National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Pea Ridge National Military Park Natural Resource Condition Assessment

Natural Resource Report NPS/HTLN/NRR—2011/426

ON THE COVER
Habitat at Pea Ridge National Military Park
Photo from Heartland Network Files

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Natural Resource Report NPS/HTLN/NRR—2011/426

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Contents

Contents (continued)

Contents (continued)

Contents (continued)

Page

Figures

Page

Figures (continued)

Page

Figures (continued)

Page

Figues (continued)

Page

Tables

Page

Tables (continued)

Page

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Abstract

In accordance with National Park Service requirements, staff with the Missouri Resource Assessment Partnership and the Heartland Inventory and Monitoring Network conducted a natural resource condition assessment (NRCA) for Pea Ridge National Military Park (PERI). NRCA's are intended to provide a synthesized assessment of current conditions in the park. The NCRA for PERI builds on methods developed for a similar effort for Effigy Mounds National Monument. Basic elements of the methodology include (1) reliance on a framework of essential ecological attributes provided by the Environmental Protection agency, (2) development of a list of resource types, indicators, and attributes for assessment, and (3) application of assessments by reporting unit, including park wide, major terrestrial landscapes types, and major streams and tributaries. Current condition was assigned to indicators based on contemporary data and management targets were defined based on best available information, which ranged from quantitative sampling data to expert opinion.

A logic model-based framework was created to evaluate each indicator for which both current data and a management target were available. The framework is hierarchical so that indicators within an attribute are evaluated as well as attributes within a resource type and/or reporting unit. A hierarchical framework allows for integrated analysis among different components of the resource types and reporting units that are found within the park. The logic-based framework was designed to address the validity of the statement "the current condition approximates the management target". For each level in the hierarchy, an assessment score is provided that corresponds to the degree that the statement is valid. A logic-based integrated analysis is not a quantitative analysis of the park resources; rather it is a method of qualitative reasoning. The framework reflects expert knowledge about the park resources and provides a formal structure of how the resource components can be arranged or summarized. This type of analysis is learning based and focused on supporting the decision making processes related to natural resource management. Result scores are on a [0 – 1] scale with zero reflecting that there is no validity to the statement while a score of one signifies that the statement is valid. In addition, scores between zero and one provide a continuum of degree of validity which allows for partial support to be recognized. Five partial support categories were created based on 0.2 breaks in scores between 0.01 and 0.99 (Figure A-A).

Figure A-A. Color coded evaluation score categories derived from rescaled evaluation scores.

Numerical evaluations of logic models provide a continuous range of results. The categorized output was used to build a dashboard for reporting to increase ease of interpretation (Fig. A-B).

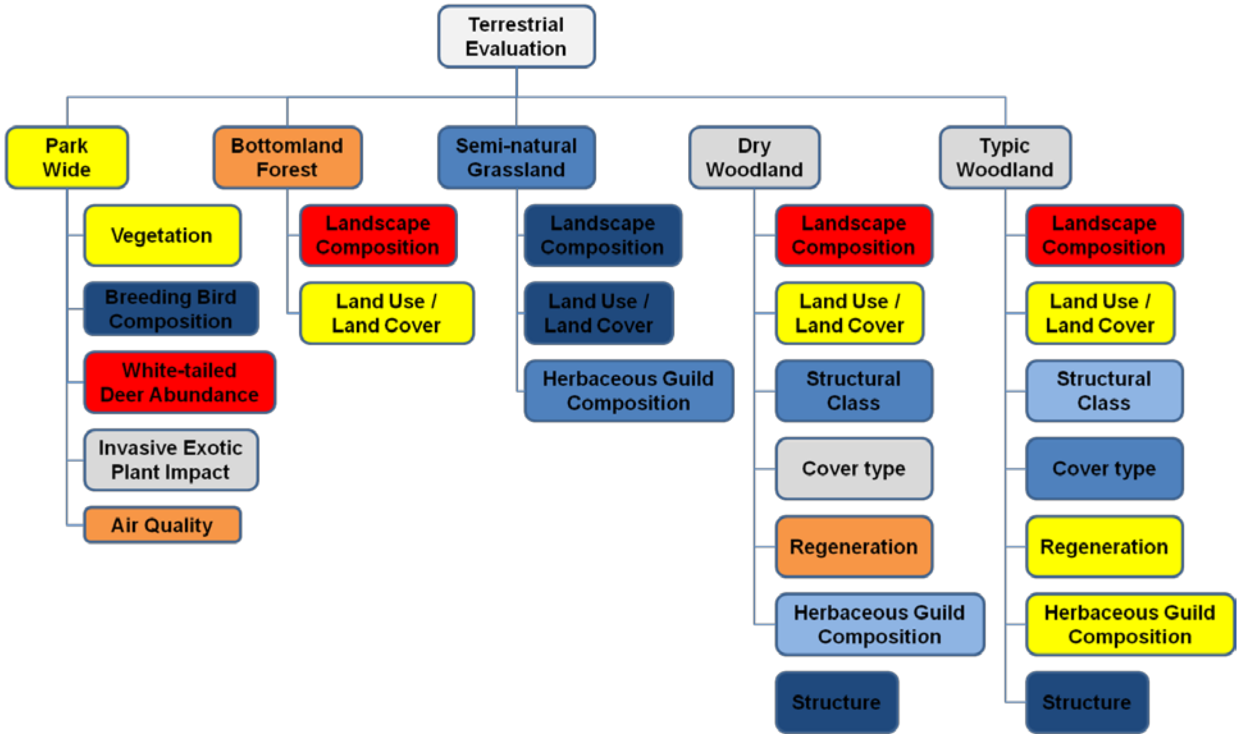

Figure A-B. Color coded evaluation results for each terrestrial reporting unit and its associated resource type and/or attributes.

Areas dedicated primarily to natural resource management at PERI are largely wooded, and are on the hilly northern and central side of the park or at the far south fringes, including areas associated with lower Pratt Creek and Winton Spring Branch. These two streams appear to be in generally good condition, with fauna characteristic of Ozark headwaters streams (Fig. A-C).

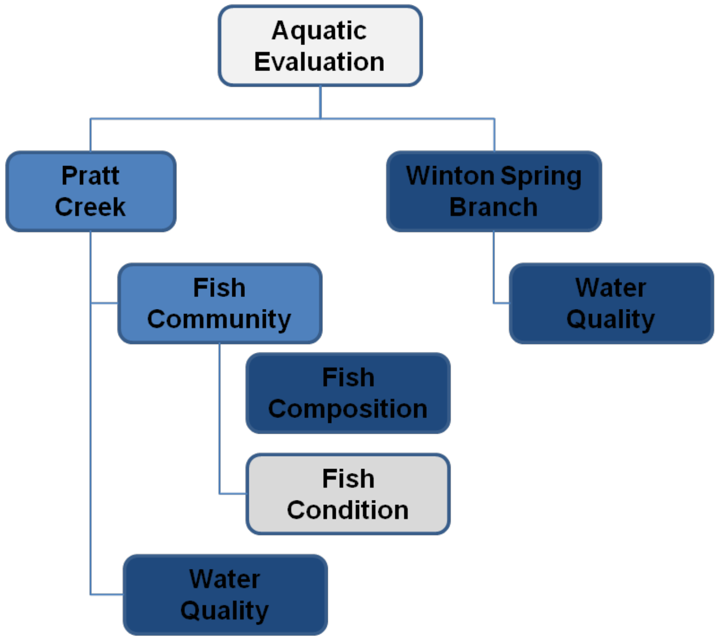

Figure A-C. Color coded evaluation results for each aquatic reporting unit and its associated resource types.

Natural resource conditions of oak-hickory woodlands are generally good except where well-defined eastern redcedar dominated old fields occur. Patch numbers are relatively high and patch size small, but these numbers are somewhat inflated due to interspersion of different community types, each of which may be of appropriate composition and structure. Prominent natural communities include typic oak-hickory woodlands, slope oak-hickory woodlands, and dry oak woodlands. These woodlands provide habitat for breeding birds that require mature forests, including Acadian Flycatchers and Yellow-throated Vireos, both species of continental concern. Few invasive and exotic plant species, aside from eastern redcedar, occur in this area. Areas of successional deciduous sparse woodland and shrubland may provide important local habitat diversity for breeding birds of continental concern such as Indigo Buntings and Eastern Towhees. The southern and central portions of the park are dedicated mainly to providing a representation of landscapes at the time of the battle for interpretive purposes. Large mowed grasslands meet patch number and size targets, but non-native and disturbance species are dominant across much of the area. Natural resource management options are limited, but grasslands on the eastern and northeastern side of the park that are not mowed during the breeding season do provide habitat for grassland obligate breeding birds, including Grasshopper Sparrows and Henslow's Sparrows.

Acknowledgements

All members of the condition assessment team (Table 3-1) made valuable contributions to the document, often by authoring sections within their area of expertise. Dyan Pursell deserves kudos for her development and attribution of the land cover map. Ronnie Lea, Phillip Hanberry, and Aaron Garringer each made significant contributions. Jeff Albright has provided valuable support throughout the project. Funding was provided by the Water Resources Division of the NPS Natural Resource Stewardship and Science.

Prologue

Publisher's Note: This was one of several projects used to demonstrate a variety of study approaches and reporting products for a new series of natural resource condition assessments in national park units. Projects such as this one, undertaken during initial development phases for the new series, contributed to revised project standards and guidelines issued in 2009 and 2010 (applicable to projects started in 2009 or later years). Some or all of the work done for this project preceded those revisions. Consequently, aspects of this project's study approach and some report format and/or content details may not be consistent with the revised guidance, and may differ in comparison to what is found in more recently published reports from this series.

Publisher's Note: Some or all of the work done for this project preceded the revised guidance issued for this project series in 2009/2010. See Prologue (p. xvii) for more information.

Chapter 1 NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and associated indicators in national park units, hereafter "parks". For these indicator-level analyses they also report on trends (as possible), critical data gaps, and general level of confidence for study findings. The indicators targeted for evaluation depend on a park's resource setting, status of stewardship planning and science in recommending priority indicators for that park, and availability of useful data and qualified expertise to assess current conditions for each of the indicators included on the list of potential study indicators.

NRCAs represent a relatively new approach to assessing and reporting park resource conditions. They are meant to complement, but not replace, traditional issue and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- are multi-disciplinary in scope[1]
- employ hierarchical indicator frameworks[2]
- identify or develop reference conditions/values to compare current condition data against, and to help in the development of management target conditions[3,4]
- emphasize spatial evaluation and GIS (map) products[5]
- should strive to provide a meaningful summary of overall findings by park areas[6]
- follow national NRCA guidelines and standards for study design and reporting products

Although current condition reporting relative to reference conditions and values is the primary objective, NRCAs are encouraged to also report on trends for any study indicators where the underlying data and methods support it. Resource condition influences (threats and stressors) are also considered. They can include historic resource conditions or land uses or activities as well as park or surrounding watershed and landscape-scale condition influences.

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[1] However, number and breadth of study indicators will vary by park

[2] Frameworks help guide indicator selection and subsequent reporting of condition findings

[3] NRCAs must consider ecologically-based reference conditions, must also consider applicable legal/regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or multiple types of reference conditions/values.

[4] Reference values can be single-point values or ranges, represent conditions to be achieved or threshold "triggers" to avoid, and can be expressed in semi-quantitative to highly quantitative terms; in many cases they are identified as best professional judgment estimates or interim values

[5] As appropriate and possible, NRCAs describe condition gradients or differences across the park for each study indicator and develop GIS coverages and maps that depict those differences

[6] In addition to reporting indicator-level findings, investigators are asked to take a bigger picture view and summarize key findings by park areas; each park identifies the reporting areas to be used for this purpose

For this type of resource assessment, credibility derives from the data, methods, and reference values used in the project work—are they appropriate for the stated purpose and adequately documented? For each study indicator where current condition or trend is reported it is important to identify critical data gaps and express "level of confidence" in at least qualitative terms. Input and review from park staff and National Park Service (NPS) subject matter experts at critical points during the project timeline is also important: 1) to assist identification and selection of study indicators; 2) to recommend or comment on data sets, methods, and reference conditions and values proposed for use in the study; 3) to help provide a multi-disciplinary review and accuracy check for draft study findings and products, ; and 4) to assist the spatial delineation of resources within the park boundary and surrounding area of interest

NRCAs provide a useful complement to more rigorous NPS science support programs such as the NPS Inventory and Monitoring Program. For example, NRCAs can provide current condition estimates and help establish reference conditions or baseline values for a park's monitoring "vital signs". They can also bring in additional (non NPS) data relevant to understanding current conditions for those vital signs. In some cases, NPS inventory data sets are also incorporated into NRCA analyses and reporting products.

In-depth analysis of climate change impacts on park natural resources is not a priority objective for NRCAs. However, the existing condition analyses and data sets developed in an NRCA should be directly useful in subsequent climate change studies and planning efforts.

NRCAs do not establish desired conditions for study indicators. Decisions about desired conditions must be made through sanctioned park planning and management processes. The proper role for NRCAs is to provide information that will help park managers with an ongoing, longer term effort to describe and quantify their park's desired resource conditions. In the near term, NRCA findings should be directly useful for strategic park resource planning[7] and to help parks report to government "resource condition status" measures[8].

Due to their modest funding, relatively quick timeframe for completion and reliance on existing data and information, NRCAs are not expected to be exhaustive. Indicators will be analyzed using rigorous and statistically repeatable methods where existing data and expertise allow. In many cases the study methods will involve an informal synthesis of existing data from diverse sources. A successful NRCA delivers science-based information that is both credible and practically useful for a variety of park decision making, planning, and partnership activities.

Over the next several years, NPS hopes to fund an NRCA project for each of the 270 parks served by the NPS Inventory and Monitoring Program. Additional NRCA information can be found at: http://www.nature.nps.gov/water/NRCondition_Assessment_Program/Index.cfm.

[7] NRCAs are an especially useful lead-in to working on a park Resource Stewardship Strategy(RSS) but study scope can be tailored to also work well as a post-RSS project

[8] While reporting requirements can fluctuate over time, spatial and reference-based condition data as provided by NRCAs will help parks report to some current (and anticipated) National Park Service, Department of Interior, and Office of Management and Budget accountability measures.

NRCA Approach for Pea Ridge National Military Park

Prior to beginning the NRCA for Pea Ridge National Military Park (PERI) we completed a NRCA for Effigy Mounds National Monument (EFMO). As part of that study, we identified three areas of compromise in various approaches to natural resource condition assessments (NRCAs): breadth, rigor, and focus.

- **Breadth** reflects the amount and disparity of information considered in the assessment. A project with wide breadth would seek to examine many indicators of various types (e.g. biological, processes, landscape), and/or a broad consideration of multiple threats and stressors.

- **Rigor** reflects the effort devoted to developing reference conditions, defining stressors, or characterizing resources.

  Breadth and rigor are generally inversely related. That is, as the number of indicators increases, so does the difficulty of addressing each one rigorously.

- **Focus** reflects the distribution of effort between: 1) characterization of the resource and threat assessment, and 2) selection of indicators and determination of reference condition. Ideally projects would characterize the resource and threats, as well as select indicators and determine reference conditions.

We used these three gradients to form a three-dimensional "assessment space" as a heuristic framework for designing the PERI NRCA. One can think of assessment space as a balloon and the air inside as the funding limit. As the balloon is squeezed to expand one area, another area necessarily shrinks proportionately. This reflects the trade-off in focus, breadth and rigor given limited funding. This approach provides a range of “good models” for future assessments, the selection of which will depend on the starting point and emphases of a particular project. Combinations of breadth, rigor, and focus that are not obtainable given limited funding or not ambitious enough can be judged within the assessment space (Figure 1-1).

For the NRCA at PERI, we opted for slightly more narrow breadth but greater rigor and focus versus the early EFMO assessment. This was mainly due to lessons learned during the EFMO NRCA process in terms of limitations on availability of meaningful, spatially-specific data and in term of performing assessments at meaningful scales of resolution. The approach retains a focus on development of reference condition targets. These reference conditions allowed a hierarchical assessment of ecological attributes within reporting units using logic models (see Natural Resource Condition Assessment Terminology below). Ecological attributes were classified generally in accordance with an Environmental Protection Agency framework, while reporting units were defined based on major land and aquatic features within the park.

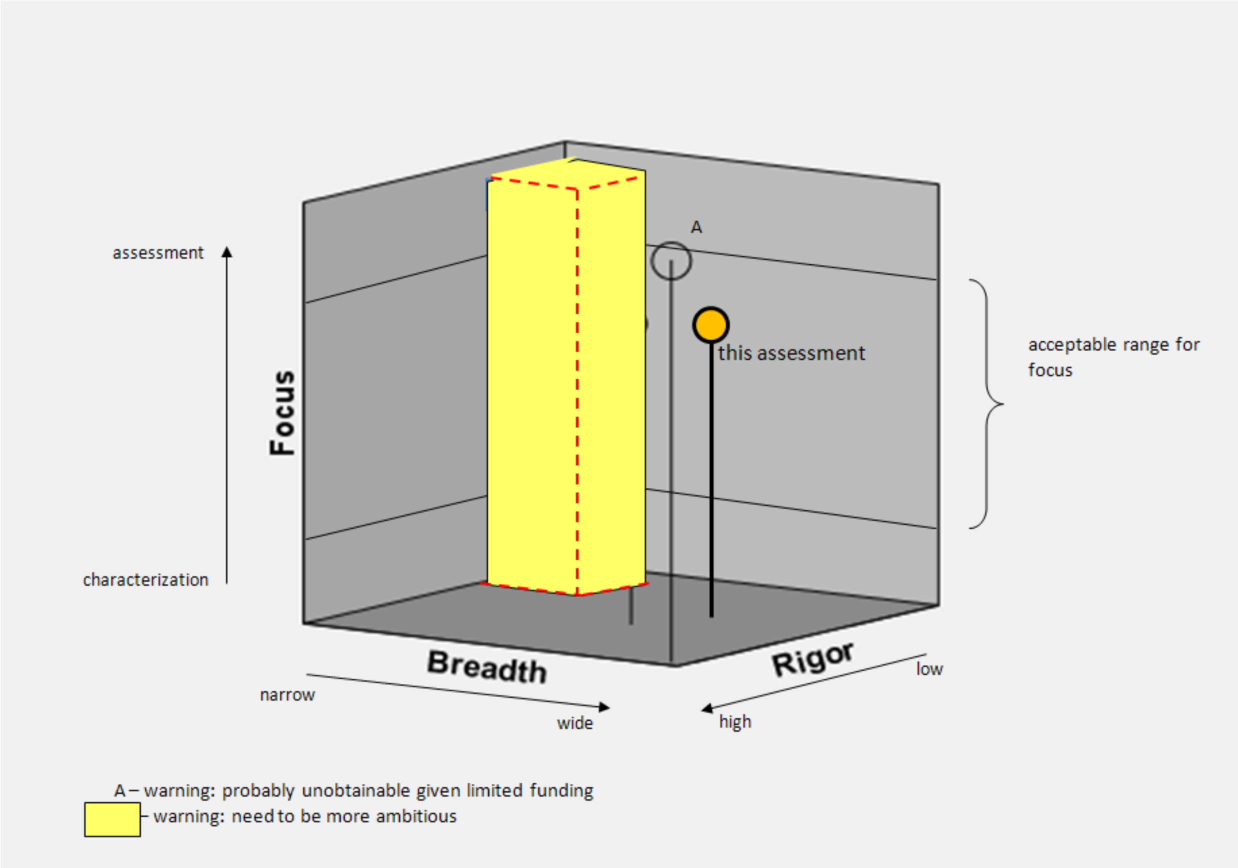

Figure 1-1. Assessment space used to design the Natural Resource Condition Assessment for Pea Ridge National Military Park.

Natural Resource Condition Assessment Terminology

This NRCA uses several terms in a very specific way, and these terms are critical for understanding the NRCA. While many conservation planning efforts use the same or similar terminology, we have defined several terms of importance here for reference while using the NRCA.

- Reporting Unit – A spatially defined area which serves as the unit of analysis for a natural resource condition assessment (NRCA). Natural, cultural, or management-based criteria may be used to define reporting units. The number of reporting units must be reasonable in order to limit the complexity of the NRCA.

- Resource Type – A natural resource that is of interest to park managers and that can be assessed based on attributes and indicators (see "attribute" and "indicator" below). Resource types are generally spatially nested within reporting units and are the subjects of analysis in a natural resource condition assessment (NRCA).

- Attribute – A category of interest in an ecological system. Intended as a generic term, attributes are generally non-spatial ecological categories that describe natural resources and may be assessed using one or many indicators (see "indicator" below).

- Indicator – Indicators are variables of interest in an ecological system that can be characterized with a single, direct measurement. They are the finest level of detail at which data are collected.

- Current Condition – The current measurement of an indicator. (To assess the current condition of attributes, we use logical operators to synthesize multiple indicators; see Chapter 6.)

- Management Target – Desired future values for indicators derived by considering both reference conditions and practical and interpretive considerations defined by park goals. Reference conditions are benchmark quantitative, conceptual, or descriptive values that reflect the best estimated of prevailing historic conditions.

We focus on management targets because they are often more easily defined in quantitative terms, since these are inferred both from known and surmised reference conditions, and from practical and interpretive considerations defined by park management goals. Quantifying reference conditions is often difficult or impossible due to the limited and fragmentary nature of historical data (Swetnam et al. 1999). Management targets are defined for each indicator and are summarized in Chapter 5.

Chapter 2 Park Resource Setting and Resource Stewardship Context

Park Resource Setting

Description and Characterization of Park Natural Resources

Pea Ridge National Military Park interprets and commemorates sites of the critical March 1862 Civil War battle near Pea Ridge, Arkansas (Figure 2-1, Figure 2-2). The park is approximately 4,300 acres, encompassing the entire series of engagements as well as part of the original trenches at the Federal camp. Pea Ridge National Military Park was created by an Act of Congress in 1956. The park is split between the Springfield Plains and Dissected Springfield Plateau-Elk River Hills (southern half), of the Ozarks, and is dominated by Pea Ridge Mountain. Areas indirectly connected to the battle provide a historical backdrop for this battle, and management of oak forest, bottomland forest, and grassland enhances battlefield scene restoration (NPS 2010b).

The park boundaries contain sites of engagements and strategic importance, including marching routes, and a recreation of the Elkhorn Tavern. Trenches from the conflict have eroded, and the only remnants are of earthworks about two miles long, dug by Union soldiers to the south side of their camp on the high bluffs north of Little Sugar Creek. There is a paved interpretive trail to the trenches. Several historic roads used during the course of the battle are still visible, including Telegraph Road, named for its telegraph line, which was inoperative at the time of the battle. Telegraph Road crosses the park along a north-south line, passing to the east of Pea Ridge and in front of Elkhorn Tavern. The Battle of Pea Ridge was focused around Elkhorn Tavern and the village of Leetown, to the north of Little Sugar Creek. Elkhorn Tavern was a two-story log house built in 1833. After the battle, rebels burned the building to the ground, leaving the foundation and the two chimneys. A new tavern, a one-story wood frame structure, was built on the foundation immediately after the War, and by the 1880s, a second story was added. Further alterations were removed by the Park Service, in 1966, to restore the structure to its well-documented 1880s appearance. Leetown, the site of the other major engagement in the Battle of Pea Ridge, was a small village, and most of the buildings were destroyed after the battle (NPS 2010b).

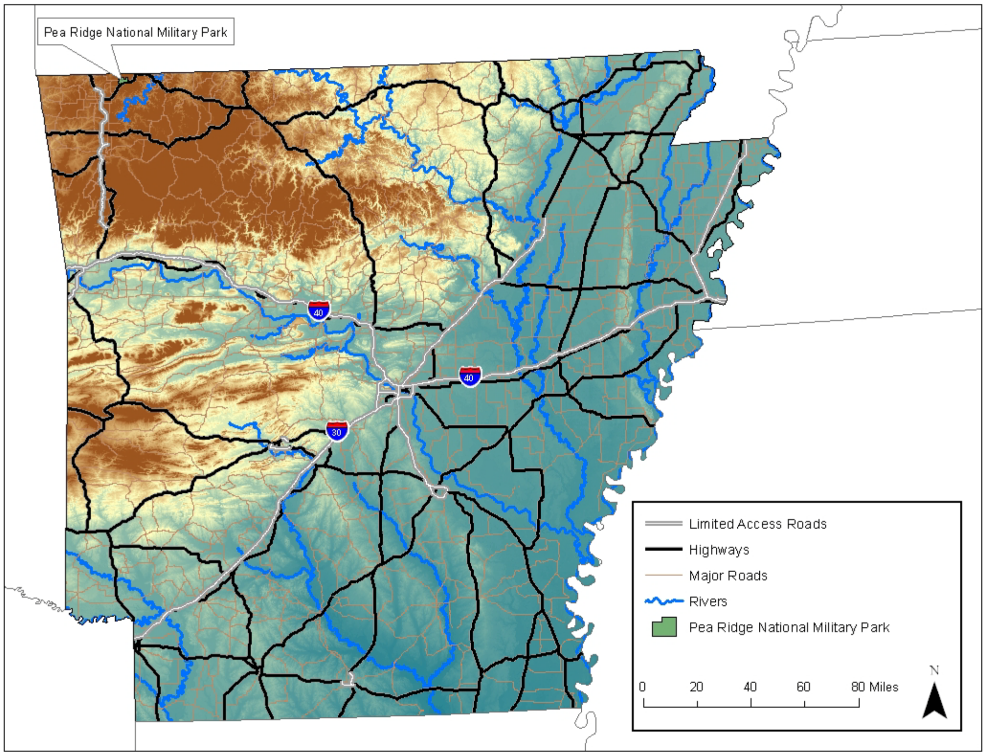

Figure 2-1. Location of Pea Ridge National Military Park within the state of Arkansas.

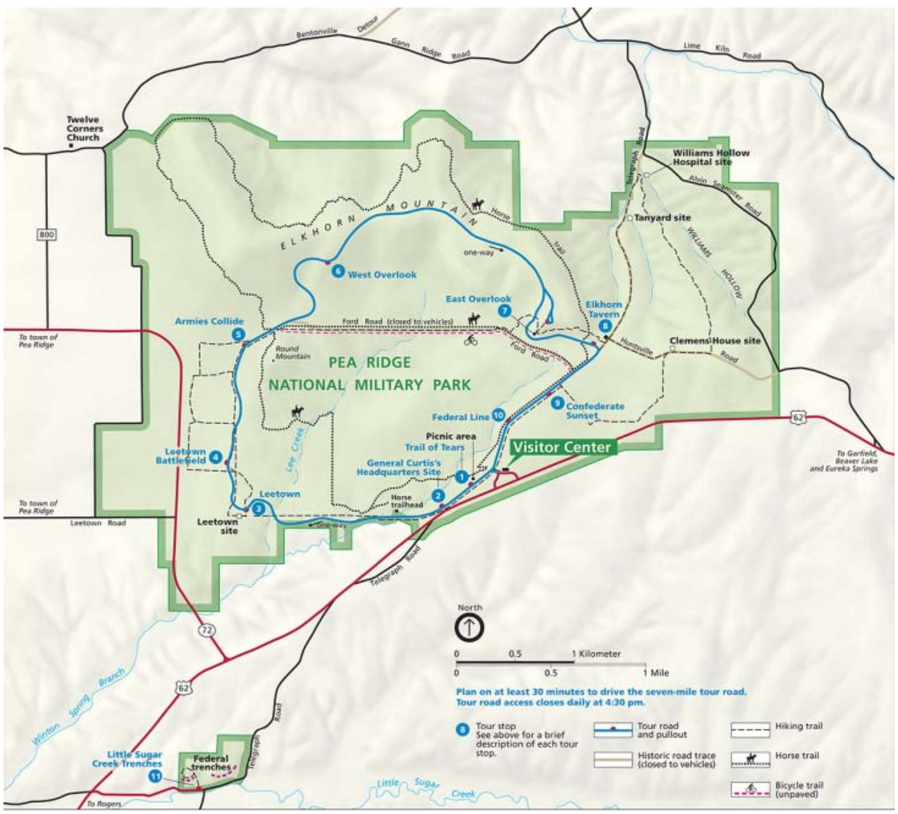

Figure 2-2. Pea Ridge National Military Park (NPS 2010b).

Landscape and Watershed Context and Threat Assessment

Pea Ridge National Military Park (PERI) is within the Ozark Highlands level III ecoregion, on the border between the relatively flat Springfield Plains and more hilly Dissected Springfield Plateau-Elk River Hills level IV Ecoregion (see Environmental Protection Agency web site at http://www.epa.gov/wed/pages/ecoregions/level_iii_iv.htm). The northern and northeastern sides of the park contain high ridges and steep slopes whereas areas to the south and southwest are generally lower and flatter. Historic upland landscapes were likely a mix of oak or oak-hickory woodlands and forests. Wet prairies or flatwoods may have provided local diversity on the west side of the park, and nearby areas may have been kept more open by more frequent ground fires. Prevailing vegetation patterns probably varied with time and chance events, so a given site might have been more or less densely wooded at any given point in pre-European times. More mesic forests occur on floodplains of small streams and on wet slopes and ravine bottoms, especially near the northern and northeastern border of park. Drier forests dominate the high ridge running east to west on the northern side of the park. The contemporary landscape to the south is characterized by tame tall fescue pastures that have resulted from succession of old fields or heavy grazing by domestic livestock following land clearing. To the north, fewer pastures, more grazed woodlands and cleared valleys, and areas dedicated to forestry, are characteristic of the more rugged topography.

The area near PERI is under intense development pressure from the growth of the Bentonville/Rogers metropolitan area, less than 10 km to the southeast. Bella Vista, about 10 km to the east, is a large, mainly retirement community with golf courses and sparse housing that covers more than 50 square kilometers. A buffered road network provides an index to immediate threat of development, and shows urban encroachment threats, especially from west and southwest of the park (Figure 2-3).

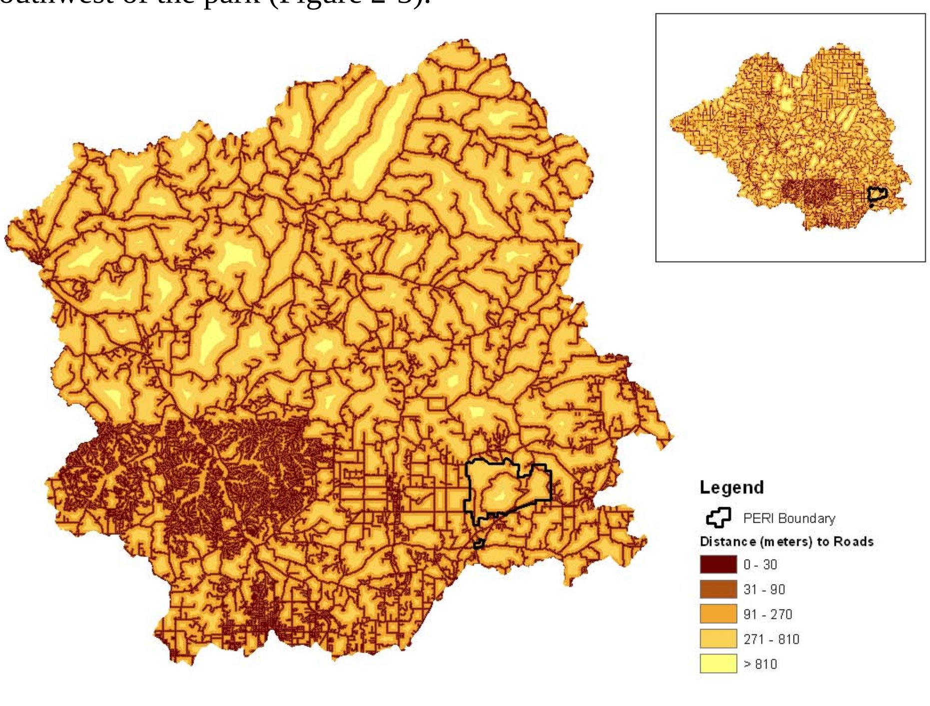

Figure 2-3. A buffered road network provides a visual index to development threats in the region around Pea Ridge National Military Park.

Considering human threats such as land use and pollution discharges as indicators of watershed health provides context for understanding the condition of key aquatic indicators (Joubert and Loomis 2005). Knowing the suite of potential threats and those that are most pervasive on the landscape helps resource managers regulate human impacts on the environment by allowing managers to target specific threats at specific locations.

The watershed threats assessment relies on data developed by the Missouri Resource Assessment partnership (MoRAP) for the EPA and Missouri DNR (see Annis et al. 2010) coupled with additional data specific to the state of Arkansas that was quantified for use in this assessment. The data suite consists of approximately 36 datasets considered potential threats to aquatic ecological integrity from human activities. Figure 2-4 and Figure 2-5 show the land cover and selected threats within the PERI watersheds. The complete list of the threats considered and their data sources are listed in Table 2-1. This data was used to create a human threat index (HTI) that helps to "score" every stream segment with regard to the full complement of threat data used by considering both local and upstream character (Figure 2-6). Larger HTI values indicate more potential threat. It should be noted that each potential human threat does not necessarily impact aquatic resources at all times, but each one does have the potential to impact aquatic resources at any given time. While the HTI is designed for larger spatial scales, it may still be used as a screening tool to gauge the vulnerability of watersheds to impairment (Joubert and Loomis 2005) and the degree and causes of impairment to streams in PERI.

Climate

In the Ozark Highlands, winter snowfall averages 10 inches with normal January low/high temperatures of 12/24^{o} F with 100 days below freezing (McNab and Avers 1994, Missouri Climate Center 2010). July average high temperatures are between 87-90^{o} F, with a yearly range of 40-50 days above 90^{o} F (Missouri Climate Center 2010). The growing season lasts between 180-200 days and average annual precipitation ranges from 40-48 inches (McNab and Avers 1994).

Landform History

Pea Ridge National Military Park is on the Springfield Plateau, of the Ozark Highlands ecological subsection. The area is locally dominated by Pea Ridge, a long mountain that rises to 1600 feet in the northern part and runs from east to west almost the width of the park. Round Top, a smaller mountain is just to the south. Soils within the park are mostly silt loams (Hinterthuer 2003). The Springfield Plateau is primarily underlain with Mississippian and Pennsylvanian age rocks, which also underlie the northern edge of the Ozarks along the Missouri River. The distributional limit of many species characteristic of the Ozarks correspond with the Mississippian-age geologic formations, separating younger Pennsylvanian formations that dominate the Central Plains from the older Ordovician formations that are the primary type found in the central Ozarks. The sedimentary rock of this subregion is dominated by cherty limestone and dolomite, with smaller contributions of sandstone and shale. The geology in the region consists of limestone, dolomite, sandstone, chert, shale, and rhyolite with numerous karst formations, such as sinkholes, springs, seeps, and losing streams. Potential vegetation within the Springfield plateau features a mixture of tallgrass prairie, deciduous forest, and savannah. As such, the region forms a transition zone between prairies to the north, mountainous areas to the south, and deciduous forests to the east (Chapman et al. 2002).

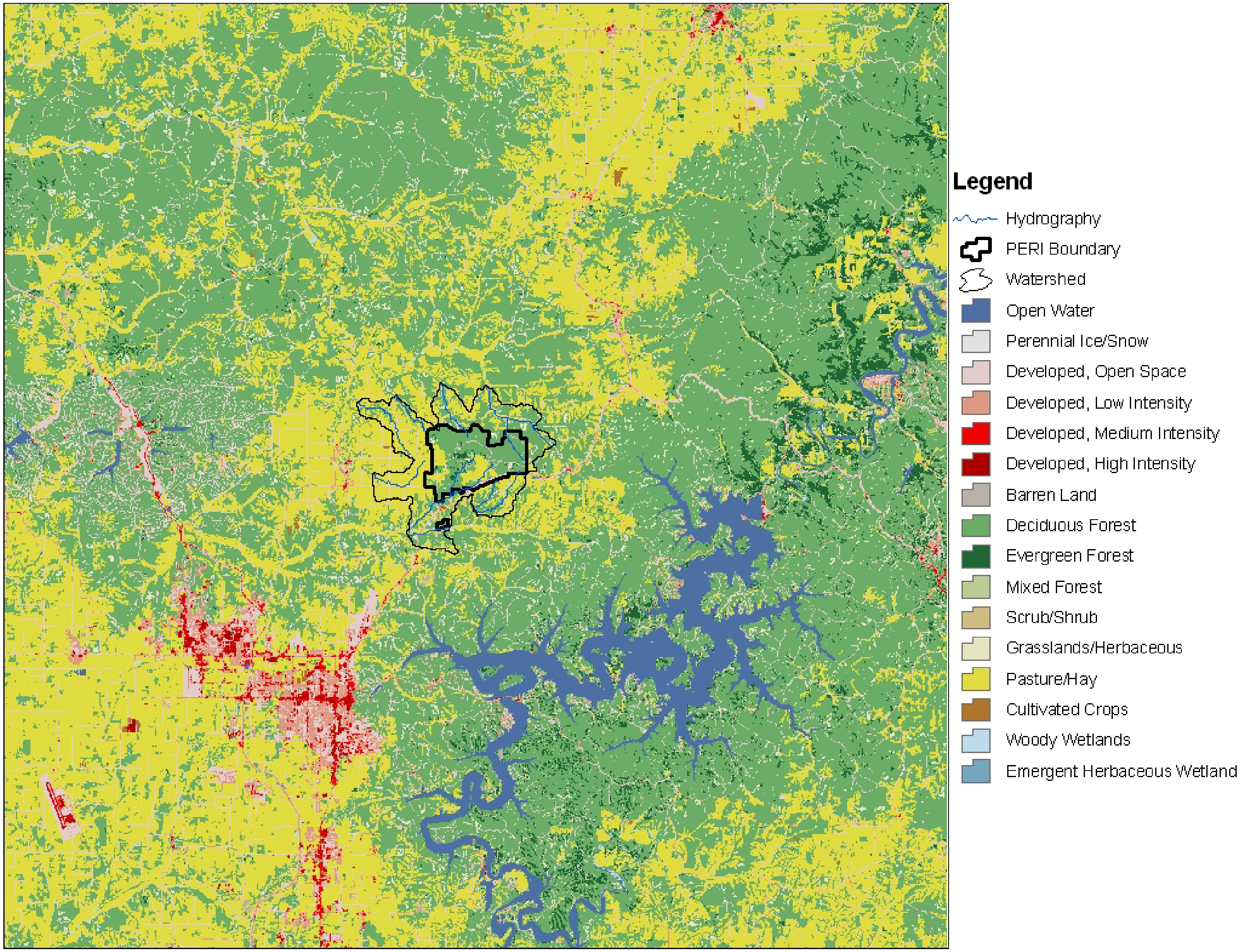

Figure 2-4. Land cover within and surrounding the watershed of Pea Ridge National Military Park based on the 2001 NLCD.

