitoring at Hot Springs National Park

Year 1 (2009)

Natural Resource Technical Report NPS/HTLN/NRTR—2010/288

ON THE COVER
Trail in xeric oak forest at Hot Springs National Park.

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Abstract

In 2009, surveyors documented thirty-seven invasive exotic plant taxa in Hot Springs National Park. Seven species were on the early detection watch list; thirty species were known to occur on the park. The most widespread and abundant of the exotic plant species observed included Chinese privet and Japanese honeysuckle, which each covered at least four acres within the study area. Out of the thirty-seven invasive exotic plants, twenty-nine species each occurred on less than one acre. In general, several invasive exotic plants are a major problem in the study area at Hot Springs National Park, but successful control is possible for a large group of species. The acreage estimates presented in the report may be used to plan management activities leading to control of exotic plants and the accomplishment of GPRA goal IA1b.

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 and/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 manage 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 the vital signs selection process in 2003, Heartland Network parks recognized the need for exotic plant monitoring (DeBacker et al. 2004). Nine parks (CUVA, EFMO, GWCA, HEHO, HOCU, HOME, LIBO, OZAR, PERI) identified invasive exotic plants as their most important management issue, two parks (TAPR, WICR) identified invasive exotic

plants as their second most important management issue, and PIPE identified invasive exotic plants as its third most important management issue. 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 at Hot Springs National 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. Roadways and trails within Hot Springs National Park may serve as introduction pathways for invasive exotic plant species.

2. The proximity of Hot Springs National Park to the city of Hot Springs likely contributes to the occurrence of invasive exotic species within the park.

3. Park use of prescribed fire may serve to control a number of invasive exotic plant species; mechanical methods may prove to be difficult for more abundant and widespread species.

Methods

Watch list

The invasive exotic plants on two watch lists were 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". The latter list included a species, Eastern baccharis (*Baccharis halimifolia*), that is native to the coastal plain in Arkansas. While aquatic species are listed on the watch lists, terrestrial plants were the focus of this survey.

Field methods

In October 2009, invasive exotic plant species on designated watch lists (Table 1) were sought in Hot Springs National Park (Figure 1). Contractors from the Institute of Botanical Training, LLC navigated along 342 contiguous line transects, averaging 200 m in length and located along park trails and roads; identified invasive exotic plants within 12 m of each side of the trail or road (i.e., total belt-width = 24 m); and attributed a coarse cover value to each species (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 $\geq$ 1,000 m^2). Of these transects, 32 were less than 200 m (82m-200m) and 25 transects were greater than 200 m (200m-290 m) in length. Of the original 351 transects scheduled for study, surveyors excluded transects 53-55, 79, and 122-126, which were inaccessible due to isolation by private property.

Analytical methods

The invasive exotic plants encountered within the study area at Hot Springs National Park were attributed to line transects in a GIS (Figures 2 – 38). We calculated the study area to be 167.7 hectares (414.5 acres): the product of the total trail length surveyed and the 24 m belt-width, exclusive of the trail. A study area-wide cover range was estimated for each invasive exotic plant encountered. To calculate the minimum end of the estimated cover range for each species, we summed the lower endpoints associated with the assigned cover class values for that species; maximum cover for each species was calculated similarly, using the upper endpoints of the cover values. The study area-wide frequency of invasive exotic plants was calculated as the percentage of occupied transects.

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 2009, a total of 37 invasive exotic plant species were found during the survey at Hot Springs National Park (Table 2). The distribution and abundance of invasive exotic plant species within the study area varied widely. Chinese privet (*Ligustrum sinense*) was the most abundant species observed, covering at least 5 acres and occupying 59.4% of the inventory transects. Japanese honeysuckle (*Lonicera japonica*), the second most abundant species, appeared on a minimum of 4.3 acres; however, Japanese honeysuckle had the highest frequency of all the invasive exotic plant species documented (64.6%). Silktree (*Albizia julibrissin*) and English ivy (*Hedera helix*) each covered at least 1 acre and occurred at frequencies of 30.1% and 10.5%, respectively. Only four other species displayed cover range values in excess of 1 acre (maximum estimate): Bermudagrass (*Cynodon dactylon*) (12.3%), Chinese wisteria (*Wisteria sinensis*) (8.5%), sacred bamboo (*Nandina domestica*) (43.6%), and sericea lespedeza (*Lespedeza cuneata*) (17.8%). Although total cover of sacred bamboo was low, this species occurred in a relatively high proportion of inventory transects. The other 29 species documented in this survey each covered less than 1 acre and occurred in fewer than 10% of transects, with the exception of Nepalese browntop (*Microstegium vimineum*) and Taiwanese photinia (*Photinia serratifolia*) with frequencies of 15.8% and 13.7%, respectively.

In general, increased abundance and frequency of invasive exotic plant species occurred in the portions of the study area in close proximity to the urban areas of the city of Hot Springs (Thomas and Thomas, pers. com.). Directly adjacent to the city, the southeast portion of the park contained the greatest abundance and frequency of species. Additionally, surveyors noted that many of the observed species also appeared in the commercial and residential regions of the city of Hot Springs. This area also had the greatest concentration of trails and roadways in the park. Road and trail corridors, as well as the proximity of Hot Springs National Park to an urban area, are likely major sources of invasive exotic plant introductions into the park.

Autumn olive (*Elaeagnus umbellata*) ranks as the only invasive exotic plant in the study area with a definitively high ecological impact (Table 2). The ecological impact for the other species ranged from high-medium to insignificant. Japanese honeysuckle, Bermudagrass, Nepalese browntop, Johnsongrass (*Sorghum halepense*), Japanese meadowsweet (*Spiraea japonica*), and European privet (*Ligustrum vulgare*) were ranked as species generating high/medium management difficulty; however, the majority of the species are of little management concern with ratings of only medium to insignificant management difficulty. Recognizing that the feasibility of control often strongly influences decisions regarding invasive exotic plant management, autumn olive with a high ecological impact was noted as having low management difficulty. Additionally, many invasive exotic species occurred on less than 1 acre. Controlling as many species as possible now should provide a relatively high benefit for the cost. On the other hand, control of Japanese honeysuckle and Bermudagrass may prove to be difficult as both species were abundant in Hot Springs National Park and were noted as having high-medium management difficulty.

In summary, this report provides information on invasive, exotic plant abundance and distribution as well as the ecological impacts and management difficulty associated with these species. The information is designed to assist natural resource managers in planning invasive exotic plant management on national parks.

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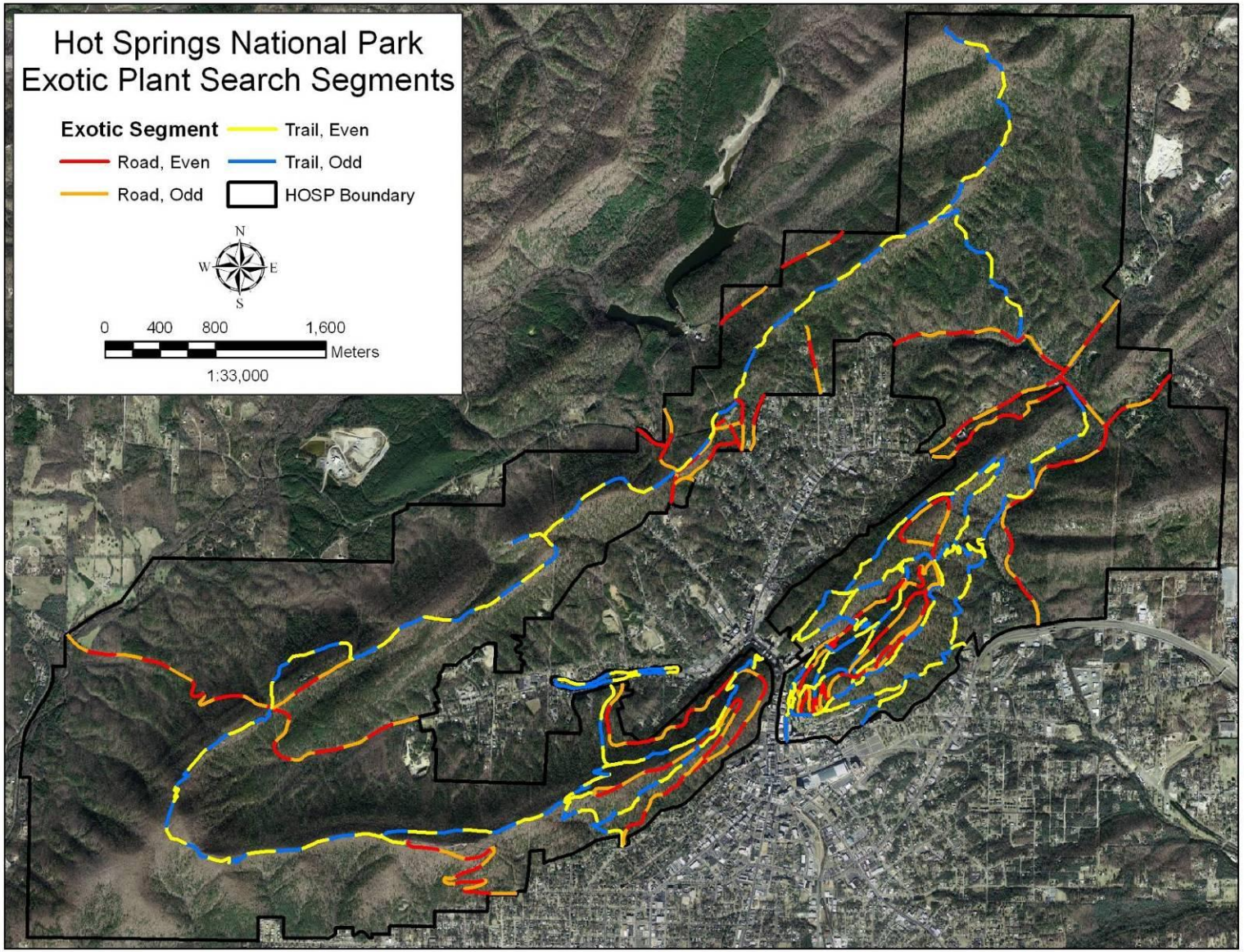

Figure 1. Invasive exotic plant line transects at Hot Springs National Park. The blue, yellow, orange, and red transects indicate the search locations for invasive exotic plants in 2009.

Table 1. Watch Lists for Hot Springs National Park. Aquatic plants are denoted with ^.

Early Detection Watch List		Park-Established Watch List	
Alliaria petiolata	Garlic mustard	*Ailanthus altissima*	Tree of heaven
Alternanthera philoxeroides^	Alligatorweed	*Albizia julibrissin*	Silktree
Alternanthera sessilis^	Sessile chaff-flower	*Baccharis halimifolia*	Eastern baccharis
Ampelopsis brevipedunculata	Amur peppervine	*Berberis thunbergii*	Japanese barberry
Arctium minus	Lesser burdock	*Bromus inermis*	Smooth brome
Arundo donax	Giant reed	*Bromus sterilis*	Poverty brome
Bothriochloa bladhii	Caucasian bluestem	*Cirsium vulgare*	Bull thistle
Bromus racemosus	Bald brome	*Cynodon dactylon*	Bermudagrass
Bromus tectorum	Cheatgrass	*Daucus carota*	Queen Anne's lace
Carduus nutans	Nodding plumeless thistle	*Dioscorea oppositifolia*	Chinese yam
Celastrus orbiculatus	Oriental bittersweet	*Echinochloa crus-galli*	Barnyard grass
Centaurea stoebe ssp. *Micranthos*	Spotted knapweed	*Elaeagnus angustifolia*	Russian olive
Cirsium arvense	Bull thistle	*Elaeagnus pungens*	Thorny olive
Coronilla varia	Crown vetch	*Glechoma hederacea*	Ground ivy
Dipsacus fullonum	Fuller's teasel	*Hedera helix*	English ivy
Egeria densa	Brazilian waterweed	*Hypericum perforatum*	St. John's-wort
Eichhornia crassipes^	Common water hyacinth	*Lespedeza cuneata*	Sericea lespedeza
Elymus repens	Quackgrass	*Ligustrum japonicum*	Japanese privet
Eragrostis curvula	Weeping lovegrass	*Ligustrum sinense*	Chinese privet
Euonymus fortunei	Winter creeper	*Ligustrum vulgare*	European privet
Euphorbia cyparissias	Cypress spurge	*Linaria vulgaris*	Butter and eggs
Hemerocallis fulva	Orange daylily	*Lolium pratense*	Meadow fescue
Hesperis matronalis	Dames rocket	*Lonicera japonica*	Japanese honeysuckle
Holcus lanatus	Common velvetgrass	*Lonicera morrowii*	Morrow's honeysuckle
Humulus japonicus	Japanese hop	*Lonicera tatarica*	Tatarian honeysuckle
Hydrilla verticillata^	Waterthyme	*Melia azedarach*	Chinaberrytree
Imperata cylindrica	Cogon satin-tail	*Miscanthus sinensis*	Chinese silvergrass
Iris pseudacorus^	Paleyellow iris	*Morus alba*	White mulberry
Leonurus cardiaca	Common motherwort	*Nandina domestica*	Sacred bamboo
Lespedeza bicolor	Shrub lespedeza	*Paulownia tomentosa*	Princesstree
Ligustrum lucidum	Glossy privet	*Photinia serratifolia*	Taiwanese photinia
Lolium arundinaceum	Tall fescue	*Poa pratensis*	Kentucky bluegrass

Table 1 (cont.). Watch Lists for Hot Springs National Park.

Early Detection Watch List		Park-Established Watch List	
Lolium spp.	Fescue	*Poncirus trifoliata*	Hardy orange
Lonicera maackii	Amur honeysuckle	*Populus alba*	White poplar
Lotus corniculatus	Bird's-foot trefoil	*Potentilla recta*	Sulphur cinquefoil
Lygodium japonicum	Japanese climbing fern	*Pueraria montana var. lobata*	Kudzu
Lysimachia nummularia	Creeping jenny	*Pyrus calleryana*	Callery pear
Lythrum salicaria	Purple loosestrife	*Robinia pseudoacacia*	Black locust
Melilotus officinalis	Yellow sweetclover	*Rorippa nasturtium-aquaticum*	Watercress
Microstegium vimineum	Nepalese browntop	*Rumex acetosella*	Sheep sorrel
Murdannia keisak	wartremoving herb	*Rumex crispus*	Curly dock
Myosotis scorpioides	True forget-me-not	*Sorghum halepense*	Johnsongrass
Myriophyllum aquaticum^	Parrot feather water-milfoil	*Sphenoclea zeylanica*	Chicken-spike
Myriophyllum spicatum^	Eurasian watermilfoil	*Spiraea japonica*	Japanese meadowsweet
Najas minor	Brittle naiad	*Torilis arvensis*	Field hedgeparsley
Pastinaca sativa	Wild parsnip	*Torilis japonica*	Erect hedgeparsley
Phalaris arundinacea	Reed canarygrass	*Ulmus pumila*	Siberian elm
Phragmites australis	Common reed	*Verbascum thapsus*	Common mullein
Phyllostachys spp.	Bamboo	*Vinca major*	Bigleaf periwinkle
Poa compressa	Canada bluegrass	*Vinca minor*	Common periwinkle
Polygonum cuspidatum	Japanese knotweed	*Wisteria floribunda*	Japanese wisteria
Potamogeton crispus^	Curly pondweed	*Wisteria sinensis*	Chinese wisteria
Prunus mahaleb	Perfumed cherry		
Rhamnus cathartica	Common buckthorn		
Rosa multiflora	Multiflora rose		
Salvinia molesta	Giant salvinia ^		
Saponaria officinalis	Bouncing-bet		
Solanum viarum	Tropical soda-apple		
Tamarix ramosissima	Saltcedar		
Tanacetum vulgare	Common tansy		
Triadica sebifera	Chinese tallowtree		
Typha angustifolia	Narrowleaf cattail		
Typha X glauca	Blue cattail		

Table 2. Overview of invasive exotic plants found on Hot Springs National Park in 2009. Inequalities are shown instead of cover values for species with maximum cover less than 1 acre. Ecological impact and general management difficulty based on NatureServe I-Rank subranks, Morse et al. 2004. Subranks are given as high (H), medium (M), low (L), insignificant (I), unknown (U), a range of ranks (indicated by /), or not available (---).

Scientific Name	Common Name	Watch list	Study Area-wide cover (acres)	Frequency (Percent)	Ecological impact	Management difficulty
Ligustrum sinense	Chinese privet	Park-established	5.0 - 15.0	59.4	M	L
Lonicera japonica	Japanese honeysuckle	Park-established	4.3 - 13.4	64.6	M	HM
Albizia julibrissin	silktree	Park-established	1.1 - 3.1	30.1	HL	ML
Hedera helix	English ivy	Park-established	1.0 - 3.4	10.5	MI	L
Cynodon dactylon	Bermudagrass	Park-established	0.9 - 3.5	12.3	ML	HM
Wisteria sinensis	Chinese wisteria	Park-established	0.6 - 1.6	8.5	ML	L
Nandina domestica	sacred bamboo	Park-established	0.4 - 1.6	43.6	HM	----
Lespedeza cuneata	sericea lespedeza	Park-established	0.4 - 1.3	17.8	M	M
Microstegium vimineum	Nepalese browntop	Early detection	< 1.0	15.8	M	HM
Vinca major	bigleaf periwinkle	Park-established	< 0.75	4.1	ML	M
Ligustrum japonicum	Japanese privet	Park-established	< 0.5	3.8	ML	HL
Photinia serratifolia	Taiwanese photinia	Park-established	< 0.5	13.7	----	----
Euonymus fortunei	winter creeper	Early detection	< 0.25	2.6	M	LI
Glechoma hederacea	ground ivy	Park-established	< 0.25	2.6	LI	ML
Melia azedarach	Chinaberrytree	Park-established	< 0.25	4.7	ML	ML
Paulownia tomentosa	princesstree	Park-established	< 0.25	5.3	ML	L
Ailanthus altissima	tree of heaven	Park-established	< 0.1	3.2	ML	ML
Celastrus orbiculatus	Oriental bittersweet	Early detection	< 0.1	0.6	ML	M
Daucus carota	Queen Anne's lace	Park-established	< 0.1	2.3	I	I
Elaeagnus pungens	thorny olive	Park-established	< 0.1	0.9	LI	HL
Elaeagnus umbellata	autumn olive	Park-established	< 0.1	1.2	H	L
Hemerocallis fulva	orange daylily	Park-established	< 0.1	1.2	M	ML
Pueraria montana	kudzu	Early detection	< 0.1	1.8	M	ML
Pyrus calleryana	Callery pear	Park-established	< 0.1	7.6	LI	ML
Robinia pseudoacacia	black locust	Park-established	< 0.1	0.6	HM	M
Sorghum halepense	Johnsongrass	Park-established	< 0.1	2.3	ML	HM
Spiraea japonica	Japanese meadowsweet	Park-established	< 0.1	0.9	ML	HM
Vinca minor	common periwinkle	Park-established	< 0.1	0.3	I	----
Baccharis halimifolia	eastern baccharis	Park-established	< 0.01	0.6	----	----
Hesperis matronalis	dames rocket	Early detection	< 0.01	0.3	MI	HL

Table 2 (cont.). Overview of invasive exotic plants found on Hot Springs National Park in 2009.