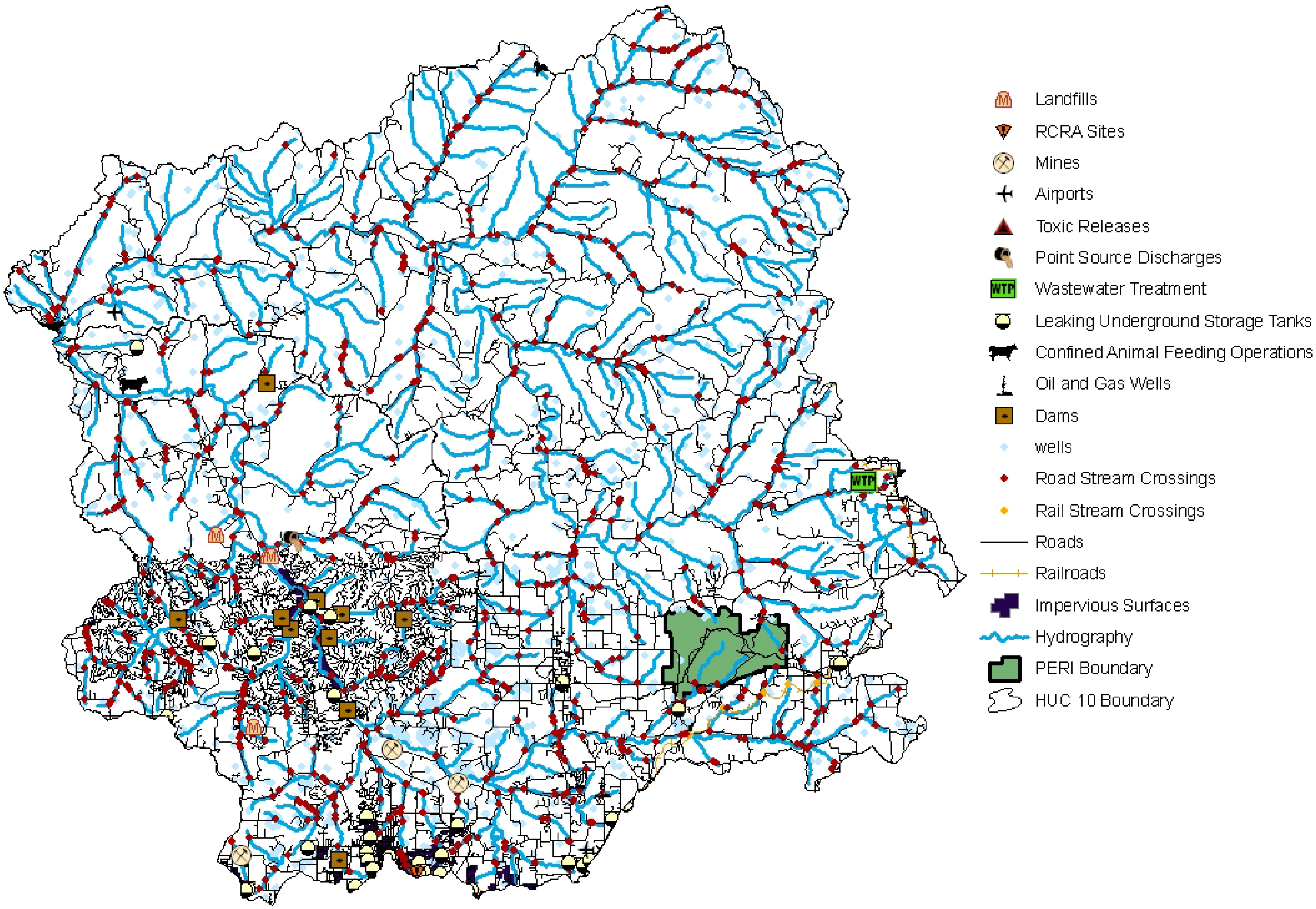

Figure 2-5. Location of potential threats in the HUC 10 encompassing Pea Ridge National Military Park.

Table 2-1. List of all potential human threats considered and the data source for each threat.

Potential Threats	Source
Impervious Surfaces	2001 NLCD
Cropland	2001 NLCD
Pasture/Hay	2001 NLCD
Impervious in stream buffer	2001 NLCD
Cropland in stream buffer	2001 NLCD
Pasture/Hay in stream buffer	2001 NLCD
Water Wells	Arkansas Natural Resources Commission
Major Impoundments	1:100,000 NHDPlus, 1:24,000 NWI, and modified 1:100,000 NHD
Headwater Impoundments	Elevation Derivatives for National Applications, NLCD, NWI, and modified 1:100,000 NHD
Distance downstream to lakes	1:100,000 NHDPlus, 1:24,000 NWI, and modified 1:100,000 NHD
Fragmentation of streams	1:100,000 NHDPlus, 1:24,000 NWI, and modified 1:100,000 NHD
Road Length	TIGER/line roads file
Road/Stream Crossings	TIGER/line roads file and modified 1:100,000 NHD
Railroad Length	TIGER/line rail file
Rail/Stream Crossings	TIGER/line rail file and modified 1:100,000 NHD
Pipelines (crude oil)	EPA Region 7
Pipelines (liquid fuels)	EPA Region 7
Pipelines (gases)	EPA Region 7
Powerlines	Geocomm Data Clearinghouse
Crop Pesticides	NLCD and US Agricultural Census data
Population Density	U.S. Census Bureau
Livestock Sales	Dunn and Bradstreet 2003
Ditch/Channelized Streams	1:24,000 NHD, NWI, and modified 1:100,000 NHD
Airports	National Transportation Atlas Databases 2007
Dams	National Inventory of Dams 1993-1994
Military sites	Bureau of Transportation Statistics-1998-2001
Coal Mines	EPA Basins 2001
Lead Mines	EPA Basins Version 3.0
Other Mines	Arkansas Dept. of Environmental Quality
Oil and Gas Wells	Arkansas Oil and Gas Commission
Leaking Underground Storage Tanks	Arkansas Dept. of Environmental Quality
Superfund Sites	EPA Geodata dataset
Toxic Release Sites	EPA Geodata dataset
Wastewater Treatment Facilities	EPA National Pollutant Discharge Elimination System/ Permit Compliance System
Confined Animal Feeding Operations	Dunn and Bradstreet 2003
Landfills	EPA Basins 2001
NPDES	Subset EPA National Pollutant Discharge Elimination System/ Permit Compliance System
RCRIS	EPA Geodata dataset

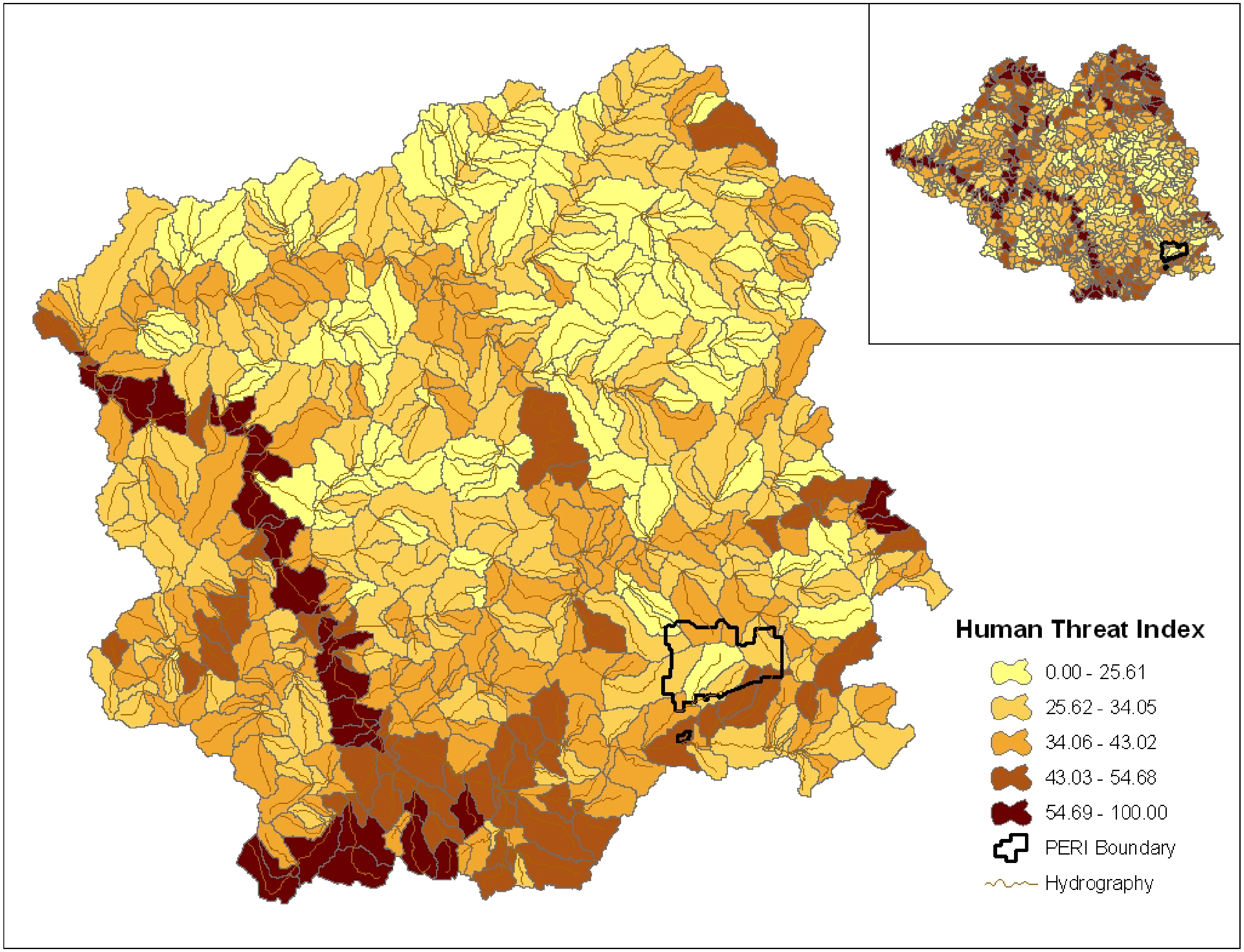

Figure 2-6. Human Threat Index for the HUC 10 encompassing Pea Ridge National Military Park with the HUC 8 inset.

Cultural History

The Battle of Pea Ridge occurred on March 7 and 8, 1862, in northwestern Arkansas, when the Federal Army of the Southwest defeated the combined Confederate Army of the West. Pea Ridge was a decisive victory, particularly considering Federal forces at Pea Ridge were outnumbered by the Confederates, by about 16,000 Confederates to 10,000 Union soldiers. The battle confirmed Missouri's position in the Union, rather than joining the Confederacy, and reduced Confederate strength during the Civil War (Scott and Pitcaithley 1979).

Brigadier General Samuel R. Curtis, along with other capable Union leaders who would continue successful military careers, were able to adapt to the plan by the Confederates, led by Confederate Major General Earl Van Dorn, to invade and gain control of Missouri. On March 7, General Earl Van Dorn marched to attack the Union camp near Pea Ridge, Arkansas, while two brigadier generals, Ben McCulloch and James McQueen McIntosh, marched to a flanking position. Federal troops, after learning of Van Dorn's approach, marched north from their camp to meet the Confederate advance in the Elkhorn Tavern and Tanyard area east of Pea Ridge. In addition, General Samuel Curtis sent a smaller force, led by Colonel Peter Osterhaus, northwest toward Lee Town. The Confederates controlled Elkhorn Tavern and Telegraph Road by nightfall, but the next day, General Samuel R. Curtis counterattacked and forced the Confederates back, and after running short of ammunition, the Confederates retreated eastward and scattered. Near Lee Town, Confederate and Federal troops fought until two Confederate generals, Ben McCulloch and James McQueen McIntosh were killed, and capture of the remaining ranking colonel reduced Confederate leadership, ending the engagement (Scott and Pitcaithley 1979).

The Confederate Army of the West entered battle with more soldiers and more artillery than the Federal Army of the Southwest, who were 250 miles from their supply base. However, Confederate General Earl Van Dorn marched his men too hard during a freezing storm. Additionally, he neither had adequate supplies for the campaign nor sent for supply trains. McCulloch and McIntosh were killed while out of position as division commanders, and after their deaths, no one was capable of leading the division (Scott and Pitcaithley 1979).

Natural Communities

Pea Ridge National Military Park (PERI) currently supports vegetation that matches reasonably with conditions at the time of the civil war in order to illustrate battlefield conditions. Stands of oak (*Quercus velutina, Q. stellata, Q. rubra, Q. alba*) and hickory (*Carya ovata, C. texana*) form relatively dense woodlands or forests on the northern side of the park (Chapman et al. 2002, James 2008). Elkhorn Mountain supports drier woodlands whereas slopes and lower-lying areas over limestone and dolomite support dry-mesic woodlands and forests where these have not been too recently cleared. Mowed grasslands dissected by roadways and depicting the location of historical fields occupy lower uplands on the southern half of the park (Hinterthuer 2003, NPS 2010b). In forested areas, a number of small fields have been abandoned within the past 80 years and currently are dominated or co-dominated by eastern redcedar (*Juniperus virginiana*; James 2008). No known federally threatened or endangered plant or animal species occur in the park, but several Ozark endemics occur. This includes several populations of Ozark chinquapin (*Castanea pumila* var. *ozarkensis*), a state species of concern (Hinterthuer 2003). Ozark endemic fish species present include the cardinal shiner (*Luxilus cardinalis*) and stippled darter

(*Etheostoma punctulatum*; Justus and Peterson 2005b). On the other hand, there are over 40 documented invasive plant species (Hinterthuer 2003).

Aquatic Resources In and Near Pea Ridge National Military Park

Pea Ridge National Military Park contains portions of three small streams that originate within the boundaries of the park including Lee Creek, Winton Spring Run, and Pratt Creek. In addition, Little Sugar Creek flows along the southern boundary of the southern park unit. All of these streams are part of the Arkansas River Basin. Surveys from 2003 document 16 fish species occurring in these four streams, though most of these are from Little Sugar Creek (Justus and Petersen 2005b). Most of the documented fish species are generally associated with small streams of the Ozark Plateau.

The Oklahoma salamander (*Eurycea tynerenis*) was recently discovered in three small spring-fed streams in PERI by HTLN staff (Bowles et al. 2010) and as Bowles et al. describe, its presence generally indicates that the streams have good water quality. The Oklahoma salamander typically inhabits relatively undisturbed small woodland streams or spring-brooks with thermal constancy. The salamander is endemic to the central United States including northeastern Oklahoma and southwest Missouri to northwestern Arkansas.

Wildlife

Fauna of Pea Ridge National Military Park, Arkansas (PERI) are typical of grasslands, old fields, and deciduous woodlands in the Ozark Highlands. For example, sixty-three species of birds were recorded at PERI during site visits in May 2008, and the most common species was the Yellow-throated Vireo (*Vireo flavifrons*; Peitz 2009). Most bird habitat sampled was deciduous forest, although a few relatively large patches of grassland did support breeding pairs of grassland obligate birds (see Breeding Birds, Chapter 5). An inventory report on the presence/absence of mammals at PERI lists 44 mammals as present or probably present at the park (Williams 2009). No Federal or State listed mammals are reported. However, three species are listed by the Arkansas Natural Heritage Commission as species of conservation status. These three species, eastern spotted skunk (*Spilogale putorius*), little brown bat (*Myotis lucifugus*), and southeastern shrew (*Sorex longirostris*) are considered to be “probably present” in the park (Williams 2009).

Resource Stewardship Context

Park Enabling Legislation

Pea Ridge National Military Park covers about 4,300 acres in the foothills of northwestern Arkansas in Benton County. National Park Service administrates the park, which also is on the Civil War Discovery Trail, the Lower Missouri Civil War Heritage Trail, and the Trail of Tears National Historic Trail. The park was founded by Congress in 1956 and dedicated in 1963 (NPS 2010b).

Fundamental Resources and Values

The future strategy for Pea Ridge National Military Park is to restore cultural areas to battle-era conditions, while restoring natural areas. The park has formed partnerships with the Pea Ridge Military Park Foundation, Unilever and Wal-Mart, and citizen volunteers involved in restoration.

The park will encourage stewardship of cultural resources and active environmental practices by visitors, and provide activities and education for local young people (NPS 2007c).

Pea Ridge National Military Park continues progress in opening historical roads, building historical fences, and removing modern developments such as utility poles. As for natural resources, the park is establishing native grasses and controlling invasive species (NPS 2007c). Under a Fire Management Plan, the park is restoring and maintaining fire-adapted oak-hickory forests with a natural disturbance regime, while controlling eastern redcedar encroachment (James 2008).

Other Important Resources and Values

The park contains nearly 90% of the battlefield. Within the 4300 acres are numerous archeological sites, historic sites, structures, and cultural landscapes associated with the battle. The park was established to commemorate the Battle of Pea Ridge and preserve the area in which it occurred. Along with preservation are management efforts focused on visitor experiences. The natural setting of the battle is integrated into interpreting the historic events of the park. Developed management zones focus on preserving historic characteristics of the battle, both natural and cultural landscape. These zones include the natural communities of the Ozark Plateau, the cultural areas of the battleground, and sensitive resources such as roads and trenches.

Desired Conditions for Natural Resources

Desired conditions are qualitative descriptions of the integrity and character for a set of resources and values, including visitor experiences, which the NPS has committed to achieve and maintain. Area-specific desired conditions include these qualitative descriptions as well as guidance on visitor experience opportunities and appropriate kinds and levels of management, development, and access for each area of the park. The desired conditions for natural resources at PERI are:

- Inventories are conducted to identify landscapes potentially eligible for listing in the national register, and to assist in future management decisions for landscapes and associated resources, both cultural and natural. Most reports are cited and briefly reviewed in Chapter 4, and note-worthy inventories include those by Bearss (1962) on conditions at the time of the battle, James (2009) on forests, Peitz (2009) on birds and their associated habitats, and Wright et al. (1970) on existing vegetation. Together, these assessments provide the basis for making sound decisions about management, treatment, and use. The management of cultural landscapes focuses on preserving the landscape's physical attributes, biotic systems, and use when that use contributes to its historical significance.

- The National Park Service actively seeks to understand and preserve the soil resources, and to prevent, to the extent possible, the unnatural erosion, physical removal, or contamination of the soil, or its contamination of other resources. Natural soil resources and processes function in as natural a condition as possible, except where special considerations are allowable under policy. When soil excavation is an unavoidable part of an approved facility development project, the National Park Service will minimize soil excavation, erosion, and offsite soil migration during and after the activity.

- Surface water and groundwater are protected, and water quality meets or exceeds all applicable water quality standards. NPS and NPS-permitted programs and facilities are maintained and operated to avoid pollution of surface water and groundwater.

- Natural floodplain values are preserved or restored. Long-term and short-term environmental effects associated with the occupancy and modifications of floodplains are avoided.

- The National Park Service will maintain, as part of the natural ecosystem, all native plants and animals.

- Populations of native plant and animal species function in as natural a condition as possible except where special considerations are warranted. Native species populations that have been severely reduced in or extirpated from the national monument are restored where feasible and sustainable. The management of exotic plant and animal species, including eradication, will be conducted wherever such species threaten national monument resources or public health and when control is prudent and feasible. Federal and state-listed threatened and endangered species and their habitats are protected and sustained. Native threatened and endangered species populations that have been severely reduced in or extirpated from the national monument are restored where feasible and sustainable.

- Cultural and natural resources are conserved “unimpaired” for the enjoyment of future generations. Visitors have opportunities for forms of enjoyment that are uniquely suited and appropriate to the superlative natural and cultural resources found in the national monument. No activities occur that would cause derogation of the values and purposes for which the park has been established. For all zones, units, or other management divisions in the monument, the types and levels of visitor use are consistent with the desired resource and visitor experience conditions prescribed for those areas. NPS staff will identify implementation commitments for user capacities for all areas of the national monument.

Park staff at PERI actively work to preserve and manage cultural and natural resources. Interpretation of the battlefield and restoration of natural resources are primary considerations. Natural resource management and restoration is balanced with the need to provide for accurate interpretation of conditions at the time of the battle, including the maintenance of viewsheds and historic structures and selected cropland areas. Therefore, PERI seeks to contribute toward the conservation and restoration of streams, upland woodlands, upland grasslands, and floodplain forests concomitant with interpretation of conditions at the time of the battle.

Chapter 3 Study Approach

Preliminary Scoping

Scientists from the Missouri Resource Assessment Partnership (MoRAP), NPS Heartland Inventory and Monitoring Network (HTLN), and park managers from Pea Ridge National Military Park (PERI) comprised the assessment team (Table 3-1). We use the U.S. Environmental Protection Agency's Scientific Advisory Board's Ecological Framework for Assessing and Reporting on Ecological Condition (SAB framework, EPA 2002) to guide the NRCA. The breadth and logical organization of indicators led us to adopt the framework to select and organize indicators for PERI. With the SAB Framework as a guide, the assessment team collectively agreed on the most important resource types, attributes, and indicators for inclusion in the NRCA. We also reviewed management plans and natural resource studies to ensure that the selected indicators complimented these efforts.

Table 3-1. Team members for the Pea Ridge National Military Park Natural Resource Condition Assessment.

Name	Affiliation
Gust Annis	Missouri Resource Assessment Partnership
David Bowles	NPS, Heartland Inventory and Monitoring Network
Mike DeBacker	NPS, Heartland Inventory and Monitoring Network
David Diamond	Missouri Resource Assessment Partnership
Hope Dodd	NPS, Heartland Inventory and Monitoring Network
Kevin Eads	Pea Ridge National Military Park
Lee Elliott	Missouri Resource Assessment Partnership
Jennifer Haack	NPS, Heartland Inventory and Monitoring Network
Phillip Hanberry	Missouri Resource Assessment Partnership
Kevin James	NPS, Heartland Inventory and Monitoring Network
Ronnie Lea	Missouri Resource Assessment Partnership
Sherry Leis	NPS, Fire Management Program
Nolan Moore	Pea Ridge National Military Park
David Peitz	NPS, Heartland Inventory and Monitoring Network
Dyan Pursell	Missouri Resource Assessment Partnership
Gareth Rowell	NPS, Heartland Inventory and Monitoring Network
John Scott	Pea Ridge National Military Park
Diane True	Missouri Resource Assessment Partnership
Craig Young	NPS, Heartland Inventory and Monitoring Network

Assessment Framework Used in the Study

The SAB framework provided a hierarchical checklist of essential ecological attributes (EEAs), categories/subcategories, and indicators that should be considered when evaluating the health of ecological systems (EPA 2002, Table 3-2). The conceptual EEAs include three ecological attributes that are primarily patterns—landscape condition, biotic condition, and chemical/physical characteristics—and three that are primarily processes—hydrology/geomorphology, ecological processes, and natural disturbance. The hierarchical organization of the EEAs was developed from a conceptual model of ecological structure, composition, and function at a variety of scales (EPA 2002).

In some assessments, indicators of ecological condition are included with indicators of stressors (e.g., road density) (EPA 2002). In the NRCA, we focused on indicators of condition given the one-to-many relationship between stressors and condition (EPA 2002, Figure 3-1). The watershed stressor assessment may be used in parallel with the condition indicators to begin to understand the relationship between anthropogenic activities and the condition of park resources.

Table 3-2. Six essential attributes and sub-categories defined by the Environmental Protection Agency's Framework for Assessing and Reporting Ecological Condition (2002).

Landscape Condition
- Extent of Ecological System/Habitat Types
- Landscape Composition
- Landscape Pattern and Structure

Biotic Condition
- Ecosystems and Communities
  - Community Extent
  - Community Composition
  - Trophic Structure
  - Community Dynamics
  - Physical Structure
- Species and Populations
  - Population Size
  - Genetic Diversity
  - Population Structure
  - Population Dynamics
  - Habitat Suitability
- Organism Condition
  - Physiological Status
  - Symptoms of Disease or Trauma
  - Signs of disease

Chemical and Physical Characteristics (Water, Air, Soil, and Sediment)
- Nutrient Concentrations
  - Nitrogen
  - Phosphorus
  - Other Nutrients
- Trace Inorganic and Organic Chemicals
  - Metals
  - Other Trace Elements
  - Organic Compounds
- Other Chemical Parameters
  - pH
  - Dissolved Oxygen
  - Salinity
  - Organic Matter
  - Other
- Physical Parameters

Ecological Processes
- Energy Flow
  - Primary Production
  - Net Ecosystem Production
  - Growth Efficiency
- Material Flow
  - Organic Carbon Cycling
  - Nitrogen and Phosphorus Cycling
  - Other Nutrient Cycling

Hydrology and Geomorphology
- Surface and Groundwater flows
  - Pattern of Surface Flows
  - Hydrodynamics
  - Pattern of Groundwater Flows
  - Salinity Patterns
  - Water Storage
- Dynamic Structural Characteristics
  - Channel/Shoreline Morphology, Complexity
  - Extent/Distribution of Connected Floodplain
  - Aquatic Physical Habitat Complexity
- Sediment and Material Transport
  - Sediment Supply/Movement
  - Particle Size Distribution Patterns
  - Other Material Flux

Natural Disturbance Regimes
- Frequency
- Intensity
- Extent
- Duration

Figure 3-1. Schematic showing the one-to-many relationship between essential ecological attributes and stressors in the Environmental Protection Agency's Framework for Assessing and Reporting Ecological Condition (2002).

Resource Types, Attributes and Indicators

For PERI, we attempted to identify ecological indicators by attribute and resource type that reflect the quality or condition of park resources. In addition, the indicators are generally selected such that they are practically measurable and can be impacted by reasonable levels of management effort. Thus, each resource type may have a unique suite of attributes and indicators. Also, each reporting unit may have different attributes and indicators.

Landscape Condition

Landscape Composition

Landscape patch indicators may provide a measure of habitat quality. For example, a change in the extent and composition of natural habitat patches (i.e., vegetation condition) or a change in connectivity between habitat patches (i.e., vegetation patterns) may affect the probability of local extinction, loss of diversity of native species, and regional persistence of species (EPA 2002). Consequently, managing entire landscapes, not just individual habitat types, may be required to maintain native plant and animal diversity (Liu and Taylor 2002). To evaluate landscape condition we used two simple, basic indicators: patch count and mean patch size. Non-natural fragmentation on the landscape is evidenced by an increase in the number of patches of a given vegetation type coupled with a decrease in mean patch size.

Land Use/Land Cover

Land use and land cover are indications of the overall degree of disturbance of the landscape. Prevailing dominant land cover (e.g. grassland, deciduous forest) can be defined by site type (e.g. dry upland, floodplain) within a landscape (Nigh and Schroeder 2002, Nelson 2005). Land cover types that were not historically present on a given site type may indicate past or on-going disturbance. For example, grasslands or shrublands on site types that were historically forested often indicate past or on-going cultivation or mowing; evergreen juniper woodlands or shrublands on deciduous forest site types indicate past cultivation or the absence of the historical fire regime.

Biotic Condition

Biodiversity, defined as the variety and variability among living organisms and the environments in which they occur, is recognized at genetic, population, species, community, and ecosystem levels of biological organization (U.S. Congress 1987, Noss 1990). As a result, the SAB framework characterized biotic condition at various levels as measures of composition and structure that relate directly to functional integrity (EPA 2002). Because environmental factors and human activities affect taxonomic groups differently, each group provides a different view on ecosystem health or condition (Kirkpatrick and Brown 1994, Diamond et al. 2005).

For this reason, a variety of attributes and indicators represented biotic composition. For the terrestrial environment, these included the breeding bird community composition, abundance of deer, rare species, invasive/exotic plant species, and composition of plant communities in terms of structure and species dominance. These elements are important indicators for unique reasons.

Bird species distribution and abundance are tightly linked to habitat type and workers have identified species of concern via analysis of datasets collected nationwide (Canterbury et al. 2000, see http://www.partnersinflight.org/). Management activities aimed at specific bird species or guilds impact entire ecosystems. Moreover, birds enjoy a tremendous following among the public (Peitz 2009).

White-tailed deer (*Odocoileus virginianus*) are viewed as a valuable park natural resource with considerable interest from visitors. Since European settlement, populations have fluctuated greatly. They are recognized as keystone herbivores that impact the composition and structure of ecosystems across the nation (Waller and Alverson 1997).

Invasive and exotic species are recognized as among the most significant threats to global biodiversity (see Mooney and Hobbs 2000). Finally, plant communities have been altered or eliminated across vast areas of the modern landscape, and dominant cover types and their structural characteristics explain recent disturbance history (Oliver and Larson 1996). Monitoring of structure and recruitment can also predict future composition (Collins 2000).

Fish community composition was a focus for assessment of lotic environments, because many species are considered intolerant of habitat alterations (Karr 1981, Robison and Buchanan 1988, Pflieger, 1997, Barbour et al. 1999) and their assemblages can serve as a useful tool to assess changes in water and habitat quality (Hoefs and Boyle 1990, Justus and Peterson 2005a, 2005b, Peitz 2005, Petersen and Justus 2005a, 2005b). Accordingly, the composition and abundance of fish populations historically have been used to assess the biological integrity of streams (Barbour et al. 1999; Moulton et al. 2002). Moreover, the intrinsic value of fish to the public as environmental indicators and as a recreational opportunity makes the status of fish diversity a valuable interpretive topic for parks.

Aquatic invertebrates are often used to detect changes in the integrity of aquatic ecosystems over time and can be used as a surrogate for water quality conditions (Bowles 2010). This indicator was not included in the assessment of PERI because of a lack of data.

Chemical and Physical Characteristics

<u>Water quality</u>

Water temperature: Water temperature affects biological and chemical characteristics of streams (Binkley and Brown 1993). For example, temperature changes can shift the structure of aquatic communities (Karr and Schlosser 1978, Matthews 1987). Temperature increases can limit residence to those species able to tolerate increased temperatures (Karr and Schlosser 1978). Sowa and Rabeni (1995) found temperature to be an important factor determining the distribution and abundance of smallmouth bass (*Micropterus dolomieu*) and largemouth bass (*Micropterus salmoides*) in Missouri and suggested that elevated stream temperatures would allow largemouth bass to replace resident smallmouth bass populations. Reduced temperatures in streams during the winter can cause severe metabolic stress on fish (Cunjak 1988), while extreme temperature fluctuations can lead to direct thermal shock of eggs and fry as well as cause changes in reproductive behavior (Shuter et al. 1980).

Specific conductance: Specific conductance (SC) is a measure of the ability of water to conduct an electrical current. Conductivity increases with an increasing amount and mobility of ions. These ions, the byproduct of the breakdown of larger compounds, conduct electricity because they are negatively or positively charged when dissolved in water. Therefore, SC is an indirect measure of the presence of dissolved solids such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, and iron, and can be used as an indicator of water pollution.

Dissolved oxygen: An adequate supply of dissolved oxygen (DO) is a basic requirement for healthy aquatic ecosystems. While some aquatic organisms are adapted to low oxygen conditions, most species require DO levels greater than 5 or 6 mg/L. Larval and juvenile fish often require even higher concentrations of dissolved oxygen. DO levels fluctuate in the water column under natural conditions, but severe depletion usually results from introduction of large quantities of biodegradable organic materials into surface waters or during prolonged periods of hot weather that reduce the oxygen retention capacity of water.

pH: The pH of water is the standard measure of the concentration of hydrogen ions. A pH value of 7 represents a neutral condition. A low pH value (less than 5) indicates acidic conditions; a high pH (greater than 9) indicates alkaline conditions. Acidic and alkaline waters may limit many biological processes, such as reproduction, in freshwater ecosystems. Acidic conditions may result in increased lability of toxics that are normally bound to sediments.

Turbidity/Suspended sediments: Sediment additions affect primary production through reduced light penetration and increased scour of periphyton from streambed substrates during periods of high flow (Alabaster and Lloyd 1982, Newcombe and MacDonald 1991). Reductions in primary production can lead to subsequent reductions in secondary production since many invertebrates, primarily grazers, depend on periphyton for food (Newcombe and MacDonald 1991). Sediment increases also degrade fish spawning areas, which may lead to behavioral changes in spawning, increased egg mortality, or decreased larval growth and development (Rabeni 1993). These direct effects on fish populations may eventually reduce fish diversity (Berkman and Rabeni 1987). Similar to temperature, species inhabiting Ozark streams are typically adapted to crystal clear waters with minimal suspended sediments, even during elevated discharges (Smale and Rabeni 1991). Watersheds contributing flow to PERI streams are vulnerable to increased sedimentation and runoff from land use activities inside and outside of the park.

Air quality

Given that NPS air quality monitoring programs have shown that air pollutants are transported long distances and have been detected at all NPS monitoring sites (NPS 2002), we included ozone and atmospheric deposition as indicators in the NRCA. Air pollution affects natural and cultural resources throughout much of the park system through visibility reduction, biological and human health effects, and degradation of historic structures and artifacts. The NPS generally considers stable or improving air quality as signs of success, but also strives to comply with national air quality standards (NPS 2007a). See: (http://www.nature.nps.gov/air/permits/aris/networks/htln.cfm) for more information about air quality monitoring.

Ozone: Ozone is a very widespread air pollutant in urban and rural areas that at high concentrations is harmful to human health and damaging to vegetation (NPS 2010a). Ozone affects plants through diffusion into leaf stomata (Hogsett and Anderson 1998) and may cause foliar injury and reduced growth in some sensitive plant species (NPS 2002). Ozone is formed in the atmosphere when pollutants, especially nitrogen oxides (NO_x) and volatile organic compounds (VOC_S), react with sunlight. Anthropogenic sources of NO_x and VOC_S are emitted from industrial facilities, electric utilities, vehicle exhaust, and chemical solvents. Human health effects associated with ozone include reduced lung function, irritated throat and airways, increased susceptibility to respiratory infection, and aggravation of lung diseases.

Atmospheric deposition: Atmospheric deposition refers to the process in which airborne chemicals, including pollutants, are deposited to the earth. Atmospheric deposition includes wet deposition in rain or snow, occult deposition in cloud or fog, and dry deposition from settling, impaction, and adsorption (NPS 2007b). Atmospheric deposition of sulfur and nitrogen compounds can cause significant ecosystem effects such as acidification or eutrophication of soil and water (NPS 2007a). Acidification of soils, lakes, and streams can result in changes in community structure, biodiversity, reproduction, and decomposition. Documented impacts in some parks include stressed trees, acidified streams, and reduction in species of fish and other aquatic life in affected waters (NPS 2002).

Although nitrogen is an essential plant nutrient, increased levels of atmospheric nitrogen deposition can stress ecosystems. Excess nitrogen acts as fertilizer, favoring some types of plants and leaving others at a competitive disadvantage. This creates an imbalance in natural ecosystems, and long–term effects of these changes may include shifts in types of plant and animal species, increase in insect and disease outbreaks, and disruption of ecosystem processes such as nutrient cycling, and changes in fire frequency.

Wet deposition occurs when pollutants are deposited in combination with precipitation, predominantly by rain and snow, but also by clouds and fog. The NPS monitors wet deposition through the National Atmospheric Deposition Program (NADP) and is the only component monitored extensively across the United States. Dry deposition of particles and gases occurs by complex processes such as settling, impaction, and adsorption. Dry deposition is monitored through the Clean Air Status and Trends Network (CASTNet).

Hydrology and Geomorphology

The hydrology and geomorphology of ecological systems reflect the dynamic interplay of water flow and landforms. In river systems, for example, water flow patterns and the physical interaction among a river, its riverbed, and the surrounding land determines whether a diverse array of natural habitats and native species are maintained. Characteristics included in this category include channel morphology and shoreline characteristics, channel complexity, distribution and extent of connected floodplain, and aquatic physical habitat complexity.

Water Flow

The timing, magnitude, and variability of surface and groundwater flows control the transport of nutrients, salts, contaminants, and sediments, while also determining the inundation period of aquatic and wetland habitats. Water flow and sediment movement controls structural characteristics in streambeds, banks, and riparian wetlands. Native species have adapted accordingly; for example, many anadromous fish require clean gravels for spawning, and invertebrates choose particular particle sizes for attachment or burrowing. Disturbances in stream flow (i.e., severe fluctuations in flow resulting from floods, drought, or hydrological alteration) are important abiotic factors structuring fish and invertebrate communities (Starrett 1951, Schlosser 1985, Coon 1987, Bain et al. 1988, Resh et al. 1988, Schlosser and Ebel 1989, Schlosser 1990, Poff et al. 1997). This indicator was not included in the assessment of PERI because of a lack of data.

Natural Disturbance Regime

All ecological systems are dynamic, due in part to discrete and recurrent disturbances that may be physical, chemical, or biological in nature. Examples of natural disturbances include wind and ice storms, wildfires, floods, drought, insect outbreaks, microbial or disease epidemics, invasions of nonnative species, volcanic eruptions, earthquakes and avalanches. The frequency, intensity, extent, and duration of the events taken together are referred to as the “disturbance regime.”

Wildland fire is a natural disturbance process that has great potential to change park landscapes. Many plants and animals cannot survive without the cycles of fire to which they are adapted. National Park Service policy stresses managing rather than simply suppressing fire, which requires planning for its eventuality and promoting the use of fire as a land management tool. Natural fires have been all but eliminated from PERI and surrounding areas. Periodic ground fires may have promoted dominance of fire-tolerant species in pre-European times, especially in dry woodlands and upland flats at PERI.

Chapter 4 Study Methods

Landscape Condition

Landscape Composition and Land Use/Land Cover

A fine-resolution current vegetation map formed the basis for calculation of landscape condition metrics such as patch count and mean patch size, which are associated with landscape composition, and area of natural or semi-natural, successional, and cultural types. These variables were summarized by reporting unit, which were defined based on potential and current vegetation and land use (see Reporting Units, Chapter 5).

The current vegetation classification was produced by considering land cover and ecological site type. Land cover was coded by hand on-screen to 2 m resolution image objects generated using e-Cognition software from merged leaf-on and leaf-off air photos (Table 4-1, Figure 4-1). Abiotic site type was defined by merging similar ecological land types, which in turn were generated from digital county soil survey map unit polygons. In addition, we identified steep slopes (>20%) using 10 m resolution digital elevation models. Finally, current vegetation was assigned to each combination of land cover and abiotic site type (Figure 4-2).

Table 4-1. Land cover classes assigned to image objects for Pea Ridge National Military Park.

Land Cover Classes
Impervious
High Intensity Urban
Low Intensity Urban
Barren or Sparsely Vegetated
Grassland
Deciduous Forest
Evergreen Forest
Mixed Forest
Deciduous Woody/Herbaceous
Evergreen Woody/Herbaceous
Mixed Woody/Herbaceous
Herbaceous-Dominated Wetland
Open Water

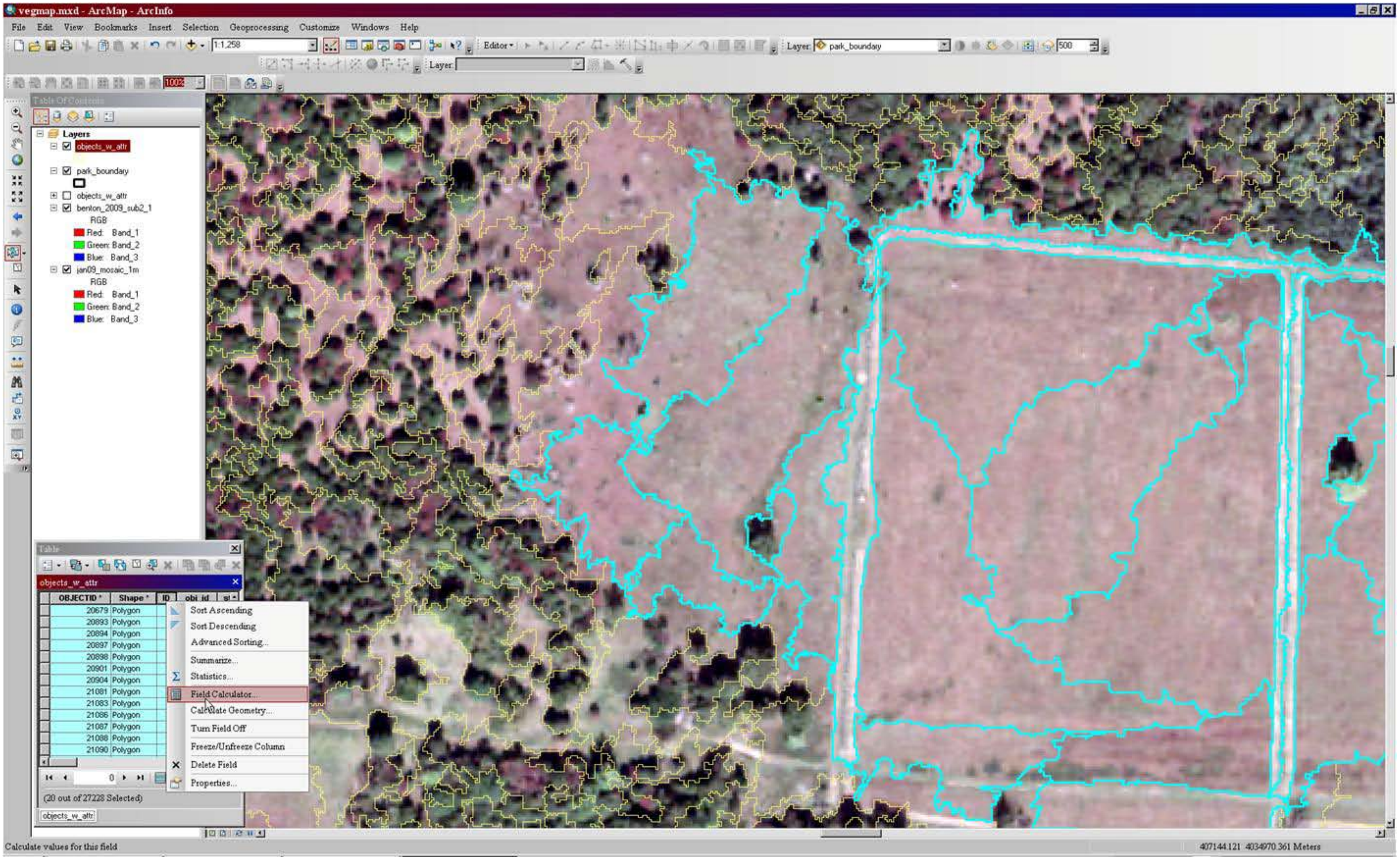

Figure 4-1. Process for assigning land cover classification to 1 m resolution image objects on-screen.

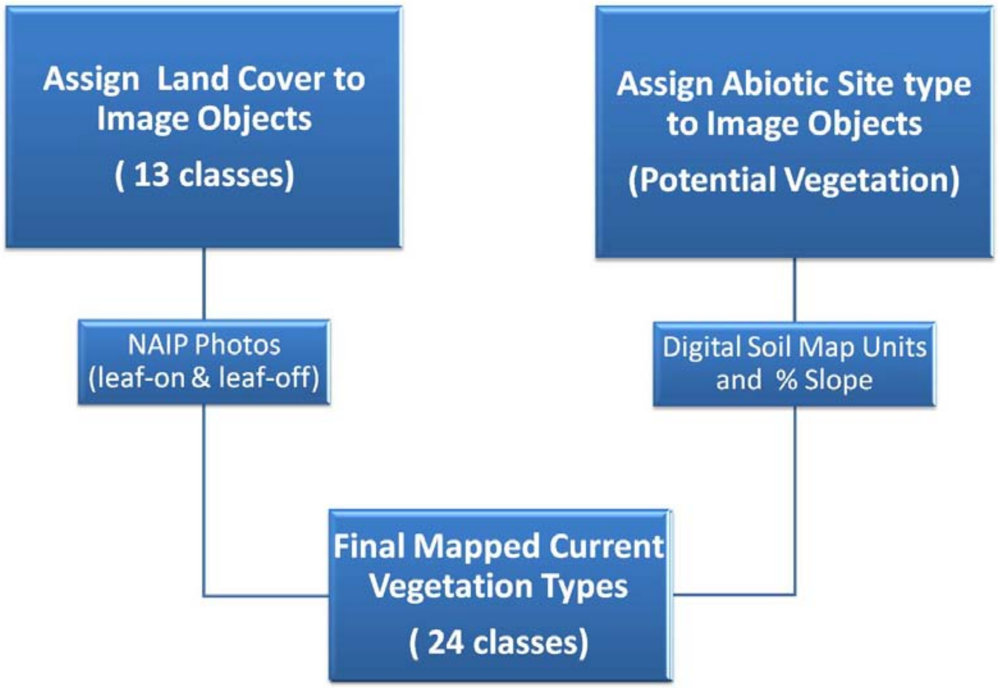

Figure 4-2. Current vegetation was assigned to image objects based on ecological site type (site potential) and current land cover.

Biotic Condition

Bird Community Composition

PERI is in a transition zone between grassland and woodland, is topographically relatively diverse, and therefore has a diversity of different habitat types. Bird community monitoring at PERI aims to identify changes over time due to management activities or natural causes. An intensive breeding bird survey was done at PERI in the summer of 2008 using a standardized protocol (Peitz et al. 2008, Peitz 2009). Habitat variables and birds were both sampled at 38 permanent 400 X 400 m cells located 200 m apart along parallel transects. Variable circular plot methodology was used, wherein observers look and listen for birds during 5-minute sampling periods, and corrections are made based on delectability by species. In addition, bird habitat data were collected from 50-m radius plots at each listening station, including data on abiotic (e.g. %slope) and biotic (e.g. vegetation structure) variables.

White-tailed Deer

Populations of white-tailed deer are monitored each year during the winter at PERI using spotlight surveys from the 10.17 km loop road. This road was selected as a monitoring route because it is easily accessible and traverses all of the major habitat types within the park. Surveys are conducted using two 1,000,000 candlepower spotlights from a vehicle moving no more than 16 km/hr. Two observes, one on the left and one on the right side of the vehicle, spot deer and determine distance using a rangefinder, or for individuals <20 m from the vehicle, by visual estimates.

Invasive Exotic Plants

Invasive and exotic plants are recognized by the NPS as a threat to native biodiversity across the nation. In response, the Heartland Network Inventory and Monitoring Program tracks invasive species in a systematic way at PERI. A park-based watch list of possible invasive exotic species has been generated, and 101, 6 m wide, 400 m long (some were shorter based on park boundaries and other constraints) belt transects have been sampled (Young et al. 2007). Presence of target species was noted and cover estimated by cover class. Grassy habitats were excluded from the samples, so results mainly provide an index to invasive and exotic species within woodlands and forests at PERI.

Plant Community Structure and Composition

Three separate, complimentary monitoring efforts document plant community composition at PERI. Fourteen sites are monitored as part of the fire management plan, seven sites (all forested) are monitored by the Heartland Inventory and Monitoring Network as part of the forest community monitoring effort, and data from 99 sites were collected as part of the breeding bird monitoring protocol (See James 2008, Peitz 2009). The Heartland Network's effort focused on the natural forested areas of the park. Forest stands are sampled using a set of ten nested circular plots along two, 50 m parallel lines that are 20 m apart. Five sets of nested circular plots are located along each of the two lines, or ten sets of nested plots. Four plot sizes, 10 square meters, 1 square meter, 0.1 square meter, and 0.01 square meter, are sampled. Data collected vary by plot size, and summary statistics on species richness and diversity, the ratio of exotics to native species, species abundance and frequency, woody species density and basal area, overstory canopy cover, and ground cover are calculated (James 2008). Fire monitoring plots are designed to determine change over both short and longer periods, and plot information collected focuses on dominance by species by tree basal size class (See National Park Service 2003).

The breeding bird vegetation data set was collected from 50-meter radius plots at 99 sites placed at regular intervals along a grid (Peitz 2008; see Bird Community Composition, above). Overall habitat type (e.g. woodland, shrub, field/prairie, etc.) was estimated by cover class within the plot. Within 5 meter subplots, canopy cover, height, and basal area were estimated by life form (e.g. hardwood, conifer), as was vegetation density at different height intervals and stems per hectare of trees by family. Finally, ground and foliar cover (<1.5 m tall) was estimated within 1.78 meter sample plots by plant guild, including warm- and cool-season grasses, forbs, moss and lichens, shrubs and vines, tree seedlings, and total foliar cover.

The breeding bird vegetation data set was selected to further analysis because it contains the largest volume of uniformly collected information. Management targets for vegetation composition such as canopy cover, basal area, and density were taken from literature on similar communities (see Nelson 2005, Nigh and Schroeder 2002, and especially Missouri forest and woodland natural community profiles posed at http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed 10/15/2010). These values generally represent a fairly wide range, since natural communities are quite variable over time and space based both on disturbance regimes and abiotic site type.

Fish Community Composition

For aquatic ecosystems fish data are often the most readily available source of aquatic community data. This indicator seeks to examine the condition of the fish community by using five common indicators of fish community condition.

Actual fish collection data for streams within the PERI boundary was acquired from two sources. Collections made via electrofishing in September of 2003 came from Justus and Petersen (2005b). More recent collections from 2009 also via electrofishing were from unpublished Heartland Network data (Figure 4-3). We developed current conditions from Dodd (unpublished data).

A total of five potential metrics were used to assess the current condition, though only three metrics could be computed for a single reporting unit (Pratt Creek). These included a fish Index of Biotic Integrity (IBI), Simpson's Diversity Index, and the composition of benthic (darters, sculpins, madtoms) species. The IBI was used to give an overall rating of the stream quality based on characteristics (i.e. metrics) of the fish community. The Simpson's Index uses species richness and abundance to estimate the diversity of the fish community and decreases with increasing diversity (0 = completely diverse; 1 = no diversity). Benthic species (darters, sculpins, and madtoms) represent species that are intolerant to human disturbance and are therefore a good indicator of stream health.

Because there is limited information published on fish communities in watersheds close to PERI, we used the mean from data collected in 2003 and 2009 as the management target. The reference condition used for benthic species metrics was generally computed using the mean plus one standard deviation. The reference condition for the Simpson's Diversity Index was computed using the mean from 2003 and 2009 minus one standard deviation because this index has an inverse relationship with diversity. The fish index of biotic integrity including the management target and reference condition was developed for the Ozark Highlands by Dauwalter et al. (2003).

Aquatic Invertebrate Community

Data was not available on the aquatic invertebrate community in PERI therefore this indicator was not reported on.

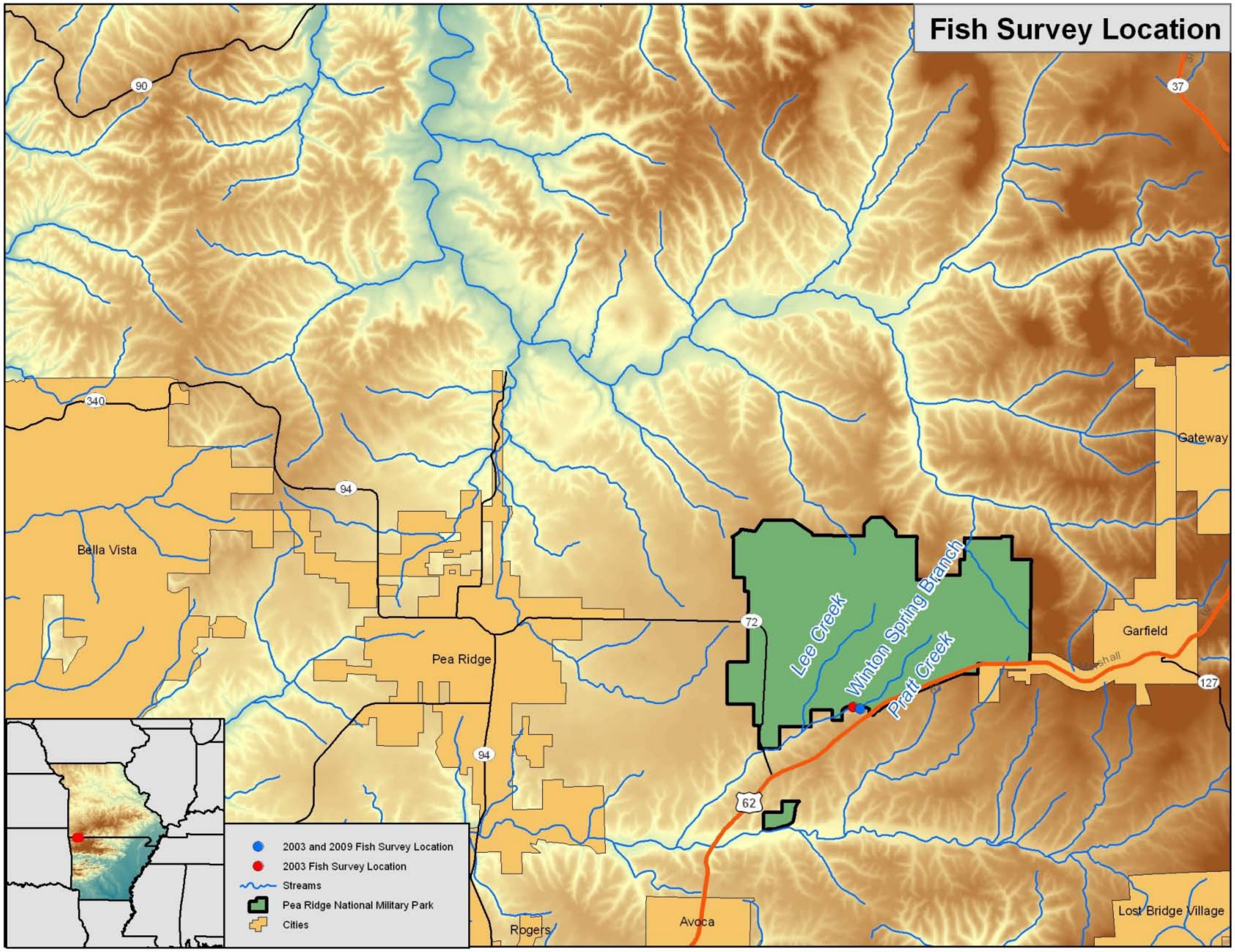

Figure 4-3. Fish survey location for surveys conducted in 2003 (Justus and Peterson 2005b) and 2009 in Pratt Creek and Winton Spring Branch.

Chemical and Physical Characteristics

Water Quality, Suspended Sediments, and Temperature

<u>Temperature, Specific Conductance, Dissolved Oxygen, pH, and Turbidity</u>:
Data for water quality were available and reported on for temperature, specific conductance, dissolved oxygen, pH, and turbidity. Water quality information for 2004, 2005, 2006 and 2009 is based on Core 5 indicators taken from Moore and Keaton (undated) and unpublished Heartland data. Data for 2009 was collected continuously with data loggers using the monitoring protocol described in Dodd et al. (2008). NPS established management targets based on Brown and Czarnecki (undated).

Air Quality

Air quality is an important environmental issue facing most National Parks. Data collected through the NPS air quality programs show that park units are not islands isolated from urban, agricultural, and industrial pollutants. Manmade and natural air pollutants are transported long distances and have been detected at all NPS monitoring sites (NPS 2002). Air pollution affects natural and cultural resources throughout much of the park system through visibility reduction, biological and human health effects, and degradation of historic structures and artifacts.

The National Park Service is interested in achieving the best possible air quality in its parks because air quality impacts ecological health, scenic views, human health, and visitor enjoyment. The NPS generally considers stable or improving air quality as signs of success, but also strives to comply with national air quality standards with the ultimate goal clean clear air in national parks (NPS 2007a). It is important to note that stable trends are not necessarily indicative of good air quality if an area is already experiencing poor quality air.

<u>Ozone</u>
We used data from NPS's Air Resources Division available at http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm. These ozone values represent estimates for PERI based on interpolations calculated as a 5-year average concentration. Ozone concentrations were measured as the 4th highest 8-hour average and expressed as parts per billion (ppb), which allowed comparison to the ozone standard of 75 ppb established by EPA in March 2008. A rating of poor was assigned to concentrations greater than or equal to the standard (≥ 76 ppb). A fair rating was assigned to concentrations greater than 80% of the standard (61 to 75 ppb). A good rating was assigned to concentrations less than 80% of the standard (less than or equal to 60 ppb).

<u>Wet Deposition</u>
We used data from NPS's Air Resources Division available at http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm. Deposition estimates represent estimates for PERI based on interpolations calculated as a 5-year average concentration. We established a condition rating using thresholds for N (total inorganic nitrogen from ammonium and nitrate ions in wet deposition) and S (total sulfur from sulfate ions in wet deposition) as described by NPS. Estimates for natural background wet deposition rates for either N or S are 0.13 kg/ha/yr in the Western United States and 0.25 kg/ha/yr in the Eastern United States (NPS 2007a). Nutrient sensitive ecosystems respond to wet deposition levels of approximately 1.5

kg/ha/yr (NPS cites Fenn et al. 2003, Krupa 2003). NPS (2007a) reports that wet deposition amounts of less than 1 kg/ha/yr do not cause ecosystem harm. As a result, we assigned a rating of good for wet deposition rates less than 1 kg/ha/yr; a rating of fair for wet deposition rates of from 1 to 3 kg/ha/yr; and a rating of poor wet deposition rates greater than 3 kg/ha/yr (Table 4-2).

Table 4-2. Condition rating for wet deposition of either N or S. Source: (NPS 2007a).

Deposition Condition	Wet Deposition (kg/ha/yr)
Poor	> 3
Fair	1-3
Good	< 1

Dry Deposition

We used data from NPS's Air Resources Division available at http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm. Deposition estimates represent estimates for PERI based on interpolations calculated as a 5-year average concentration. We plotted combined wet and dry deposition of nitrogen and sulfur through time over the available period of record. We did not provide condition ratings for dry deposition.

Hydrology and Geomorphology

Surface Water Flow

The hydrology and geomorphology of ecological systems reflect the dynamic interplay of water flow and landforms. In river systems, for example, water flow patterns and the physical interaction among a river, its riverbed, and the surrounding land determine whether a naturally diverse array of habitats and native species are maintained.

Surface and groundwater flows determine which habitats are wet or dry, and water flow transports nutrients, salts, contaminants, and sediments. It is less widely recognized, however, that the variability of water flows (in addition to their timing and magnitude) exerts a controlling influence on the creation and succession of habitat conditions.

Because of a lack of available data this indicator was not included in the analysis.

Natural Disturbance Regime

Fire Regime

Fire was the primary natural disturbance impacting the natural communities at PERI. We inferred historic fire return intervals by reporting unit (major community type) by referring to state and transition models for similar communities prepared for the LandFire project (see http://www.landfire.gov/NationalProductDescriptions13.php).

Chapter 5 Natural Resource Conditions

Reporting Units

For terrestrial communities, we developed reporting units that included the whole park, plus sub-divisions based on potential vegetation and on current condition (Figure 5-1). Thus the reporting units were park-wide, bottomland forest, dry woodland, semi-natural grassland, and typic woodland. The typic woodland recovery unit is based primarily on site potential, and thus circumscribes some areas that are currently grassland but where woodlands are the prevailing pre-European condition (see Appendix C). The dry woodland recovery unit is likewise based on site potential, but circumscribes little area that is current grassy. The semi-natural grassland recovery unit mainly circumscribes areas that are currently semi-natural grassland. Cultural areas such as buildings, parking lots and associated lawns and grounds, and interpretive croplands were also identified and separated from areas that will be managed for more natural or semi-natural vegetation.

Because stream character and condition can vary dramatically with drainage area (Vannote et al. 1980), we developed reporting units for Pratt Creek and Winton Spring Branch (Figure 5-2). It should be noted that Lee Creek and Williams Hollow were not used as reporting units because of a general lack of available data. Air quality, which is largely reflective of global or regional processes, was reported at the park-wide scale.

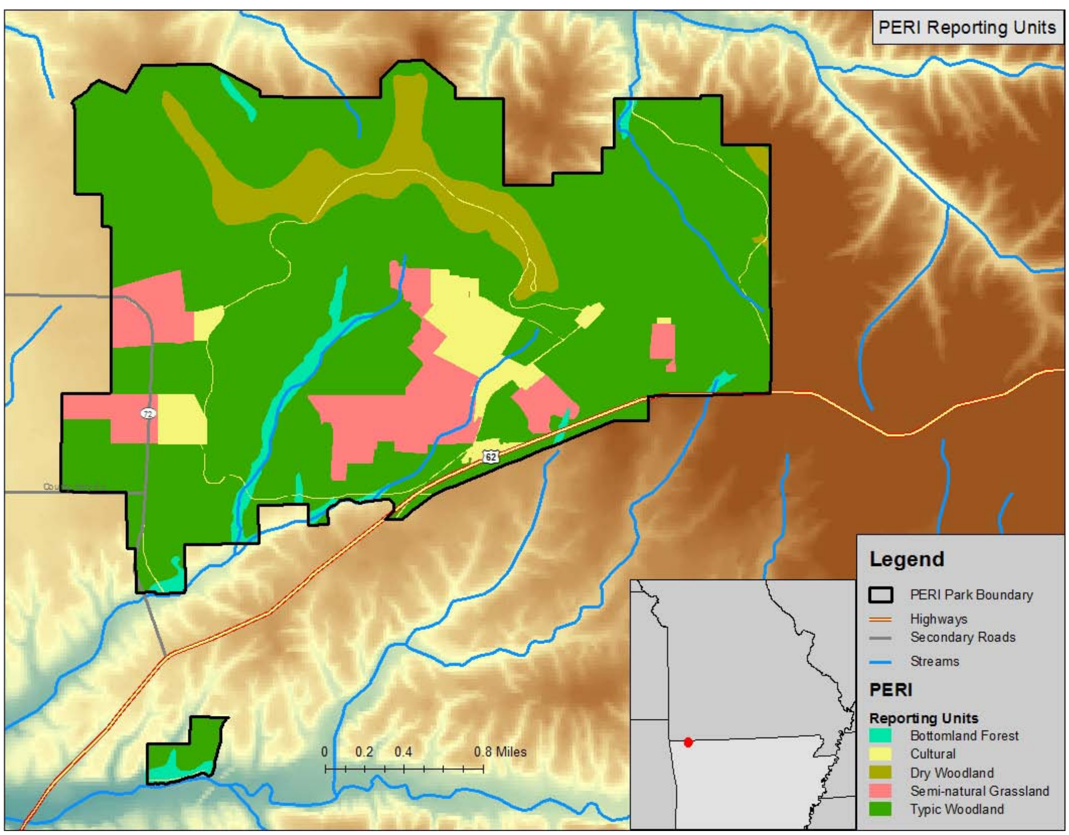

Figure 5-1. Terrestrial reporting units for Pea Ridge National Military Park were based on both current vegetation patterns and ecological site type (site potential).

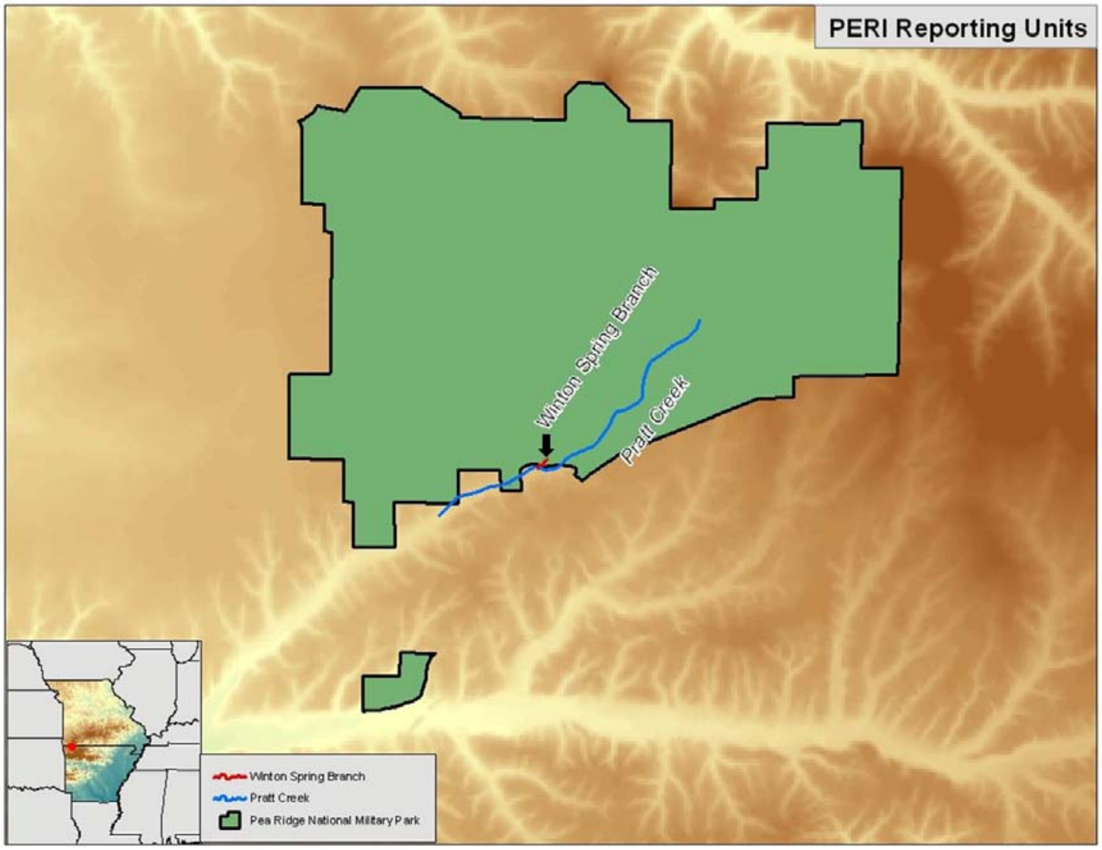

Figure 5-2. Map of stream reporting units within Pea Ridge National Military Park.

Condition Summaries by Reporting Units

In chapters 3 and 4, we organized the discussion of indicators and attributes used to characterize natural resources by the EPA assessment framework. In chapter five, we report the condition of natural resources by reporting unit, with a focus on indicators. Reporting units typically encompass multiple natural resources (i.e., resource types) and their related attributes/indicators. A resource type may occur in one or many reporting units, and management targets may differ for the same resource type in different reporting units (Table 5-1, Figure 5-1, Figure 5-2).

Table 5-1. Summary of natural resource condition indicators for Pea Ridge National Military Park. Current conditions are based on contemporary data, and management targets are based on a variety of sources, including expert judgment (see text). Indicators are presented within park reporting units (Figure 5-1, Figure 5-2) and relate to resource types and/or ecological attributes.

Reporting Unit	Resource Type	Attribute	Indicator	Management Target	Current Condition	Current Year
Park-wide						
	Vegetation					
		Landscape composition				
			patch count	< 1000	1697	2010
			mean patch size (ha)	> 2	1.01	2010

Table 5.1 Continued

Reporting Unit	Resource Type	Attribute	Indicator	Management Target	Current Condition	Current Year
		Land use/Land cover				
			semi-natural and natural types (ha)	> 1200	946	2010
			successional types (ha)	< 500	748	2010
			cultural types (ha)	< 35	22	2010
	Breeding bird community					
		grassland composition				
			grassland species richness	≥ 35	35	2008
			Partners in Flight target grassland species	≥ 12	12	2008
			number of grassland obligate species	≥ 3	3	2008
		grassland habitat				
			litter cover (%)	≥ 35	39.5	2008
			bare ground cover (%)	≤ 50	47.6	2008
			total foliar cover (%)	≥ 40	44	2008
		woodland composition				
			woodland species richness	≥ 43	43	2008
			Partners in Flight target woodland species	≥ 11	11	2008
		woodland habitat				
			canopy cover (%)	≥ 75	87.8	2008
			basal area (m2/ha)	7 - 15	7.8	2008
			mid-story structural diversity index (%)	25 - 40	30.4	2008
	White-tailed deer					
			index of relative abundance (individuals/km^2)	< 8	33.7	2010
	Invasive exotic plant impact					
			number of taxa	< 30	35	2006
			frequency on transects (%)	< 50	84.2	2006
			park-wide minimum cover estimate (%)	< 10	4.5	2006
	Air quality					
		Ozone				
			ozone (ppb)	≤ 60	70.4	2004 - 2008
		Atmospheric deposition				
			nitrogen (kg/ha/yr)	< 1	11.7	2004 - 2008
			sulfur (kg/ha/yr)	< 1	9.8	2004 - 2008
Bottomland forest						
		Landscape composition				
			patch count for bottomland forest	< 45	66	2010
			mean patch size for bottomland forest (ha)	> 1	0.38	2010
		Land use/Land cover				
			bottomland forest (ha)	> 28	25	2010
			successional types (ha)	< 3	15	2010
Semi-natural grassland						

Table 5.1 Continued

Reporting Unit	Resource Type	Attribute	Indicator	Management Target	Current Condition	Current Year
		Landscape composition				
			patch count for grassland	≤ 7	7	2010
			mean patch size for semi-natural grassland (ha)	≤ 22	22	2010
		Land use/Land cover				
			semi-natural grassland (ha)	> 150	158	2010
			successional types (ha)	≤ 10	1.24	2010
		Herbaceous guild composition				
			native grass (%)	> 60	28.5	2008
			native forbs (%)	10 - 40	8.6	2008
			native woody shrub and vine (%)	< 10	1	2008
Dry woodland						
		Landscape composition				
			patch count for dry woodland	< 40	59	2010
			mean patch size for dry woodland (ha)	> 3	1.3	2010
		Land use/Land cover				
			dry woodland (ha)	> 100	77	2010
			successional types (ha)	< 15	40	2010
		Structural class				
			hardwood canopy cover (%)	30 - 90	86.5	2008
			hardwood basal area (m^2/ha)	6.5 - 21.5	4.29	2008
			density (stems/ha, trees > 8 cm dbh)	150 - 500	313.3	2008
		Cover type				2008
			oak species basal area (m^2/ha)	4.2 - 17.2	1.23	2008
			hickory and walnut species basal area (m^2/ha)	0.65 - 7.5	0.813	2008
		Regeneration				
			cover type small saplings (>1.5 m tall, < 2 5 cm dbh) relative density (% of stems/ha)	> 30	0	2008
			cover type large saplings (>1.5 m tall; > 2.5 and < 8 cm dbh) relative density (% of stems/ha)	> 30	20	2008
			total cover type sapling relative density (% of stems/ha)	> 30	18.8	2008
		Herbaceous guild composition				
			native grass (%)	10 - 90	10	2008
			native forbs (%)	1 - 30	3	2008
			native woody shrub (%)	< 50	5.7	2008
		Structure				
			hardwood tree height (m)	≥ 10	11.1	2008
Typic woodland						
		Landscape composition				
			patch count for typic woodland	< 175	483	2010
			mean patch size for typic woodland (ha)	> 2.5	1.68	2010

Table 5.1 Continued

Reporting Unit	Resource Type	Attribute	Indicator	Management Target	Current Condition	Current Year
		Land use/Land cover				
			typic woodland (ha)	> 1050	811	2010
			successional types (ha)	< 200	455	2010
		Structural class				
			hardwood canopy cover (%)	70 - 100	88.14	2008
			hardwood basal area (m^2/ha)	14 - 29	9.5	2008
			density (stems/ha, trees > 8 cm dbh)	175 - 600	322.8	2008
		Cover type				2008
			oak species basal area (m^2/ha)	9 - 23.5	4.5	2008
			hickory and walnut species basal area (m^2/ha)	2 - 10	2	2008
		Regeneration				
			cover type small saplings (>1.5 m tall, < 2 5 cm dbh) relative density (% of stems/ha)	> 30	5.6	2008
			cover type large saplings (>1.5 m tall; > 2.5 and < 8 cm dbh) relative density (% of stems/ha)	> 30	25.7	2008
			total cover type sapling relative density (% of stems/ha)	> 30	21.7	2008
		Herbaceous guild composition				
			native grass (%)	10 - 80	6.8	2008
			native forbs (%)	1 - 40	7.4	2008
			native woody shrub (%)	15 - 50	4.1	2008
		Structure				
			hardwood tree height (m)	≥ 15	18	2008
Pratt Creek						
	Water quality					
			temperature (^oC)	0 - 34	13.2	2009
			specific conductance (µS/cm)	100 - 400	230.0	2009
			dissolved oxygen (mg/L)	5 - 15	9.6	2009
			pH	6.5 - 9.0	7.3	2009
			turbidity (NTU)	< 10	8.2	2009
	Fish community					
		Composition				
			Simpson's Diversity	≤ 0.64	0.62	2009
			benthic species composition (%)	≥ 12.8	21.8	2009
		Condition				
			Index of Biotic Integrity	> 60	53	2009
	Aquatic invertebrates					
		Biotic integrity				
			family richness	> 22	NA	2009
			genus richness	increase	NA	2009
			EPT richness	> 9	NA	2009

Table 5.1 Continued

Reporting Unit	Resource Type	Attribute	Indicator	Management Target	Current Condition	Current Year
			EPT ratio	increase	NA	2009
			Shannon Index (Genus)	> 2.47	NA	2009
			Shannon Evenness Index	increase	NA	2009
			Hilsenhoff Biotic Index	< 5.3	NA	2009
Winton Spring Branch						
	Water quality					
			temperature (^{o}C)	0 - 34	13.6	2009
			specific conductance (μS/cm)	100 - 400	272.1	2009
			dissolved oxygen (mg/L)	5 - 15	9.6	2009
			pH	6.5 - 9.0	7.0	2009
			turbidity (NTU)	< 10	2.1	2009
	Aquatic invertebrates					
		Biotic integrity				
			family richness	> 22	NA	2009
			genus richness	increase	NA	2009
			EPT richness	> 9	NA	2009
			EPT ratio	increase	NA	2009
			Shannon Index (Genus)	> 2.47	NA	2009
			Shannon Evenness Index	increase	NA	2009
			Hilsenhoff Biotic Index	< 5.3	NA	2009

Reporting Unit: Park-wide

Vegetation

Overall, PERI has 24 different current cover types, and about 946 ha (55%) are natural or semi-natural, whereas 748 ha (44%) are clearly successional types. The remaining 22 ha (<1.5%) are cultural cover types, including cover types such as trails and roads, buildings, and lawns (Table 5-2, Figure 5-3, Figure 5-4).

Table 5-2. Current (conceptual) vegetation type patch statistics and total area for Pea Ridge National Military Park.