Scientific Name	Common Name	Watch list	Study Area-wide cover (acres)	Frequency (Percent)	Ecological impact	Management difficulty
Ligustrum vulgare	European privet	Park-established	< 0.01	0.3	HL	HM
Lonicera morrowii	Morrow's honeysuckle	Park-established	< 0.01	0.3	ML	M
Rosa multiflora	multiflora rose	Early detection	< 0.01	1.5	L	L
Rumex crispus	curly dock	Park-established	< 0.01	0.3	LI	ML
Torilis japonica	erect hedgeparsley	Park-established	< 0.01	0.9	----	----
Lonicera maackii	Amur honeysuckle	Early detection	< 0.001	0.3	HM	M
Morus alba	white mulberry	Park-established	< 0.001	0.3	ML	ML

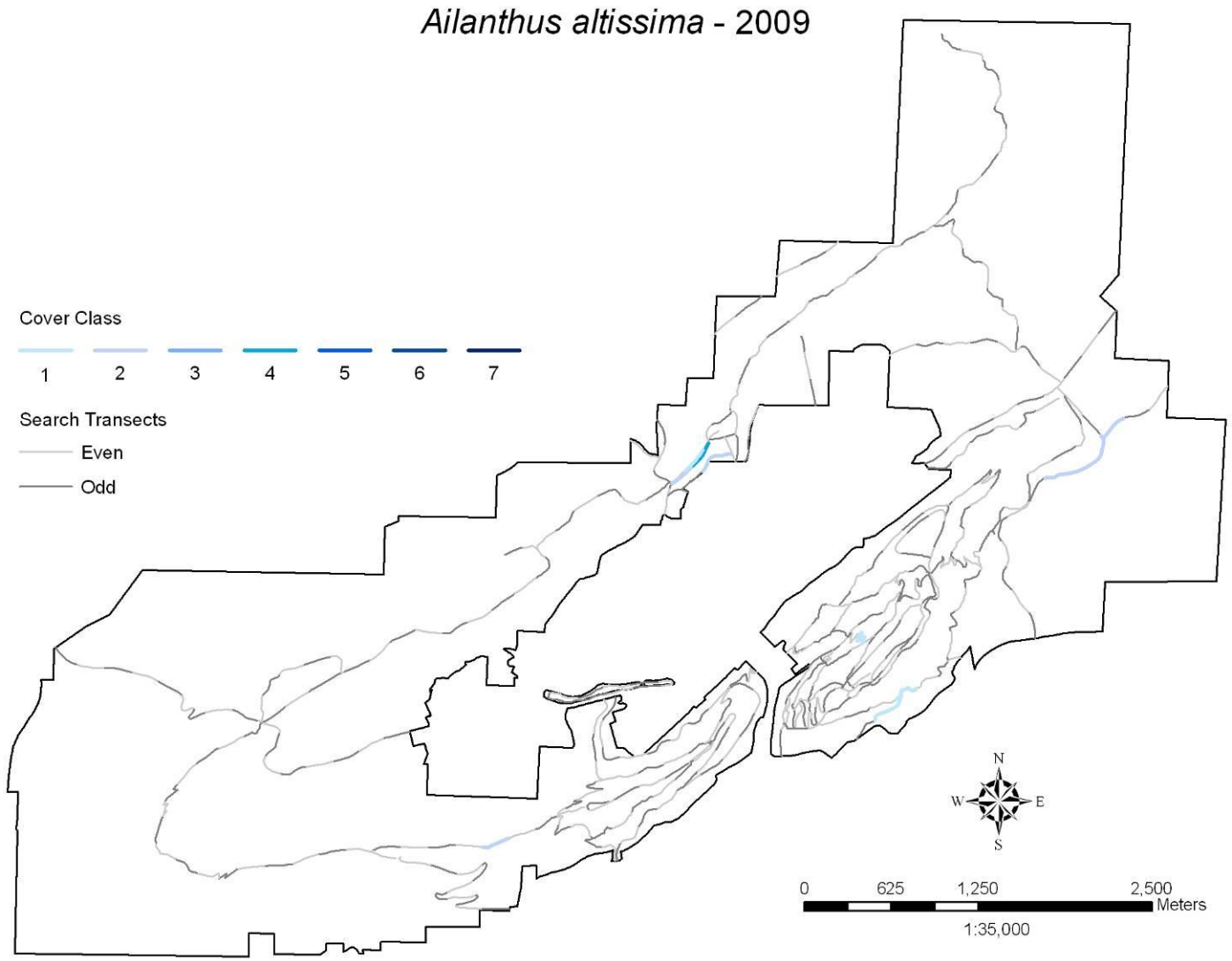

Figure 2. Abundance and distribution of *Ailanthus altissima* (tree of heaven) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

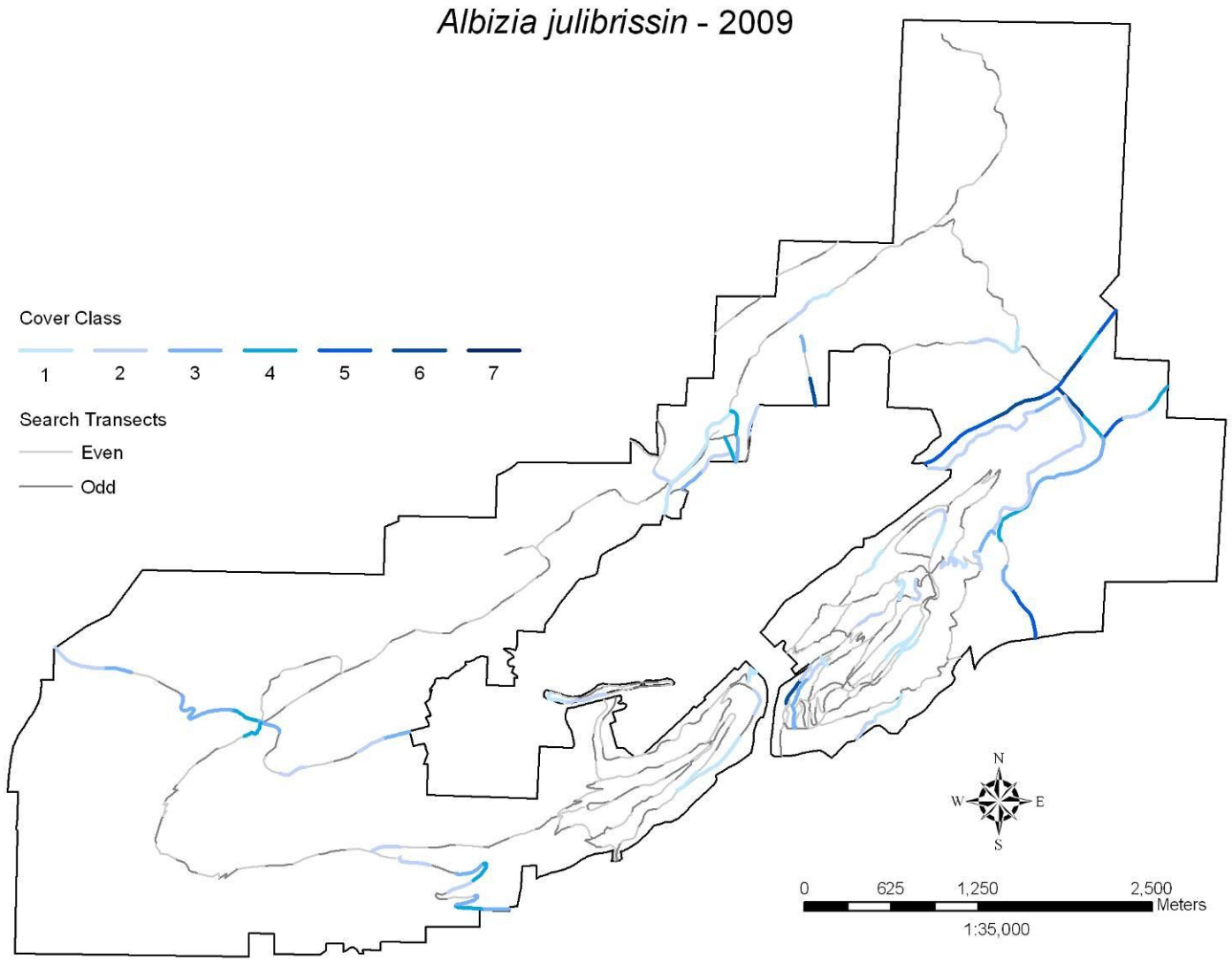

Figure 3. Abundance and distribution of *Albizia julibrissin* (silktree) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

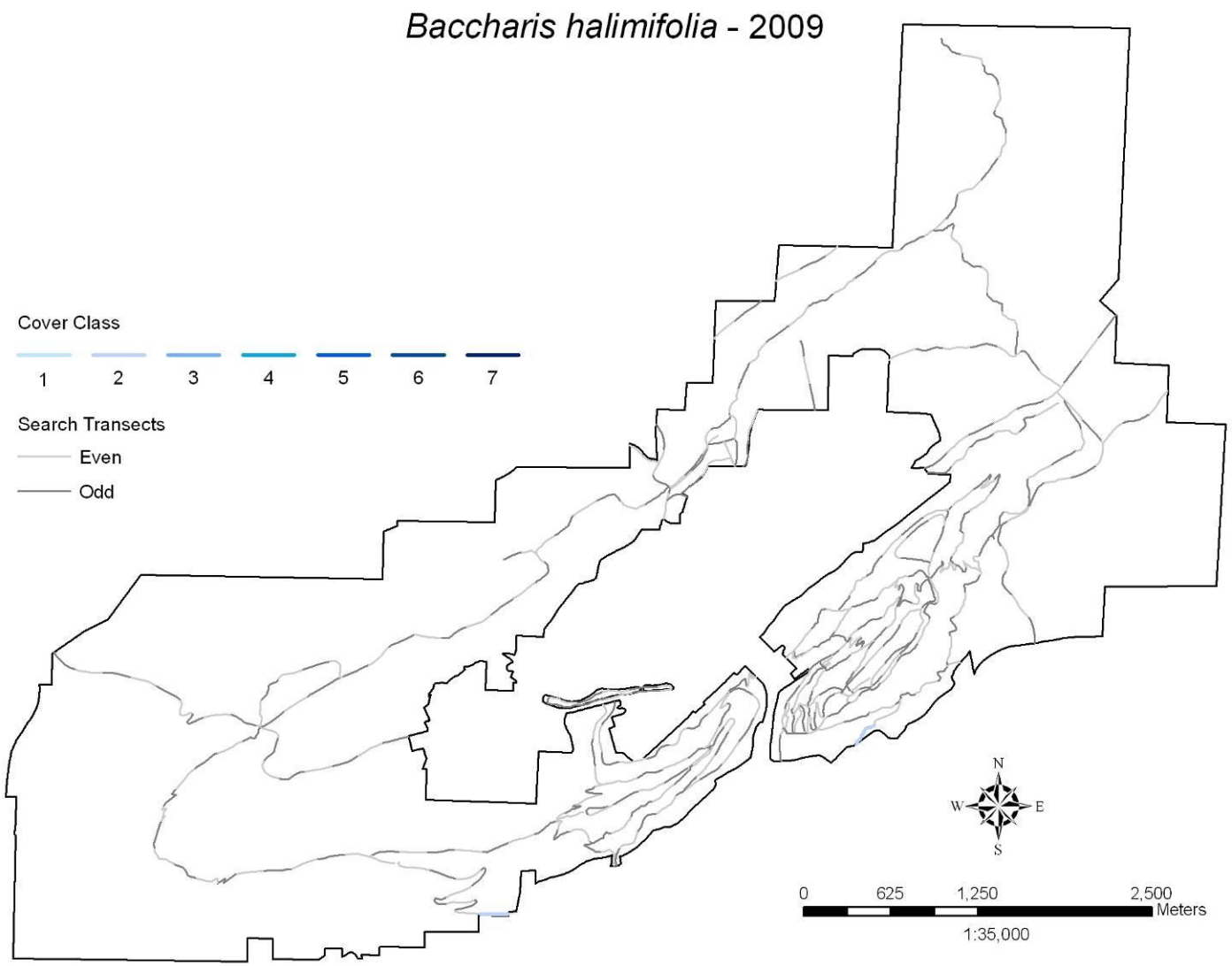

Figure 4. Abundance and distribution of *Baccharis hamifolia* (eastern baccharis) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

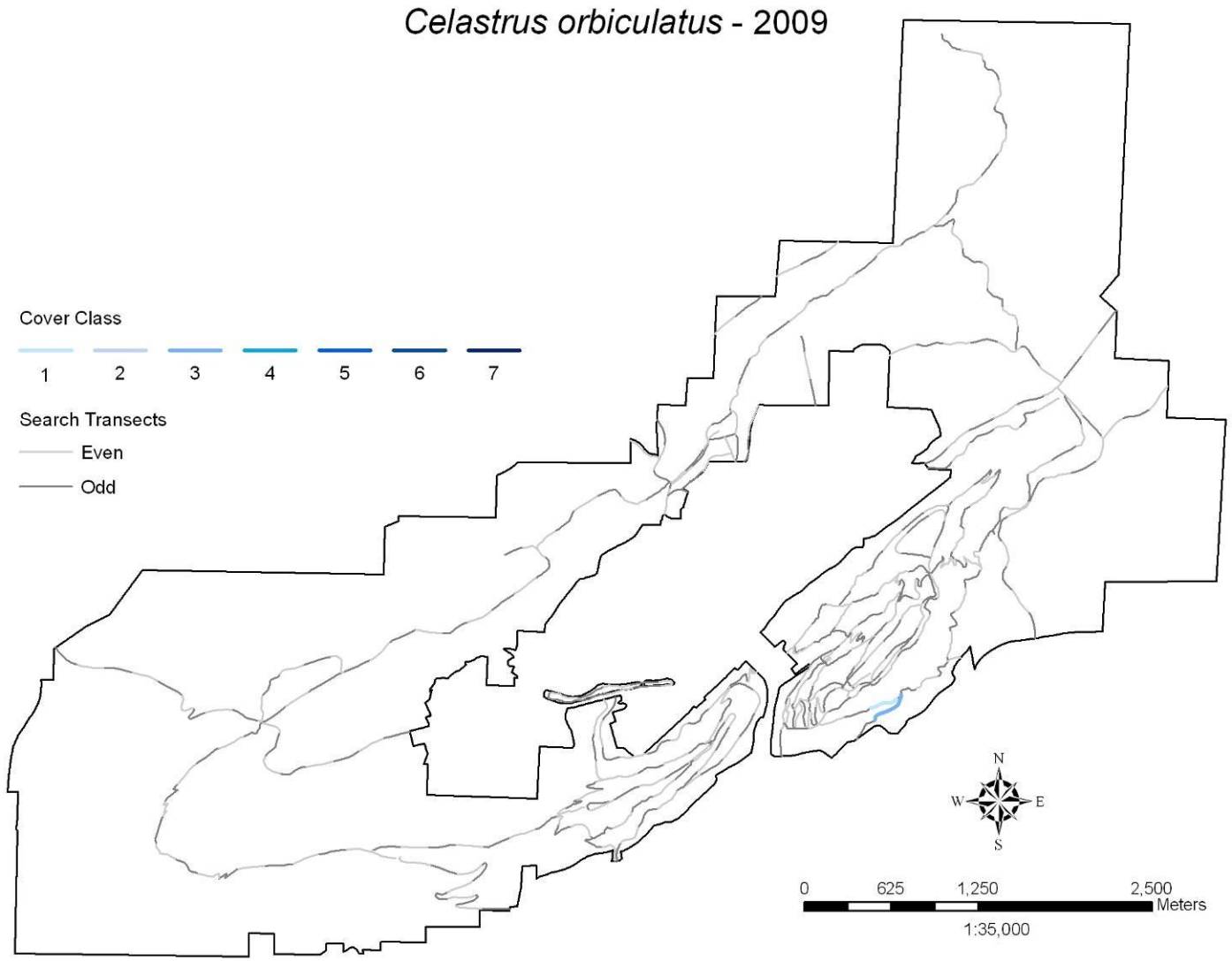

Figure 5. Abundance and distribution of *Celastrus orbiculatus* (Oriental bittersweet) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

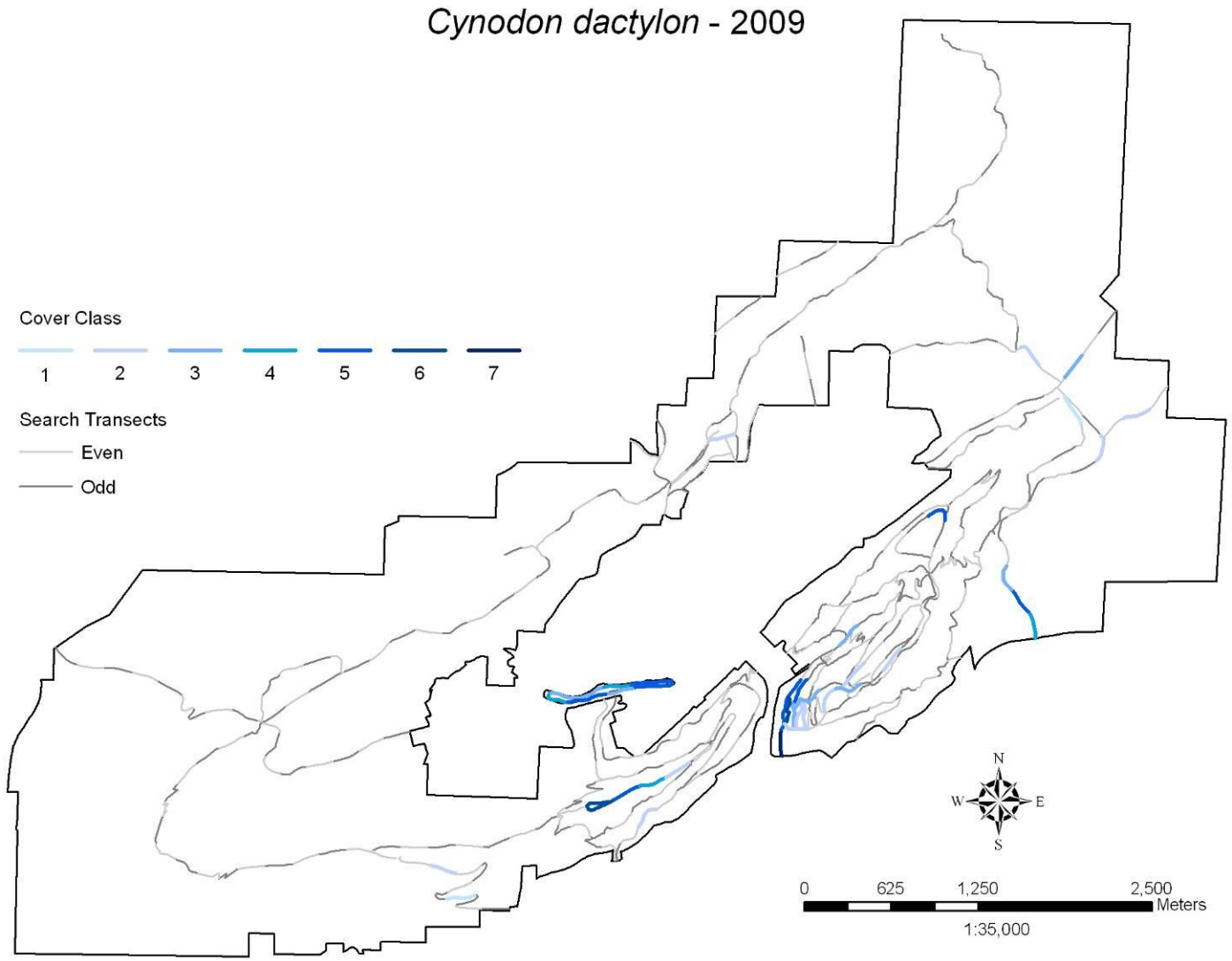

Figure 6. Abundance and distribution of *Cynodon dactylon* (Bermudagrass) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