Current Vegetation Class	Mean Patch Size (ha)	# of Patches	Class Area (ha)	% Class Area
Barren or Sparsely Vegetated	0.02	1.00	0.02	0.00
Bottomland Oak-Hardwood Forest	0.35	72.00	25.44	1.48
Bottomland Successional Deciduous Sparse Woodland and Shrubland	0.06	4.00	0.25	0.01
Bottomland Successional Eastern Redcedar Sparse Woodland and Shrubland	0.54	18.00	9.74	0.57
Bottomland Successional Eastern Redcedar Woodland and Forest	0.07	1.00	0.07	0.00
Bottomland Successional Eastern Redcedar-Deciduous Mixed Woodland and Forest	0.15	17.00	2.54	0.15
Bottomland Successional Herbaceous Vegetation	0.08	6.00	0.47	0.03
Herbaceous-dominated Wetlands (non-riverine)	0.18	1.00	0.18	0.01
Open Water	0.03	6.00	0.17	0.01
Trails and Roads	0.66	33.00	21.92	1.28
Upland Dry Oak-Hickory Woodland and Forest	1.12	69.00	77.36	4.51
Upland Typic Oak-Hickory Woodland and Forest	0.96	360.00	344.13	20.04
Upland Oak-Bluestem Flatwoods (grassy)	0.21	10.00	2.15	0.12
Upland Oak-Bluestem Flatwoods (wooded)	0.16	1.00	0.16	0.01
Upland Successional and Disturbance Grassland	1.49	235.00	350.80	20.43
Upland Successional Deciduous Sparse Woodland and Shrubland	0.20	326.00	65.74	3.83
Upland Successional Eastern Redcedar Sparse Woodland and Shrubland	0.05	143.00	7.77	0.45
Upland Successional Eastern Redcedar Woodland and Forest	0.35	214.00	75.63	4.40
Upland Successional Eastern Redcedar-Hardwood Woodland and Forest	0.62	342.00	212.39	12.37
Upland Successional Eastern Redcedar-Mixed Deciduous Sparse Woodland and Shrubland	0.17	132.00	23.00	1.34
Upland Typic Slope Oak-Hardwood Woodland and Forest	3.16	157.00	496.01	28.89
Upland Wet Slope and Valley Hardwood Forest	0.03	26.00	0.76	0.04
Urban High Intensity	0.05	1.00	0.05	0.00
Urban Low Intensity	0.03	11.00	0.37	0.02

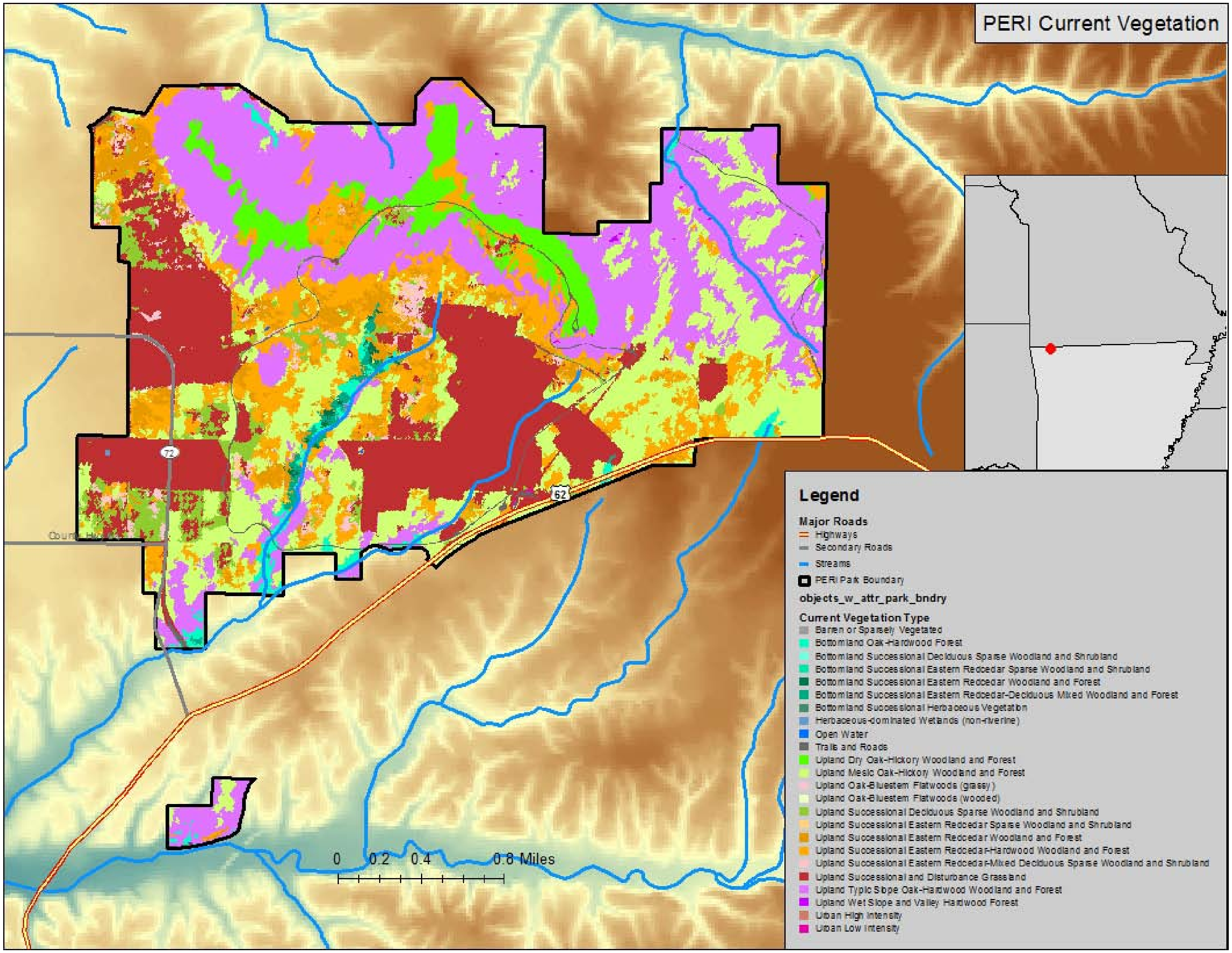

Figure 5-3. Pea Ridge National Military Park current (conceptual) vegetation cover types.

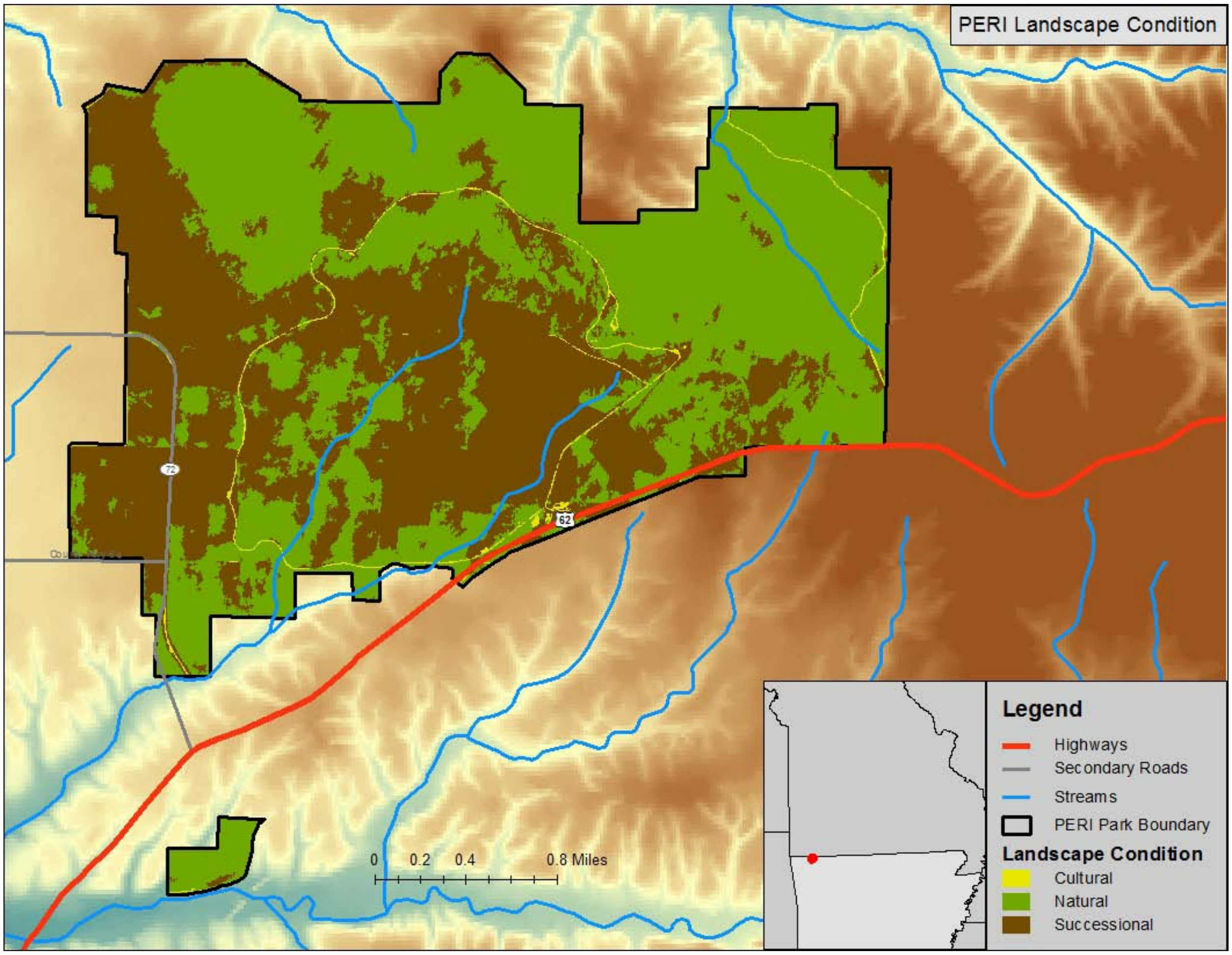

Figure 5-4. Pea Ridge National Military Park current landscape condition.

Landscape Composition

There are 1697 patches of different land cover types in the park, with an average patch size of 1.01 ha. Among land cover types that cover more than 75 hectares, or slightly more than 5% of the park, deciduous forest patches are the largest on average at 3.67 ha, and evergreen forest (juniper) patches are smallest at 0.36 ha (Table 5-3). The landscape is more fragmented overall than in historic times, and management targets were established based on subjective expert opinion. These relate to reducing the number of patches and increasing mean patch size (Table 5-1).

Table 5-3. Mean patch size, number of patches, and area for major land cover types at Pea Ridge National Military Park.

Land Use/Land Cover Class	Mean Patch Size (ha)	# of Patches	Class Area (ha)	% Class Area
Impervious	0.66	33	21.92	1.28%
High Intensity Urban	0.05	1	0.05	0.00%
Low Intensity Urban	0.03	11	0.37	0.02%
Barren or Sparsely Vegetated	0.02	1	0.02	0.00%
Grassland	1.50	235	353.42	20.58%
Deciduous Forest	3.67	257	943.87	54.97%
Evergreen Forest	0.36	220	78.17	4.55%
Mixed Forest	0.68	327	222.13	12.94%
Deciduous Woody/Herbaceous	0.20	329	65.98	3.84%
Evergreen Woody/Herbaceous	0.05	144	7.84	0.46%
Mixed Woody/Herbaceous	0.17	132	23.00	1.34%
Herbaceous-Dominated Wetland	0.18	1	0.18	0.01%
Open Water	0.03	6	0.17	0.01%

Land Use/Land Cover

The most abundant natural and semi-current vegetation types include upland typic slope oak-hardwood and forest (496 ha), upland successional and disturbance grassland (350 ha), and upland typic oak-hickory woodland and forest (344 ha). These types all account for >20% of the park, and together comprise 69% of the current vegetation cover. The upland successional and disturbance grassland occurs mainly in large blocks on the southern and eastern part of the park, and many areas are maintained as grassland for interpretation of historic conditions at the time of the battle. Successional eastern redcedar (*Juniperus virginiana*) dominated or co-dominated types together make up 331 ha, or 19.3% of the park (Figure 5-4). The management goals are based on expert opinion, and relate to increases in the area of natural and semi-natural types and reduction in the area of successional types. For eastern redcedar dominated areas, this process may occur due to natural succession without much management effort over time (Figure 5-1).

Breeding Bird Community

Of 63 breeding bird species identified, the most frequent in 99 sample grids included the Yellow-throated Vireo (*Vireo flavifrons*), Indigo Bunting (*Passerina cyanea*)**,** and Northern Cardinal (*Cardinalis cardinalis*; Peitz 2009). Partners in Flight, a coalition of agencies and individuals whose mission is to conserve North America's declining bird populations, classify sixteen species found at PERI as species of continental importance (Table 5-4). Three grassland obligate species were recorded, the Eastern Meadowlark (*Sturnella magna*), Grasshopper Sparrow (*Ammodramus savannarum*), and Henslow's Sparrow (*Ammodramus henslowii*). No woodland obligates were reported. Deciduous woodlands (1279.7 ha) dominate the bird habitat at PERI, with 76% of the plots surveyed located in this habitat type, and 24% located in habitat dominated by various grassland types and old fields (414.9 ha combined).

The bird fauna includes species that require a diversity of habitats, from mature deciduous forest, to forest with dense understory, to open brushy areas and edges, to grasslands. Six species of continental concern are common enough to serve as barometers of the different important habitats within the park (Peitz 2009). Acadian Flycatchers (*Empidonax virescens*) and Yellow-throated Vireos require mature deciduous forest, Carolina Wrens (*Thryothorus ludovicianus*) require woodlands and forests with abundant understory, Indigo buntings and Eastern Towhees (*Pipilo erythrophthalmus*) require edges or shrubby habitat, and Red-bellied Woodpeckers (*Melanerpes carolinus*) require a variety of woodland types. In addition, two grassland obligate species of continental concern, the Grasshopper Sparrow and Henslow's Sparrow, might serve as indicators of grassland habitat quality.

Management targets are based on expert opinion and focus on maintenance of the current level of biodiversity. Management of specific plots may not be practical, and thus management within the context of communities may be most appropriate, with a focus on maintaining populations of the eight species outlined above.

Table 5-4. Bird species recorded during breeding bird surveys at Pea Ridge National Military Park, Arkansas in 2008. The American Ornithologists' Union Code (AOU code) and residency status of each species is given.

Common name[1]	Species name[2]	AOU code	Residency[3]
Acadian flycatcher	***Empidonax virescens***	**ACFL**	**SR**
American crow	*Corvus brachyrhynchos*	AMCR	R
American goldfinch	*Carduelis tristis*	AMGO	R
American redstart	*Setophaga ruticilla*	AMRE	SR
American robin	*Turdus migratorius*	AMRO	R
Barn swallow	*Hirundo rustica*	BARS	SR
Barred owl[4]	*Strix varia*	BDOW	R
Bewick's wren	*Thryomanes bewickii*	BEWR	R
Black-and-white warbler	*Myniotilta varia*	BAWW	SR
Blue jay	*Cyanocitta cristata*	BLJA	R
Blue-gray gnatcatcher	*Polioptila caerulea*	BGGN	SR
Blue-winged warbler	***Vermivora pinus***	**BWWA**	**SR**
Brown thrasher	***Toxostoma rufum***	**BRTH**	**R**
Brown-headed cowbird	*Molothrus ater*	BHCO	R
Carolina chickadee	*Parus carolinensis*	CACH	R
Carolina wren	***Thryothorus ludovicianus***	**CARW**	**R**
Chipping sparrow	*Spizella passerine*	CHSP	SR
Common yellowthroat	*Geothlypis trichas*	COYE	SR
Eastern (Rufous-side) towhee	***Pipilo erythrophthalmus***	**EATO**	**WR**
Eastern bluebird	*Sialia sialis*	EABL	R
Eastern kingbird	*Tyrannus tyrannus*	EAKI	SR
Eastern meadowlark	*Sturnella magna*	EAME	R
Eastern phoebe	*Sayornis phoebe*	EAPH	R
Eastern wood-pewee	*Contopus virens*	EAWP	SR
Field sparrow	*Spizella pusilla*	FISP	R
Grasshopper sparrow	***Ammodramus savannarum***	**GRSP**	**SR**
Gray catbird	*Dumetella carolinensis*	GRCA	SR

Table 5.4 Continued

Common name[1]	Species name[2]	AOU code	Residency[3]
Great crested flycatcher	*Myiarchus crinitus*	GCFL	SR
Hairy woodpecker	*Picoides villosus*	HAWO	R
Henslow's sparrow	***Ammodramus henslowii***	**HESP**	**M**
Indigo bunting	***Passerina cyanea***	**INBU**	**SR**
Kentucky warbler	***Oporornis formosus***	**KEWA**	**SR**
Louisiana waterthrush	***Seiurus motacilla***	**LOWA**	**SR**
Mourning dove	*Zenaida macroura*	MODO	R
Northern (Baltimore) oriole[4]	*Icterus galbula*	BAOR	SR
Northern bobwhite	*Colinus virginianus*	NOBO	R
Northern cardinal	*Cardinalis cardinalis*	NOCA	R
Northern mockingbird	*Minus polyglottos*	NOMO	R
Northern parula	*Parula Americana*	NOPA	SR
Ovenbird	*Seirus aurocapillus*	OVEN	SR
Pileated woodpecker	*Dryocopus pileatus*	PIWO	R
Prairie warbler	***Dendrocia discolor***	**PRAW**	**SR**
Red-bellied woodpecker	***Melanerpes carolinus***	**RBWO**	**R**
Red-eyed vireo	*Vireo olivaceus*	REVI	SR
Red-tailed hawk	*Buteo jamaicensis*	RTHA	R
Red-winged blackbird	*Agelaius phoeniceus*	RWBL	R
Ruby-throated hummingbird	*Archilochus colubris*	RTHU	SR
Scarlet tanager	*Piranga olivacea*	SCTA	SR
Song sparrow	*Melospiza melodia*	SOSP	WR
Summer tanager	*Piranga rubra*	SUTA	SR
Swainson's thrush	*Catharus ustulatus*	SWTH	M
Turkey vulture	*Cathartes aura*	TUVU	R
(Eastern) Tufted titmouse	*Baeolophus bicolor*	ETTI	R
Veery	*Catharus fuscescens*	VEER	M
Whip-poor-will	*Caprimulgus vociferous*	WPWI	SR
White-breasted nuthatch	*Sitta carolinensis*	WBNU	R
White-eyed vireo	***Vireo griseus***	**WEVI**	**SR**
Wood thrush	***Hylocichla mustelina***	**WOTH**	**SR**
Worm-eating warbler	***Helmitheros vermivorus***	**WEWA**	**SR**
Yellow warbler	*Dendroica petechia*	YWAR	SR
Yellow-billed cuckoo	*Coccyzus americanus*	YBCU	SR
Yellow-breasted chat	*Icteria virens*	YBCH	SR
Yellow-throated vireo	***Vireo flavifrons***	**YTVI**	**SR**

[1] Bolded names are those Partners in Flight species considered of continental importance.
[2] Species names are valid and verified names taken from ITIS (Integrated Taxonomic Information System). Http://www.itis.gov/.
[3] Residency: SR = summer resident; R = year around resident; WR = winter resident; According to Stokes and Stokes (1996).
[4] Species recorded only while traveling between point transects or at other times outside of 5-min survey periods.

White-tailed Deer

From 2005 to 2010, deer density dipped from about 43 individuals/km^2 in 2005 to less than 15 individuals/km^2 in 2007, probably due to an outbreak of hemorrhagic disease (Figure 5-5).

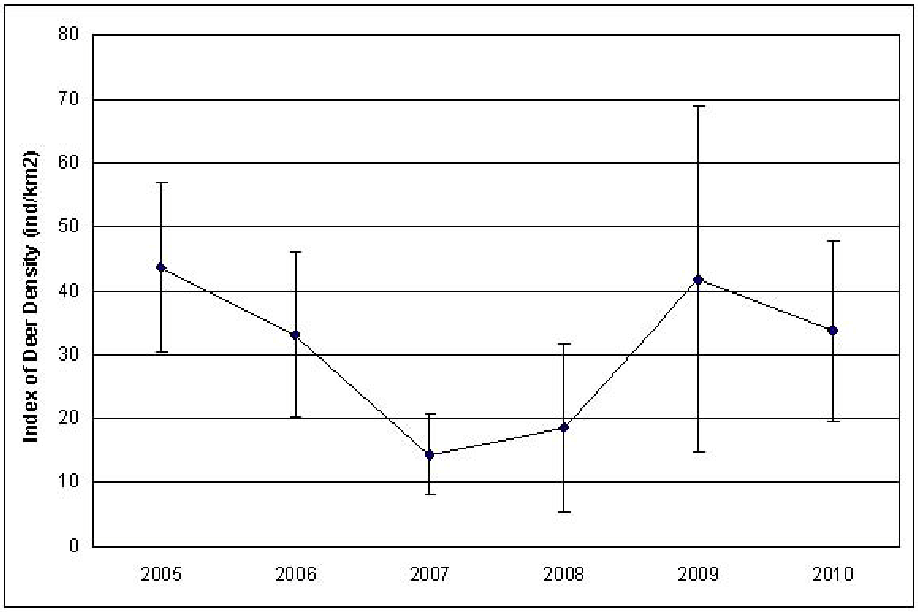

Figure 5-5. White-tailed deer population fluctuations between 2005 and 2009.

The population density rebounded to more than 40 individuals/km^2 in 2009, but then dipped again in 2010 to about 34 individuals/km^2. At this density, the deer herd is expected to heavily browse palatable woody and herbaceous species, and hence may have an impact on development of the vegetation. Hemorrhagic disease is often related to high population densities, and might therefore be cyclic. Starvation of individuals in unfavorable years may result from high population densities. Maintenance of the deer herd nearer to the ecological carrying capacity of about 8 individuals/km^2 (see Peitz 2006) may not be possible, but reduction in numbers would benefit the development of healthier deer and plant communities. Recruitment of oak species and palatable shrubs may be enhanced insofar as deer may graze on these species during the winter and early spring.

Invasive Exotic Plant Impact

Fourteen invasive or exotic species were identified during surveys conducted in 2006, and covered a minimum of 4.5% of the park (Table 5-5; Young et al. 2007). Management targets are based on expert opinion, and focus on reducing the numbers of invasive species and overall cover in the park if possible.

Table 5-5. Invasive exotic plants at Pea Ridge National Military Park. Management difficulty codes are from NatureServe (see http://www.natureserve.org/): high (H), medium (M), low (L), and unknown (U).

Species	Common Name	Park-wide cover (acres)	Frequency (percent)	Management difficulty
Juniperus virginiana	Eastern redcedar	671.8 – 1151.7	42.8	----
Lespedeza cuneata	Sericea lespedeza	6.8 – 19.9	19.1	ML
Lonicera japonica	Japanese honeysuckle	2.9 – 13.9	18.5	HM
Rosa multiflora	Multiflora rose	2.2 – 9.2	19.1	L
Lolium spp	Fescue	0.8 – 2.7	5.2	----
Microstegium vimineum	Nepalese browntop	0.3 – 2.1	8.1	HM
Robinia pseudoacacia	Black locust	0.3 – 1.6	6.4	M
Sorghum halepense	Johnsongrass	0.2 – 1.1	3.5	HM
Centaurea stoebe ssp. micranthos	Spotted knapweed	< 0.75	2.9	HL
Dactylis glomerata	Orchardgrass	< 0.75	5.2	ML
Verbascum thapsus	Common mullein	< 0.25	2.3	L
Ligustrum spp	Privet	< 0.1	0.6	ML
Bromus inermis	Smooth brome	< 0.01	1.7	----
Poa compressa	Canada bluegrass	< 0.01	0.6	HL

Grasslands were excluded from sampling, so results relate only to woodlands and forests at PERI. In this context, eastern redcedar (*Juniperus virginiana*) covered by far the most area (Table 5-5). No other species covered more than 8 hectares as a maximum estimate. However, that species, sericea lespediza (*Lespedeza cuneata*), is more common in grasslands than woodlands, and mainly occurred in the small amount of brushy and grassy habitat included within the sample. This species, along with tall fescue (*Schedonorus phoenix*), a cool-season perennial, are often among the dominants in grasslands at PERI. Only two other species, Japanese honeysuckle (*Lonicera japonica*) and multiflora rose (*Rosa multiflora*), covered at least one hectare in woodlands at PERI. The area dominated by eastern redcedar will most likely be greatly reduced over time due to natural succession and will be replaced by deciduous species. Early control efforts for other invasive and exotic species at PERI offer good prospects for positive outcomes.

Air Quality

Ozone Assessment

Results of the ozone assessment presented in (Figure 5-6) show that ozone concentrations have declined slightly in recent years with data from the most recent time period rated as fair. A number of plant species are susceptible to damage from ozone and NPS assesses the risk of ozone injury to vegetation by park. The report *Assessing the risk of foliar injury from ozone on vegetation in parks in the Heartland Network* (NPS 2004) indicates that the risk of foliar injury to plants in PERI is low. In fact PERI is rated among the lowest risk for ozone injury to vegetation for parks across the United States (Figure 5-7). Despite being low risk for ozone injury to vegetation NPS indicates that there are from 10 to 17 ozone sensitive plant species in PERI (NPS 2001, NPS 2004, and NPS 2006).

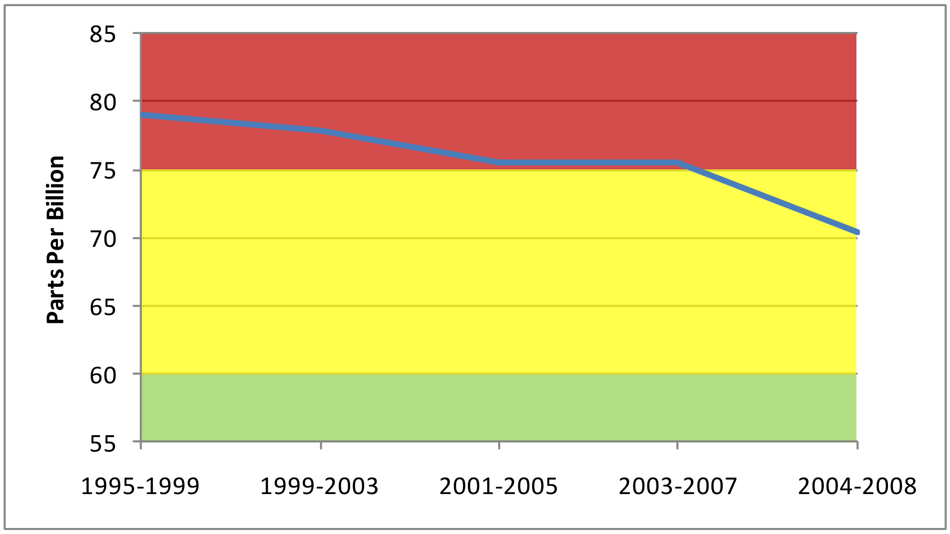

Figure 5-6. Average of fourth Maximum 8-hour Ozone levels based on five-year averages of interpolated deposition estimates (NPS 2010a). Greater than or equal to 76 ppb is considered poor, between 61-75 fair, and below 61 good (NPS 2007a).

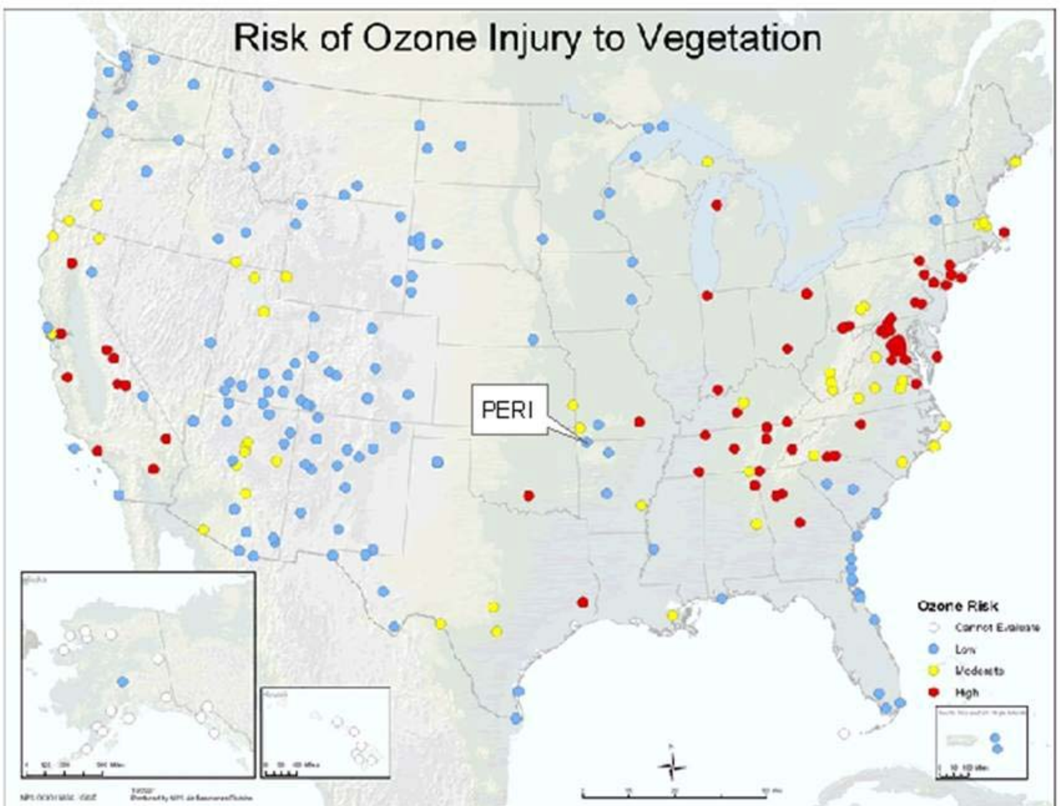

Figure 5-7. Map showing the risk of ozone injury to vegetation by park (NPS 2007d).

Atmospheric Deposition

Average interpolated estimates of wet deposition of nitrogen ranged from 11.69 to 14.49 kg/ha/yr, and estimates of wet deposition of sulfur ranged from 9.26 to 12.73 kg/ha/yr. All estimates far exceeded the threshold for "poor" of 3 kg/ha/yr (Figure 5-8). Wet deposition of from sulfates, nitrates, and ammonium account for the majority of total nitrogen and sulfur deposition (Figure 5-9, Figure 5-10).

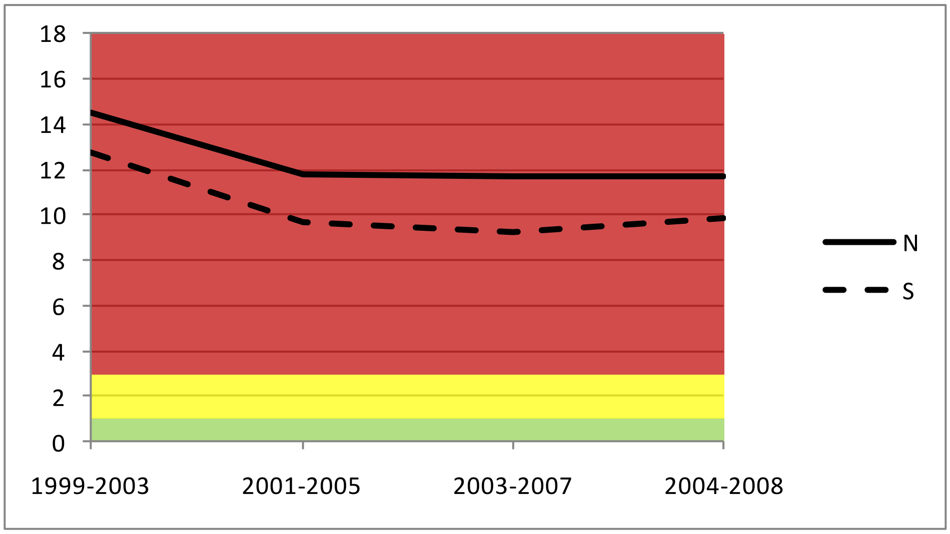

Figure 5-8. Total nitrogen and sulfur from wet deposition of sulfate (S04), nitrate (N03), and ammonium (NH4) based on five-year averages of interpolated deposition estimates (NPS 2010a). Greater than 3 ppb is considered poor, between 1 and 3 ppb fair, and below 1 ppb good.

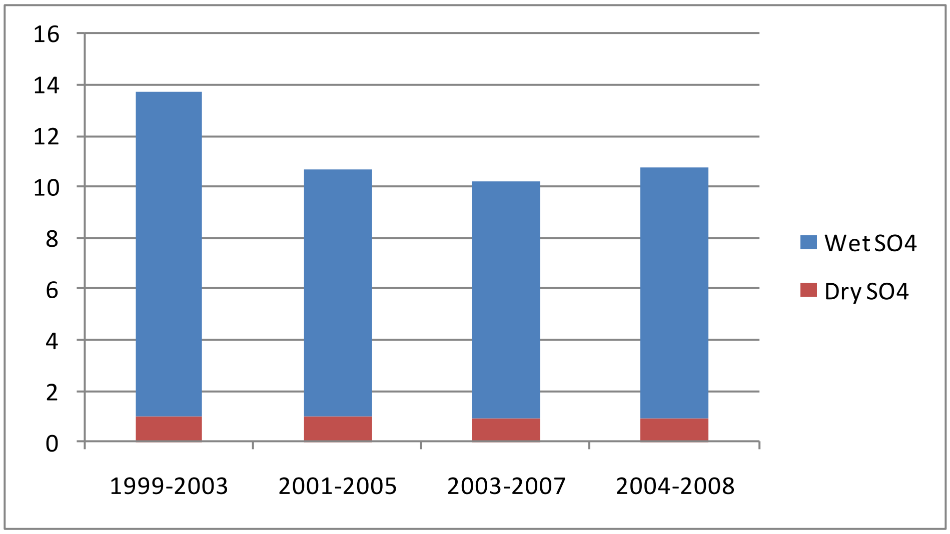

Figure 5-9. Total wet and dry sulfur deposition based on five-year averages of interpolated deposition estimates (NPS 2010a).

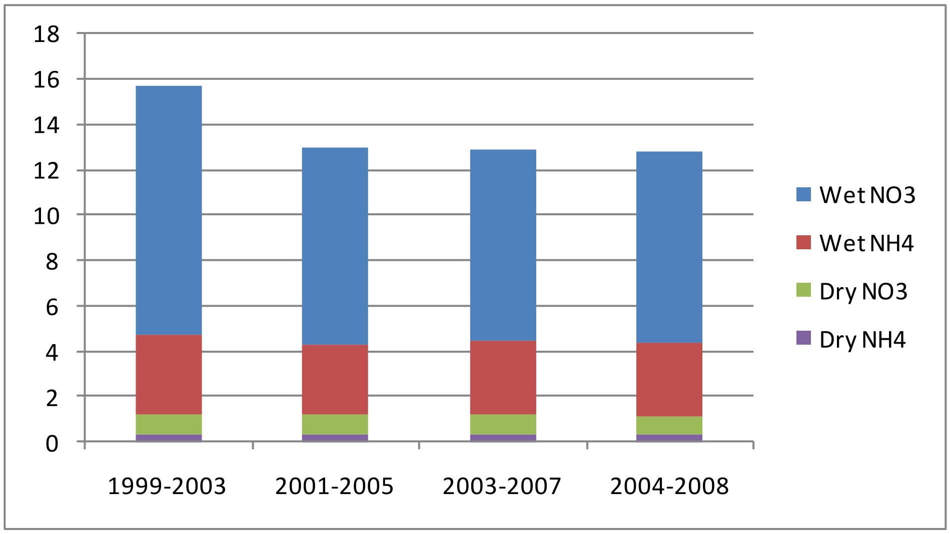

Figure 5-10. Total wet and dry nitrogen deposition based on five-year averages of interpolated deposition estimates (NPS 2010a).

Reporting Unit: Bottomland Forest

Bottomlands at PERI contain 25 ha of bottomland oak-hardwood forest and an additional 7.5 ha or typic slope oak-hardwood woodland and forest. Dominant trees include white oak (*Quercus alba*), northern red oak (*Quercus rubra*), and American elm (*Ulmus americana*; Wright et al. 1970). Essentially all of the 15 ha of successional types consists of eastern redcedar dominated or co-dominated woodlands and forests (Figure 5-11). These successional woodlands consist of old fields, and most of the eastern redcedar will likely be out-competed on these moist soils within the next several decades without active management. Bottomland forests are more fragmented, and in smaller patches, than management goals indicate. Management goals center on reducing the area of successional types, increasing patch size, and reducing patch number. Numbers were based on expert opinion informed by literature on similar communities (see Nelson 2005 and especially community profiles posted at http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed 10/15/2010).

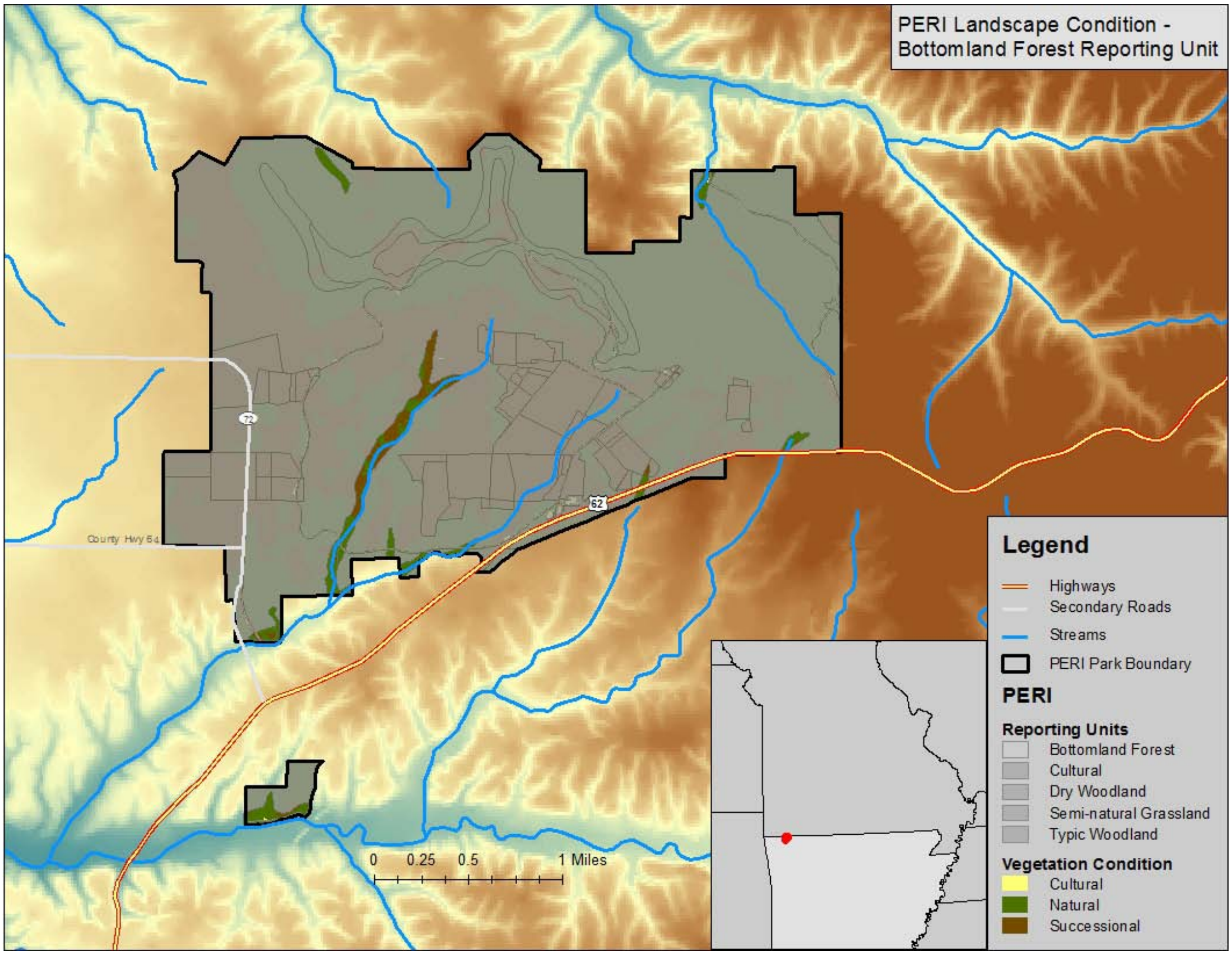

Figure 5-11. Current landscape composition for the bottomland forest reporting unit.