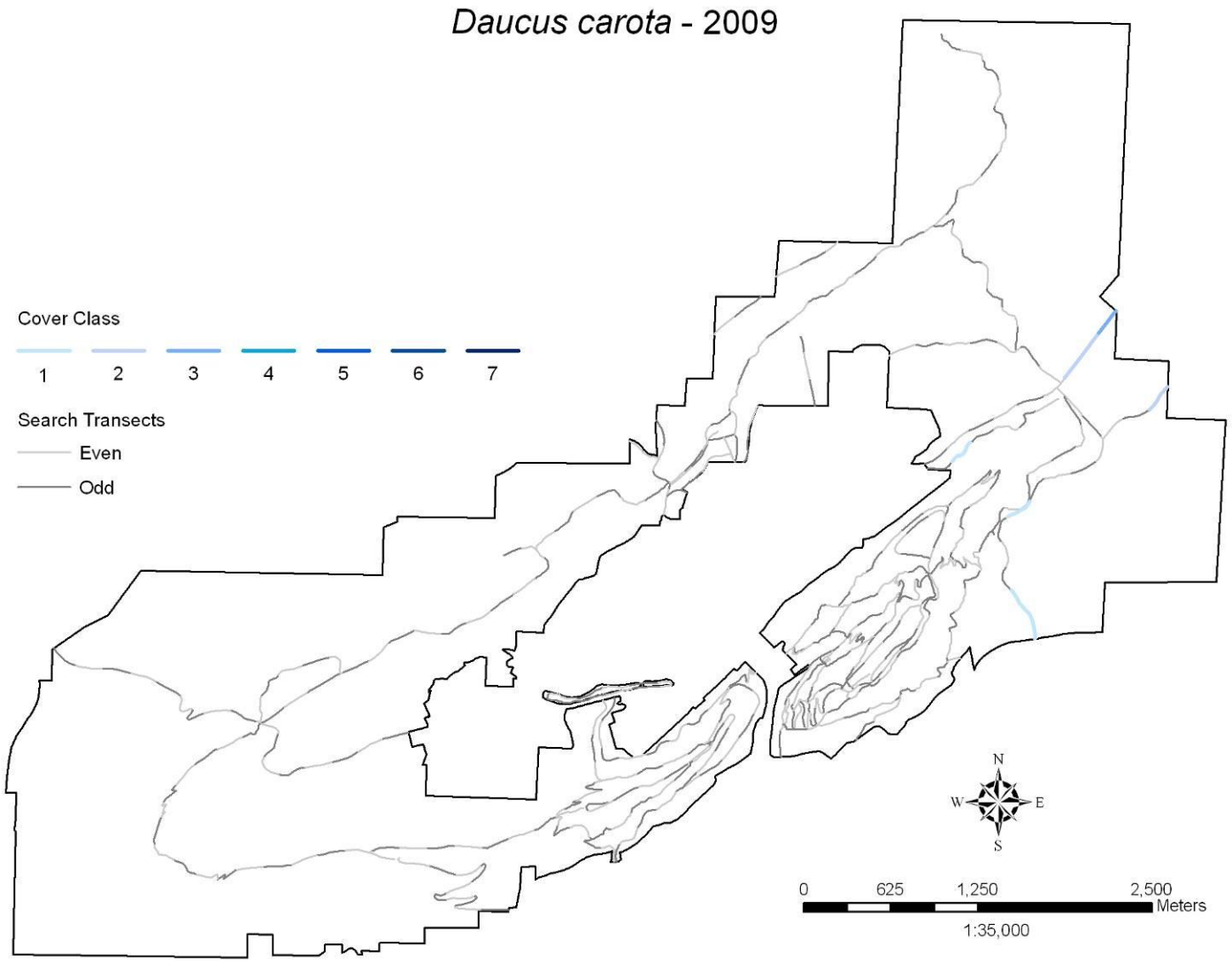

Figure 7. Abundance and distribution of *Daucus carota* (Queen Anne's lace) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

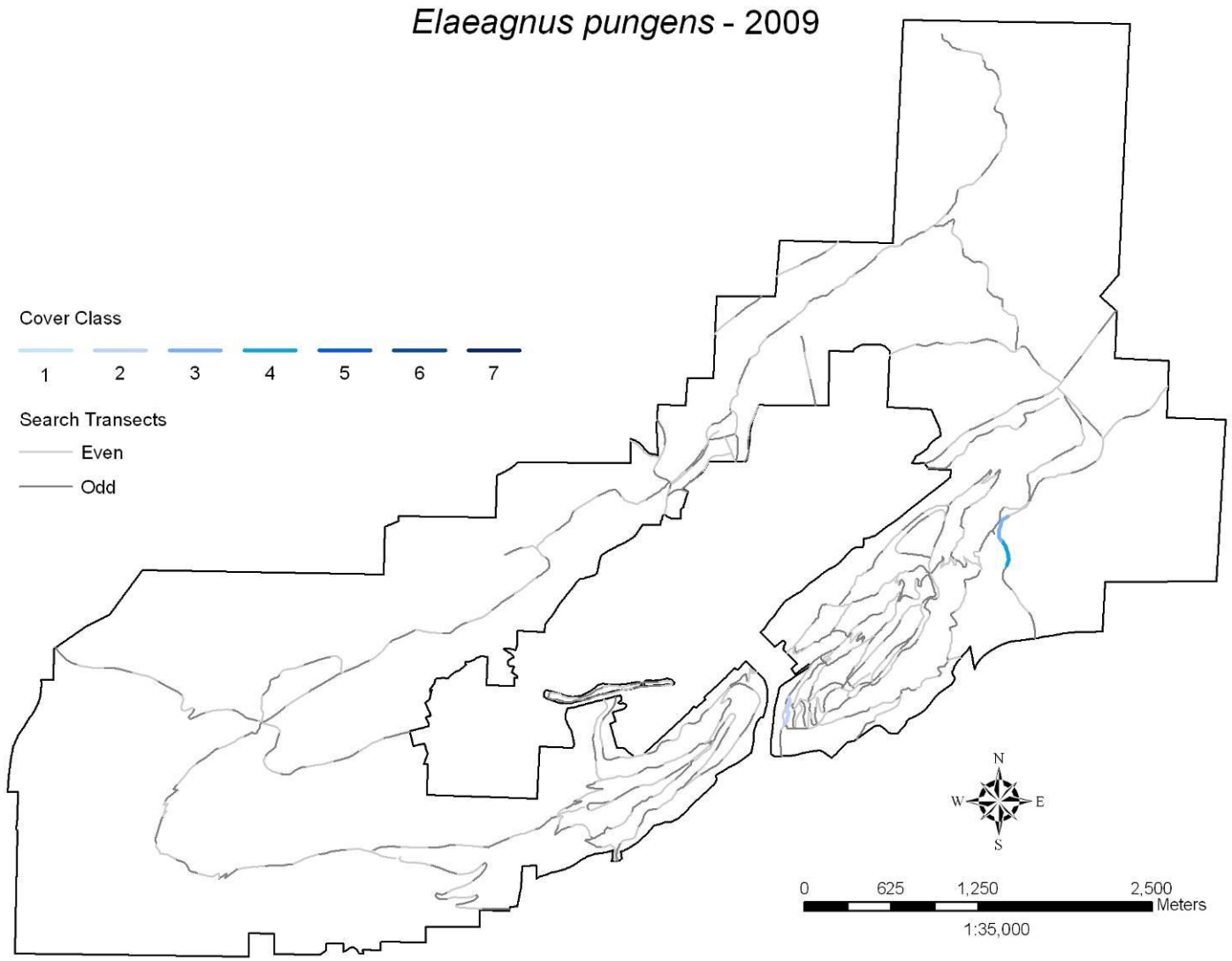

Figure 8. Abundance and distribution of *Elaeagnus pungens* (thorny olive) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

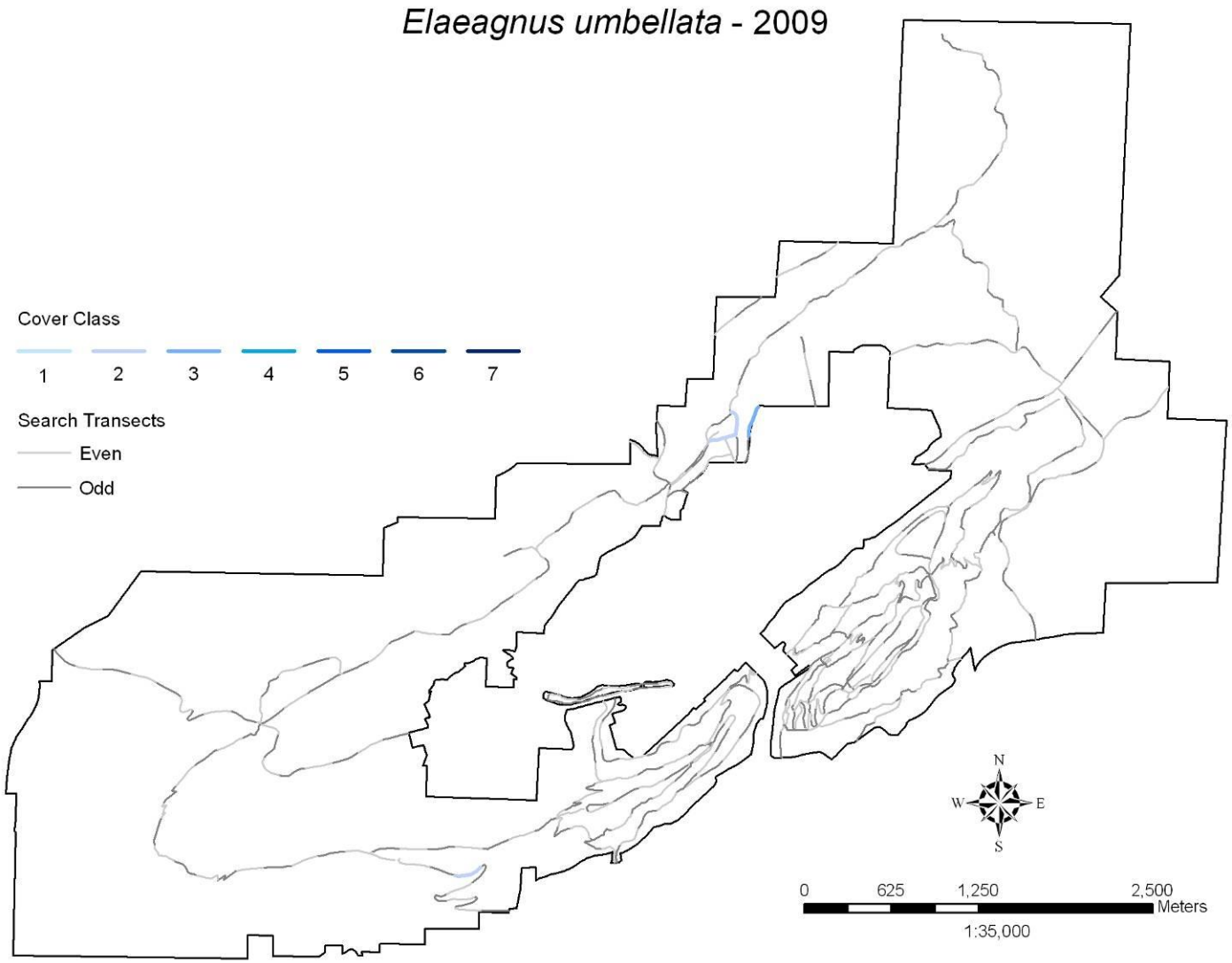

Figure 9. Abundance and distribution of *Elaeagnus umbellata* (autumn olive) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

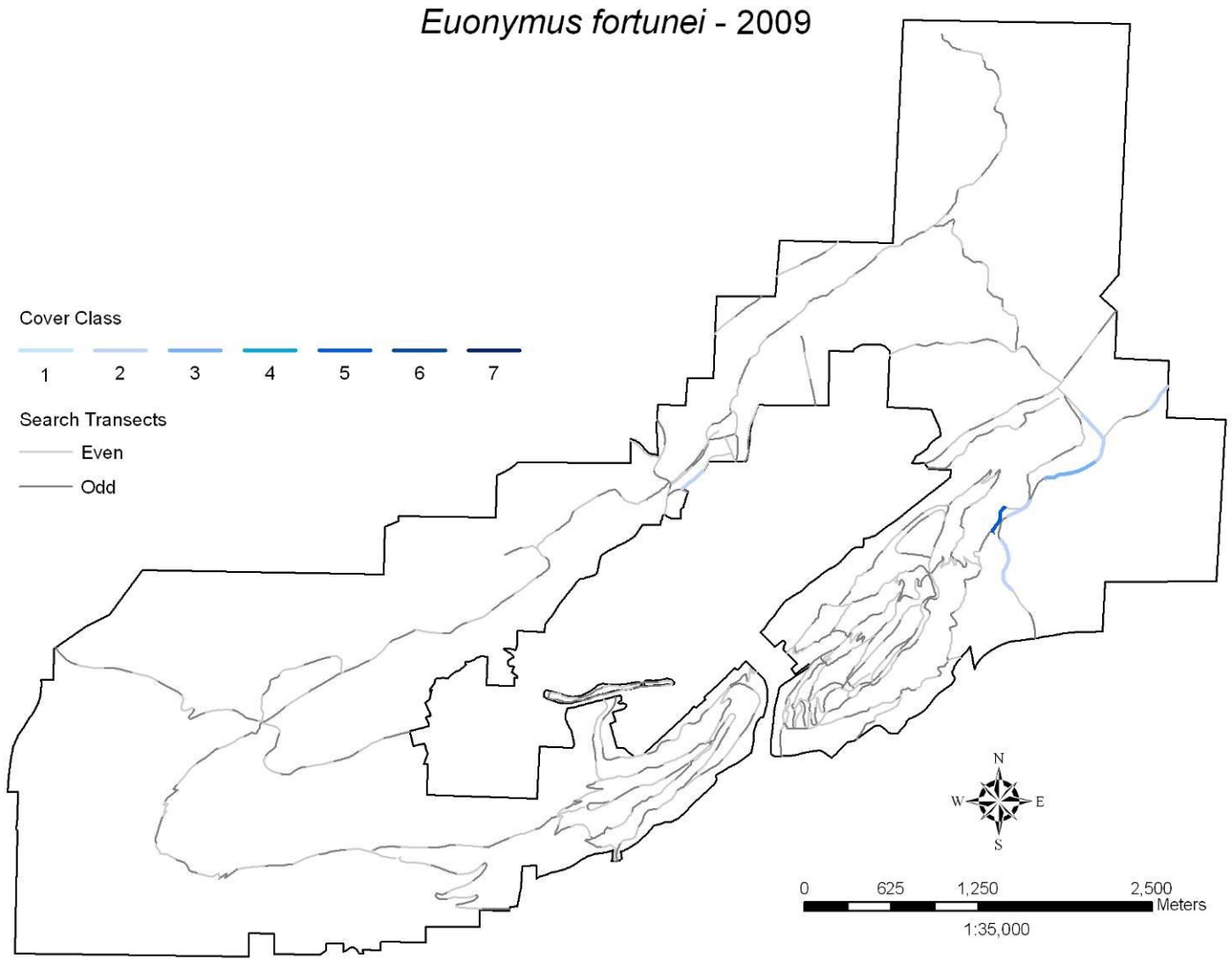

Figure 10. Abundance and distribution of *Euonymus fortunei* (winter creeper) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

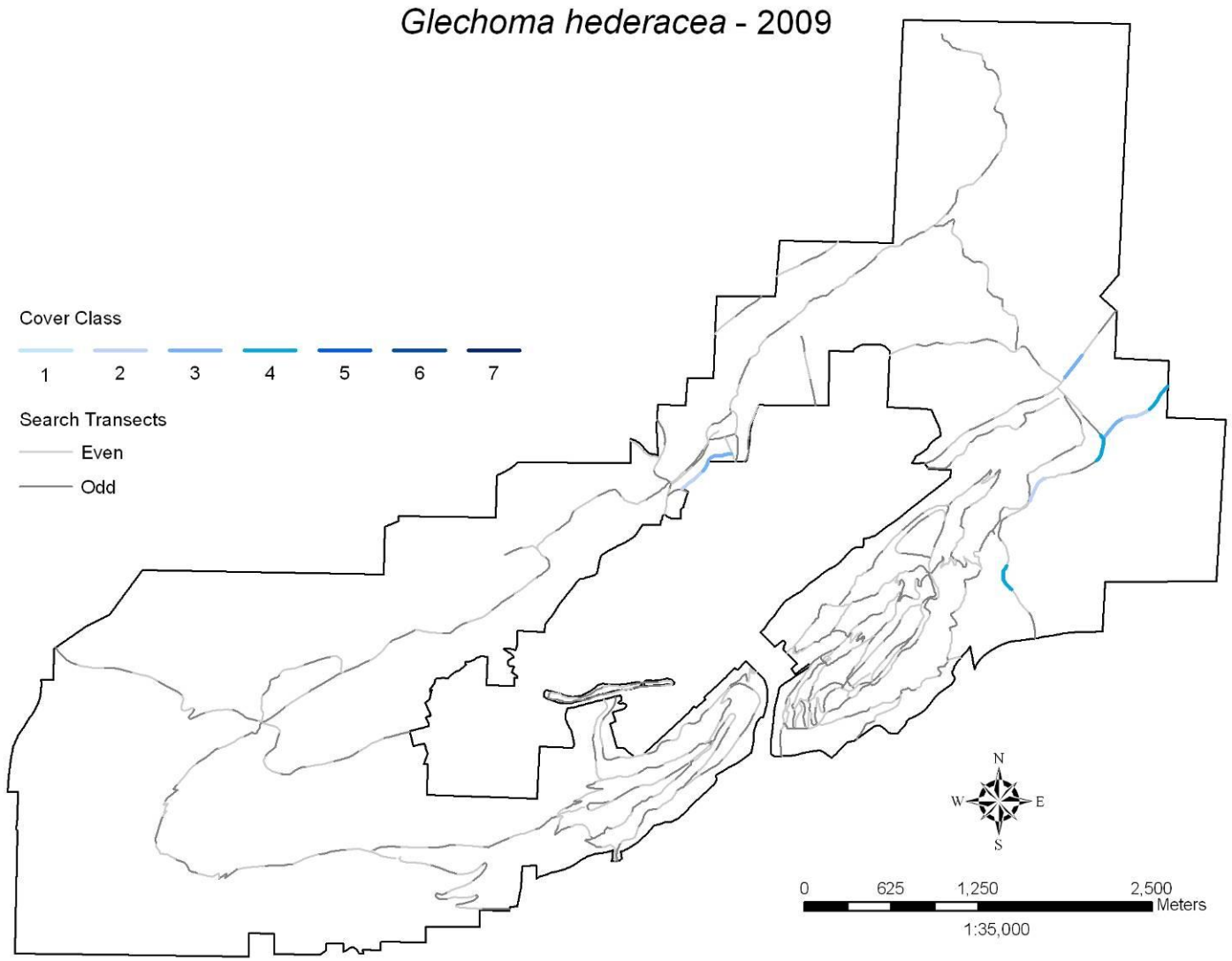

Figure 11. Abundance and distribution of *Glechoma hederacea* (ground ivy) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

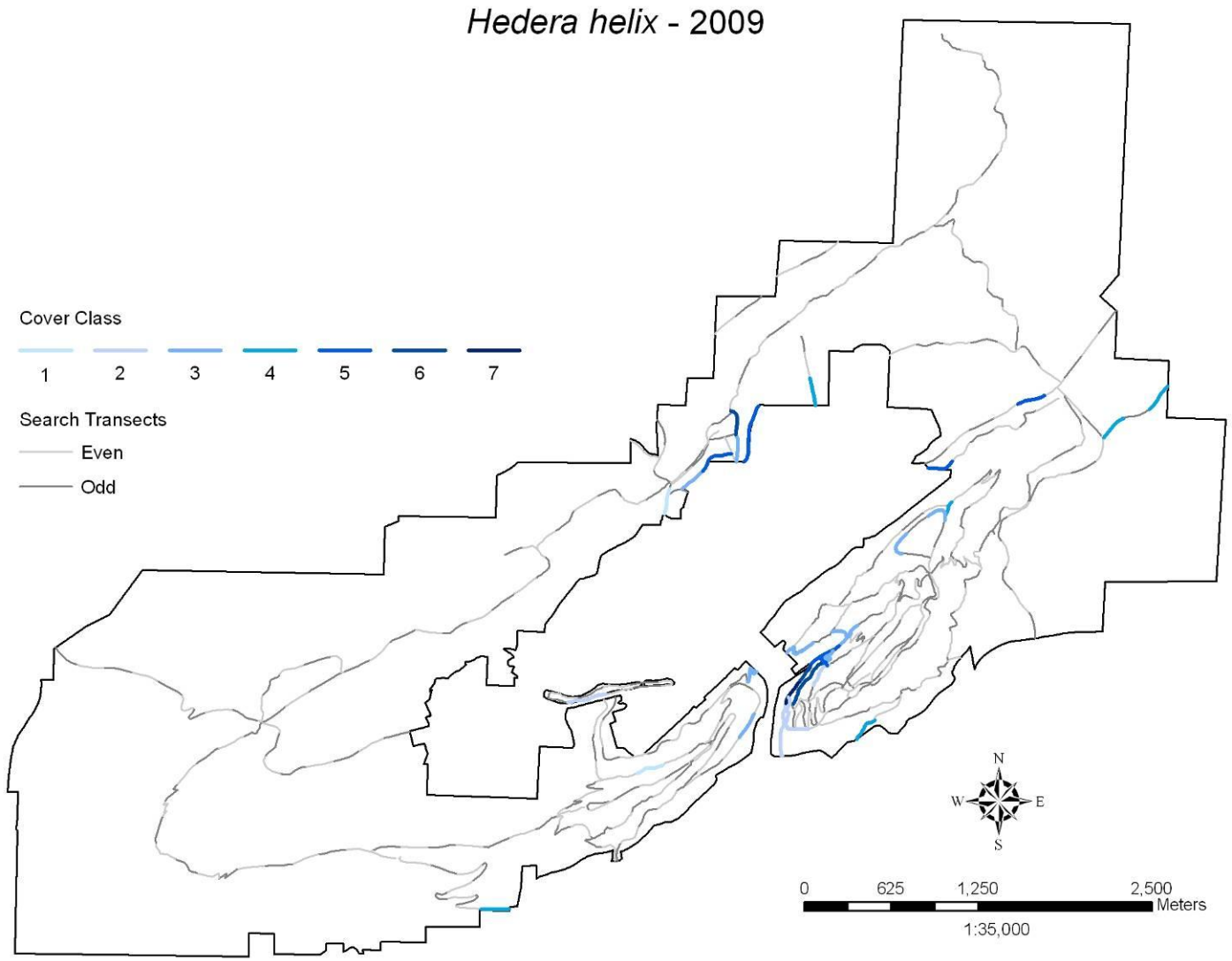

Figure 12. Abundance and distribution of *Hedera helix* (English ivy) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