Reporting Unit: Dry Woodland

This recovery unit is underlain by sandstone or shale in contrast with the limestone or dolomite for the rest of the park. Soils are relatively well-drained and nutrient-poor. Many stands of upland dry oak-hickory woodland and forest are of relatively high quality with a diverse herbaceous understory common (Wright et al. 1970). Dominate species of this community type include post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), and back hickory (*Carya texana*; Wright et al. 1970). Well-defined old fields are dominated or co-dominated by eastern redcedar, and about 40 ha consist of successional cover types. Deciduous trees will likely replace the eastern redcedar over time, but succession may take many decades in these relatively dry soils unless management actions designed to reduce evergreen trees are applied. Many of the stands are relatively open with good herbaceous cover, and this may facilitate the use of fire to help control redcedars.

Management goals center on reduction of successional cover types, reducing the number of patches, and increasing mean patch size. Numbers were based on expert opinion informed by literature on similar communities (see Nelson 2005 and especially community profiles posted at http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed 10/15/2010). Target numbers for regeneration were from Jenkins et al. (1997) and from Rice and Penfound (1955).

Reporting Unit: Semi-natural Grassland

Upland grasslands at PERI are essentially all disturbed. Restoration has been attempted on at least two patches, most notably the northern of two semi-natural grassland recovery unit patches on the west side of the park consists of a grassland restoration where a compliment of native species has been successfully established. The majority of the grasslands are mowed for interpretive purposes, and most of these mowed areas currently extend from the semi-natural grassland to the cultural recovery unit across continuous landscapes. North of the northern-most patch on the west side of the park, mowed grassland extends north from the semi-natural grassland recovery unit into the typic forest recovery unit (see Figure 5-3). Tall fescue (*Schedonorus phoenix*) is the prevailing dominant of most areas, but native species such as purpletop tridens (*Tridens flavus*), little bluestem (*Schizachyrium scoparium*), broomsedge (*Andropogon virginicus*), and Indiangrass (*Sorghastrum nutas*) are also present (personal observation). Patches are relatively few and large, mainly due to extensive mowing in areas where battlefield interpretation is the main goal (Figure 5-12). Thus, these large patches, though they do match management targets for patch number and size, consist mainly of highly disturbed and relatively low quality, homogeneous communities.

Natural resource management options are limited because much of the area is mowed to facilitate interpretation of battlefield conditions. Thus, management goals are generally met within this recovery unit (Table 5-1). Re-establishment of native grasslands across most of the area may prove problematic in the face of other park goals. Less than 1.5 ha is in successional types other than semi-natural grassland. One management option may prove feasible: minimization of mowing frequency, particularly in the northern-most, partially restored grassland on the west side of the park and the continuous grassland to the north within the typic forest recovery unit. This, coupled with allowing grasslands to succeed to woodlands within the typic forest recovery unit on the northwest side of the park, might improve conditions for target grassland obligate and shrubland/edge bird species (see Breeding Bird Community, above) and add to the overall habitat diversity within the park.

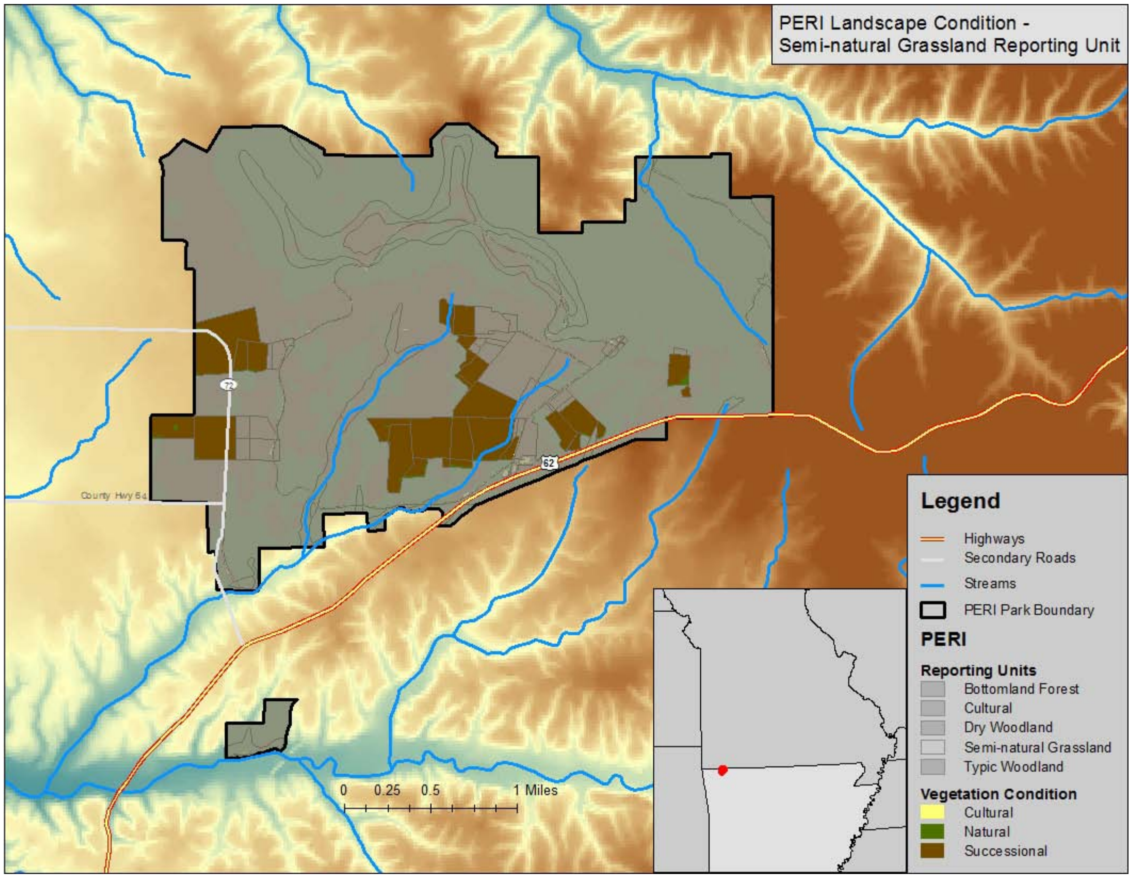

Figure 5-12. Current landscape composition for the semi-natural grassland forest reporting unit.

Reporting Unit: Typic Woodland

This recovery unit is based mainly on site potential and thus circumscribes some grassland areas, most notably on the western, northwestern, and south-central portions of the park (see Figure 5-3). Overall, upland typic oak-hardwood and typic slope oak-hardwood woodlands and forests dominate the recovery unit, and many areas are of relatively high quality (Wright et al. 1970). Dominant species include black oak (*Quercus velutina*), northern red oak (*Quercus rubra*), and hickories (*Carya* spp.). White oak (*Quercus alba*) is important on slopes only. As in the dry oak woodland reporting unit, well-defined old fields are apparent (281.4 ha), and are dominated or co-dominated by eastern redcedar. Substantial areas of successional grassland and deciduous sparse woodland, at total of 173.6 ha, also occur (Figure 5-13).

Management goals center around reducing the number of forest patches and increasing patch size, and on reduction in the area of successional types. We should note that the number of forest patches and patch size in the current landscape do not meet management goals, but these numbers are somewhat inflated because typic upland woodlands and typic slope woodlands are interspersed within the recovery unit. A continuous forested area may be recorded as two or more patches composed of these two types, and both the typic upland and typic slope types are often in relatively good condition in terms of composition and structure.

Retention of successional deciduous open woodlands and shrublands may add to the overall habitat diversity of the park and benefit some breeding bird species of continental concern (see

Breeding Bird Community, above). The area immediately north of the northern-most patch of semi-natural grassland reporting unit is currently grassland, and might reasonably be managed as a continuous unit with the adjacent grassland to the south (see Semi-natural Grassland Reporting Unit, above). Numbers were based on expert opinion informed by literature on similar communities (see Nelson 2005 and especially community profiles posted at http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed 10/15/2010). Target numbers for regeneration were from Jenkins et al. (1997) and from Rice and Penfound (1955).

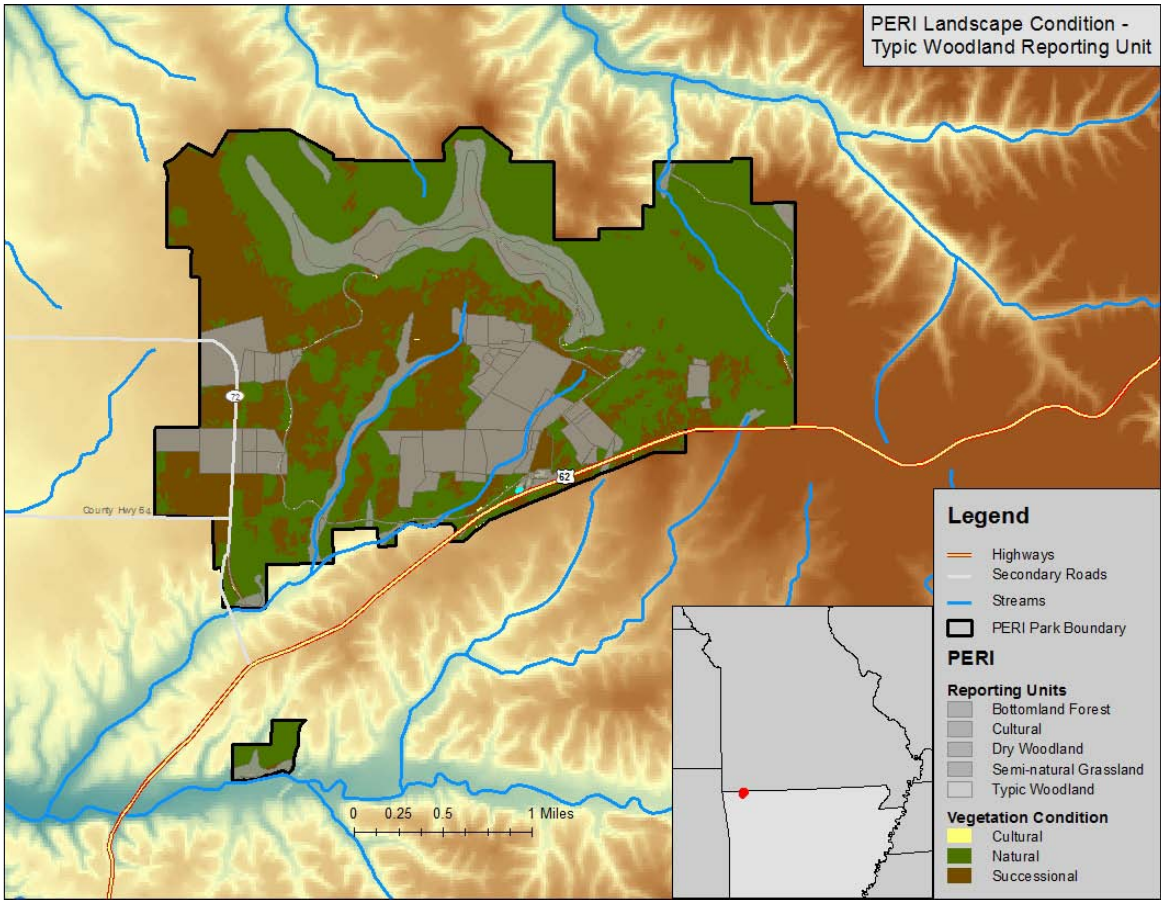

Figure 5-13. Current landscape composition for the typic woodland reporting unit.

Reporting Unit: Pratt Creek

Aquatic Threats

It is important to point out that the threat assessment for Pratt Creek is based on a stream catchment polygon assessment unit that goes outside of the park boundary (Figure 2-6). As such, the threat metrics presented in Table 5-6 reflect this additional area. Because Pratt Creek's drainage area initiates within the boundaries of PERI threats to the stream within the park are fairly limited (Table 5-6, Figure 2-4 and Figure 2-5).

Table 5-6. Quantified threats for Pea Ridge National Military Park. Values represent human threats within the stream catchment for Pratt Creek above the confluence with Lee Creek.

Human Threat	# or amount	% or Density
Pasture/Hay	1392300 m^2	48.41%
Road/Stream Crossings	3	1.04 pkm^2
Road Length	8509 m	2959 pkm^2
2000 Population	36	12.5 pkm^2

Water Quality

Water quality information collected by the Heartland network in 2009 indicate that all indicators are presently on target for Pratt Creek (Table 5-7).

Table 5-7. Water quality indicators for Pratt Creek.

Indicator	Management Target	Mean[1]	Rating
Temperature (C)			
2009	0-34 °C	13.2	On Target
Specific Conductance (µS/cm @ 25 C)			
2009	100-400 µS/cm	230	On Target
Dissolved Oxygen (mg/L)			
2009	5-15 mg/liter	9.6	On Target
pH			
2009	6.5-9.0	7.3	On Target
Turbidity (NTU)			
2009	<10 NTU	8.2	On Target

[1] Mean from unpublished Heartland data.

Fish Community Composition and Condition

The fish species that have been collected from Pratt Creek are generally associated with small streams in the Ozarks (Justus and Peterson 2005b). Based on the available collections, only five species have been documented to occur in the stream (Table 5-8). Of the three indices computed for Pratt Creek Simpson's Diversity and benthic species composition are rated as on target, while only the IBI value of 53 is off target (Table 5-9).

Table 5-8. Fish species observed[1] in Pratt Creek.

Collected Species
Banded Sculpin
Creek Chub
Orangethroat Darter
Redspot Chub
Southern Redbelly Dace

[1] Observed species from Justus and Peterson (2005b) and unpublished Heartland data.

Table 5-9. Ratings for five fish metrics computed for Pratt Creek.

Indicator	Management Target	Reference Condition	Current Mean	Rating
Simpson's Diversity	≤0.64	0.61	0.62	On Target
Sucker Composition (%)	N/A	N/A	0.00	N/A
Sunfish Composition (%)	N/A	N/A	0.00	N/A
Benthic spp. Composition (%)	≥12.8	25.5	21.80	On Target
Index of Biotic Integrity (IBI)	>60	80	53	Off Target

The conservation status of a species is designated by a number from 1 to 5, preceded by a letter designating the geographic scale of the assessment (G = Global; S = State). The five point scale ranges from 1 (critically imperiled) to 5 (demonstrably secure). Additional qualifiers may be applied to the scale. The conservation status numbers designate the following (NatureServe 2008):

1= Critically imperiled

2 = imperiled

3 = Vulnerable to extirpation or extinction

4 = Apparently secure

5 = Demonstrable widespread, abundant, and secure

Determining which and how many species are secure or imperiled is important for understanding the condition of an ecosystem and for targeting conservation. No fish species collected from Pratt Creek are designated as critically imperiled (G1), imperiled (G2), or vulnerable to extirpation (G3) on a global scale (Table 5-10). There are no S1, S2, or S3 fish species known to occur in Pratt Creek in the park.

Table 5-10. Number of globally listed (G-rank) and state listed (S-rank) fish species from actual collections for Pratt Creek in Pea Ridge National Military Park.

Rank	Collection
G4	1
G5	4
S?	5

Aquatic Invertebrates
Because of a lack of available data aquatic invertebrate could not be assessed for Pratt Creek.

Reporting Unit: Winton Spring Branch

Aquatic Threats
Because of the mapping scale threats in Winton Spring Branch were not directly assessed. However, because Winton Spring Branch is entirely within the boundary of PERI threats to this spring branch are likely minimal.

Water Quality
Like Pratt Creek, all of the water quality indicators assessed of Winton Spring Branch are rated as being on target over the available period of record (Table 5-11). Temperature, dissolved oxygen and pH readings have been fairly stable of the available three years of data, while specific conductance and turbidity have exhibited more variability.

Table 5-11. Water quality indicators for Winton Spring Branch.

Indicator	Management Target	Mean[1]	Rating
Temperature (C)			
2004	0-34 ºC	14.3	On Target
2005	0-34 ºC	14.4	On Target
2006	0-34 ºC	14.0	On Target
2009	0-34 ºC	13.6	On Target
Mean	0-34 ºC	14.1	On Target
Specific Conductance (µS/cm @ 25 C)			
2004	100-400 µS/cm	181.0	On Target
2005	100-400 µS/cm	300.0	On Target
2006	100-400 µS/cm	347.5	On Target
2009	100-400 µS/cm	272.1	On Target
Mean	100-400 µS/cm	275.2	On Target
Dissolved Oxygen (mg/L)			
2004	5-15 mg/liter	8.0	On Target
2005	5-15 mg/liter	8.2	On Target
2006	5-15 mg/liter	8 3	On Target
2009	5-15 mg/liter	9.6	On Target
Mean	5-15 mg/liter	8.5	On Target
pH			
2004	6.5-9.0	7 1	On Target
2005	6.5-9.0	7 1	On Target
2006	6.5-9.1	7.8	On Target
2009	6.5-9.0	7.0	On Target
Mean	6.5-9.0	7 3	On Target
Turbidity (NTU)			
2004	<10 NTU	8 9	On Target
2005	<10 NTU	1.4	On Target
2006	<10 NTU	0.7	On Target
2009	<10 NTU	2 1	On Target
Mean	<10 NTU	3 3	On Target

[1] Mean from Moore and Keaton (undated) and unpublished Heartland data.

Fish Community Composition

Only as single fish species, the banded sculpin, has been documented to occur in Winton Spring Branch which limits any assessment (Table 5-12).

Table 5-12. Fish species observed[1] in Winton Spring Branch.

Collected Species
Banded Sculpin

[1] Observed species from Justus and Peterson (2005b).

Aquatic Invertebrates

Because of a lack of available data aquatic invertebrate could not be assessed for Winton Spring Branch.

Chapter 6 Integrated Evaluation and Discussion

Logic-based Evaluation

Bringing together lots of metrics from numerous natural systems with the intention of assessing the condition of the park natural resources yields an impressive amount of information to interpret. To facilitate the interpretation of the condition assessment, a logic-based evaluation was undertaken. Integrating multiple evaluations into a single model requires an ecological understanding of the relationships among all of the model components. The ecological relationships are reflected in the logical connections used to create a unified framework.

A logic model-based framework was created to evaluate each indicator for which both current data and a management target were available. This type of framework is focused on the logical relationship of components within and among reporting units as presented in the previous chapter. The framework is hierarchical so that indicators within an attribute are evaluated as well as attributes within a resource type and/or reporting unit. A hierarchical framework allows for integrated analysis among different components of the resource types and reporting units that are found within the park. The logic-based framework was designed to address the validity of the statement "the current condition approximates the management target". If the statement is valid, then there is full support for the current condition approximating the management target. For each level in the hierarchy, an assessment score is provided that corresponds to the degree that the statement is valid. Result scores are on a [0 – 1] scale with zero reflecting that there is no validity (i.e. no support) to the statement while a score of one signifies that the statement is valid (i.e. full support). In addition, scores between zero and one provide a continuum of degree of validity which allows for partial support to be recognized. Evaluation scoring is based on fuzzy logic sets in which all degrees of support, not just binary "yes/no", are reported. Here each level in the hierarchy can be presented individually or as a partial assessment for all reporting units.

A logic-based integrated analysis is not a quantitative analysis of the park resources; rather it is a method of qualitative reasoning. The framework reflects expert knowledge about the park resources and provides a formal structure of how the resource components can be arranged or summarized. Such a method represents only one interpretation of the relationships within and among levels of the hierarchical framework. The core of the logic model evaluation is the knowledge base. Here we refer to a knowledge base as a formal and logical representation of best available information. Integrating data from many different attributes into a single knowledge base allows for a transparent synthesis and evaluation of park resources. This type of analysis is learning based and focused on supporting the decision making processes related to natural resource management.

Methods

The Natural Resource Condition Assessment per the national guidance represents the most up-to-date knowledge base of the parks resources. The logic model for evaluating all reporting units and associated resource types was graphically designed with NetWeaver Developer software (Rules of Thumb, Inc., North East, PA). This software uses a logic engine, similar to a database engine found in relational database software, to run the analysis. The knowledge base reflects the relationships between reporting units, resource types, attributes and indicators as presented in earlier chapters and tables included therein.

Components of the knowledge base have been arranged into a hierarchical framework. Topics within each level of the hierarchy are joined together by logical operators. These operators form a logic model upon which the knowledge base is evaluated. The complete logic model for evaluating the current condition of resource types represents one possible logical interpretation of attributes and indicators. The reporting unit and all lower levels in the hierarchy can be modified to include new management objectives or logical relationships. The flexibility of the model means that any topic can be removed or added and most importantly, reference conditions can be updated throughout the adaptive management process.

The hierarchical framework reflects the nested arrangement of both spatially delineated areas within the park boundary (i.e. reporting unit) and assessment metrics (i.e. attributes and indicators) arranged within natural resource types in those areas (Figure 6-1).

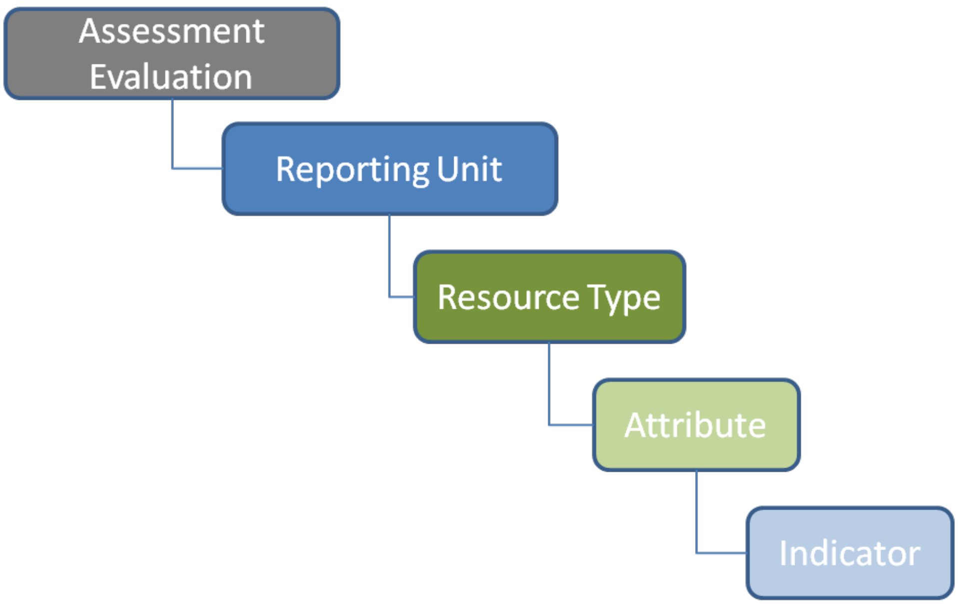

Figure 6-1. Hierarchical framework used in the integrated analysis of the Natural Resource Condition Assessment.

Applying the hierarchical arrangement (Figure 6-1) to the NRCA creates a framework that illustrates the relationships of all reporting units to their resource types, attributes and indicators (Figure 6-2, Figure 6-3). All topics in the logic-model correspond to the NRCA. Each node or level in the hierarchy represents the relationship of attributes and/or indicators within a resource type or reporting unit.

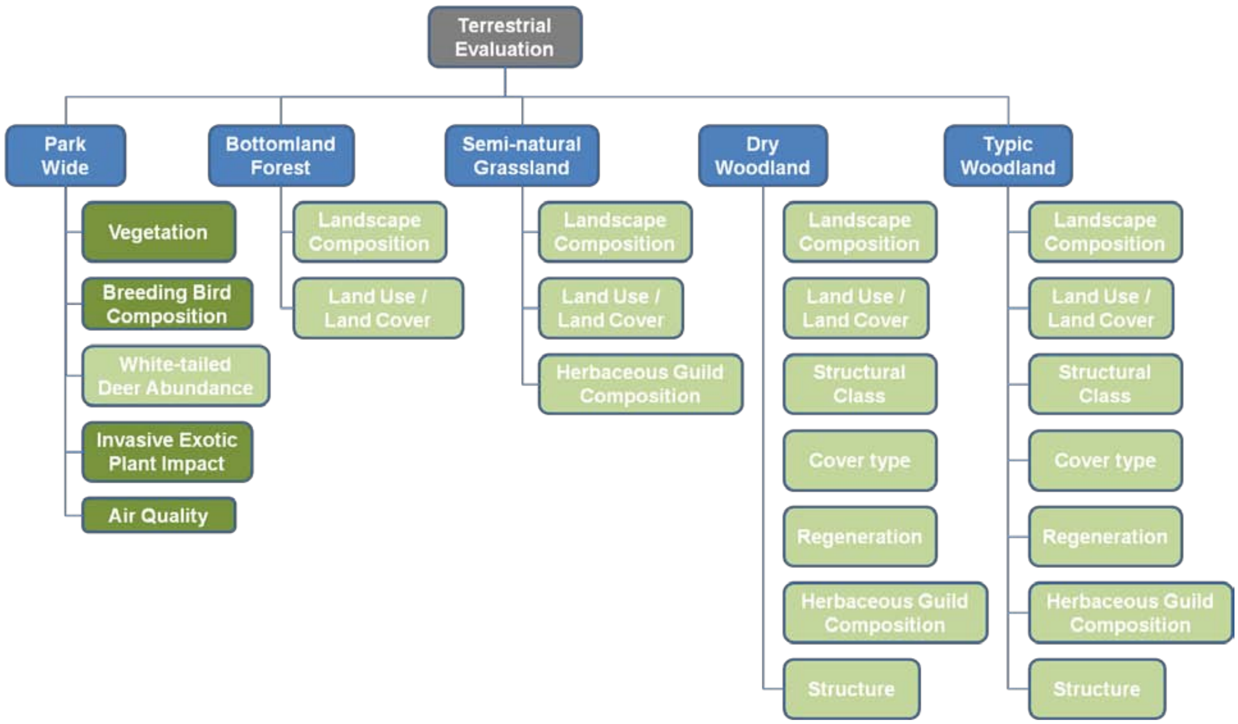

Figure 6-2. Higher levels of the model framework that reflect logical relationship of resource type (dark green) within reporting unit (blue) for the terrestrial assessment. Attributes are labeled light green.

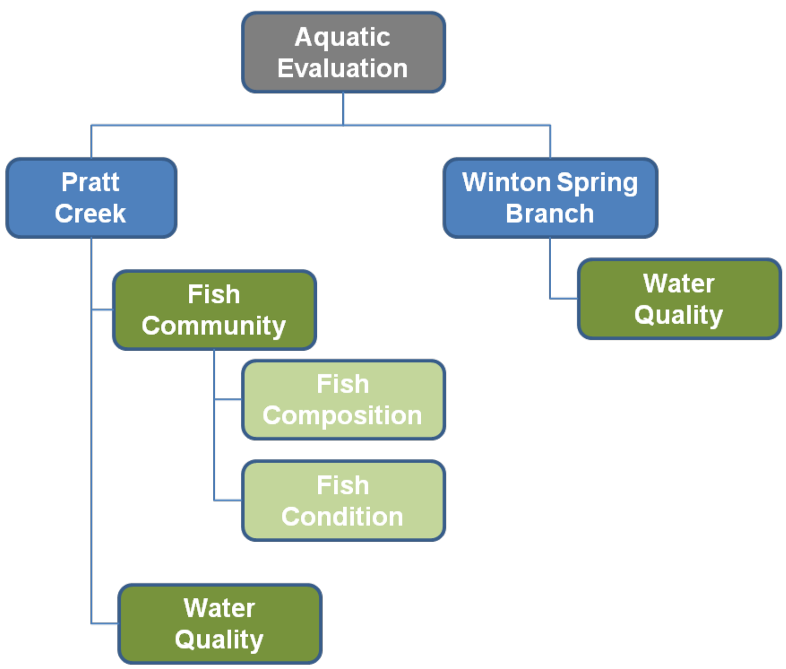

Figure 6-3. Higher levels of the model framework that reflect logical relationship of resource types within reporting unit (blue) for the aquatic assessment.

Logical operators

Indicators, attributes and resource types are evaluated at their next higher level in the model according to logical operators. These operators reflect the logical relationship within levels and how each topic contributes to the evaluation of the resource condition. Nearly all model topics are joined by the *union* operator. Topics related by a *union* incrementally contribute to the overall evaluation of the next higher level of the model. All metrics connected by a union operator contribute equally to the evaluation. Here the assumption is that each topic in the knowledge base contributes equally to the ability of the current condition to approximate the management target.

In a single case, indicators are related by an *and* operator. This type of operator requires that all indicators must be fully supported in order for the overall attribute evaluation to be supported. The landscape composition indicators are joined by the *and* operator. Therefore for current landscape condition to approximate the management target both patch count and mean patch size must be fully supported. If either indicator is not fully satisfied, then the landscape composition attribute will evaluate to no support.

Management target range

For each indicator within the hierarchical knowledge base an assessment is performed to determine how closely the current condition (input) coincides with the range of management targets (no support and full support columns in Table 6-1). Again, level of support reflects the degree to which the evaluation statement is valid. This target range was derived from management targets presented at the indicator level in Table 5-1. Converting management targets into a range of values from which the degree of support for the evaluation statement can be assessed is the basis of the integrated analysis. A conservative approach was used to develop the evaluation range of values from the initial management targets in chapter 5. Full support for the evaluation statement corresponds to the management target value(s) in Table 5-1. For those indicators with a management target greater than (>) or equal to (≥) a target number in Table 5-1, the "no support" management target value was set to 50% less than the stated target. This resulted in a range of values from no support (management target – 50%) to full support (management target). The opposite methodology was applied to those indicators with management target less than (<) or equal to (≤) a target number in Table 5-1, the "no support" management target value was set to 50% more than the stated target. For these indicators the target range is from no support (management target + 50%) to full support (management target). In some cases the management target is a range of values (i.e. pH). Therefore full support corresponds to any value within the management target range presented in Table 5-1. No support values are derived from ± 50% of the range of full support values. For example, the range of full support for pH is 6.5 – 9.0, which is a spread of 2.5. Half of this spread (1.3) was subtracted from 6.5 and added to 9.0 to provide no support values of ≤ 5.2 or ≥ 10.3. This method was used in order to provide the most information as to how closely the current condition approximates the management target when the statement is not supported. The type of management target range is indicative of the type of evaluation ramp function used in the assessment.

Evaluation ramp

For each topic in the model (from reporting unit to resource type and down to indicator) there is an evaluation statement. The statement defines what is being evaluated at that level in the model (e.g. mean patch size or total area occupied by a community type) and always reflects the degree of validity for the statement. Full support (strength of evidence = 1.0) for the statement that mean patch size approximates the management target in the upland grassland community is determined by comparing the current input value against the management target (Figure 6-4). The management target range is the evaluation ramp function in NetWeaver. The ramp function indicates that an area of 150 ha or greater provides full support for the statement while an area of 75 ha or smaller provides no support (zero strength of evidence) for the condition being valid. This is the most common evaluation ramp function used in the analysis. All indicators with a target composed of a range between two values have this type of ramp function and subsequent analysis is similar to mean patch size (Figure 6-1).

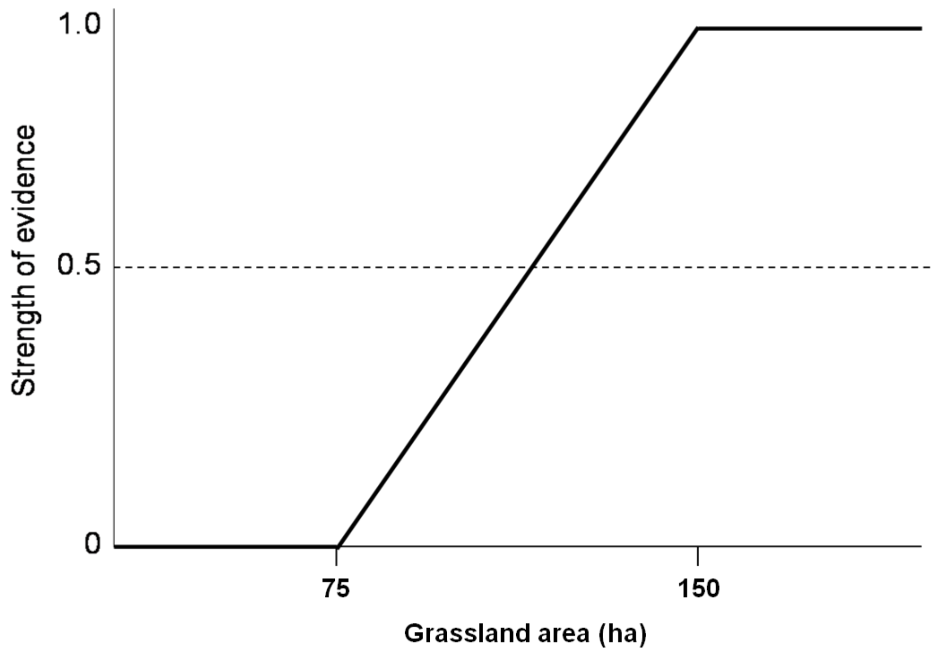

Figure 6-4. NetWeaver ramp function used to evaluate area (ha) of semi-natural grassland at Pea Ridge National Military Park, Arkansas.

Ramp functions reflect the type of evaluation required to assess the specific indicator and are based on ecological understanding of the underlying data being evaluated. For certain aspects of water quality too much or too little of a condition may not be appropriate for the community (Figure 6-5). A middle range of pH best reflects a valid pH condition for all three streams within the park.

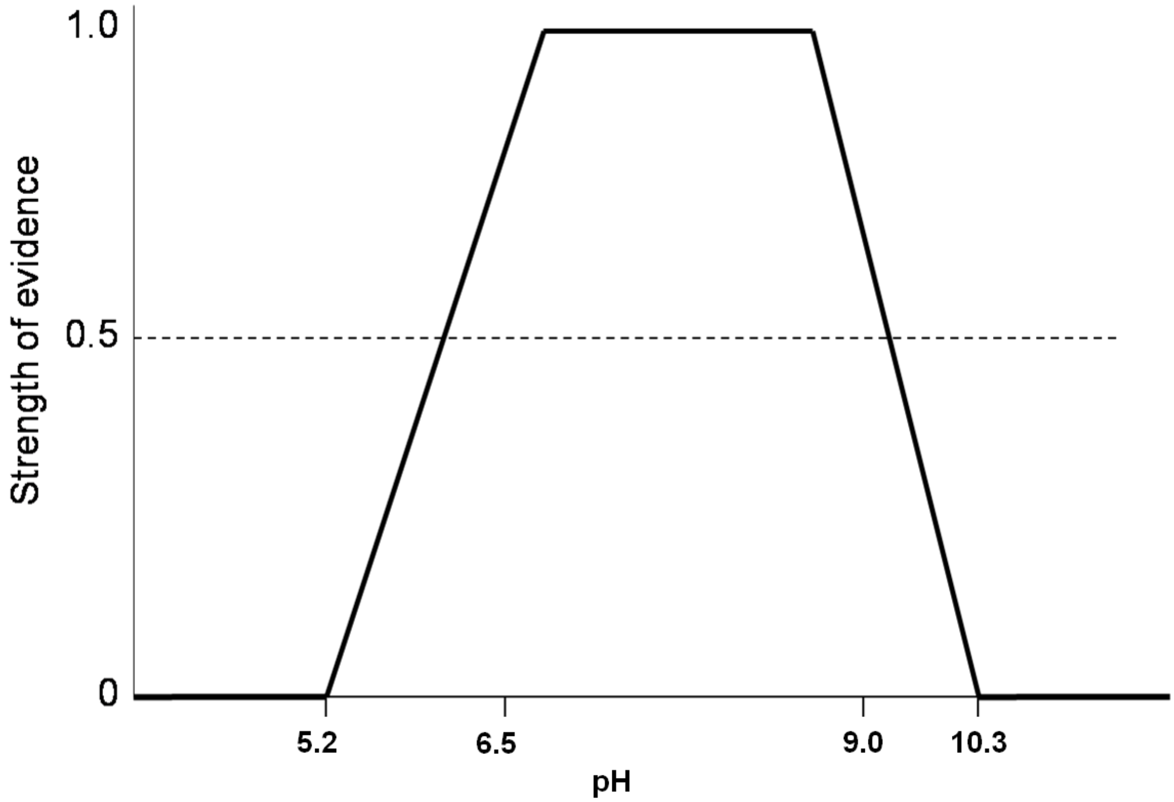

Figure 6-5. NetWeaver ramp function used to evaluate pH for all three aquatic reporting unit's of Pea Ridge National Military Park, Arkansas.

Indicators with management targets and associated ramp functions similar to pH (Figure 6-5) represent the idea that more is not always better. For these indicators, an optimum range of values have been identified. Therefore full support (strength of evidence = 1.0) is achieved when the input value is between 6.5 and 9.0. No support (strength of evidence = 0) reflects any input value ≤ 5.2 or ≥ 10.3. Input values for pH between 5.2 and 6.5 or between 9.0 and 10.3 evaluate to partial support for the current condition of pH approximating the management target.

Evaluation output

Evaluation results obtained from NetWeaver are rescaled to [0 -1] to facilitate interpretation. The continuous normalized scores have been divided into seven color coded categories that reflect the degree to which the current condition approximates the management target (Figure 6-6). No support (output score = 0) is red while full support (output score = 1) is dark blue. Five partial support categories were created based on 0.2 breaks in scores between 0.01 and 0.99.

Figure 6-6. Color coded evaluation score categories derived from rescaled NetWeaver evaluation scores.

Numerical evaluations of fuzzy logic models provide a continuous range of results. The categorized output can be used to build dashboard reporting to increase ease of interpretation. The logic model, as implemented in NetWeaver, is focused on interpretation rather than prediction of the current conditions.

Results

The results of the integrated analysis reflect the evaluation of validity of the statement: "the current condition approximates the management target". The direct evaluation of current conditions is performed at the indicator level only. Above this level, evaluation scores are a function of the direct evaluation score below and the logical operator linking the indicators. Together, scores are passed upward in the hierarchy which allows for the evaluation of attributes, resource types and reporting units indirectly. As the NetWeaver output scores approach 1.0 the degree of support for the validity of the statement increases while scores closer to zero point to less support for the current condition approximating the management target. Even though this is not a quantitative analysis of indicators, it is a qualitative evaluation of the best available knowledge as identified by the Natural Resource Condition Assessment.

Results are presented and summarized to the reporting unit. Evaluation scores are presented for each level of the hierarchy up to the reporting unit level of the framework (Figure 6-7, Figure 6-8).

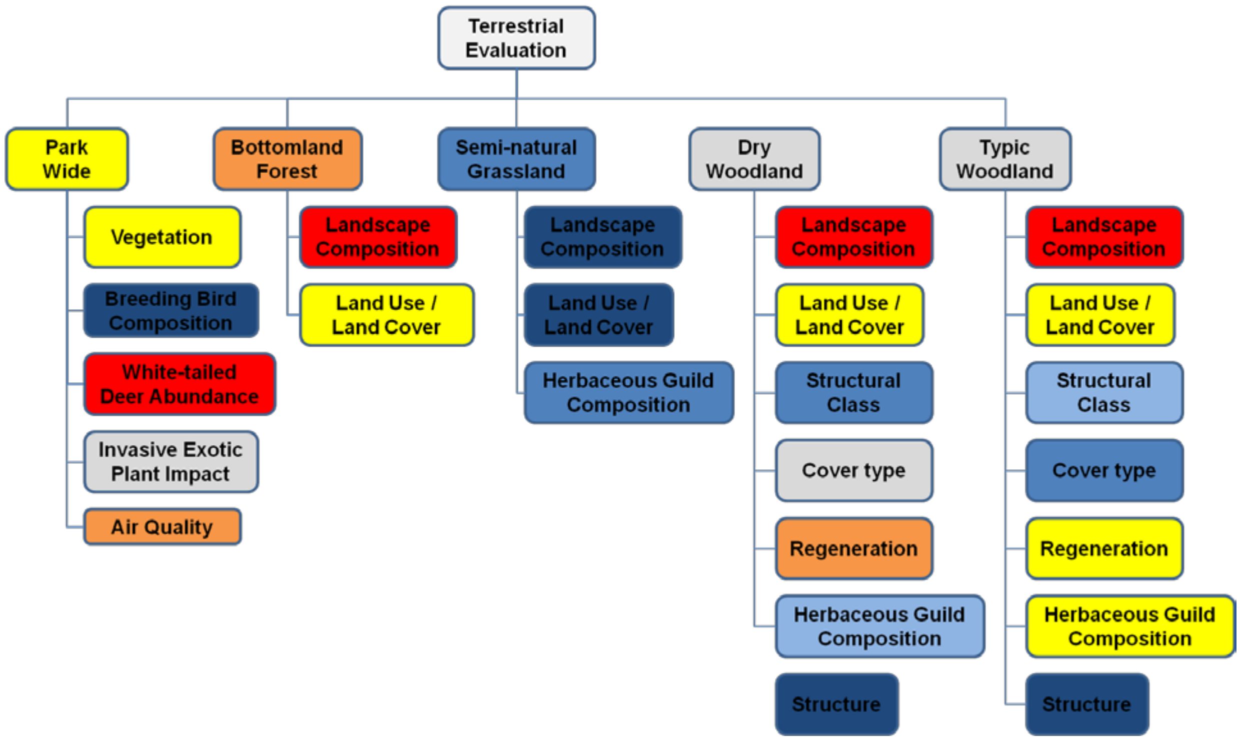

Figure 6-7. Color coded evaluation results for each terrestrial reporting unit and its associated resource type and/or attributes.

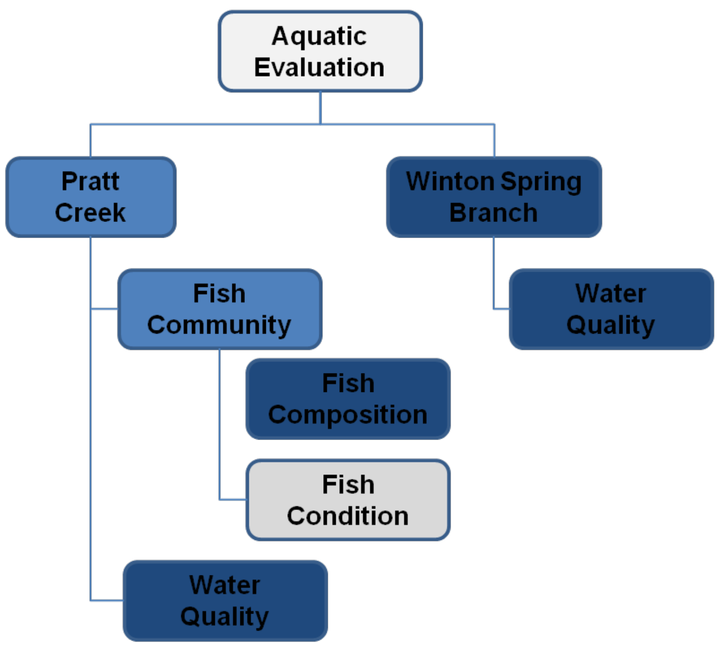

Figure 6-8. Color coded evaluation results for each aquatic reporting unit and its associated resource types.

Reporting Unit: Park-wide

Overall support for the park wide reporting unit was moderately low (output score = 0.4). The number of community patches throughout the park was too high while their mean patch size was too small, which resulted in no support (output score = 0) for landscape composition at the park wide scale (Table 6-1). This reflects a fragmented landscape composed of numerous small patches. There was moderately high support (output score = 0.78) for the composition of those patches, primarily because of the amount of cultural land cover type in the park. Park wide, the landscape contained more successional community types over natural or semi-natural types.

Across the park, there was full support for the breeding bird indicators approximating the management targets for both species composition and habitat. Indicators for grassland and woodland composition as well as grassland and woodland bird habitat all had output scores = 1.

Invasive exotic plants, while low in abundance as measured by foliar cover (output score = 1) were high in frequency of taxa (output score = 0). The number of invasive exotic taxa provided moderately high support for the evaluation (output score = .67). The high frequency of invasive plants offset the low abundance evaluation which resulted in an overall moderate support for the impact of invasive exotic plants approximating the management target.

Air quality, while beyond the scope of the park boundary, had low support for approximating the management target. Atmospheric deposition did not provide any support while the amount of ozone detected was nearly greater than the management target.

High deer abundance impacted the overall park-wide evaluation (output score = 0) and offset higher output scores of other resource types in the reporting unit.

Table 6-1. Rescaled NetWeaver output scores for the integrated analysis of the park wide reporting unit of Pea Ridge National Military Park, Arkansas.

Reporting Unit	Resource Type	Attribute	Indicator	No Support	Full Support	Input	Score
Park-wide							0.4
	Vegetation						0.26
		Landscape composition					0
			patch count	1500	1000	1697	0
			mean patch size (ha)	1	2	1.01	0.01
		Land use/Land cover					0.78
			semi-natural and natural types (ha)	600	1200	946	0.58
			successional types (ha)	750	500	748	0.01
			cultural types (ha)	52.5	35	22	1
	Breeding bird community						1
		grassland composition					1
			grassland species richness	18	35	35	1
			Partners in Flight target grassland species	6	12	12	1
			number of grassland obligate species	1	3	3	1
		grassland habitat					1
			litter cover (%)	17.5	35	39.5	1
			bare ground cover (%)	75	50	47.6	1
			total foliar cover (%)	20	40	44	1
		woodland composition					1
			woodland species richness	22	43	43	1
			Partners in Flight target woodland species	6	11	11	1
		woodland habitat					1
			canopy cover (%)	37.5	75	87.8	1
			basal area (m^2/ha)	≤ 3 or ≥ 19	7 - 15	7.8	1
			mid-story structural diversity index (%)	≤ 17 5 or ≥ 52.5	25 - 40	30.4	1
	White-tailed deer						0
			index of relative abundance (individuals/km^2)	12	8	33.7	0
	Invasive exotic plant impact						0.56
			number of taxa	45	30	35	0.67
			frequency on transects (%)	75	50	84.2	0
			park-wide minimum cover estimate (%)	15	10	4.5	1
	Air quality						0.18
		Ozone					
			ozone (ppb)	76.0	60	70.4	0.35
		Atmospheric deposition					0
			nitrogen (kg/ha/yr)	3.0	1	11.7	0
			sulfur (kg/ha/yr)	3.0	1	9.8	0

Reporting Unit: Bottomland Forest

Overall support for the bottomland forest reporting unit was low (output score = .2, Table 6-2). This reporting unit was evaluated only for landscape vegetation attributes, of which there was little support for the current condition approximating the management targets. In the bottomland forest, patch count was high while mean patch size was low. In addition too much of the reporting unit was identified as successional community type rather than a natural bottomland forest community type.

Table 6-2. Rescaled NetWeaver output scores for the integrated analysis of the bottomland forest reporting unit of Pea Ridge National Military Park, Arkansas.

Reporting Unit	Resource Type	Attribute	Indicator	No Support	Full Support	Input	Score
Bottomland forest							0.2
		Landscape composition					0
			patch count for bottomland forest	68	45	66	0.09
			mean patch size for bottomland forest (ha)	0.5	1	0.38	0
		Land use/Land cover					0 39
			bottomland forest (ha)	14	28	25	0.79
			successional types (ha)	4.5	3	15	0

Reporting Unit: Semi-natural Grassland

Overall support for the semi-natural grassland reporting unit approximating the management target was moderately high (output score = .87, Table 6-3). Unlike other terrestrial reporting units both the landscape composition and land use/land cover attributes fully support the current condition approximating the management targets for each indicator. However the low amount of native grass cover across the grassland reduced the overall evaluation score of the herbaceous guild composition attribute. This might have resulted from a large amount of non-native grass cover or the timing of data collection before warm-season grass cover peaks.

Table 6-3. Rescaled NetWeaver output scores for the integrated analysis of the semi-natural grassland reporting unit of Pea Ridge National Military Park, Arkansas.

Reporting Unit	Resource Type	Attribute	Indicator	No Support	Full Support	Input	Score
Semi-natural grassland							0.87
		Landscape composition					1
			patch count for grassland	12	7	7	1
			mean patch size for semi-natural grassland (ha)	33	22	22	1
		Land use/Land cover					1
			semi-natural grassland (ha)	75	150	158	1
			successional types (ha)	15	10	1.24	1
		Herbaceous guild composition					0.61
			native grass (%)	30	60	28.5	0
			native forbs (%)	≤ 2 or ≥ 55	10 - 40	8.6	0.83
			native woody shrub and vine (%)	15	10	1	1

Reporting Unit: Dry Woodland

Overall support for the dry woodland reporting unit is moderate (output score = .5, Table 6-4). Landscape composition and land use/land cover attributes had no support and low support, respectively for the current condition approximating the management targets. Even though the numerous small patches were not all in the dry woodland community type, they did have the appropriate amount of hardwood canopy cover and stem density (output scores = 1). Overall canopy height of hardwood trees showed full support for the management target. There was only moderate support for hardwood basal area (output score = .51). The basal area of cover type oak species did not show any support while basal area for hickory and walnut cover type species had full support. In the understory, native guild composition support was moderately high while regeneration of oak, hickory and walnut cover type species was low.

Table 6-4. Rescaled NetWeaver output scores for the integrated analysis of the dry woodland reporting unit of Pea Ridge National Military Park, Arkansas.

Reporting Unit	Resource Type	Attribute	Indicator	No Support	Full Support	Input	Score
Dry woodland							0.5
		Landscape composition					0
			patch count for dry woodland	60	40	59	0.05
			mean patch size for dry woodland (ha)	1.5	3	1 3	0
		Land use/Land cover					0.27
			dry woodland (ha)	50	100	77	0.54
			successional types (ha)	22.5	15	40	0
		Structural class					0.84
			hardwood canopy cover (%)	≤ 5 or ≥ 95	30 - 90	86.5	1
			hardwood basal area (m^2/ha)	≤ 2 or ≥ 29	6.5 - 21.5	4 29	0.51
			density (stems/ha, trees > 8 cm dbh)	≤ 25 or ≥ 675	150 - 500	313	1
		Cover type					0.5
			oak species basal area (m^2/ha)	≤ 2 or ≥ 29	4.2 - 17.2	1 23	0
			hickory and walnut species basal area (m^2/ha)	≤ .25 or ≥ 11	0.65 - 7.5	0.81	1
		Regeneration					0.20
			cover type small saplings (>1.5 m tall, < 2.5 cm dbh) relative density (% of stems/ha)	15	30	0	0
			cover type large saplings (>1.5 m tall; > 2.5 and < 8 cm dbh) relative density (% of stems/ha)	15	30	20	0.67
			total cover type sapling relative density (% of stems/ha)	15	30	18.8	0.25
		Herbaceous guild composition					0.67
			native grass (%)	≤ 5 or ≥ 95	10 - 90	10	1
			native forbs (%)	≤ .99 or ≥ 45	1 - 30	3	1
			native woody shrub (%)	25	50	5.7	0
		Structure					
			hardwood tree height (m)	5	10	11.1	1

Reporting Unit: Typic Woodland

Overall support for the upland woodland reporting unit is moderate (output score = .5, Table 6-5). The typic woodland had similar levels of support as the dry woodland for the landscape and overstory structural attributes. However the typic woodland showed greater support for cover type and regeneration attributes than the dry woodland reporting unit. The two types differed in the level of support for native guild composition in the understory with the typic woodlands being less than the dry woodland (0.35 vs. 0.67) due to the lack of native woody species and native grass in the typic woodland.

Table 6-5. Rescaled NetWeaver output scores for the integrated analysis of the typic woodland reporting unit of Pea Ridge National Military Park, Arkansas.

Reporting Unit	Resource Type	Attribute	Indicator	No Support	Full Support	Input	Score
Typic woodland							0.5
		Landscape composition					0
			patch count for typic woodland	263	175	483	0
			mean patch size for typic woodland (ha)	1.25	2 5	1.68	0.34
		Land use/Land cover					0.27
			typic woodland (ha)	525	1050	811	0.54
			successional types (ha)	300	200	455	0
		Structural class					0.8
			hardwood canopy cover (%)	55	70	88.1	1
			hardwood basal area (m^2/ha)	≤ 6.5 or ≥ 36.5	14 - 29	9.5	0.4
			density (stems/ha, trees > 8 cm dbh)	≤ 69 or ≥ 706	175 - 600	323	1
		Cover type					0.69
			oak species basal area (m^2/ha)	≤ 1.8 or ≥ 30.8	9 - 23.5	4.5	0.38
			hickory and walnut species basal area (m^2/ha)	≤ 1 or ≥ 14	2 - 10	2	1
		Regeneration					0.39
			cover type small saplings (>1.5 m tall, < 2.5 cm dbh) relative density (% of stems/ha)	15	30	5.6	0
			cover type large saplings (>1.5 m tall; > 2.5 and < 8 cm dbh) relative density (% of stems/ha)	15	30	25.7	0.71
			total cover type sapling relative density (% of stems/ha)	15	30	21.7	0.45
		Herbaceous guild composition					0.35
			native grass (%)	≤ 5 or ≥ 95	10 - 80	6.8	0.03
			native forbs (%)	≤ .99 or ≥ 60	1 - 40	7.4	1
			native woody shrub (%)	≤ 5 or ≥ 67.5	15 - 50	4.1	0
		Structure					
			hardwood tree height (m)	7.5	15	18	1

Reporting Unit: Pratt Creek

Overall support for Pratt Creek reporting unit was high (output score = .94, Table 6-6). For each of the two resource types output scores ranged from 1 (water quality) to .88 (fish community).

Overall high output scores in the hierarchy reflect moderate or better support for most lower levels in the reporting unit logic model. Only a single indicator did not have full support for the evaluation statement (IBI output score = .77).

Table 6-6. Rescaled NetWeaver output scores for the integrated analysis of the Pratt Creek reporting unit of Pea Ridge National Military Park, Arkansas.

Reporting Unit	Resource Type	Attribute	Indicator	No Support	Full Support	Input	Score
Pratt Creek							0.94
	Fish community						0.88
		Composition					1
			Simpson's Diversity	0.96	0.64	0.62	1
			benthic species composition (%)	6.4	12.8	21.8	1
		Condition					0.5
			Index of Biotic Integrity	30	60	53	0.77
	Water quality						1
			temperature (°C)	≤ -17 or ≥ 51	0 - 34	13.2	1
			specific conductance (µS/cm)	0 or ≥ 550	100 - 400	230.0	1
			dissolved oxygen (mg/L)	0 or ≥ 20	5 - 15	9.6	1
			pH	≤ 5.2 or ≥ 10.3	6.5 - 9.0	7.3	1
			turbidity (NTU)	15	10	8.2	1

Reporting Unit: Winton Spring Branch

Winton Spring Branch reporting unit was evaluated only on water quality resource type. For all indicators in the reporting unit there was full support for the current condition approximating the management target (Table 6-7).

Table 6-7. Rescaled NetWeaver output scores for the integrated analysis of the Pratt Creek reporting unit of Pea Ridge National Military Park, Arkansas.

Reporting Unit	Resource Type	Attribute	Indicator	No Support	Full Support	Input	Score
Winton Spring Branch							1
	Water quality						1
			temperature (°C)	≤ -17 or ≥ 51	0 - 34	13.6	1
			specific conductance (µS/cm)	0 or ≥ 550	100 - 400	272.1	1
			dissolved oxygen (mg/L)	0 or ≥ 20	5 - 15	9.6	1
			pH	≤ 5.2 or ≥ 10.3	6.5 - 9.0	7.0	1
			turbidity (NTU)	15	10	2.1	1

Discussion

The integrated analysis provides one way to evaluate a large number of NRCA components in a simplified manner. The logic-based evaluation achieves this level of simplification by first arranging all of the variables into a hierarchical framework which represents their ecological relationships. Secondly, this analysis makes the assumption that all variables within each level of the hierarchy contribute equally to the overall evaluation. Building off quantitative measures and expert reasoning that were employed in the NRCA to develop reference conditions, a qualitative evaluation of how closely the current condition approximates the management target was undertaken. Here the emphasis is on the evaluation statement, or the idea of how closely the current condition approximates the management target, and the logical relationship among the variables. The strength of this analysis is that it provides formal structure to a multi-faceted natural resource so that an orderly interpretation of the entire knowledge base can be performed. Ultimately it allows numerous components from multiple systems to be evaluated in a way that creates the foundation for future decision making processes. It is important to remember that the logic model represents only one of many different examples of the ecological relationships within the natural system. However, due to the modular nature of designing logic models within NetWeaver and the transparency of the logical relationships, it is easy to iterate on various logical relationships such that all aspects of the natural resources are best evaluated.

Color coded output categories allow for quick interpretation of the framework. Looking at specific output scores provides greater detail for understanding the degree of departure for support for the evaluation statement. Together, these two types of reporting evaluation results can be used to direct decision making priorities or taken as input for decision making software.

Terrestrial communities at PERI consist broadly of two types that correspond with geology and topography. Generally hillier areas in the central and northern part are covered with a mix of fairly good quality upland oak-hickory woodlands and forests and lower quality, well-defined old fields with eastern redcedar. Dry oak woodlands on Pea Ridge (Elkhorn Mountain) itself and slopes on the north side appear to be in especially good condition, with appropriate species composition and structure. Patchiness within the forest is a concern, but patch numbers may be somewhat inflated by interdigitation of different good quality forest types within a continuously forested landscape. Also, the woodland reporting unit was defined based primarily on site potential, with most areas that were likely wooded in pre-European times included. This leads to the inclusion of grasslands within the reporting unit, and adds to the patch count and area of successional types. In contrast, the semi-natural grassland reporting unit was circumscribed based primarily on current vegetation, which tends to reduce patch count and the area of successional types other than semi-natural grassland.

Flatter and generally lower central and southern areas of the park are generally dominated by mowed semi-natural tall fescue grasslands, some currently within the cultural recovery unit, some within the semi-natural grassland recovery unit, and some even within the typic woodland reporting unit on the far western. Many of these areas are maintained to facilitate interpretation of battlefield conditions, and the composition includes many non-native and disturbance species across large, continuous, often-mowed areas. Prairie restoration efforts have been partially successful in at least two patches, most notably the northern-most patch of the semi-natural grassland recovery unit on the west side of the park, which forms a continuous grassland landscape with lower quality areas immediately to the north and east (see Figure 5-3).

Most eastern redcedar stands in old fields are likely to be over-topped by deciduous trees over time, even in the absence of much active management (Nelson 2005). Few invasive and exotic species occur in woodlands, and relatively continuous stands of forest provide some areas of mature habitat important to breeding birds of continental concern such as the Acadian Flycatcher and the Yellow-throated Vireo. Management options for most of the successional grasslands are limited by park interpretive goals. Two grassland obligate species, the Grasshopper Sparrow and the Henslow's Sparrow, are generally restricted to areas that are not mowed too frequently overall, and not during the breeding season. Successional deciduous sparse woodlands and shrublands, which comprise <4% of the park, may provide habitat diversity important to breeding birds of continental concern. In this regard, active management to increase the amount of successional deciduous woody vegetation may be at the expense of semi-natural grassland (not woodland) may be advisable.

Data availability was limited for the aquatic assessments in PERI, but indicates that stream condition is generally good. The fish species found in PERI are generally associated with very small Ozark Plateau streams. Most streams flowing through PERI benefit from originating within the confines of the park and are thereby subject to fewer potential threats. Because both streams assessed in this report originate within the park most management can be focused on the lands managed by NPS. Management options include maintaining and widening riparian buffers with native trees and vegetation and limiting impervious surfaces throughout the park. Additional aquatic inventories are needed which would help present a more complete picture of the condition of aquatic resources within PERI and make the assessment of additional aquatic reporting units possible.

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Appendix A Data Source and Maps for All Potential Threats Included in the Human Threat Index

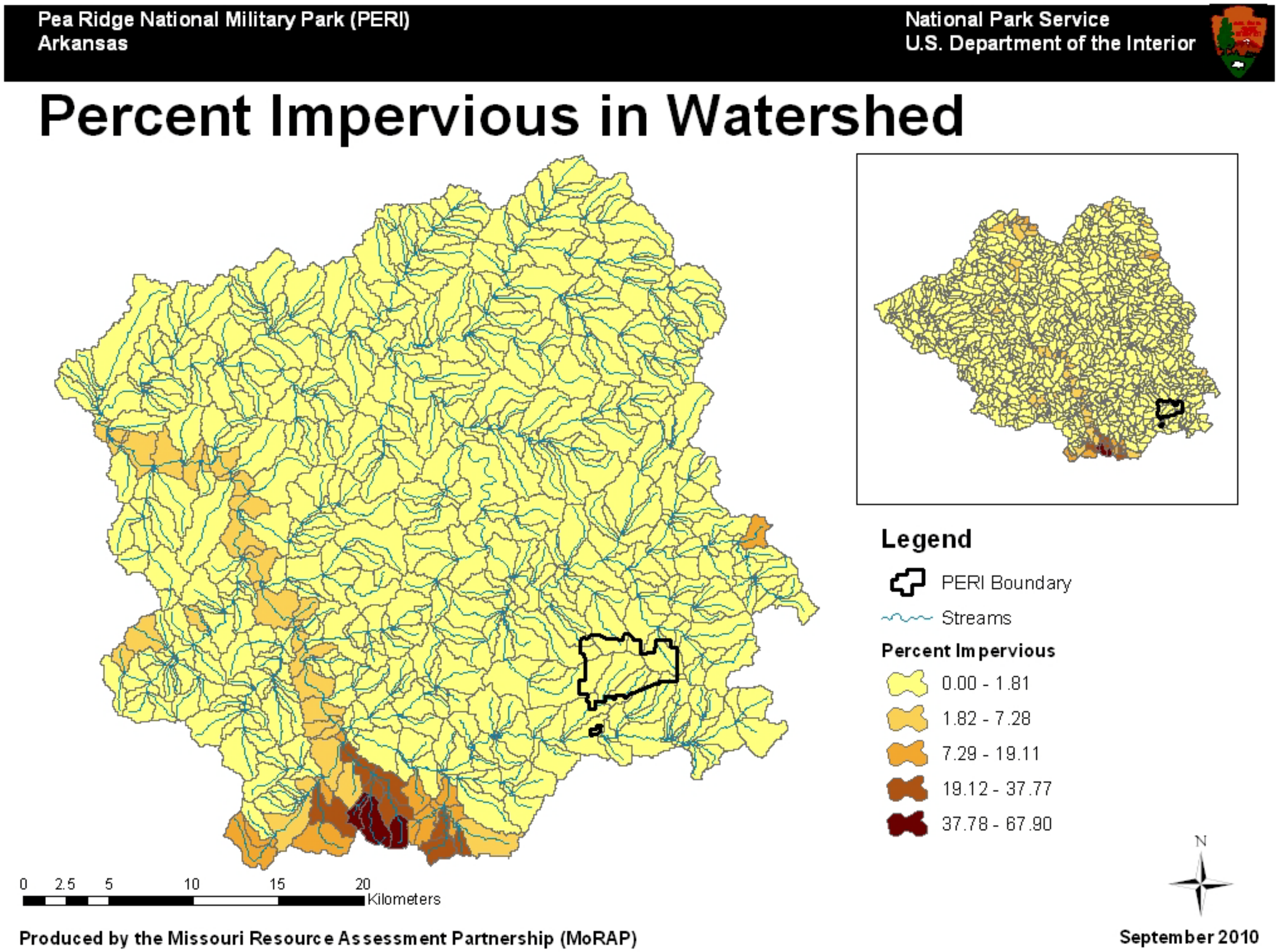

Figure A-1. Percentage of impervious surfaces above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

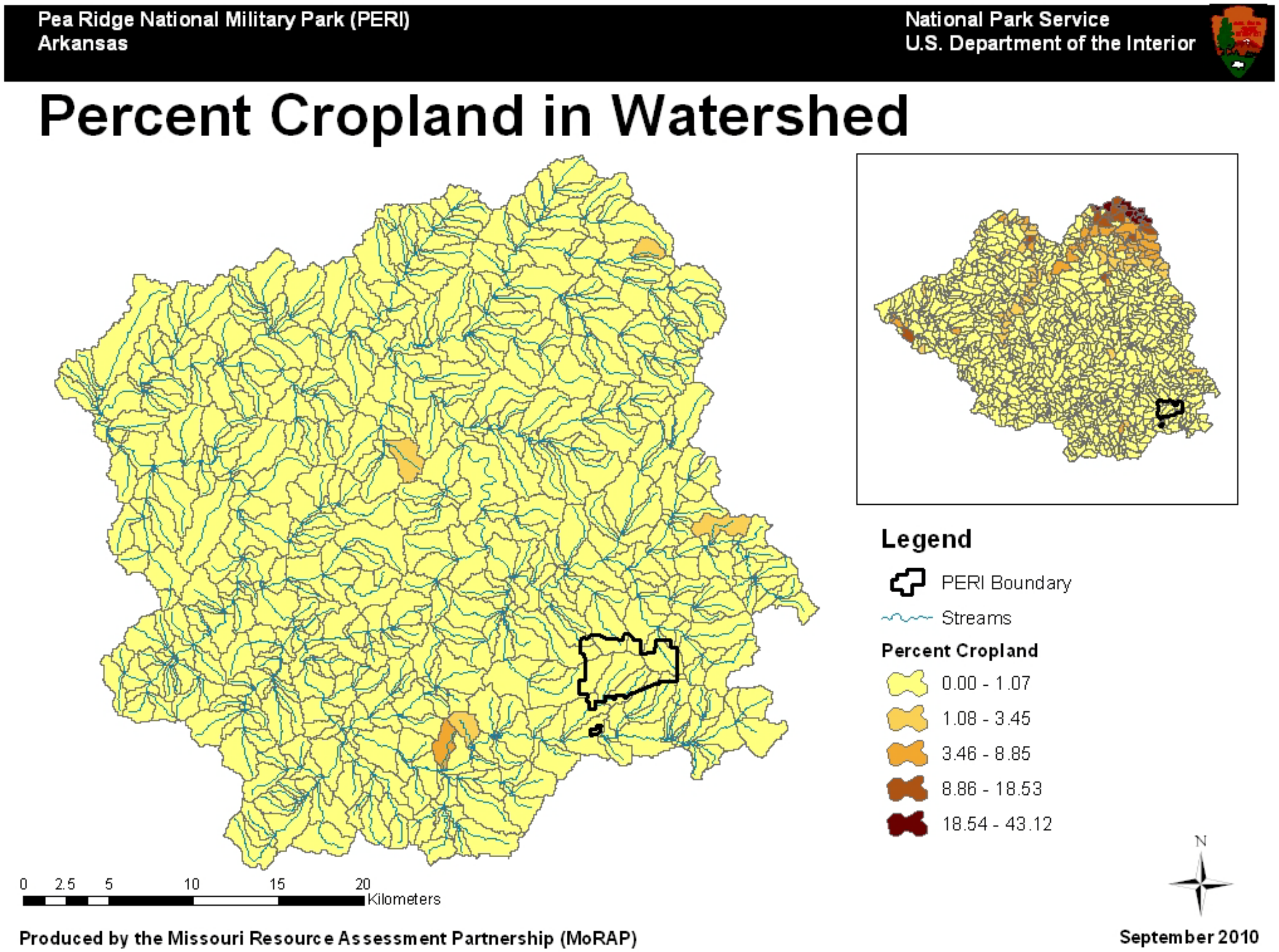

Figure A-2. Percentage of cropland above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

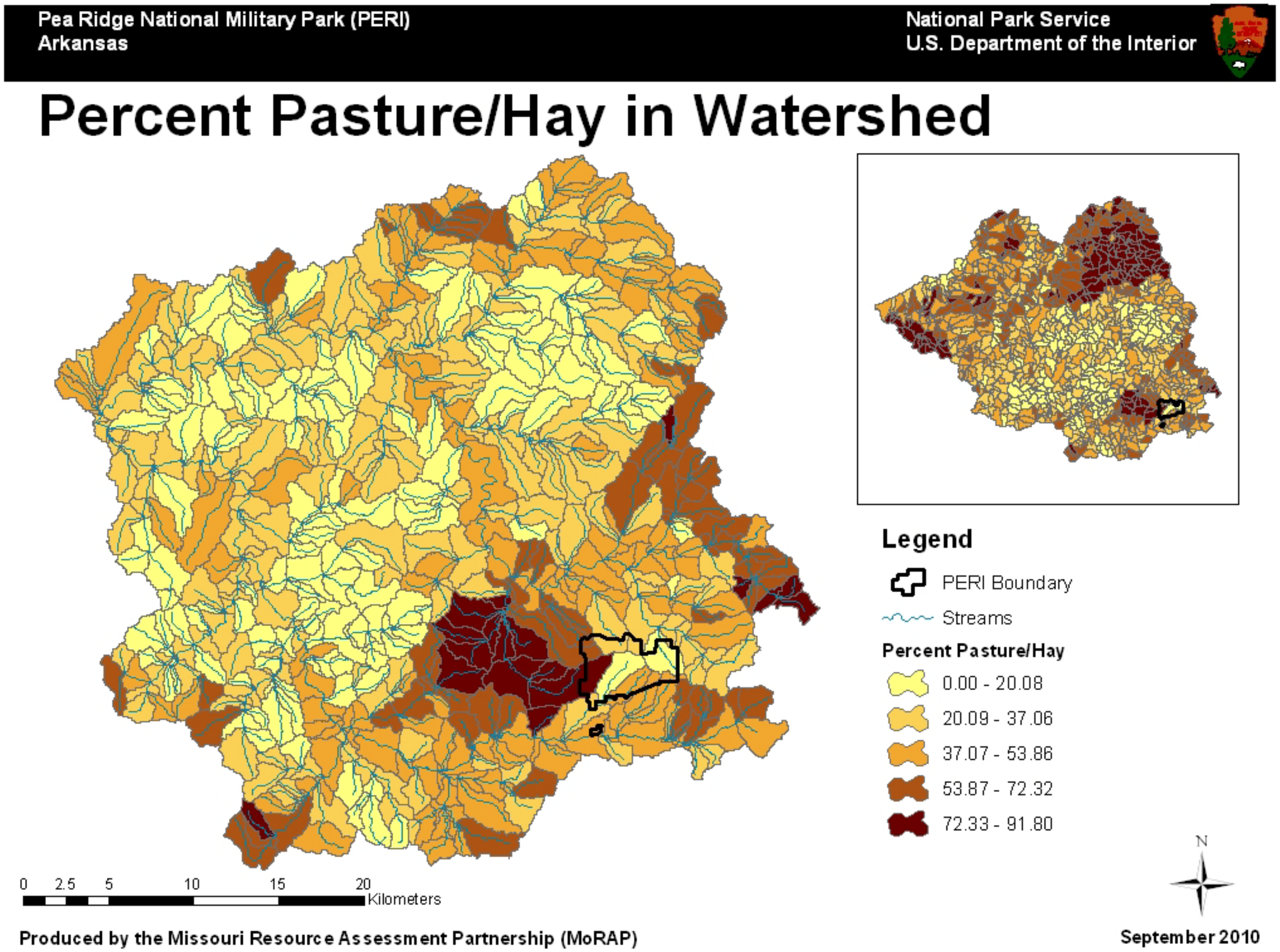

Figure A-3. Percentage of pasture/hay above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

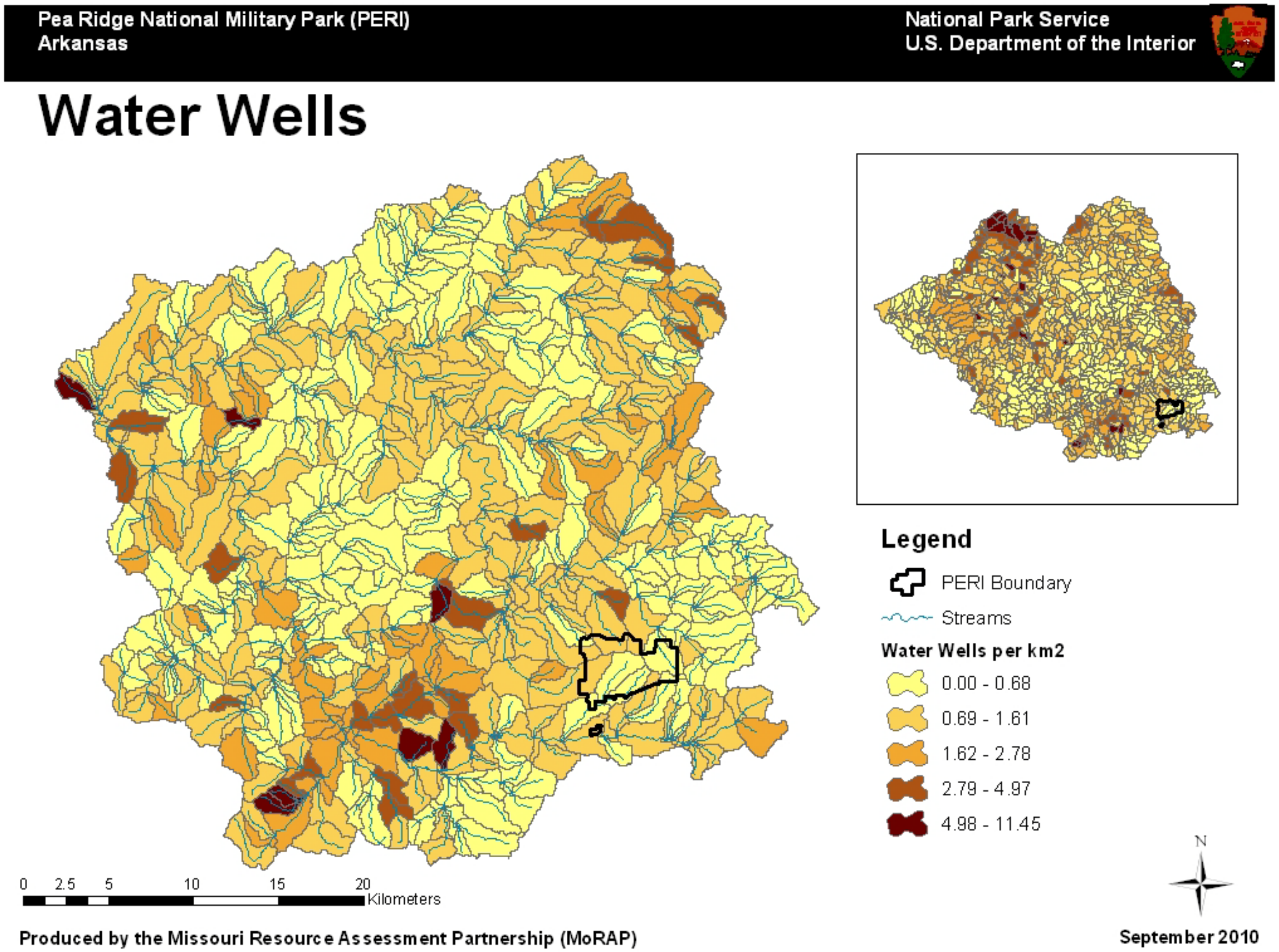

Figure A-4. Density of water wells above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