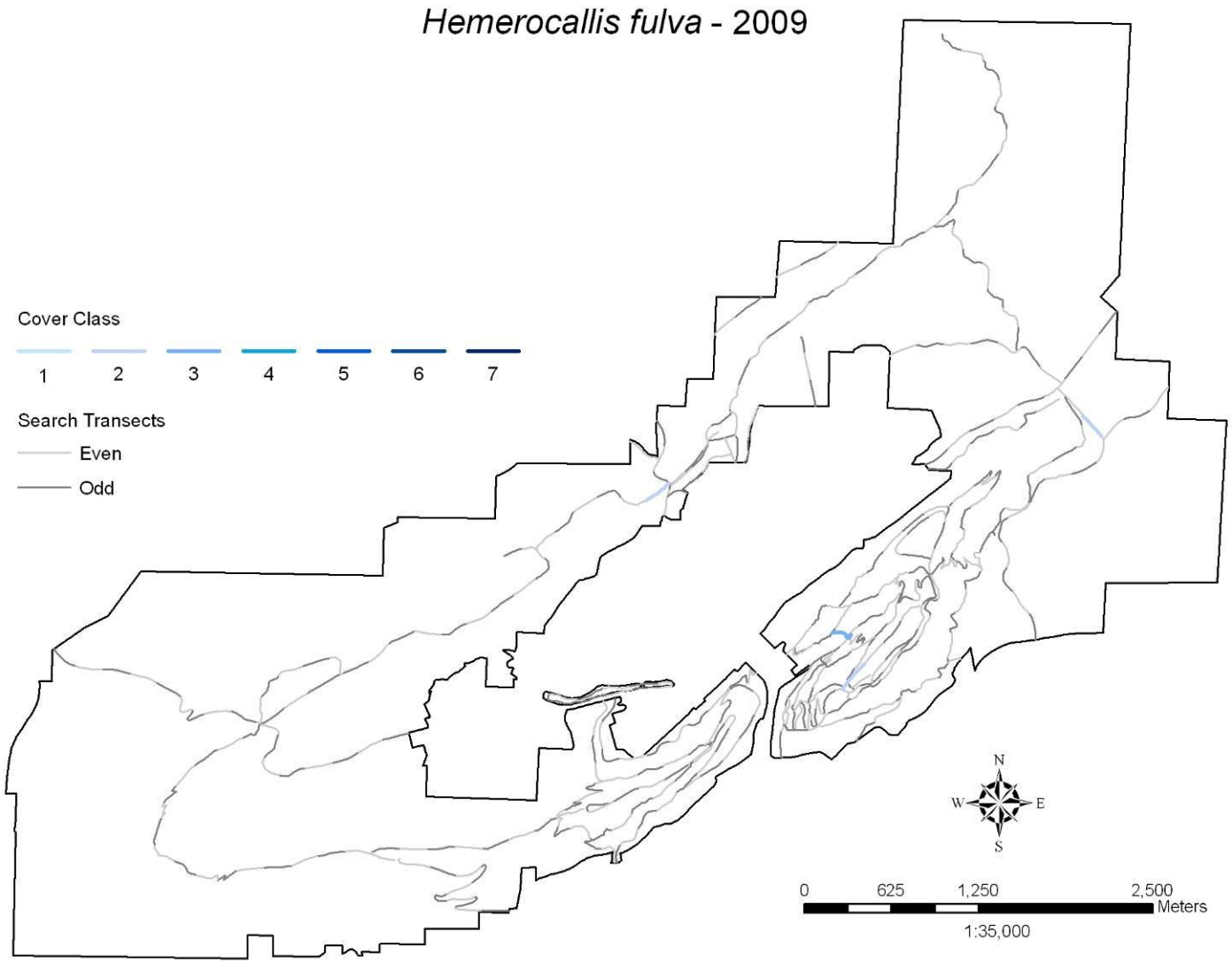

Figure 13. Abundance and distribution of *Hemerocallis fulva* (orange daylily) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

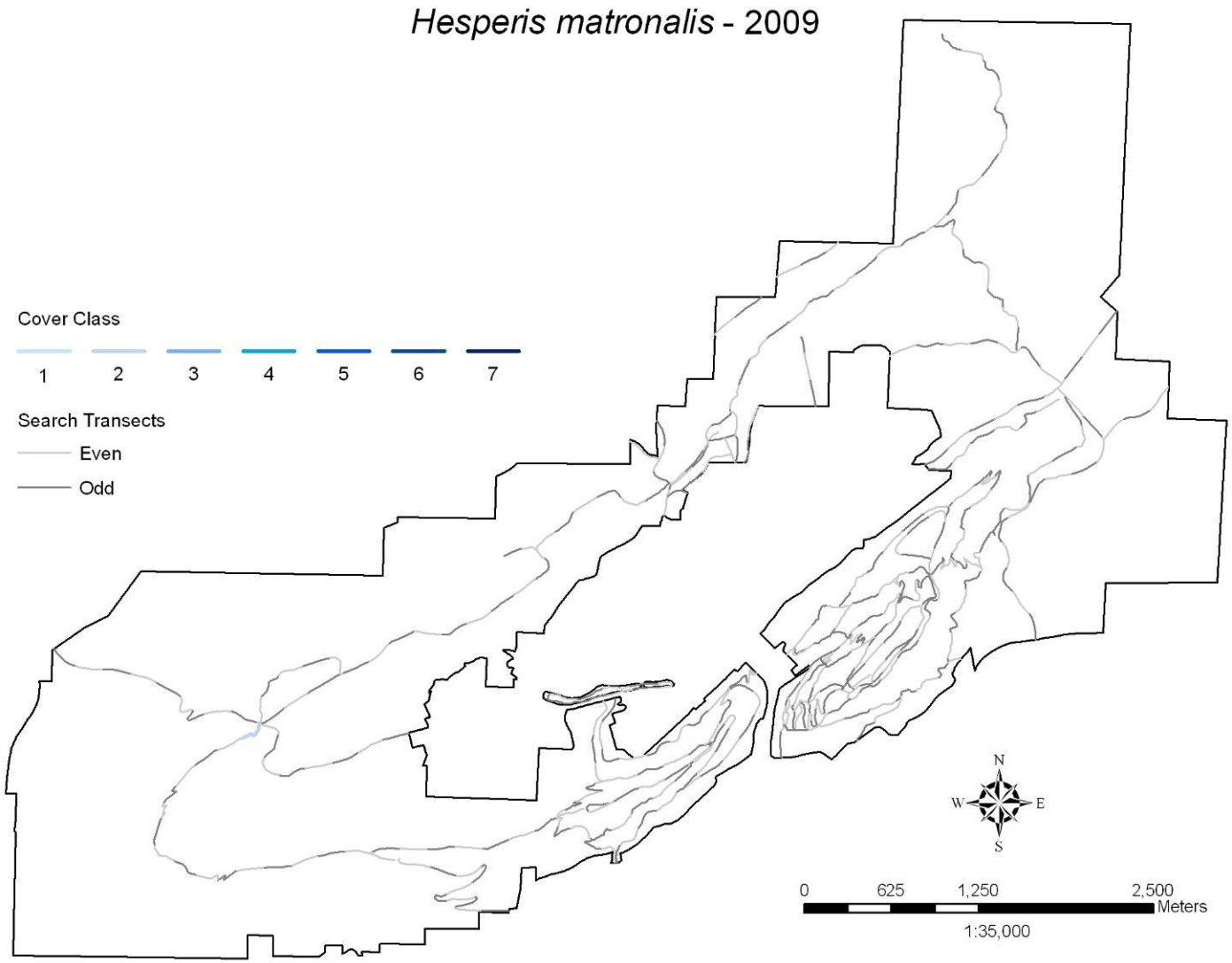

Figure 14. Abundance and distribution of *Hesperis matronalis* (dames rocket) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

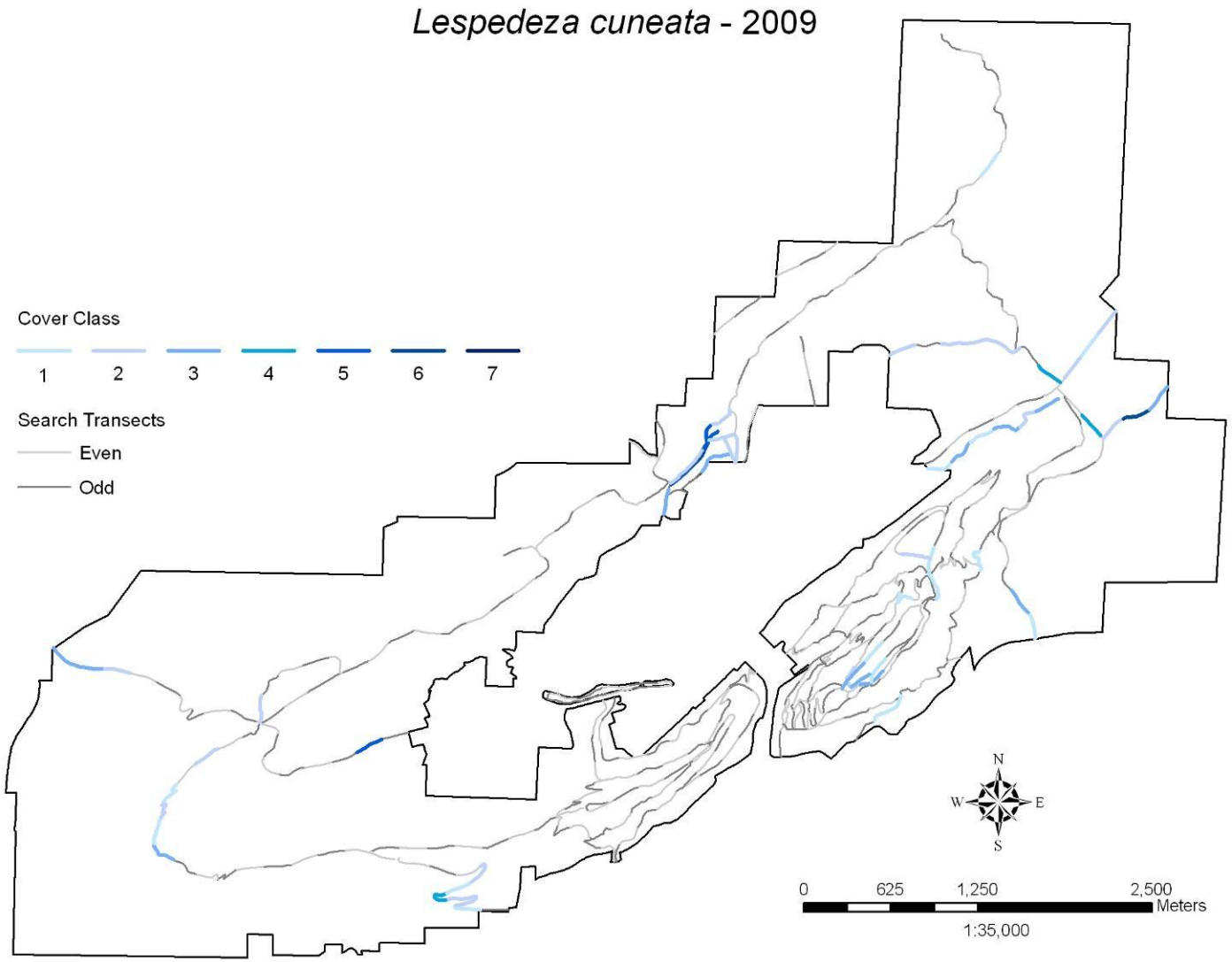

Figure 15. Abundance and distribution of *Lespedeza cuneata* (sericea lespedeza) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

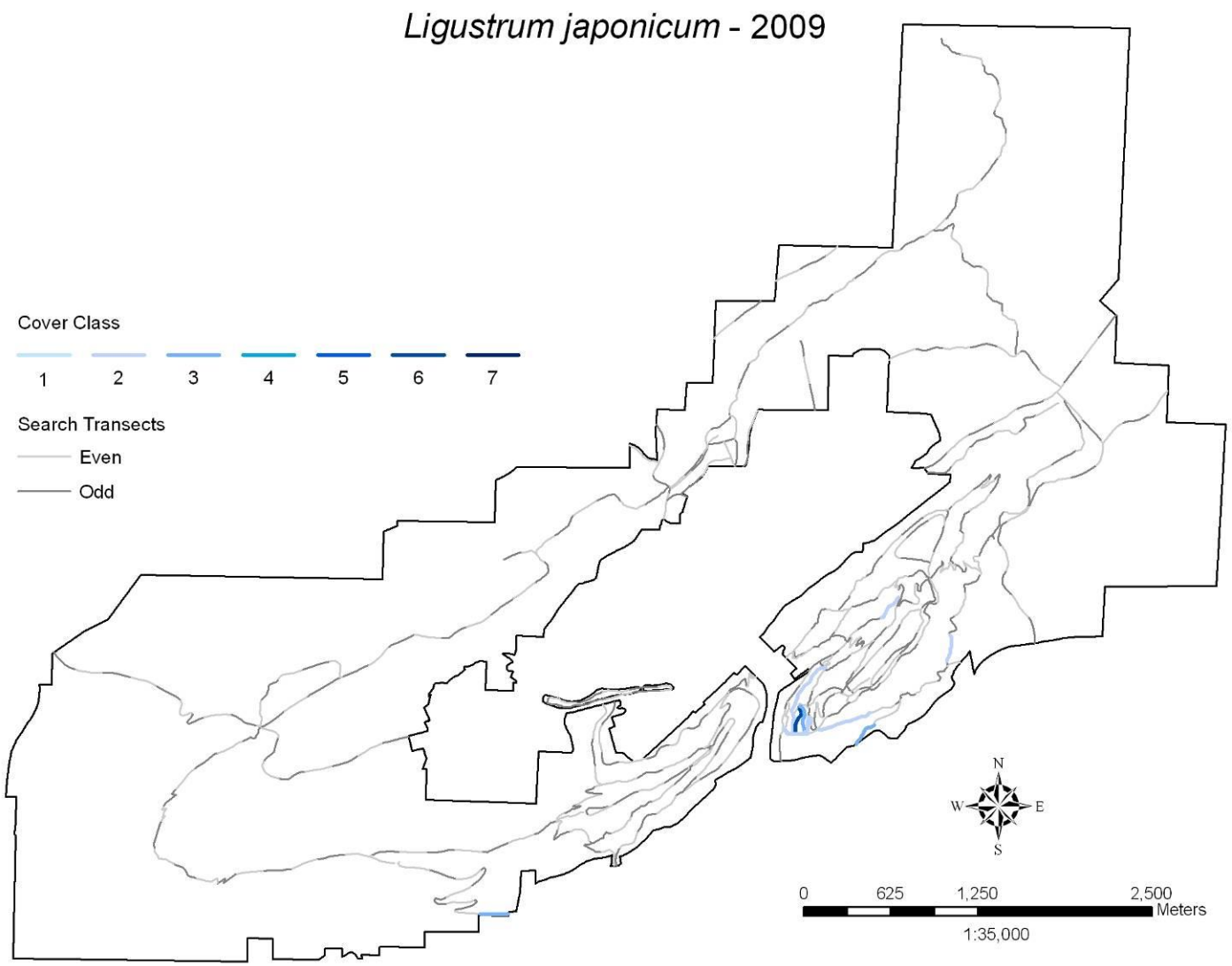

Figure 16. Abundance and distribution of *Ligustrum japonicum* (Japanese privet) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

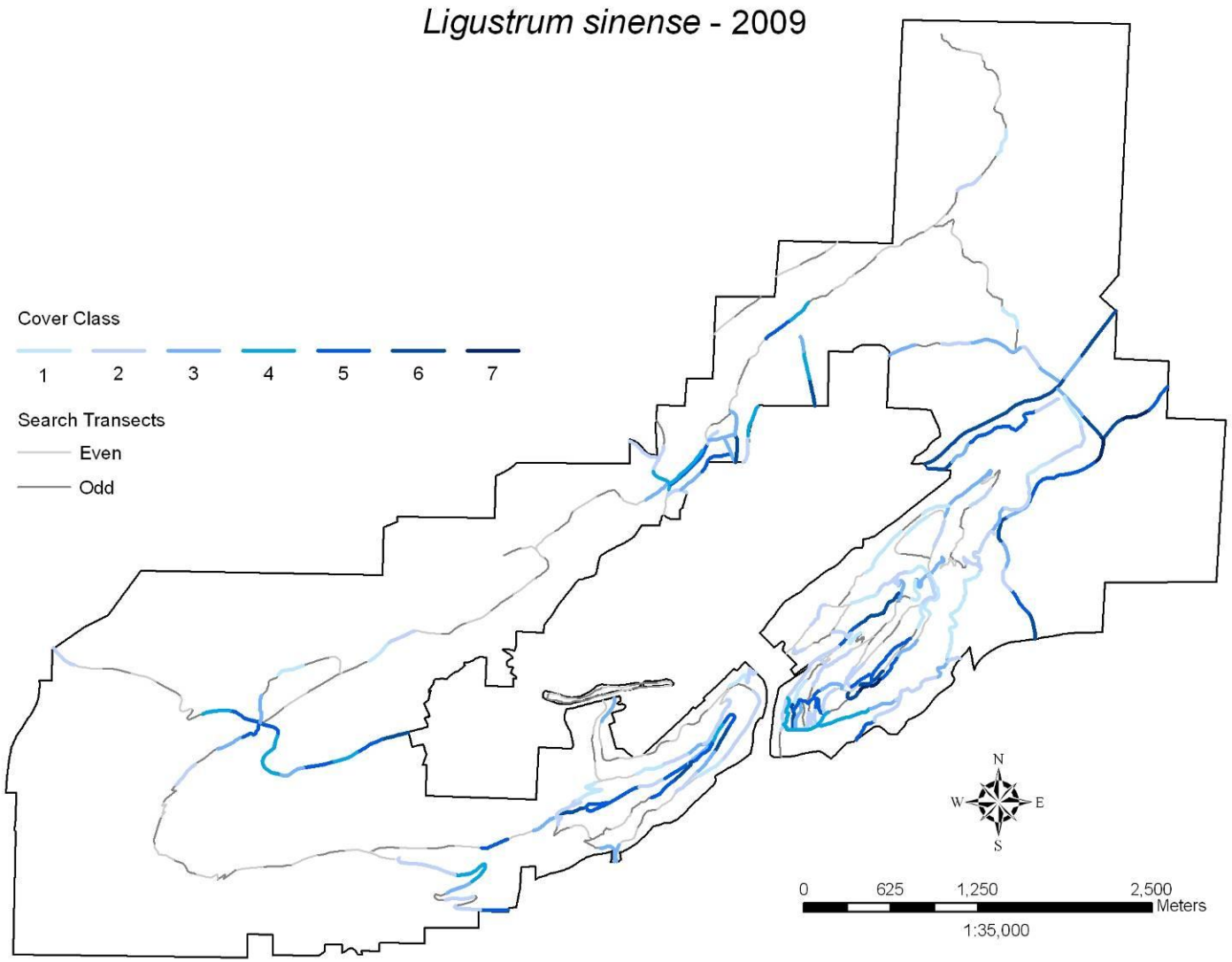

Figure 17. Abundance and distribution of *Ligustrum sinense* (Chinese privet) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