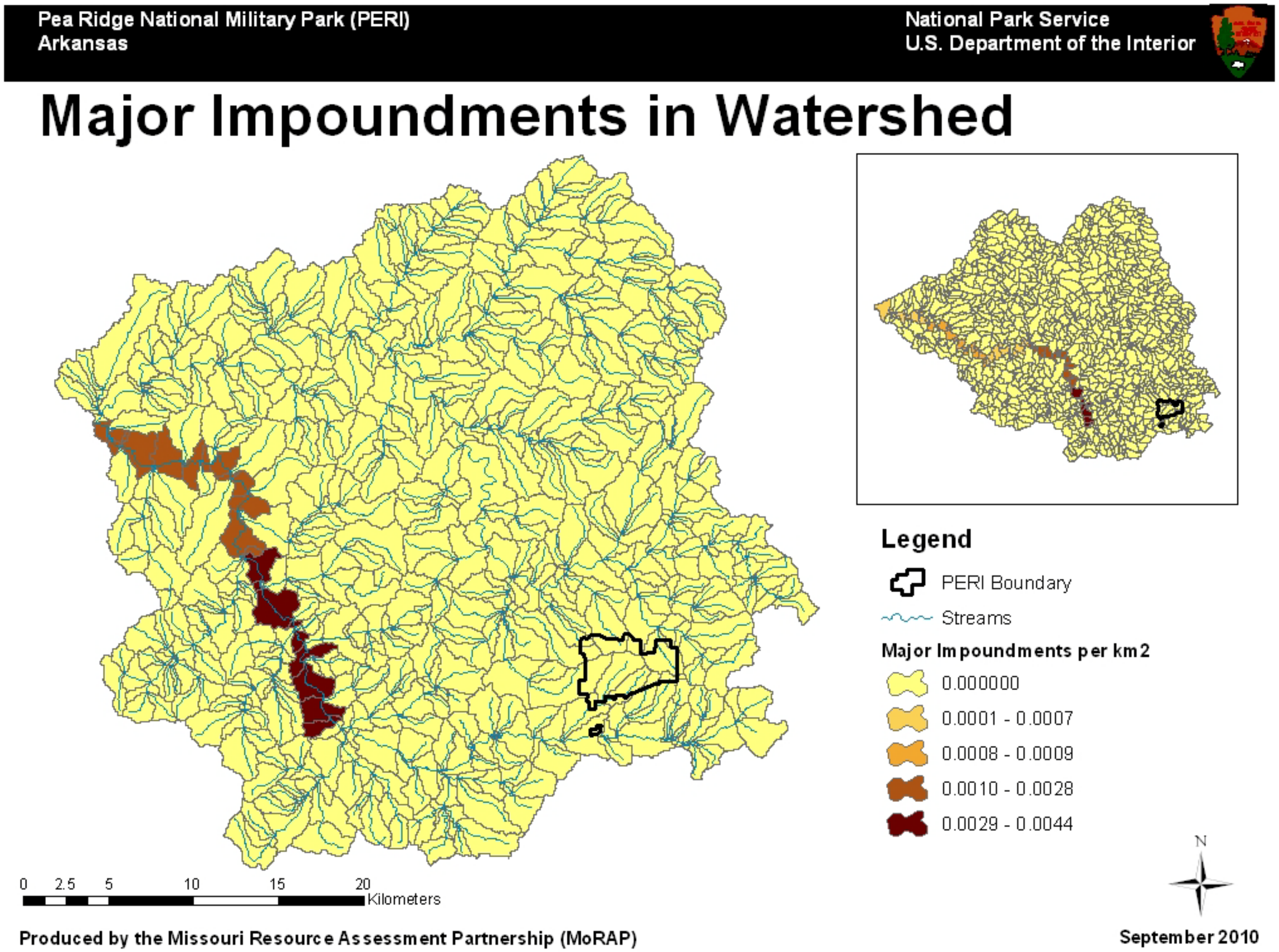

Figure A-5. Density of major impoundments above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

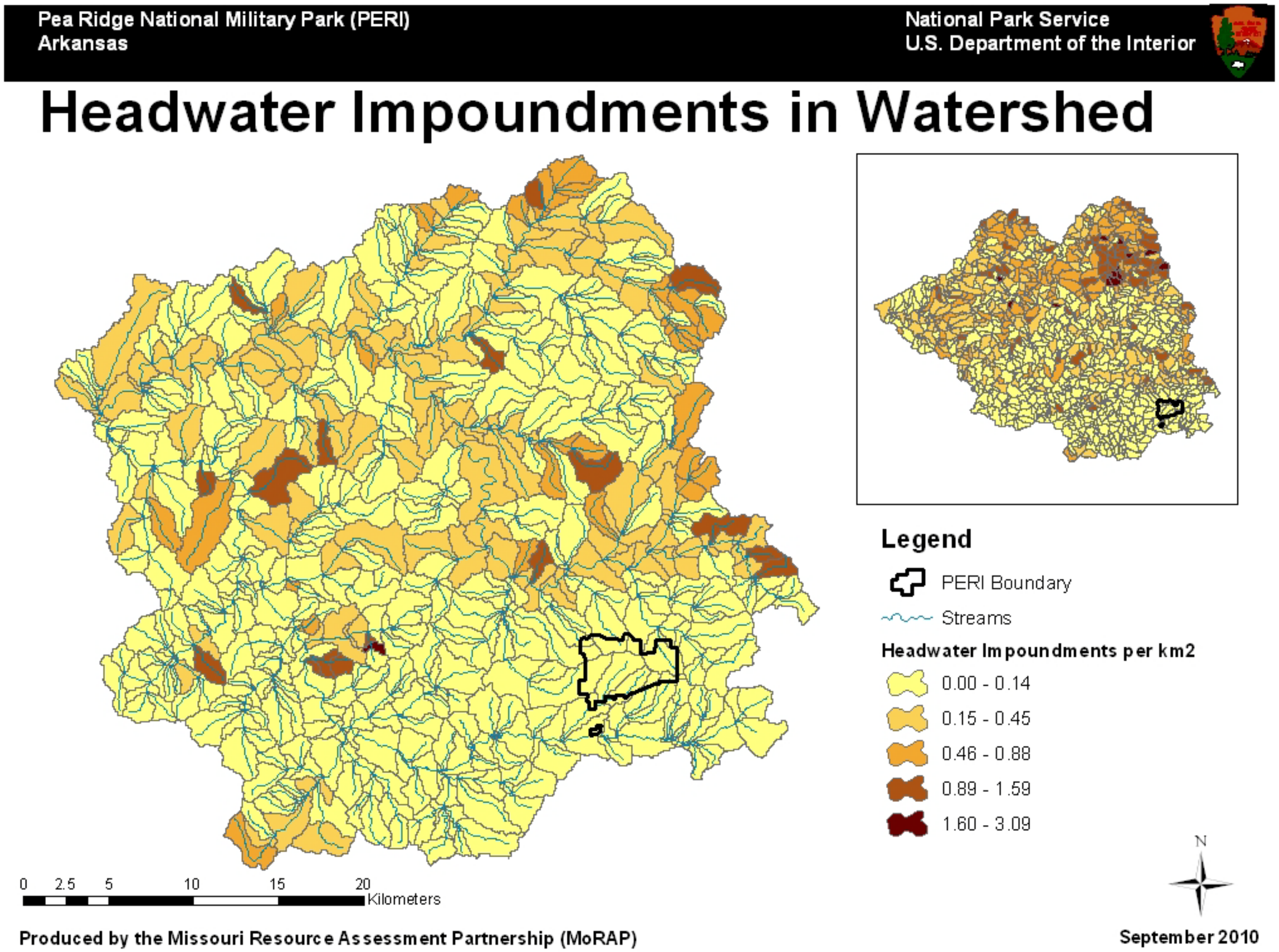

Figure A-6. Density of headwater impoundments above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

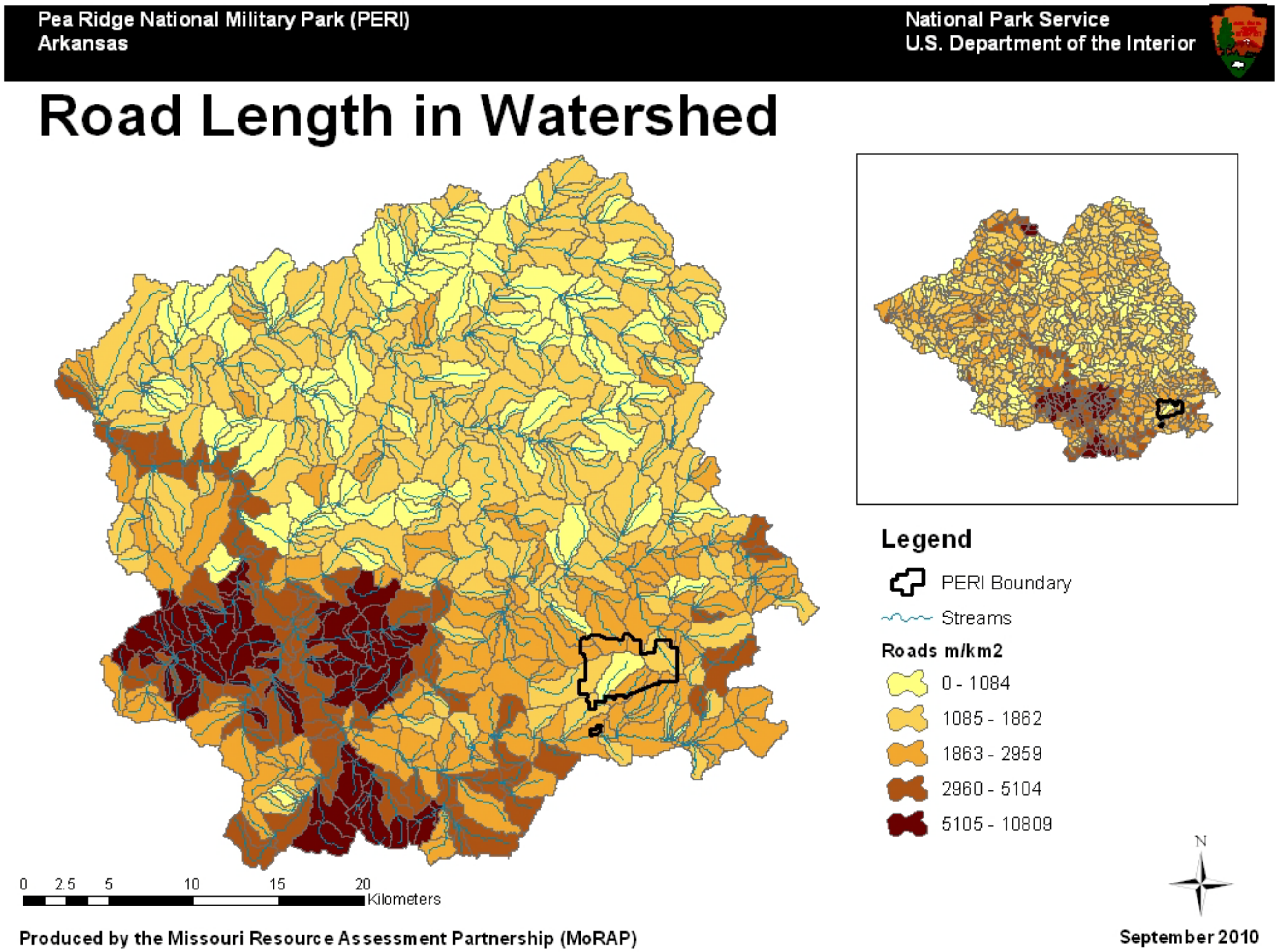

Figure A-7. Length of roads above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

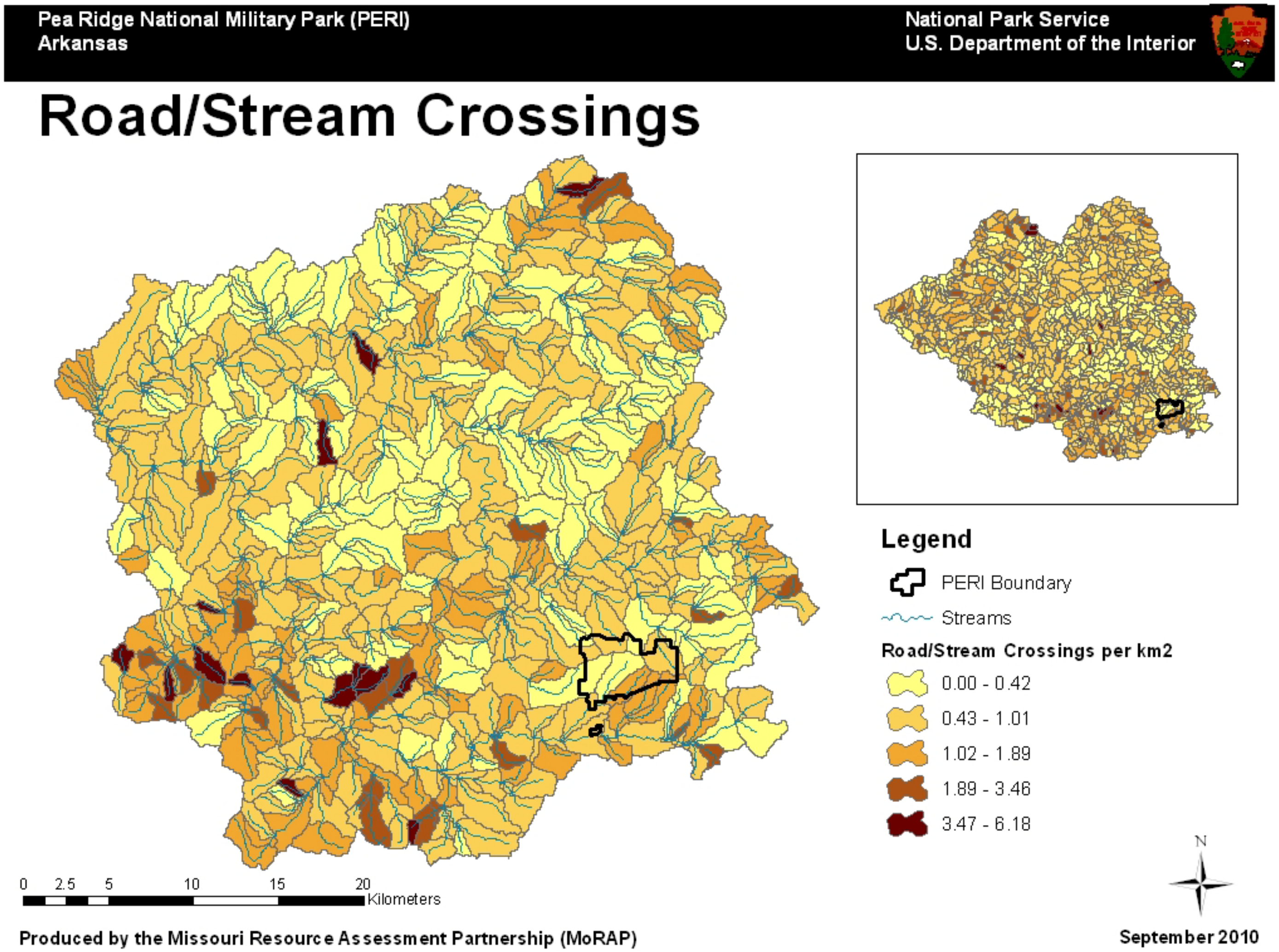

Figure A-8. Density of road/stream crossings above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

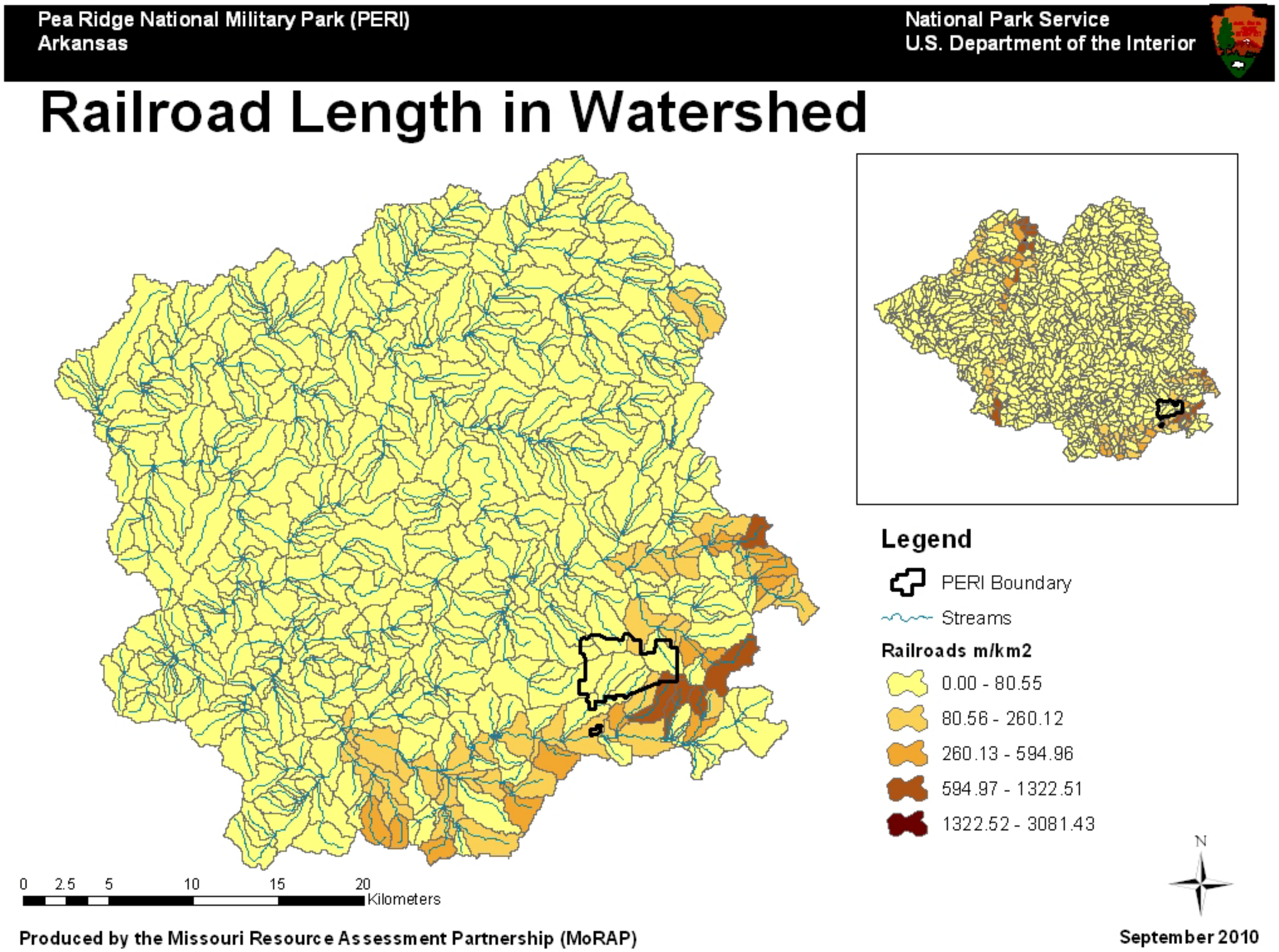

Figure A-9. Length of railroads above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

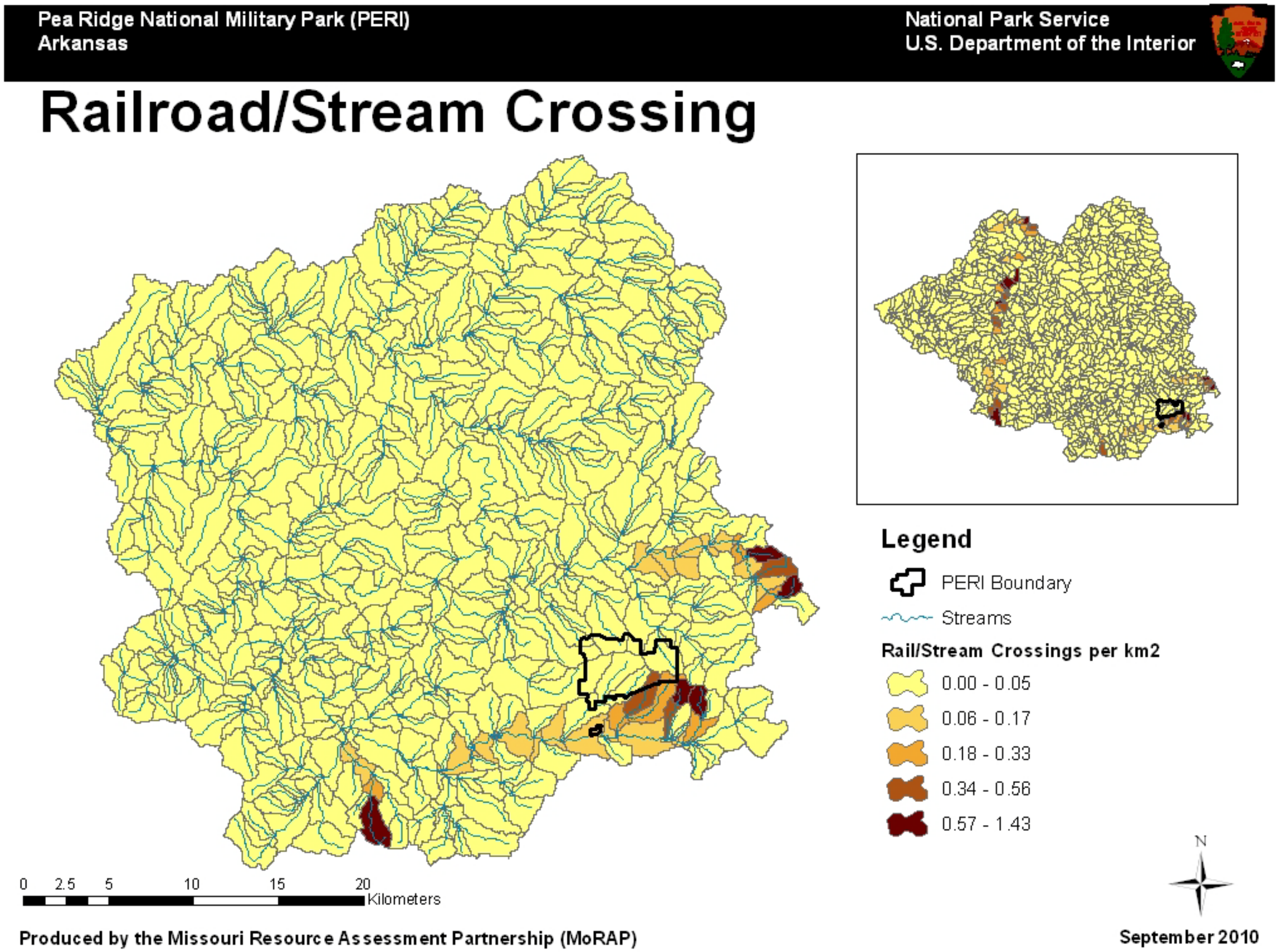

Figure A-10. Density of rail/stream crossings above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

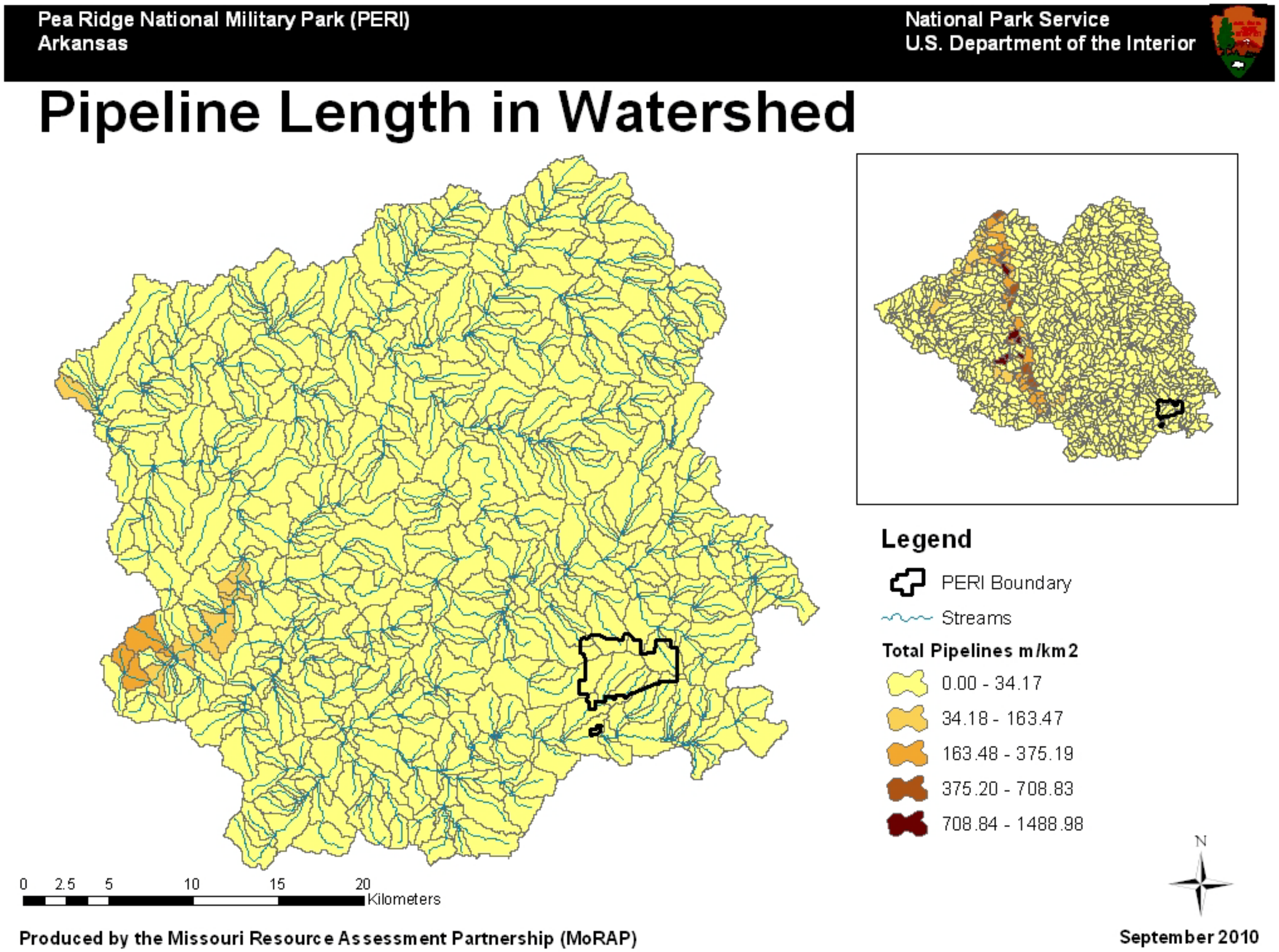

Figure A-11. Length of pipelines above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

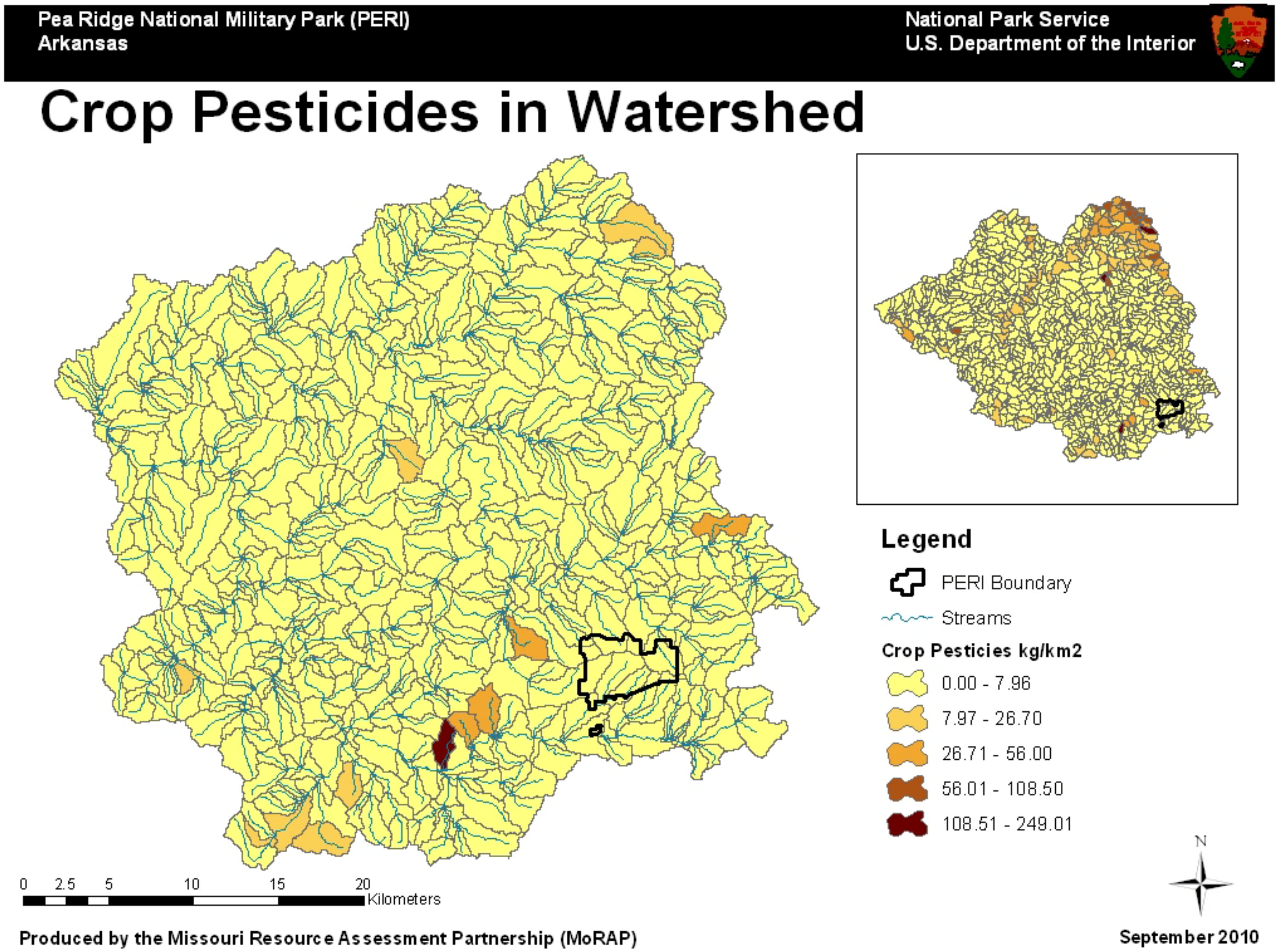

Figure A-12. Density of crop pesticides above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

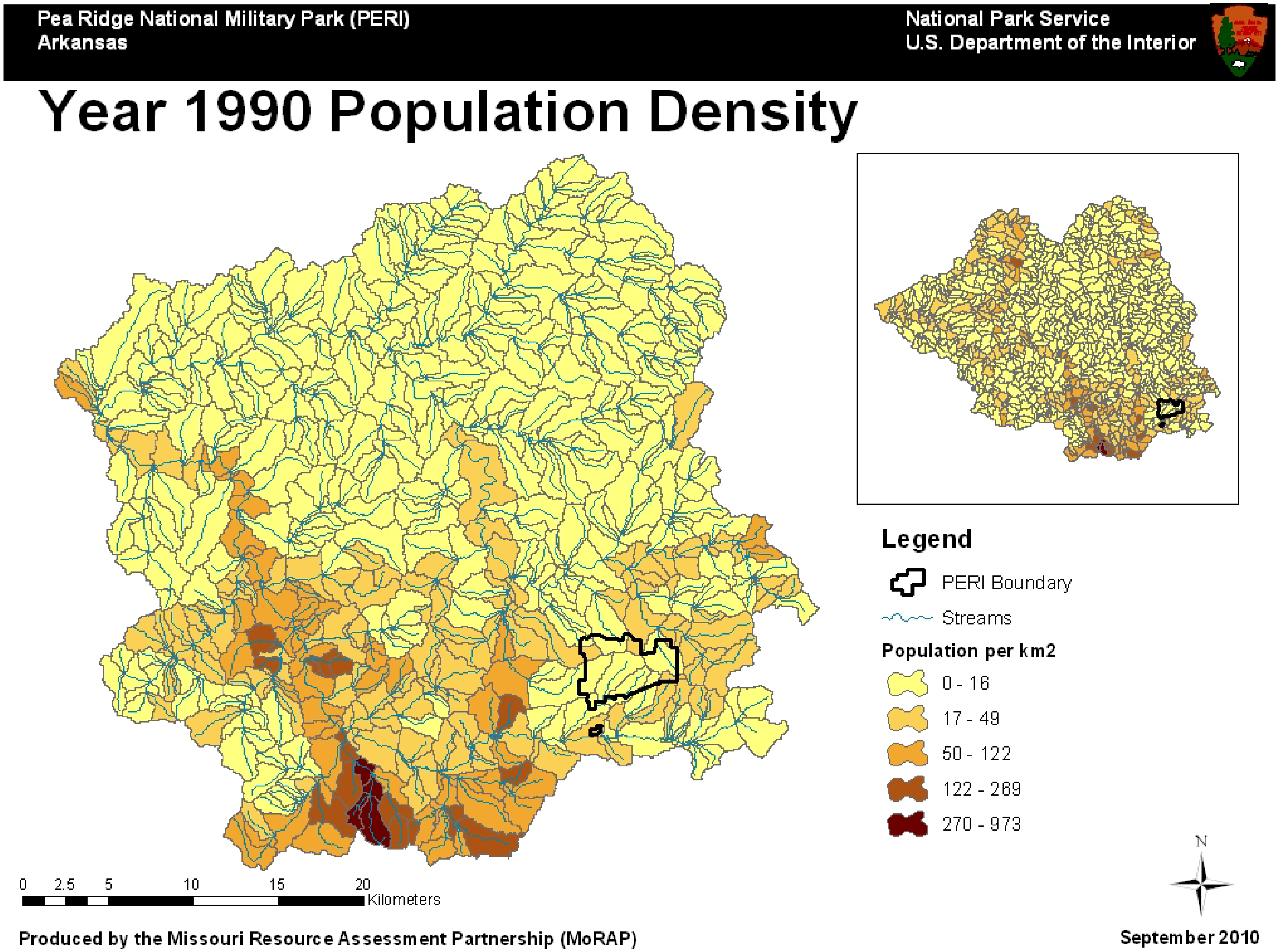

Figure A-13. Density of population in 1990 above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

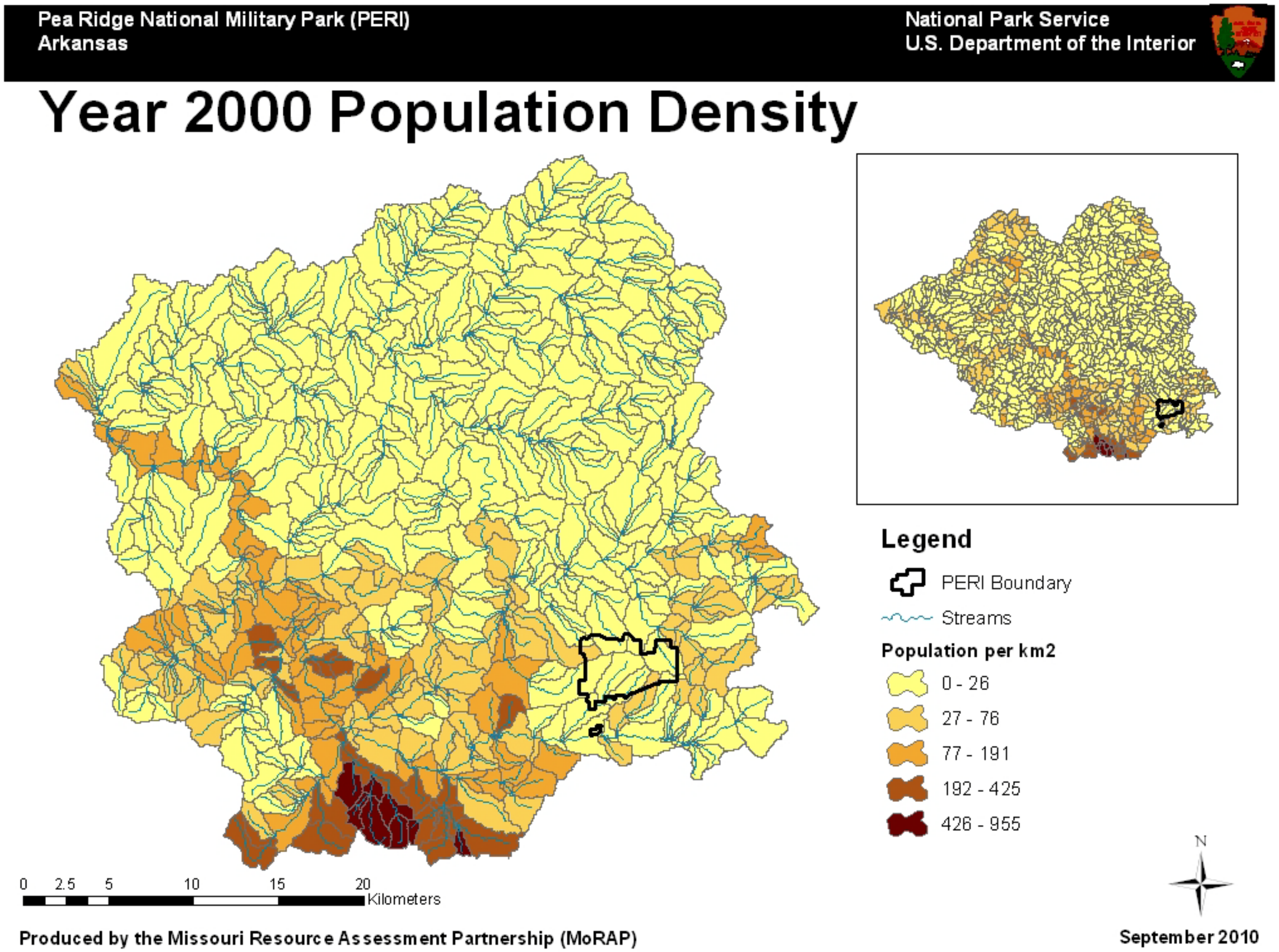

Figure A-14. Density of population in 2000 above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