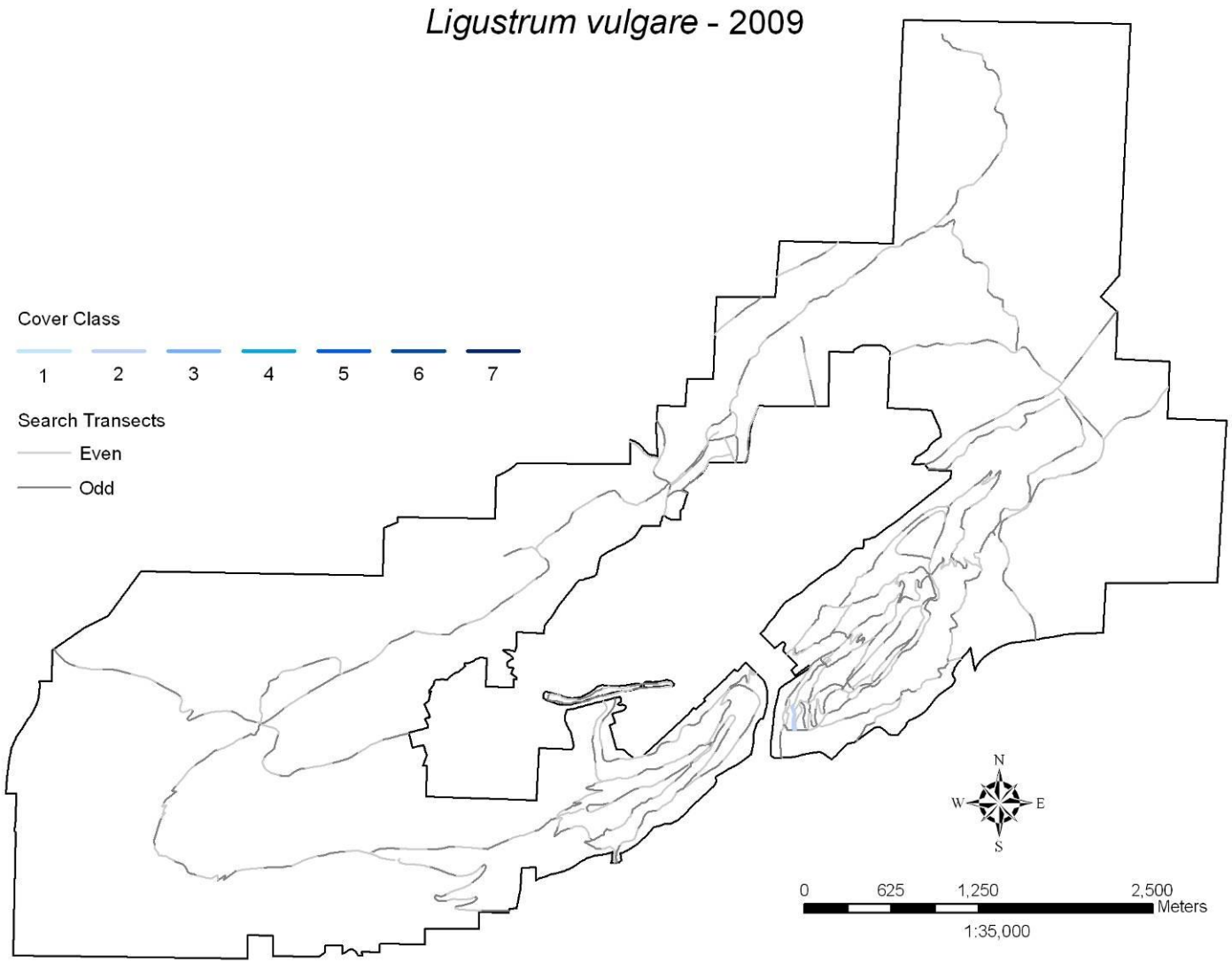

Figure 18. Abundance and distribution of *Ligustrum vulgare* (European privet) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

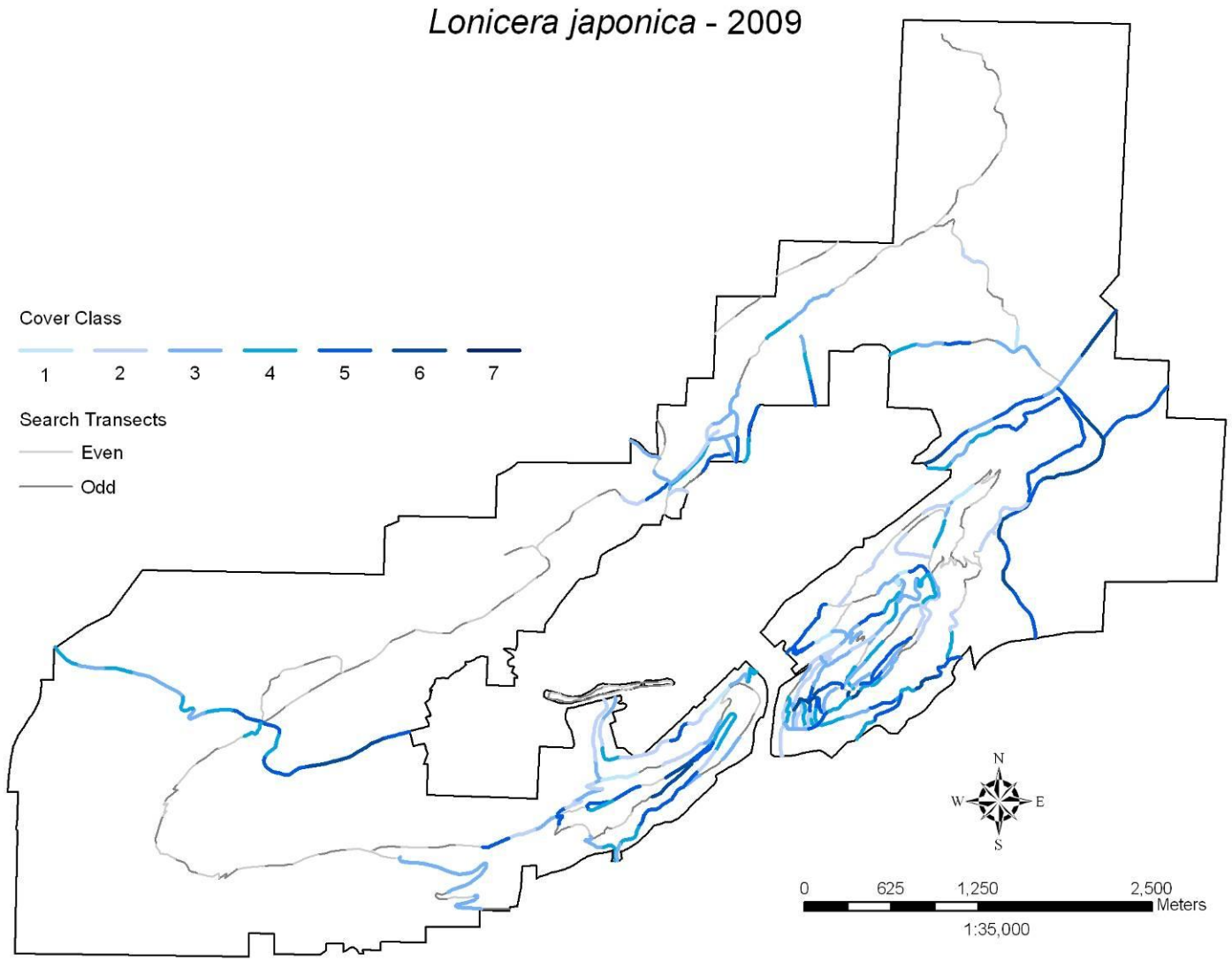

Figure 19. Abundance and distribution of *Lonicera japonica* (Japanese honeysuckle) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

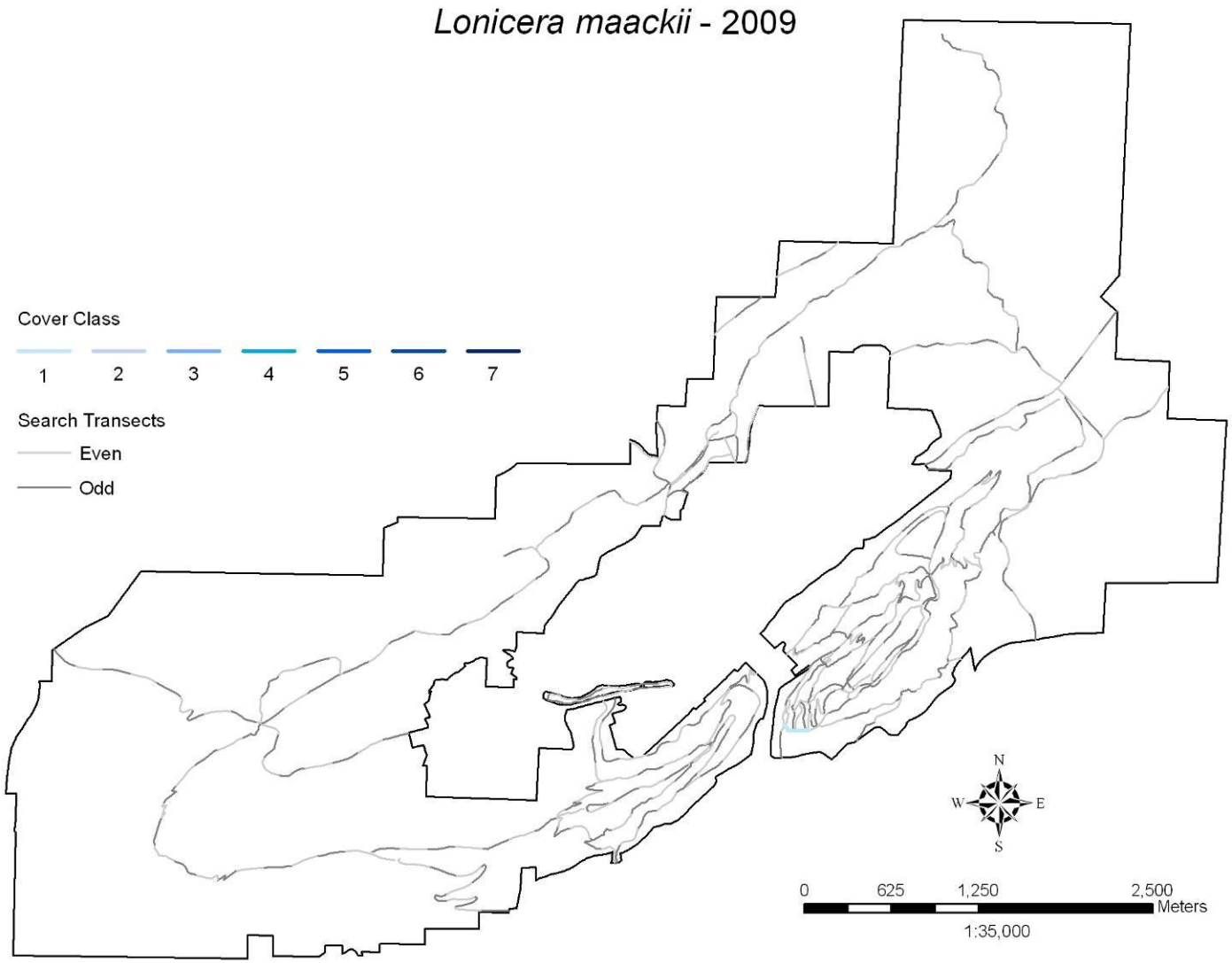

Figure 20. Abundance and distribution of *Lonicera maackii* (Amur honeysuckle) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

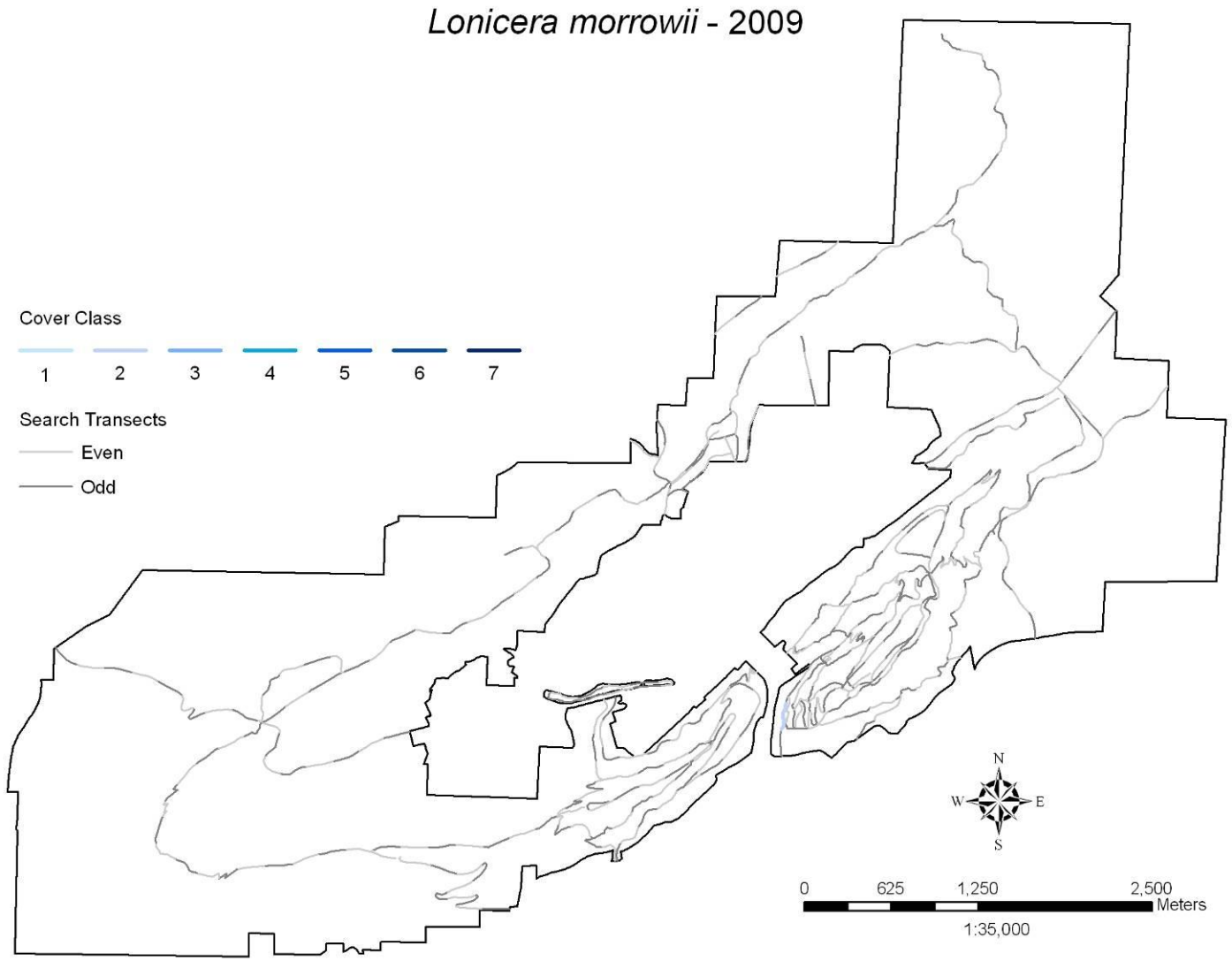

Figure 21. Abundance and distribution of *Lonicera morrowii* (Morrow's honeysuckle) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

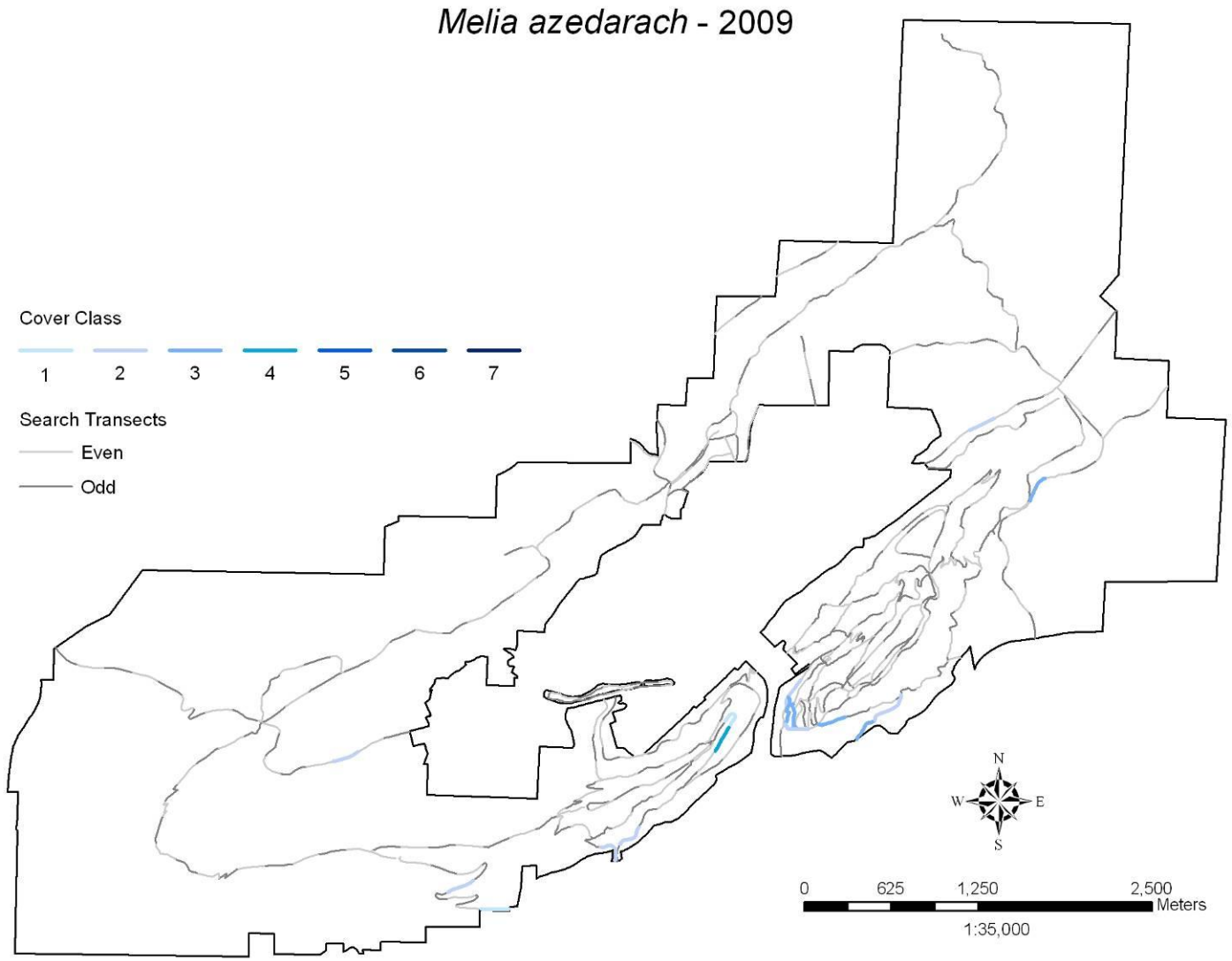

Figure 22. Abundance and distribution of *Melia azedarach* (Chinaberrytree) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

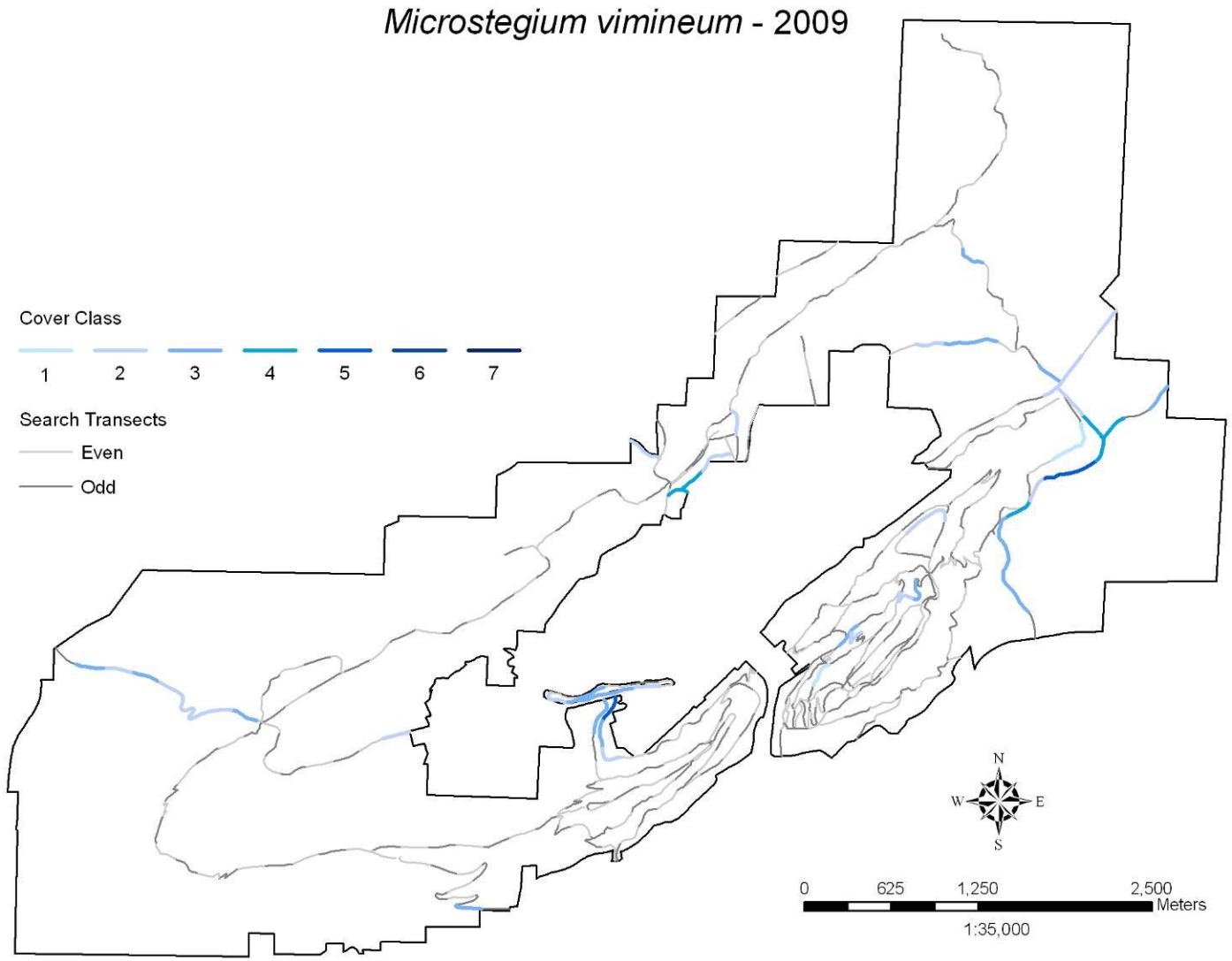

Figure 23. Abundance and distribution of *Microstegium vimineum* (Nepalese browntop) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

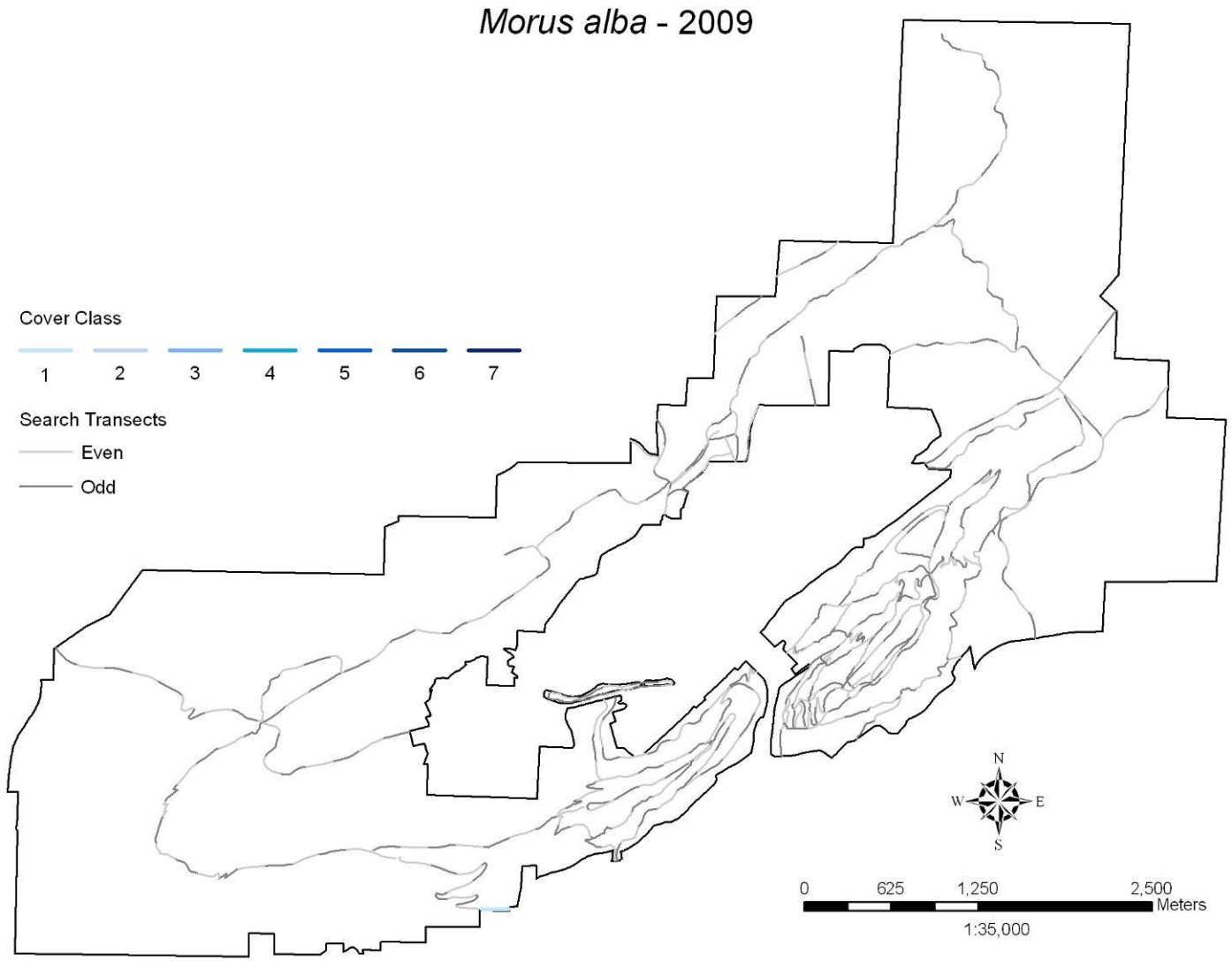

Figure 24. Abundance and distribution of *Morus alba* (white mulberry) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

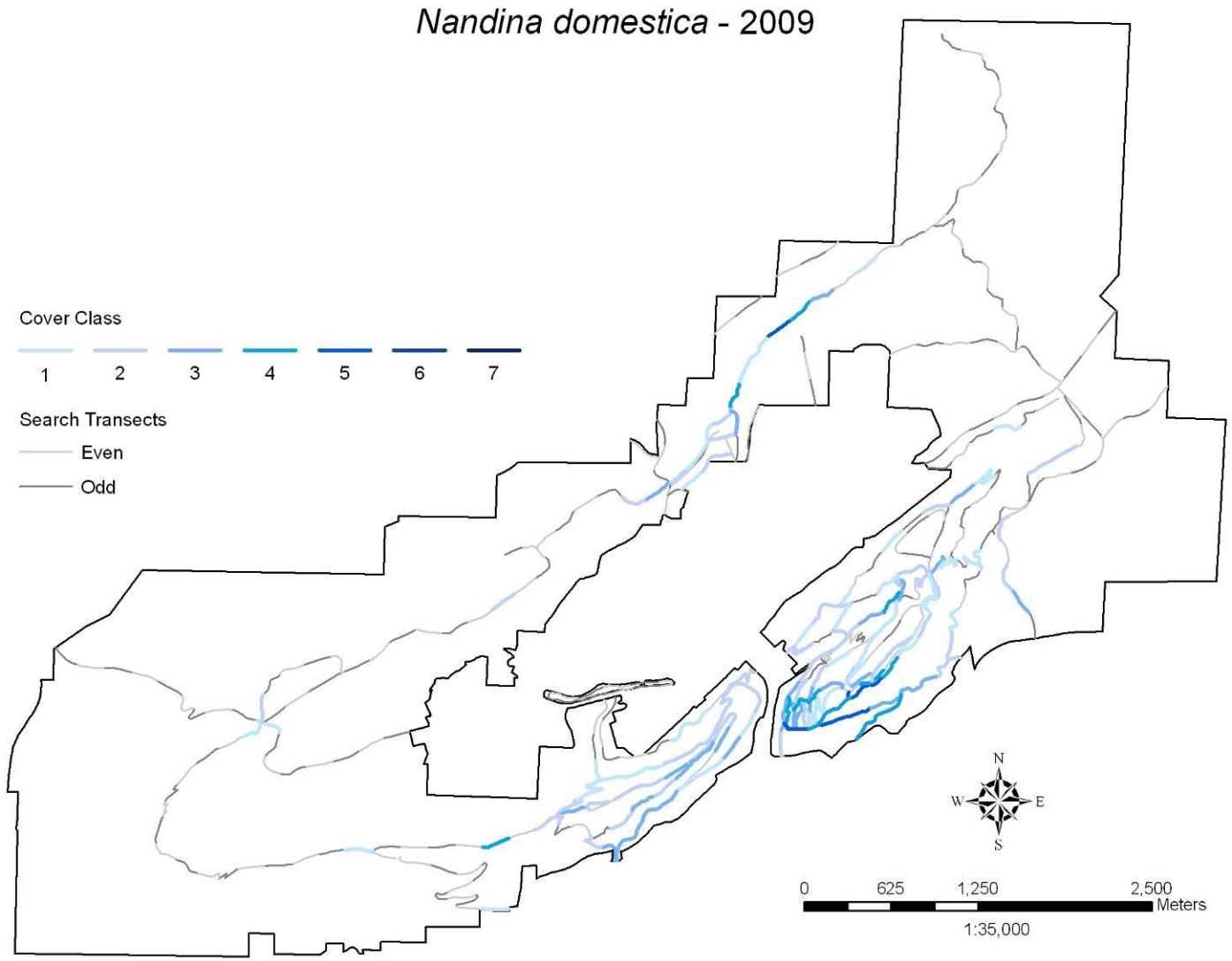

Figure 25. Abundance and distribution of *Nandina domestica* (sacred bamboo) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

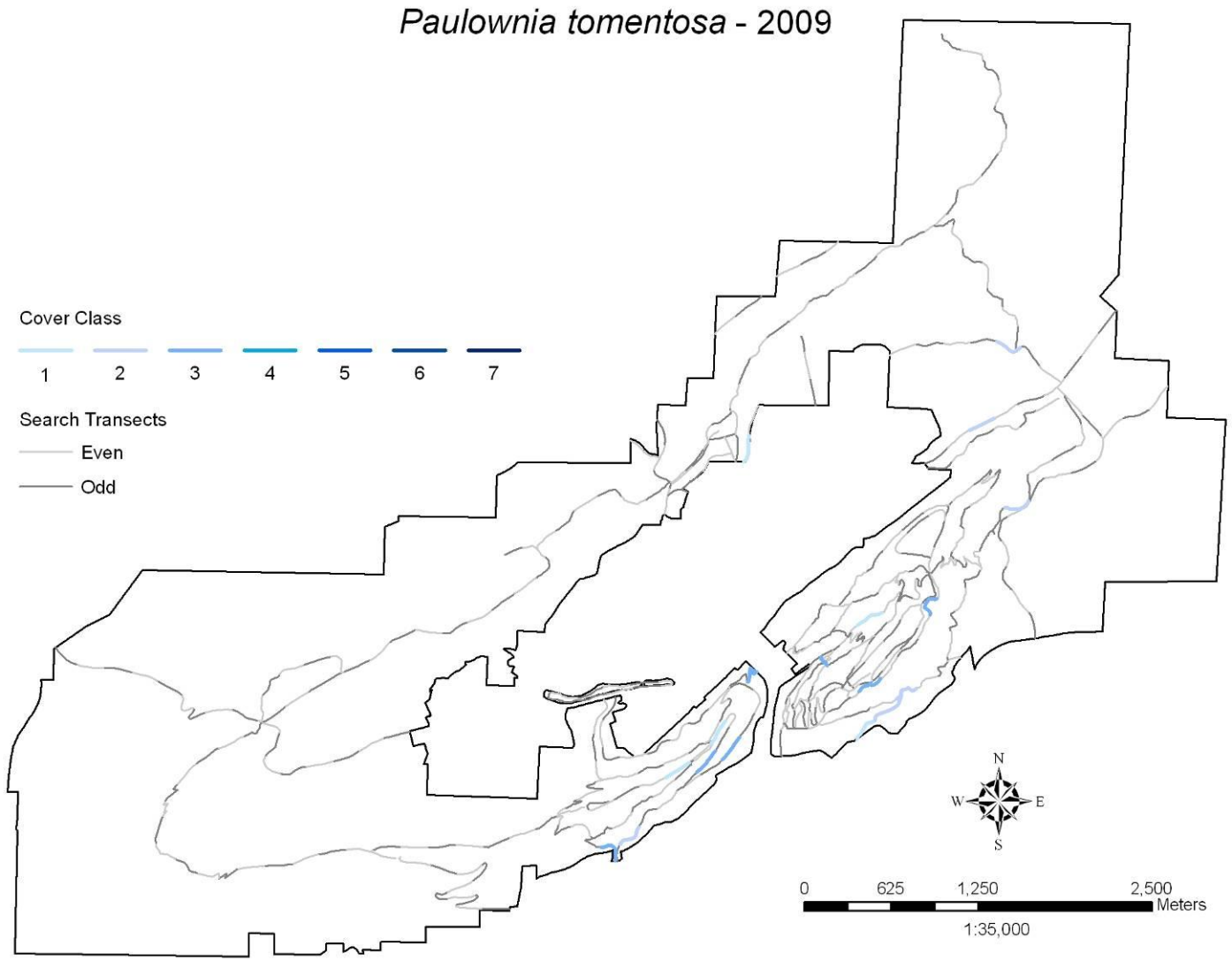

Figure 26. Abundance and distribution of *Paulownia tomentosa* (princesstree) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

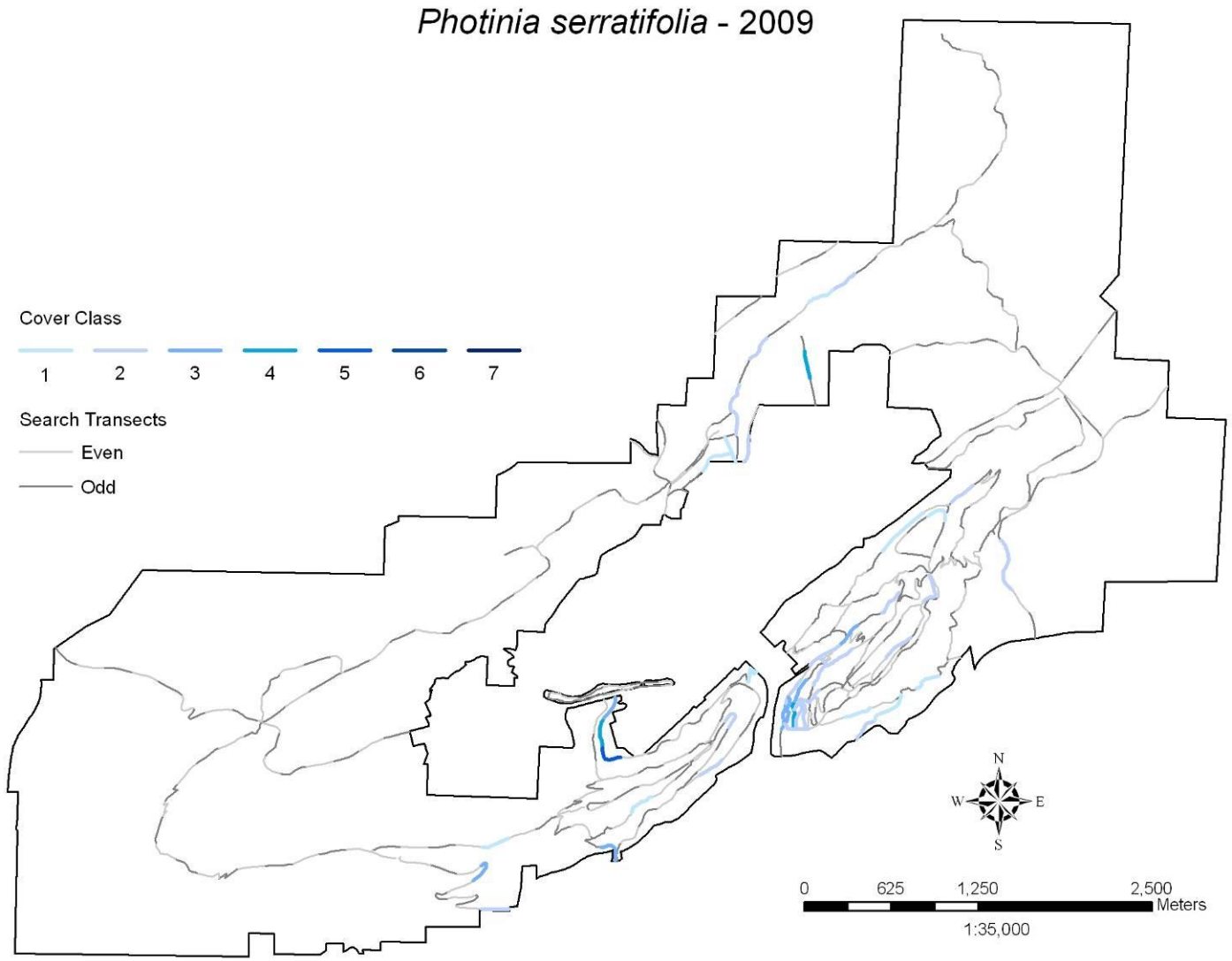

Figure 27. Abundance and distribution of *Photinia serratifolia* (Taiwanese photonia) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

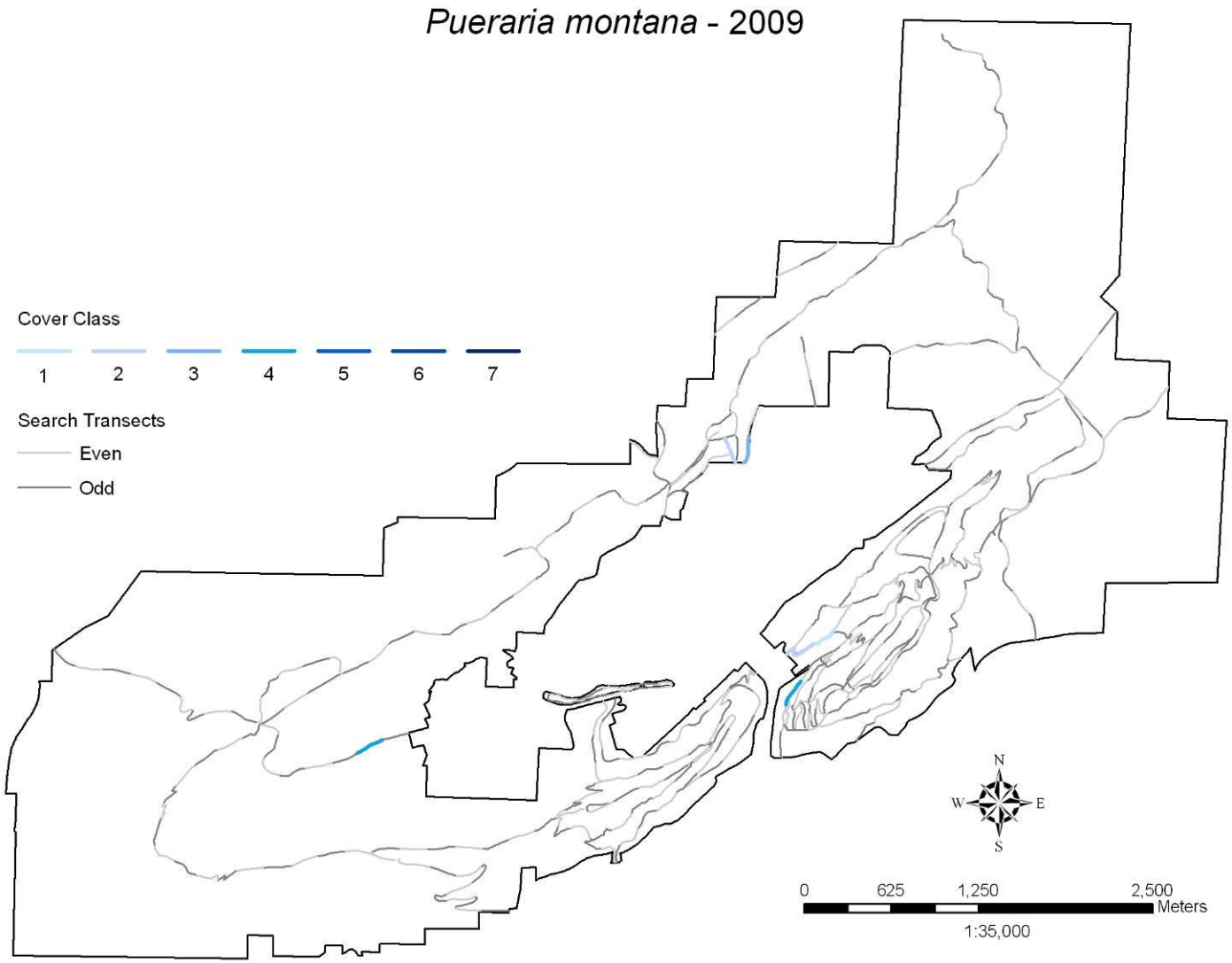

Figure 28. Abundance and distribution of *Pueraria montana* (kudzu) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

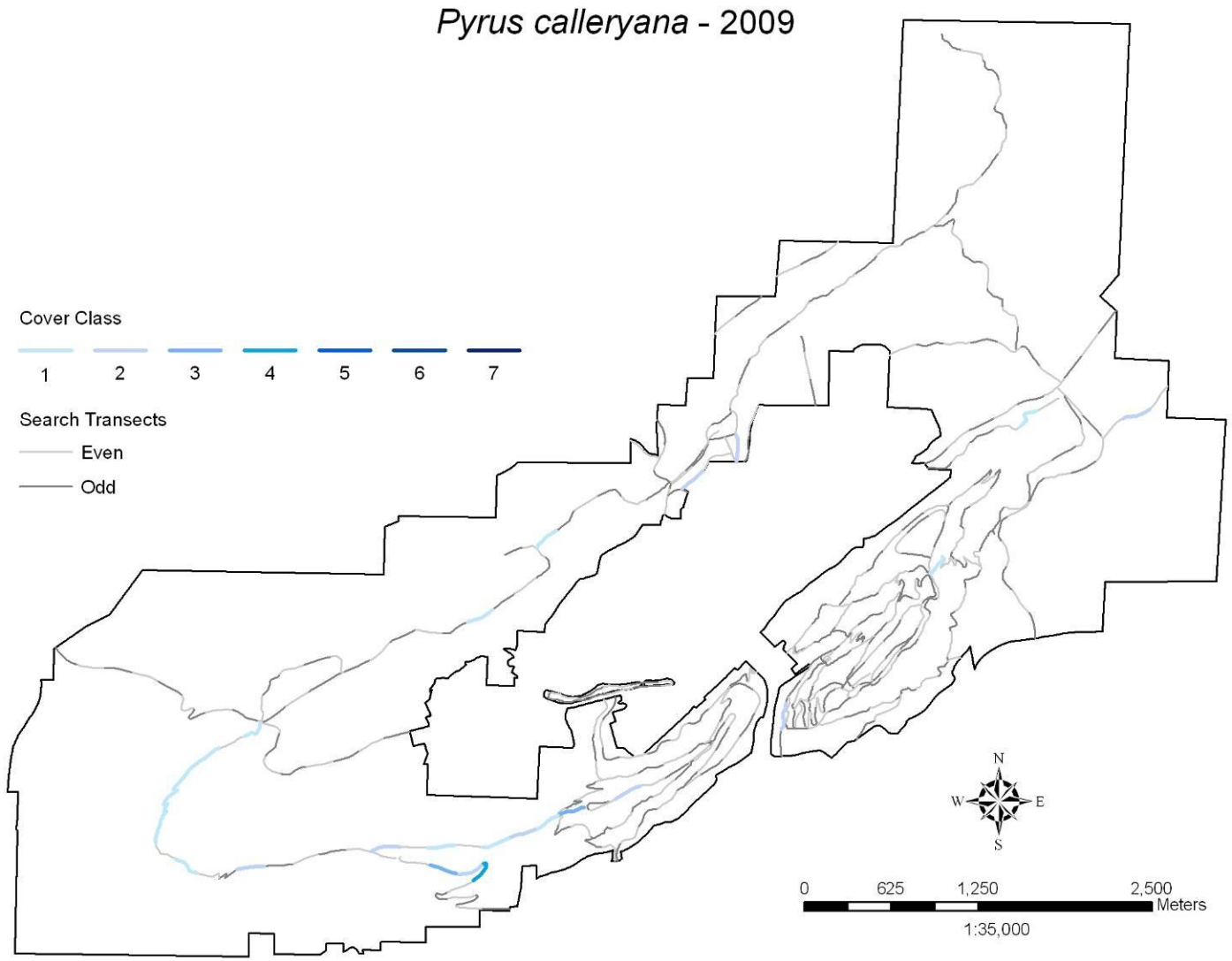

Figure 29. Abundance and distribution of *Pyrus calleryana* (Callery pear) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

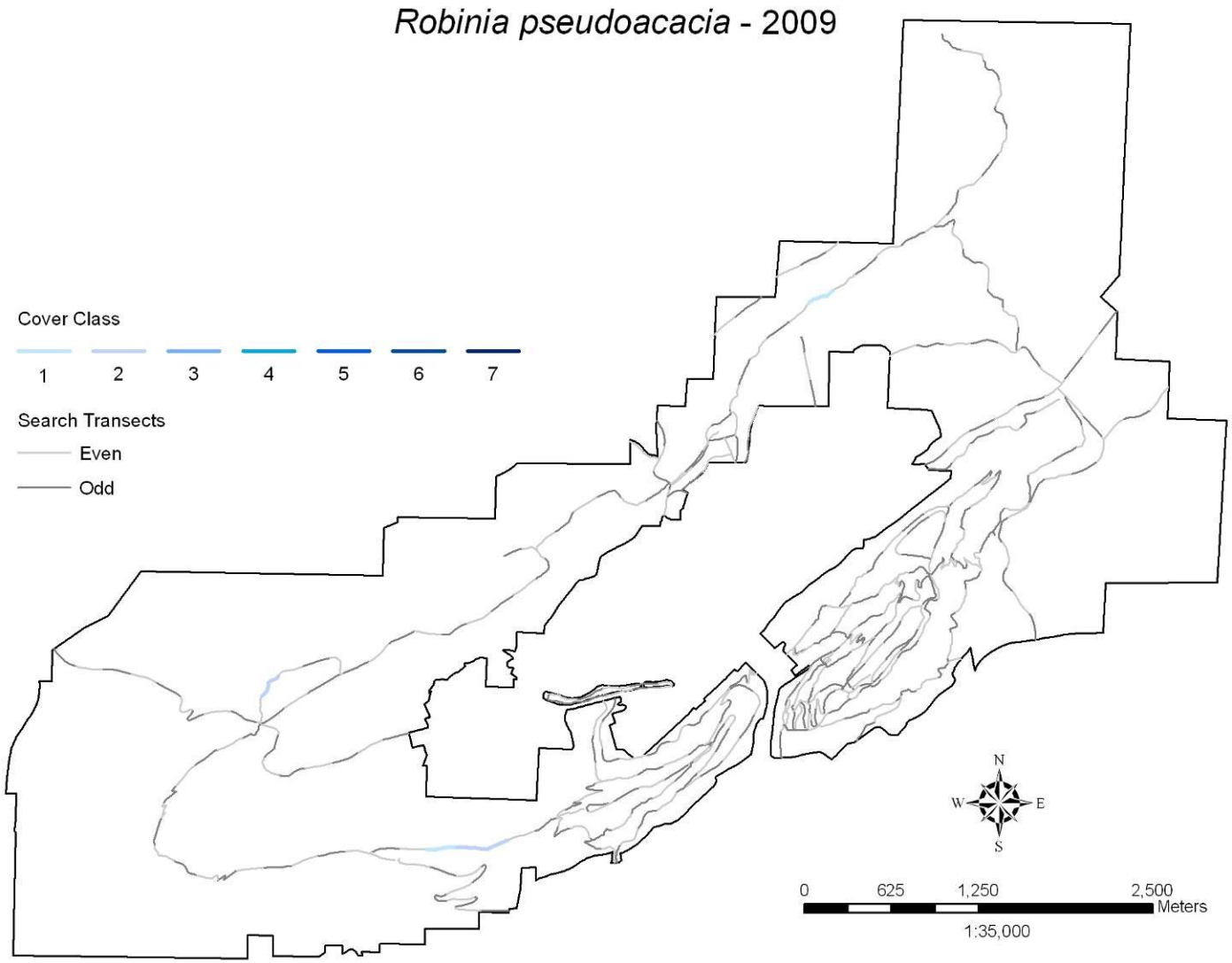

Figure 30. Abundance and distribution of *Robinia pseudoacacia* (black locust) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

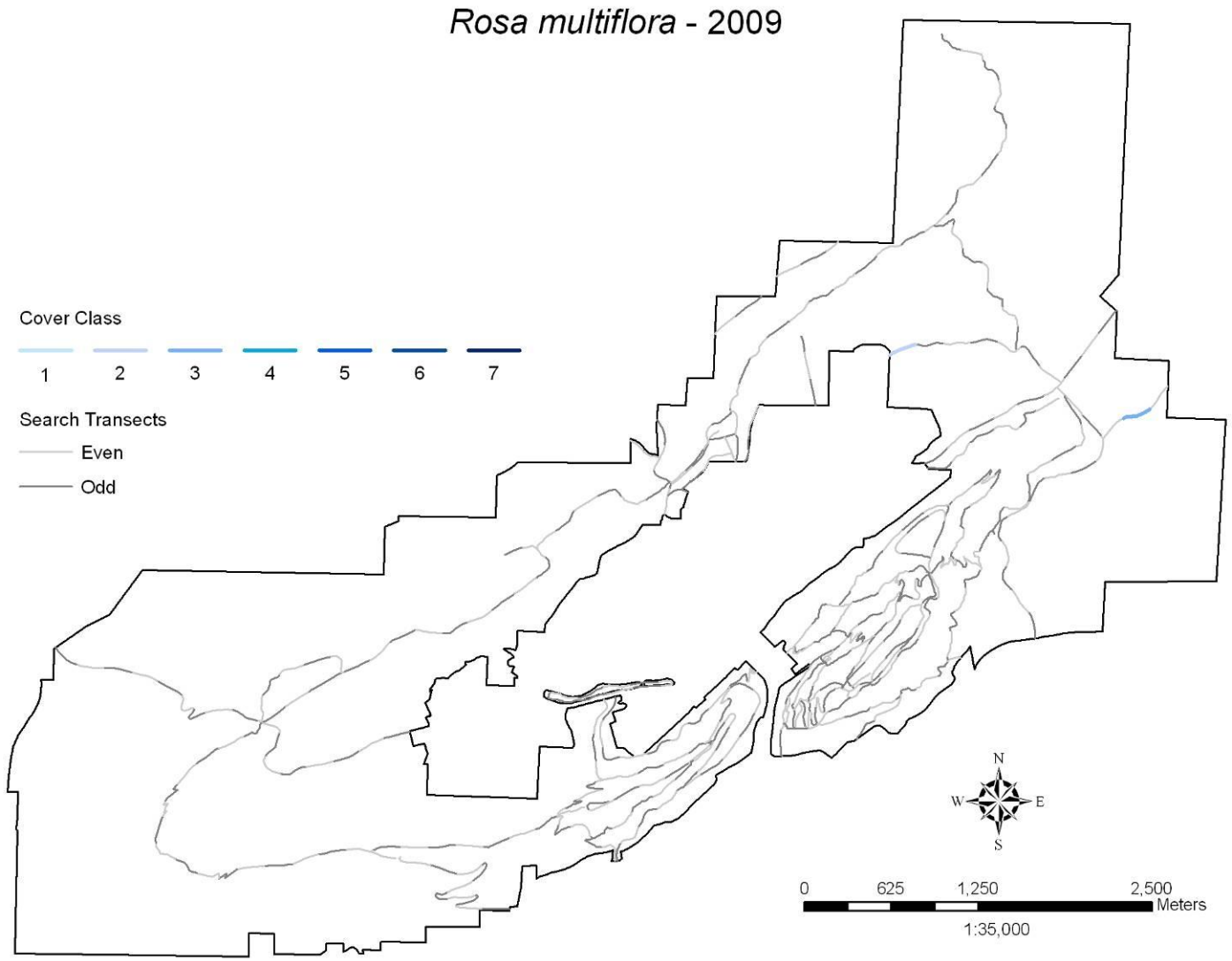

Figure 31. Abundance and distribution of *Rosa multiflora* (multiflora rose) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

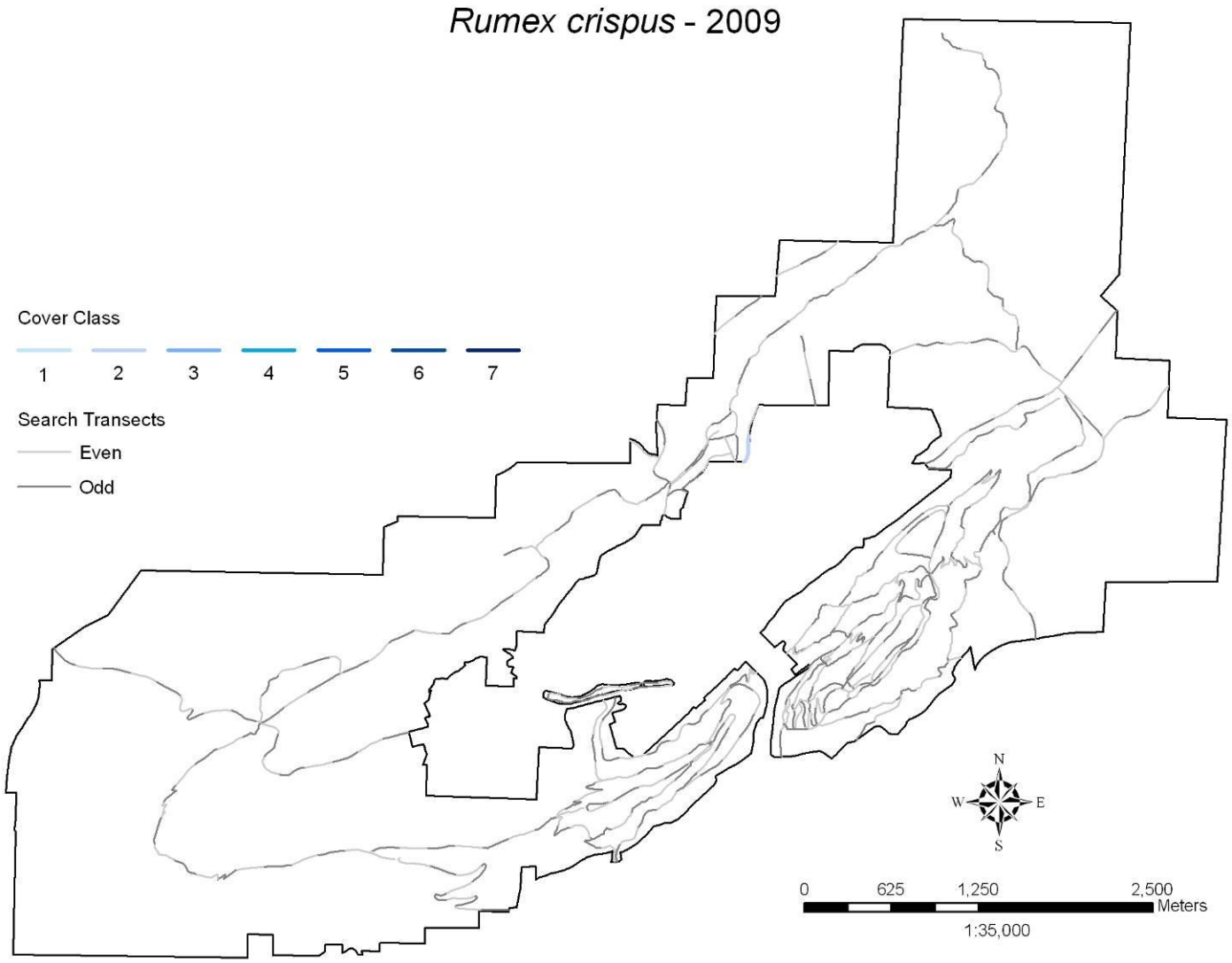

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Figure 32. Abundance and distribution of *Rumex crispus* (curly dock) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

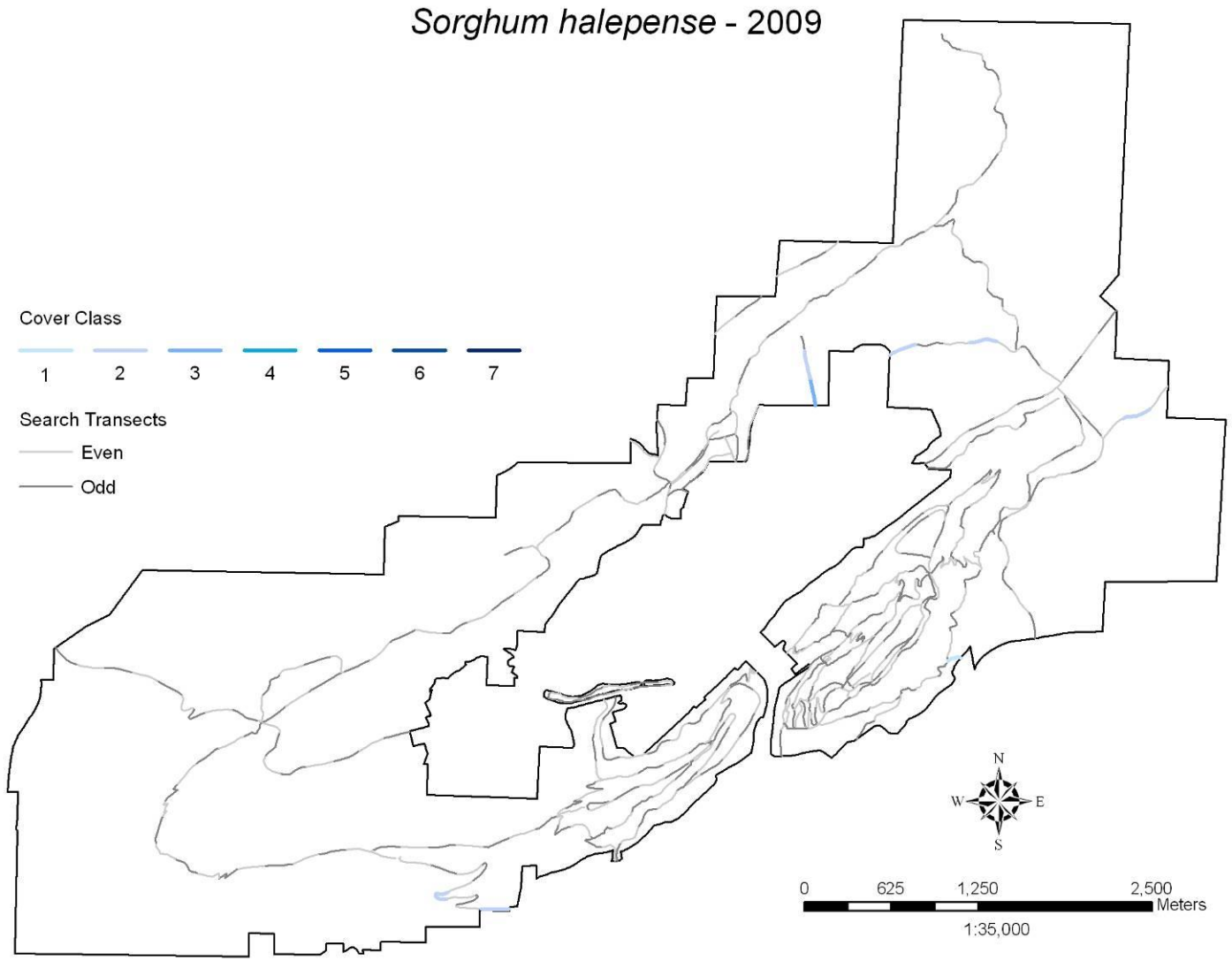

Figure 33. Abundance and distribution of *Sorghum halepense* (Johnsongrass) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

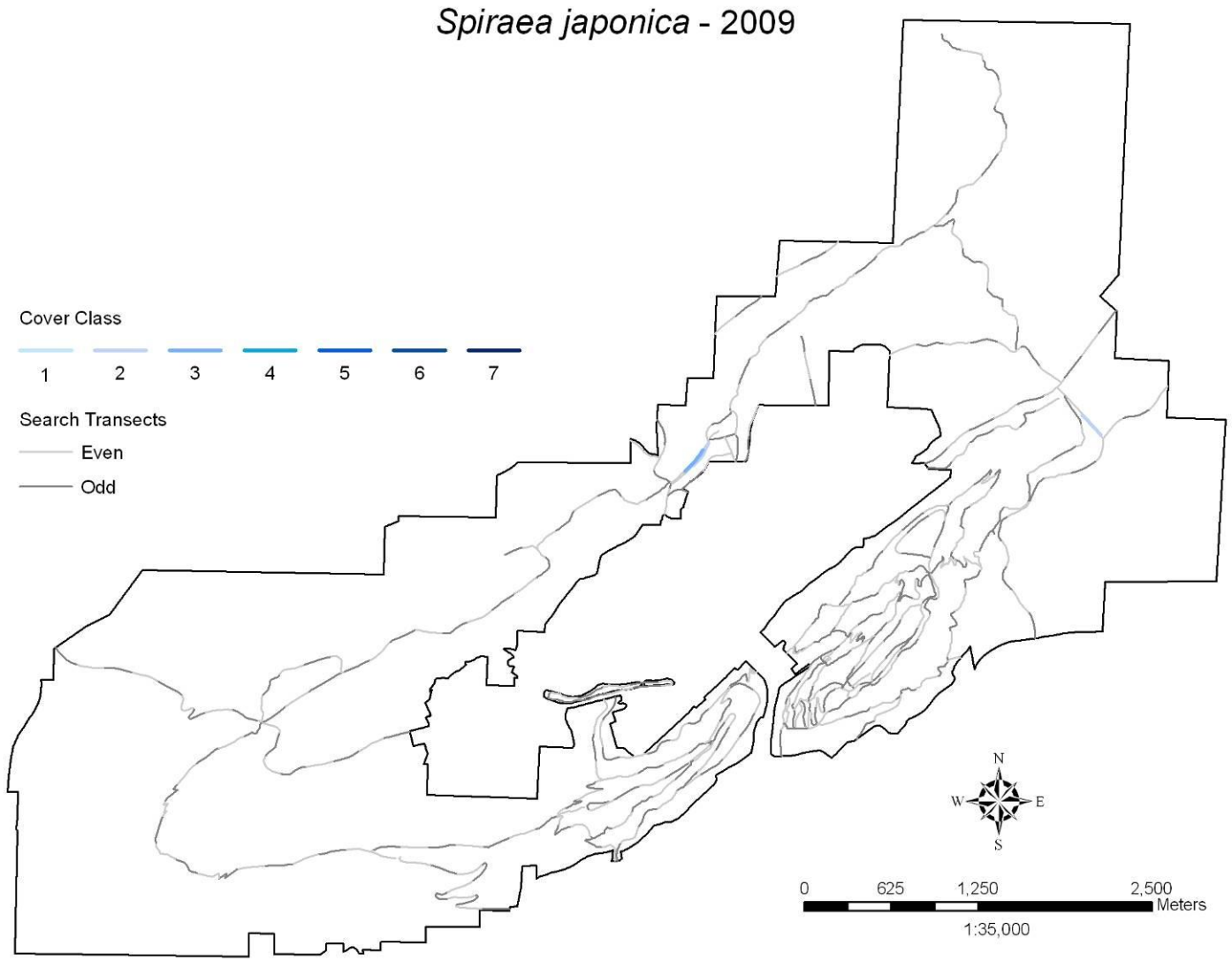

Figure 34. Abundance and distribution of *Spiraea japonica* (Japanese meadowsweet) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

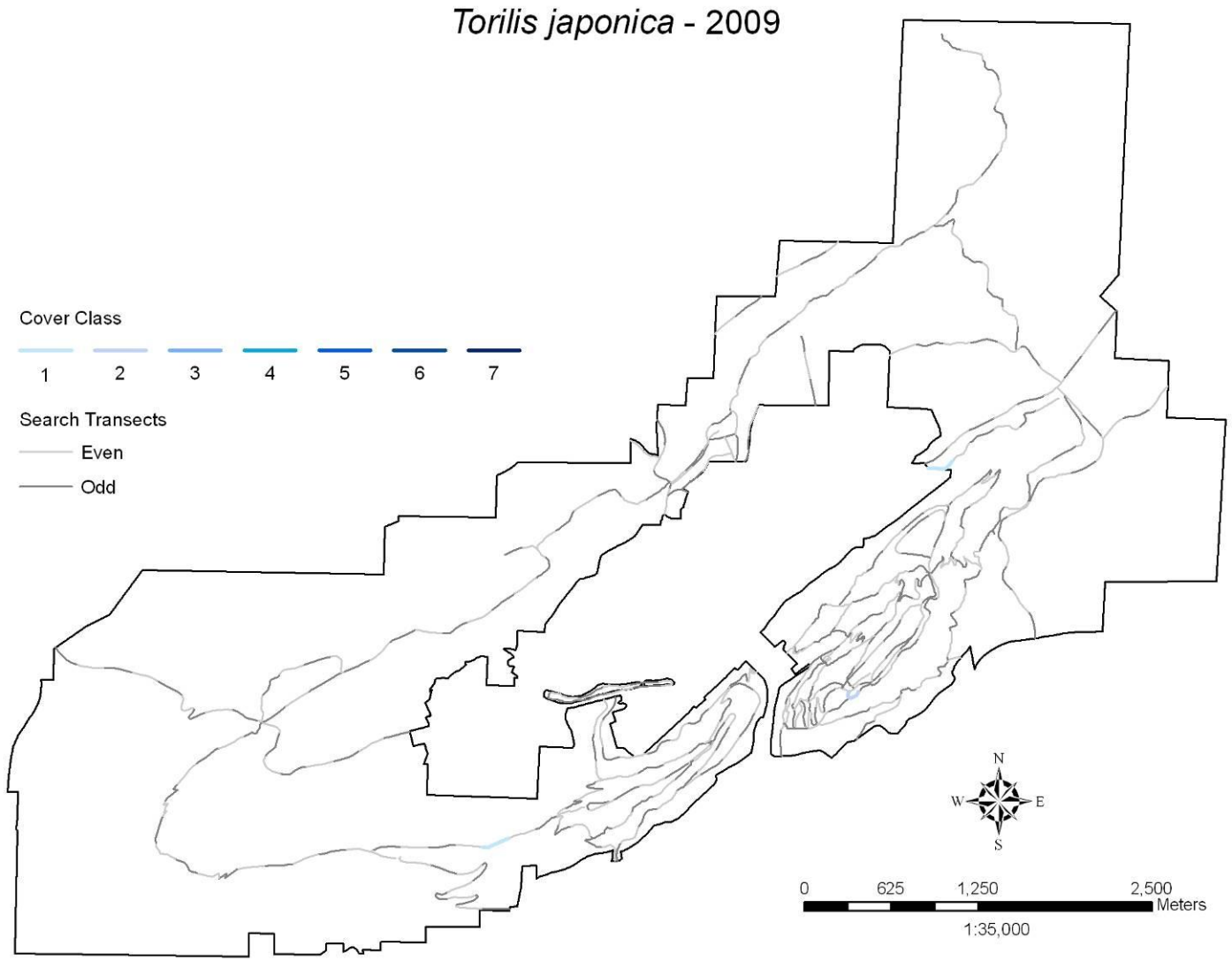

Figure 35. Abundance and distribution of *Torilis japonica* (erect hedgeparsley) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

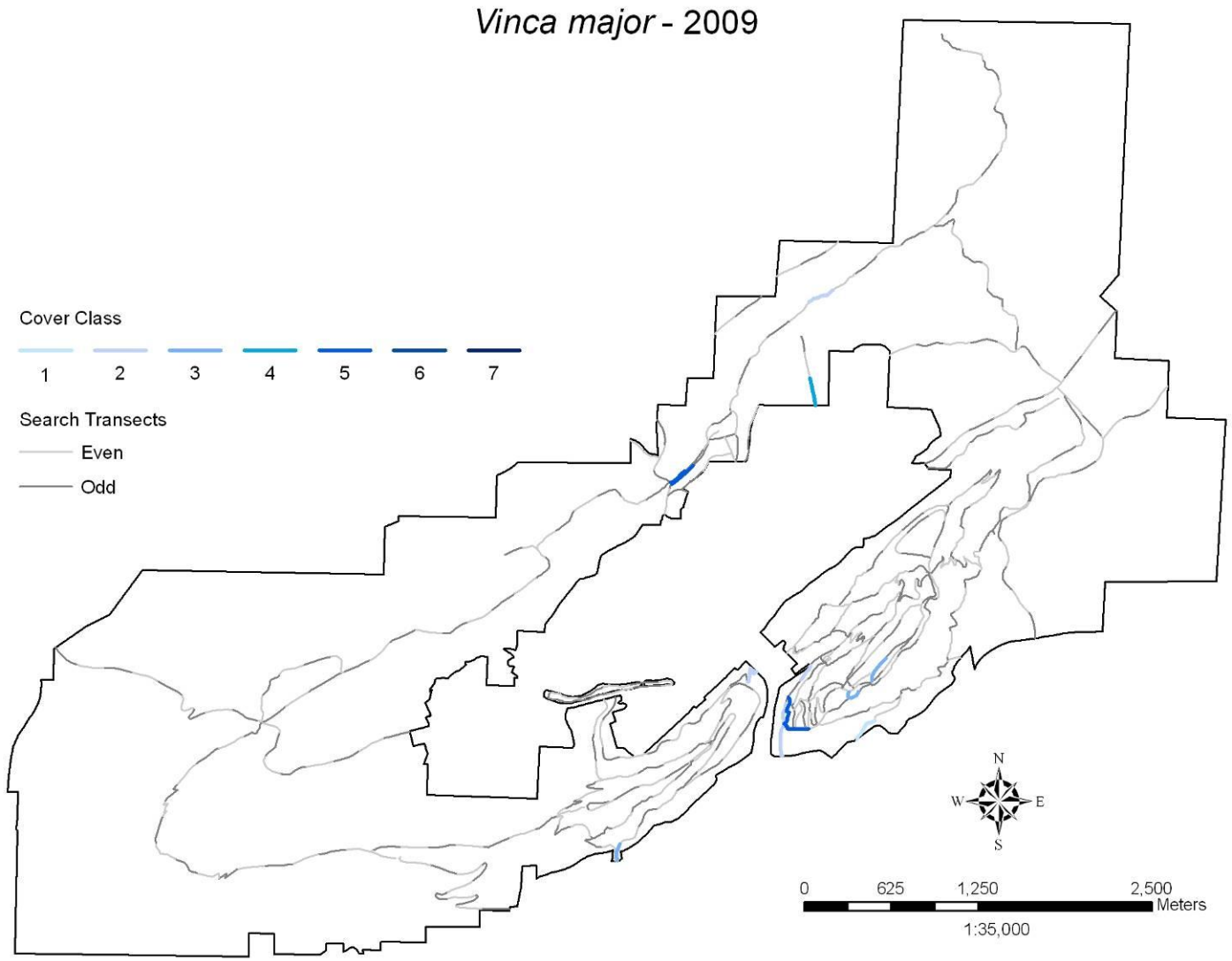

Figure 36. Abundance and distribution of *Vinca major* (bigleaf periwinkle) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

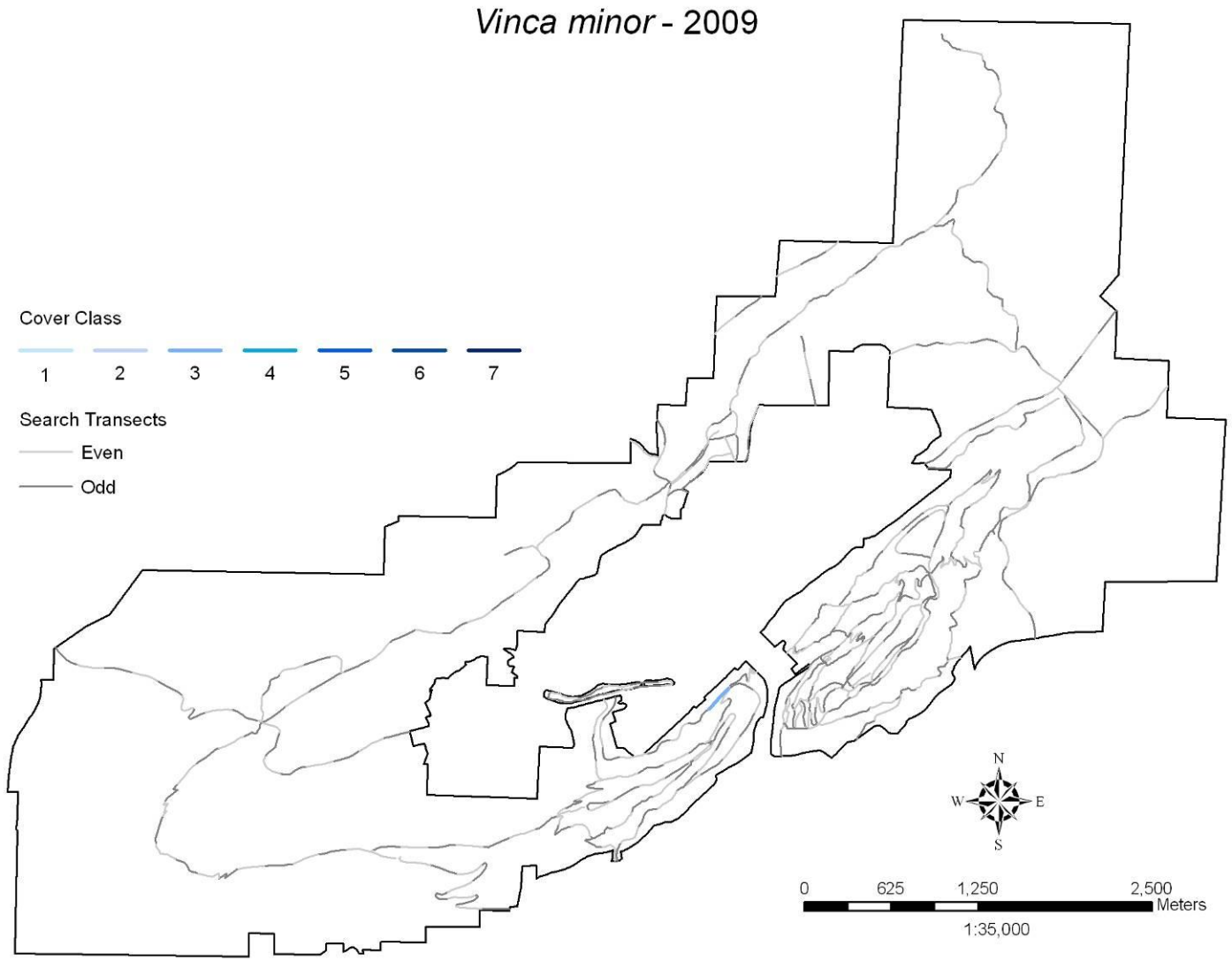

Figure 37. Abundance and distribution of *Vinca minor* (common periwinkle) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

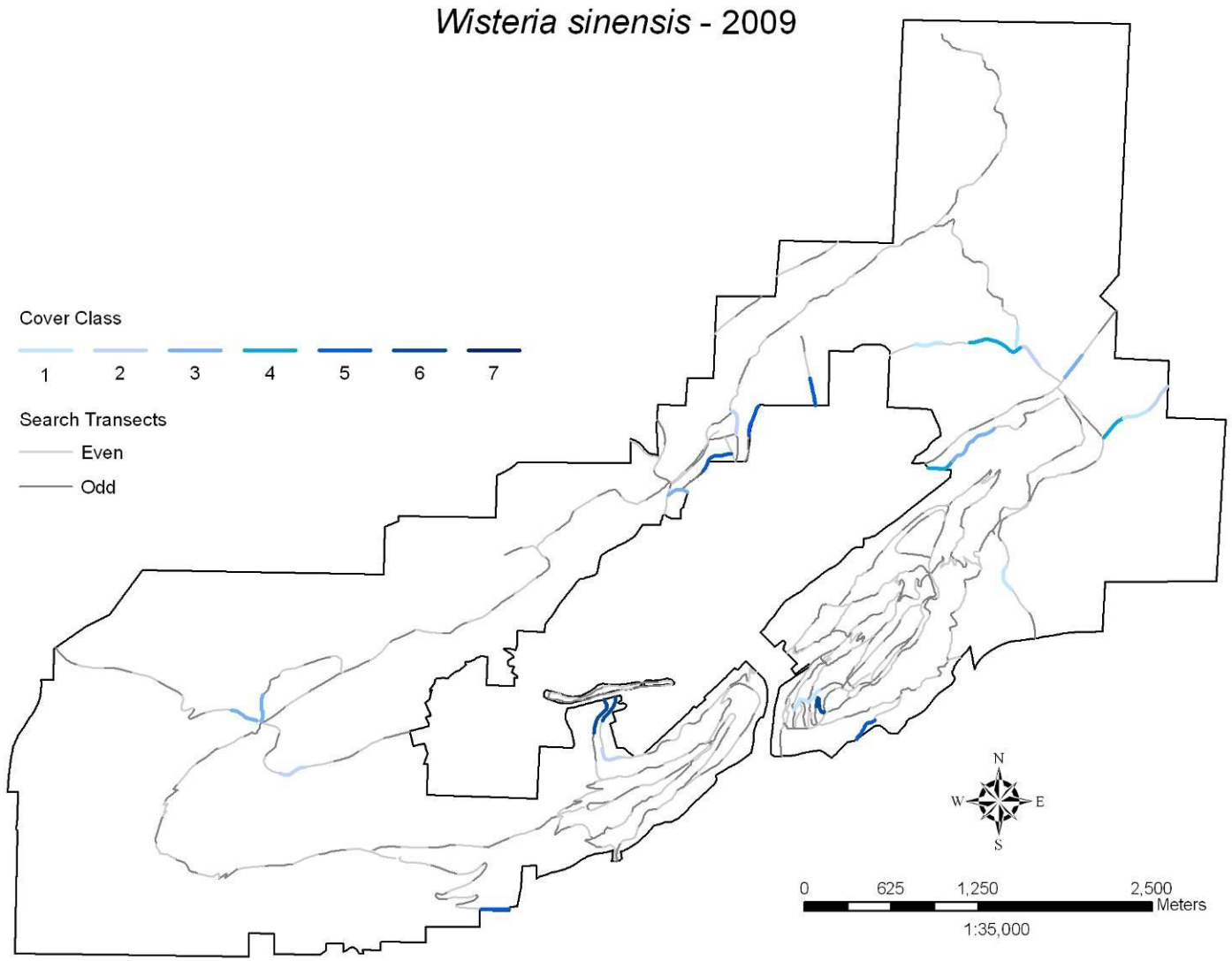

Figure 38. Abundance and distribution of *Wisteria sinensis* (Chinese wisteria) at Hot Springs National Park, 2009. Cover classes are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 499.9-999.9 m^2, and 7 ≥ 1,000 m^2.

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.

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U.S. Department of the Interior

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