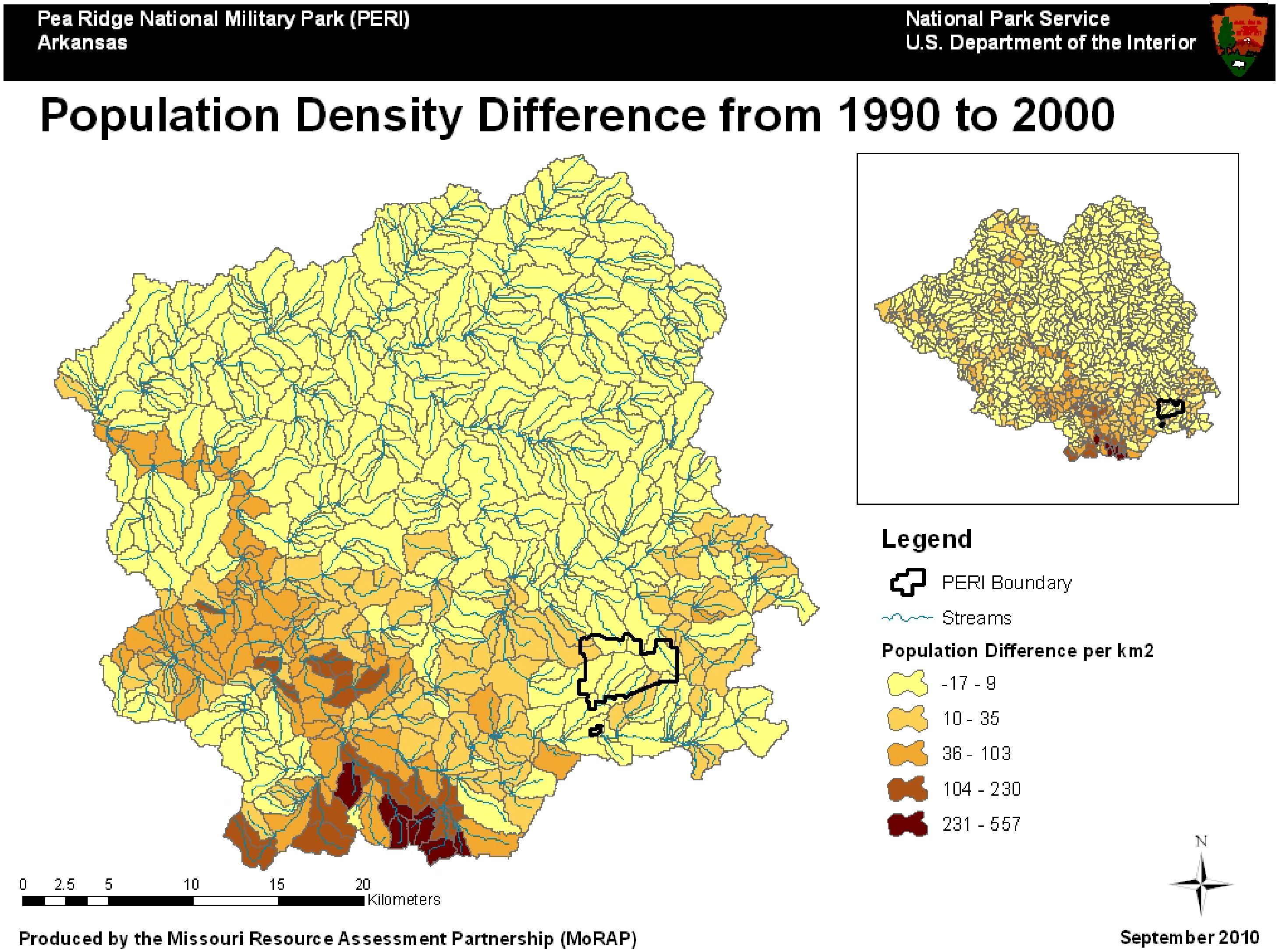

Figure A-15. Change in population density from 1990 to 2000 above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

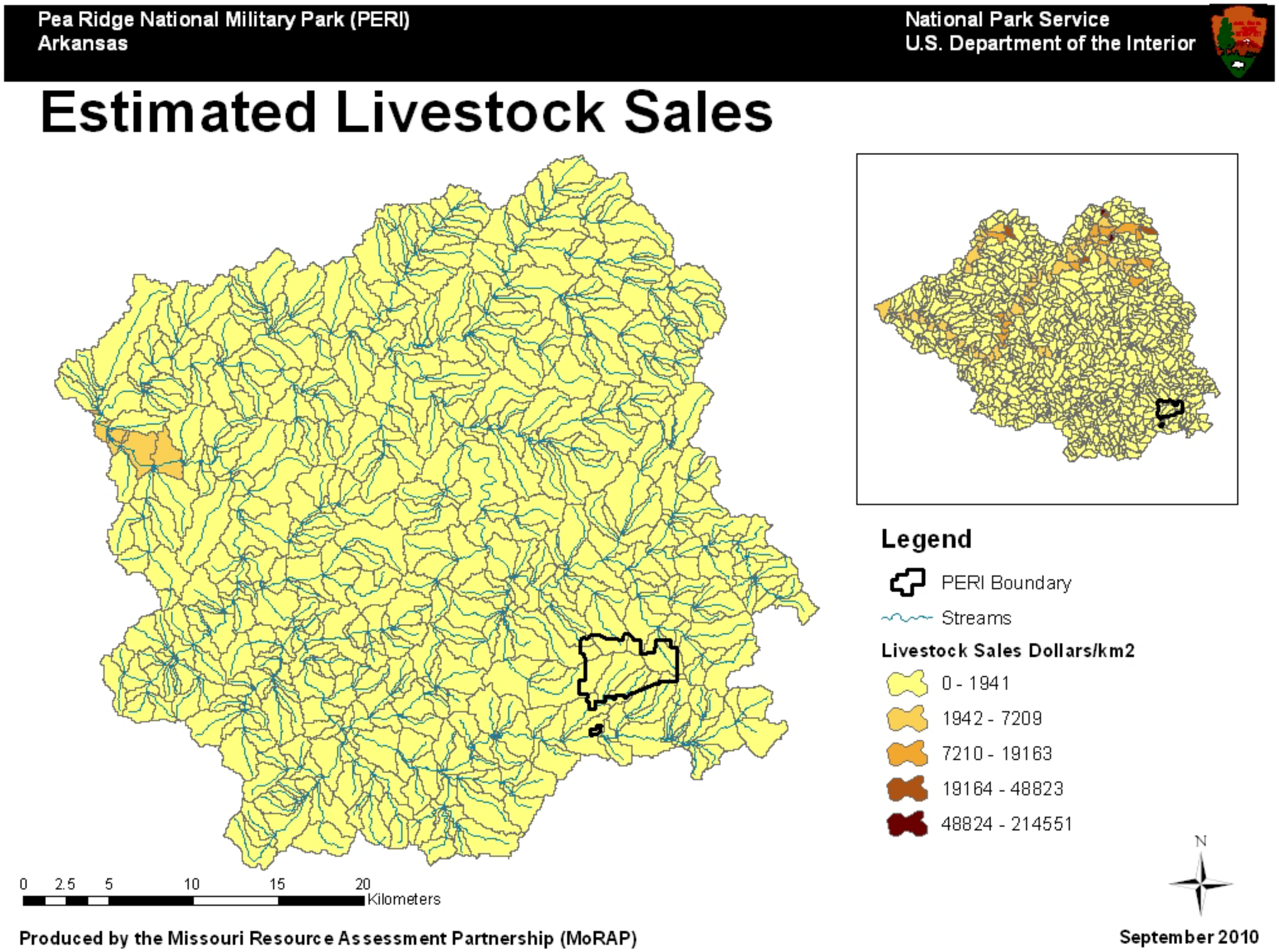

Figure A-16. Amount of livestock sales above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

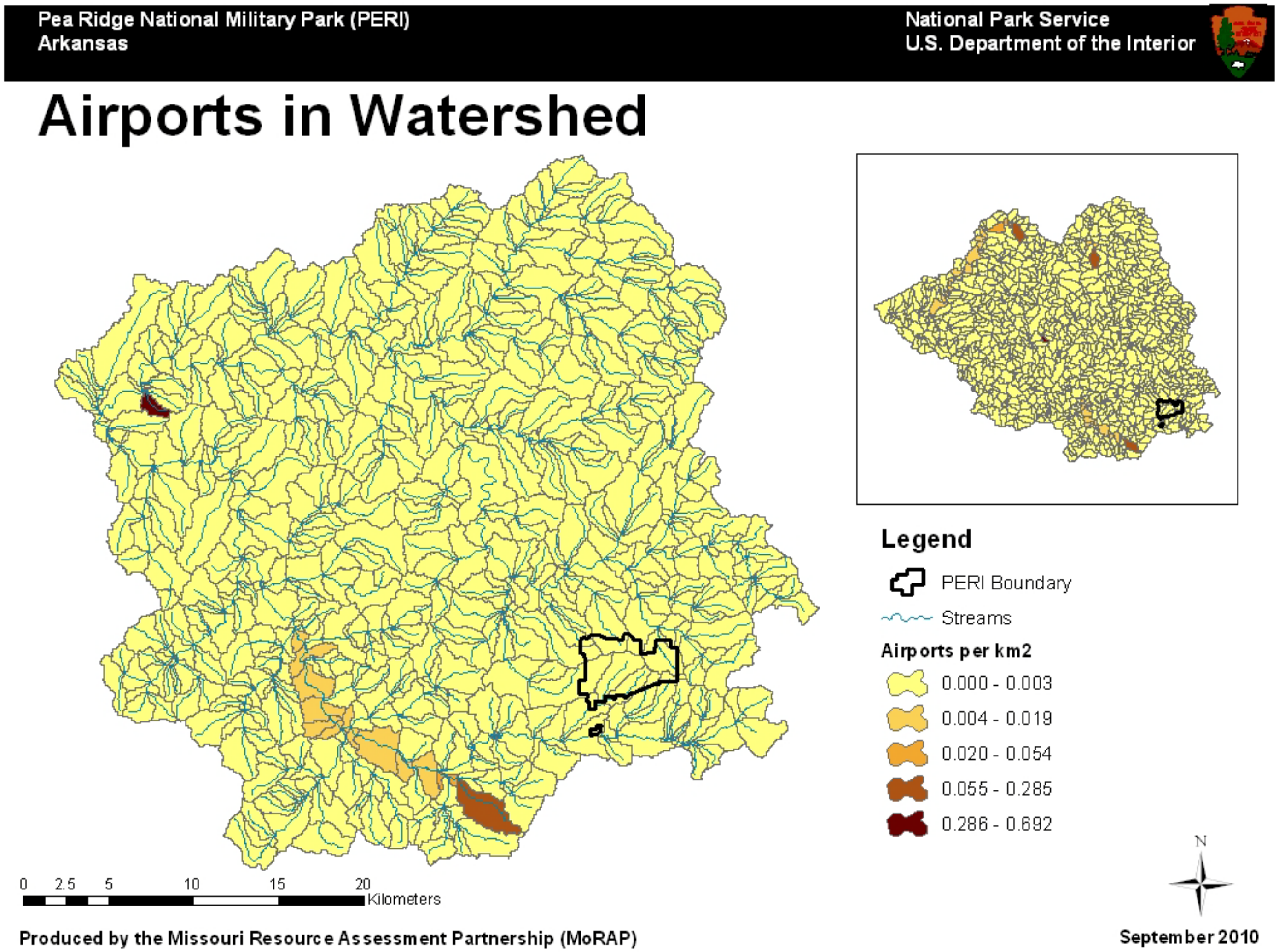

Figure A-17. Density of airports above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

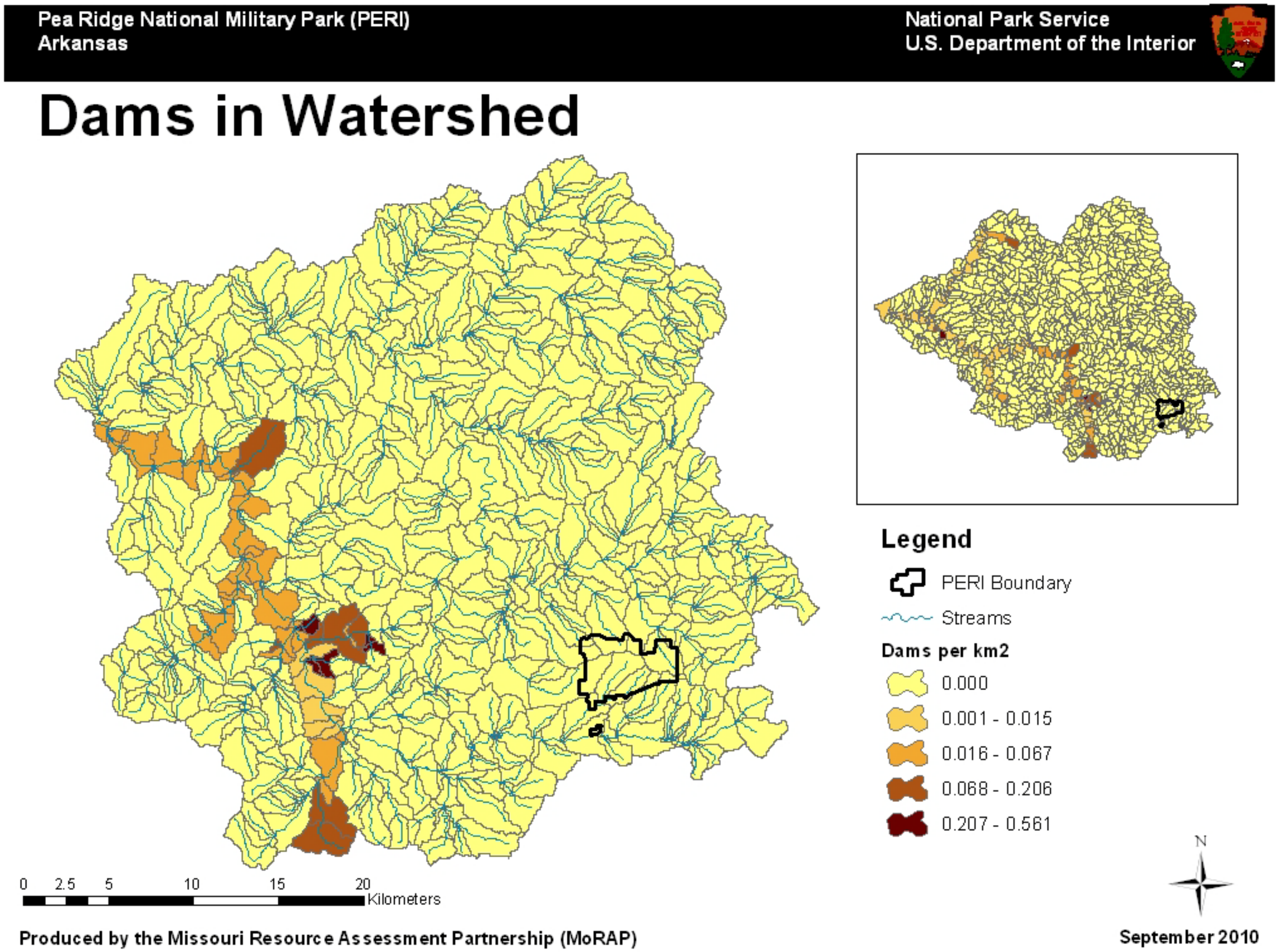

Figure A-18. Density of dams above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

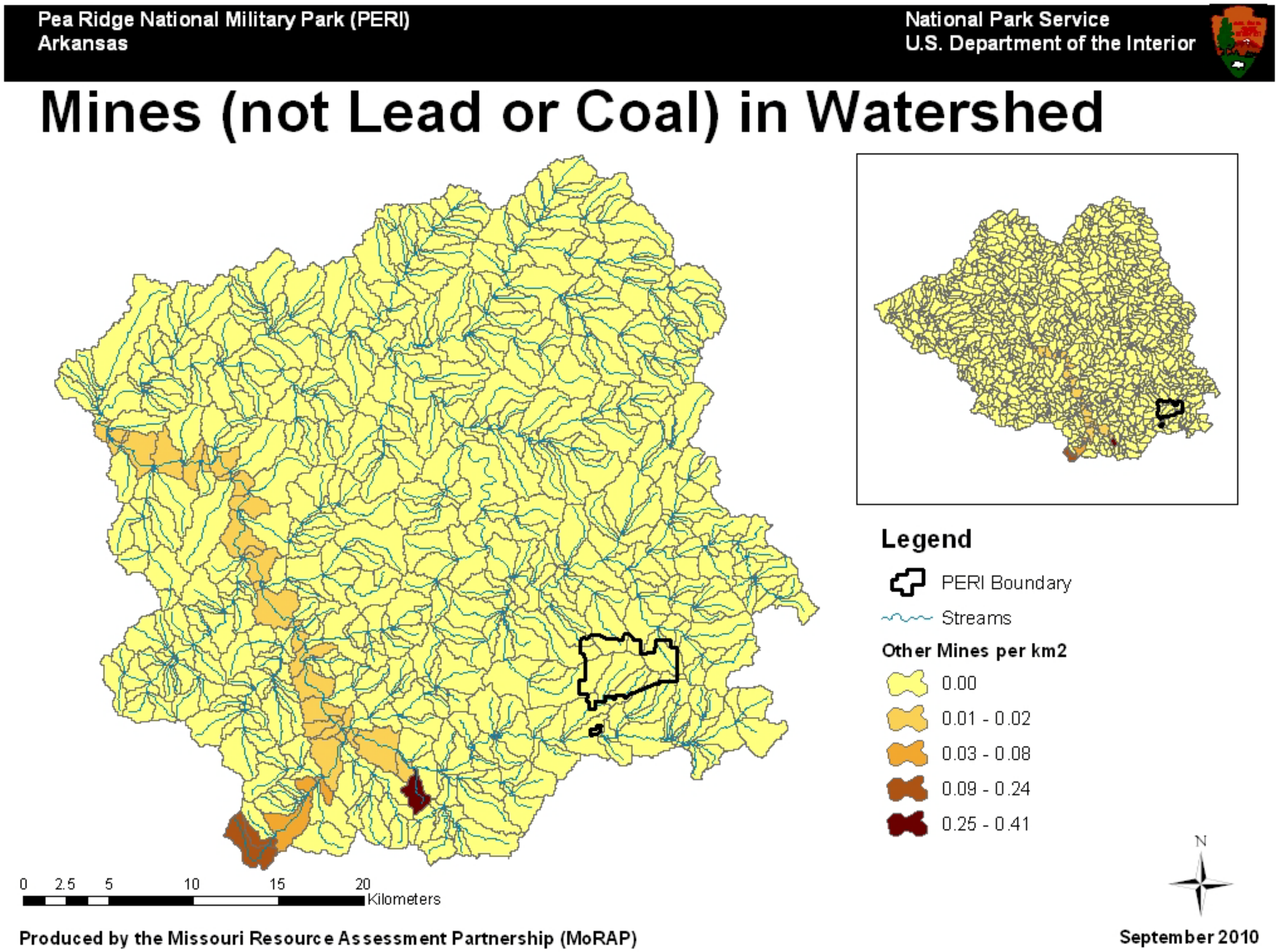

Figure A-19. Density of other mines above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

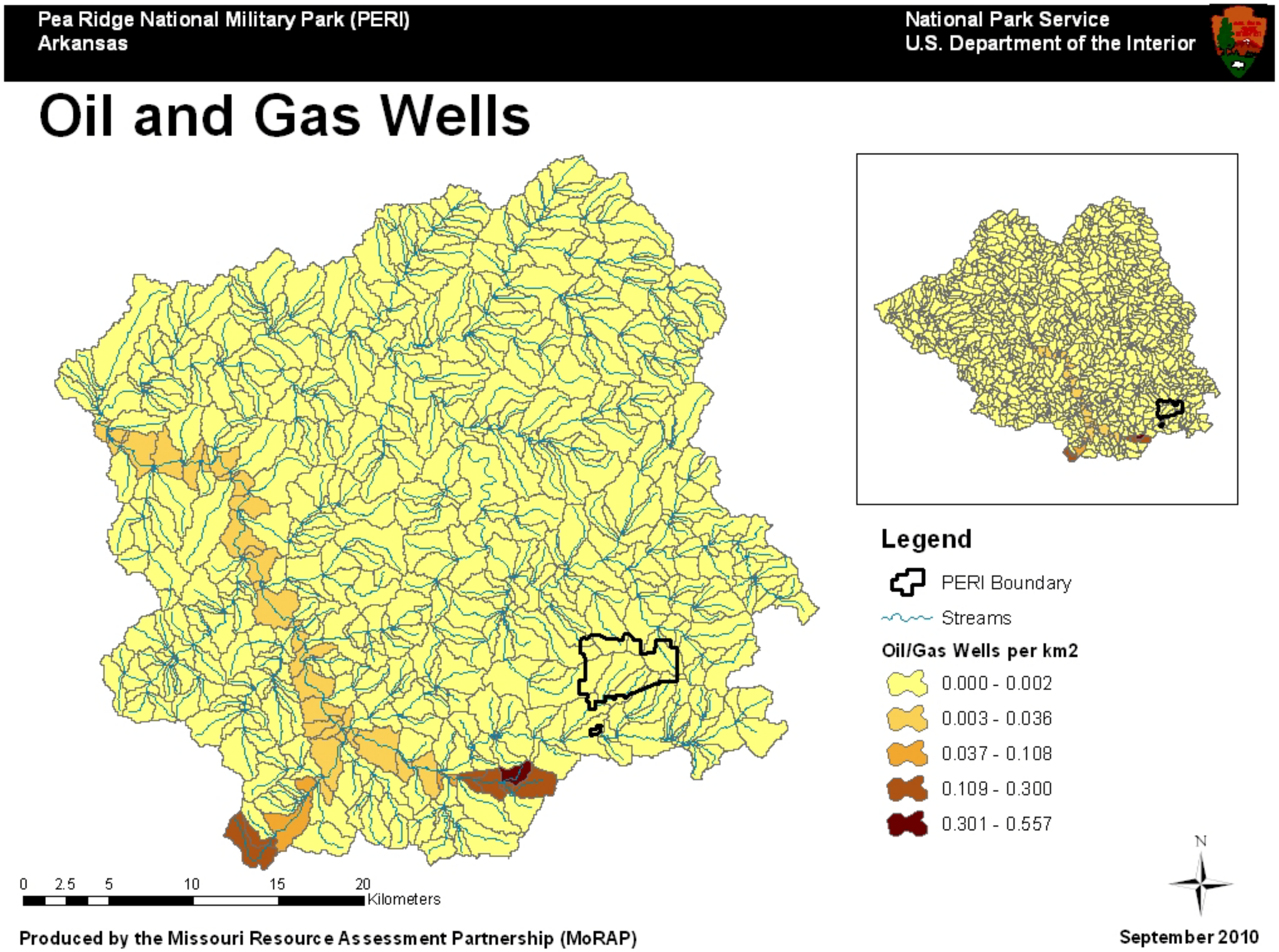

Figure A-20. Density of oil/gas wells above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

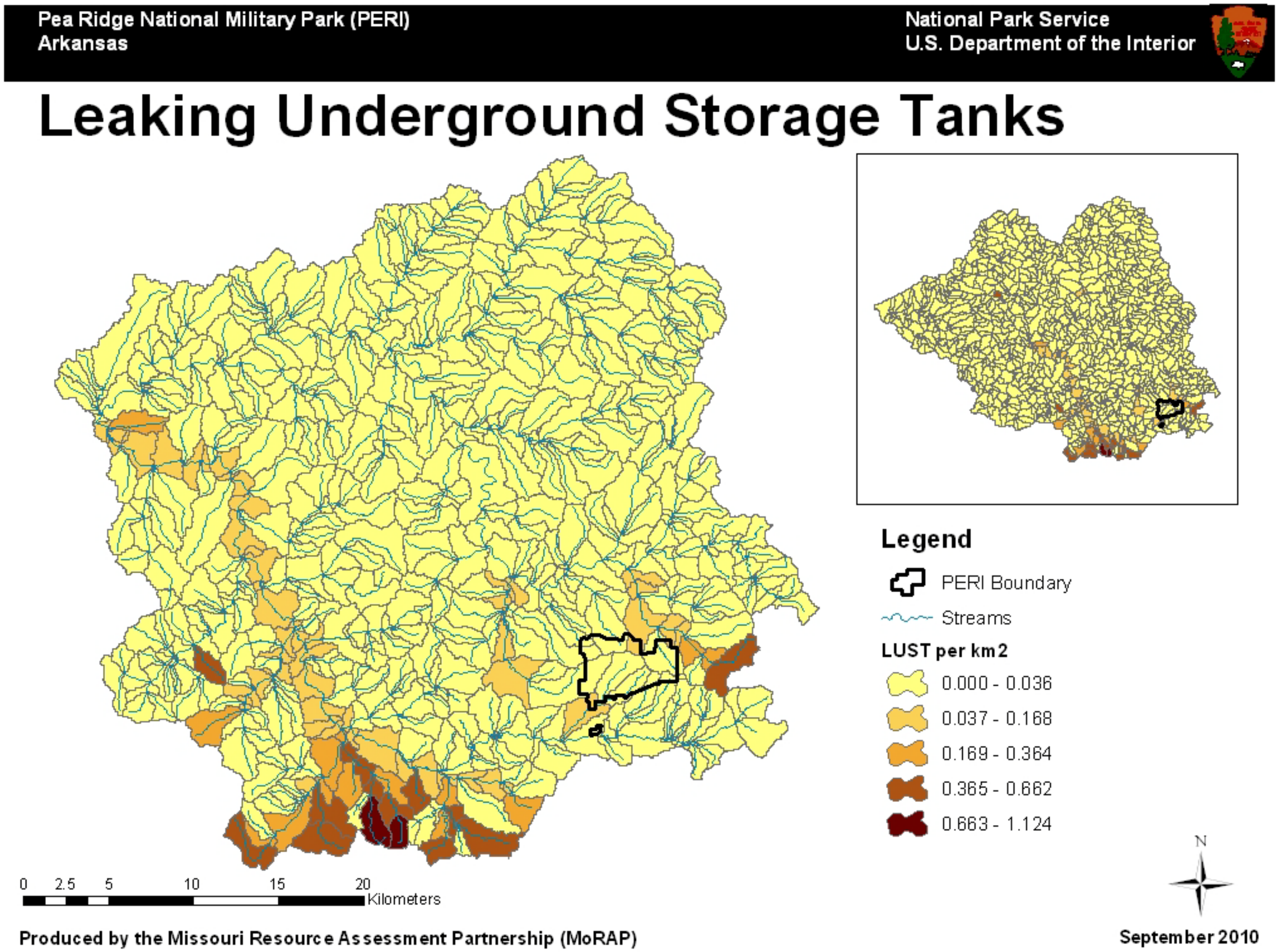

Figure A-21. Density of leaking underground storage tanks above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

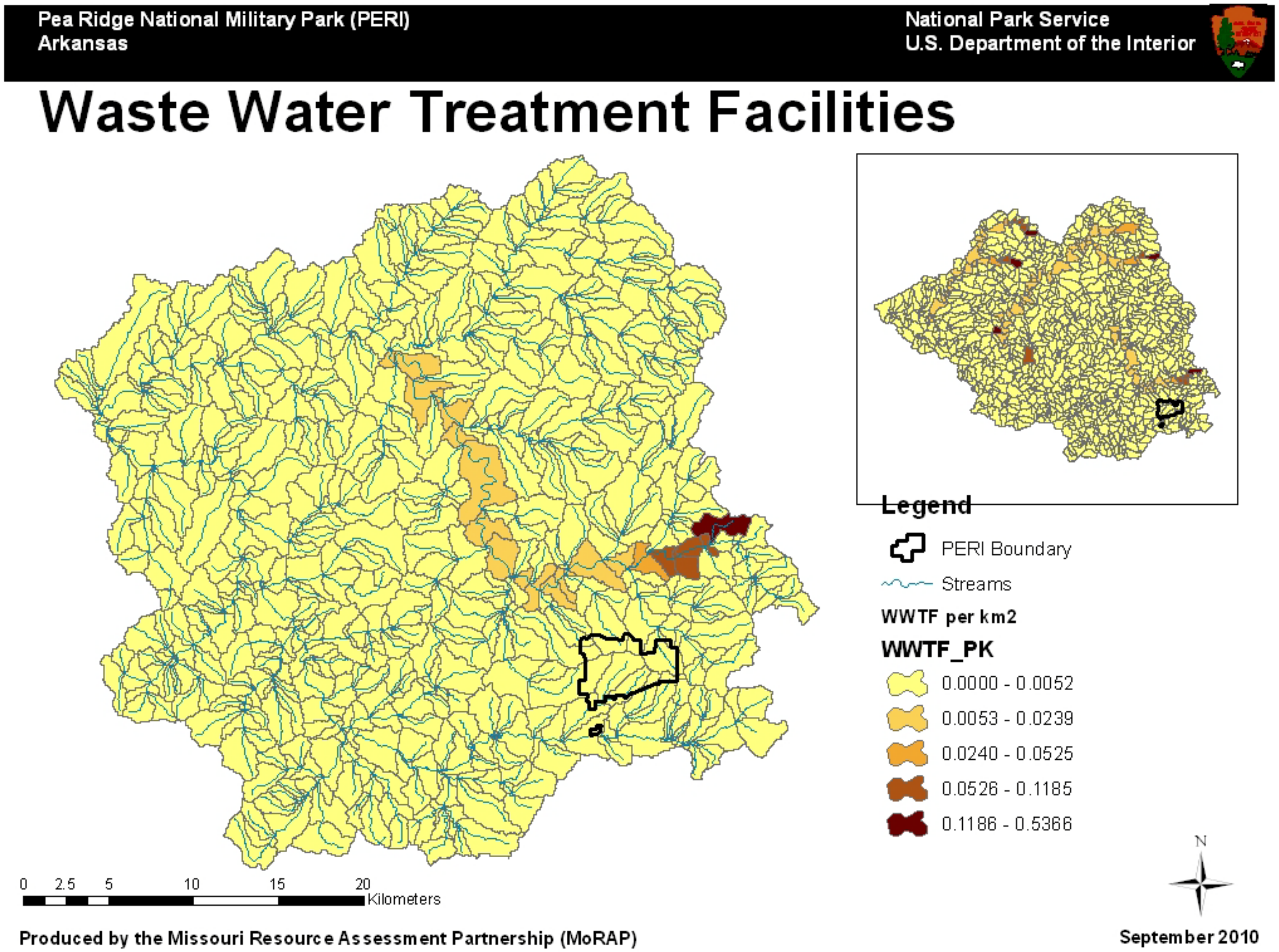

Figure A-22. Density of waste water treatment facilities above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

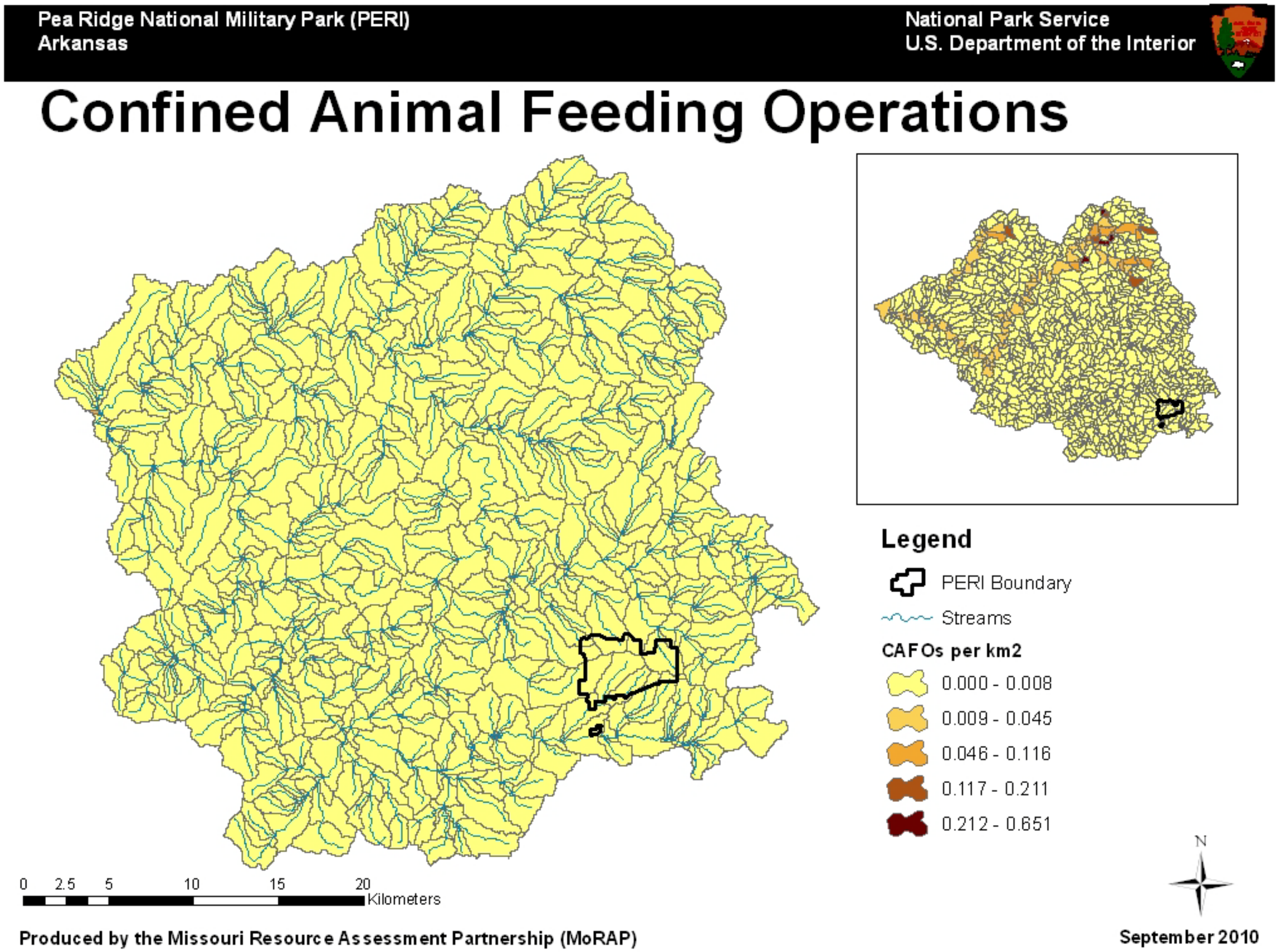

Figure A-23. Density of confined animal feeding operations above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

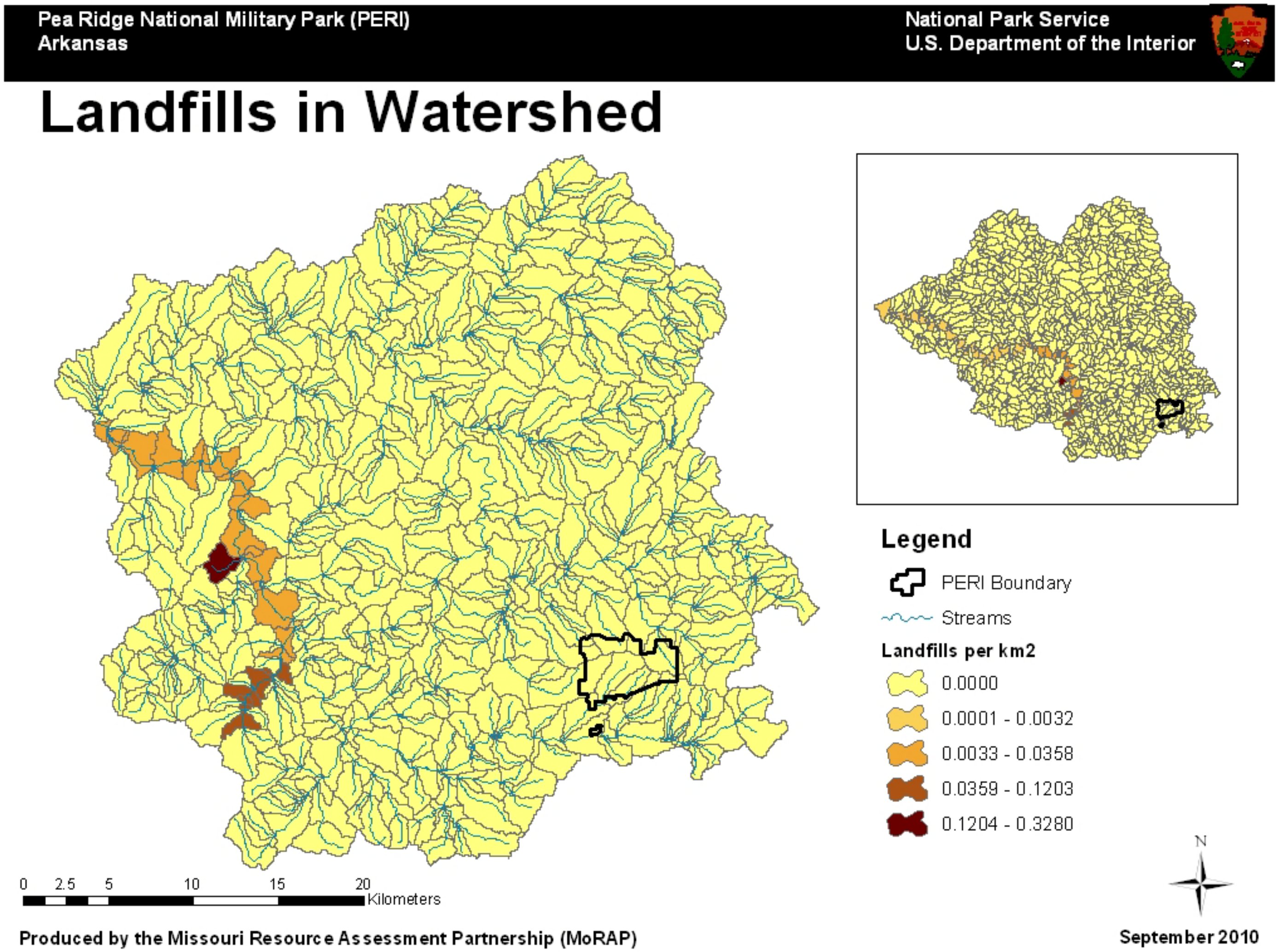

Figure A-24. Density of landfills above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

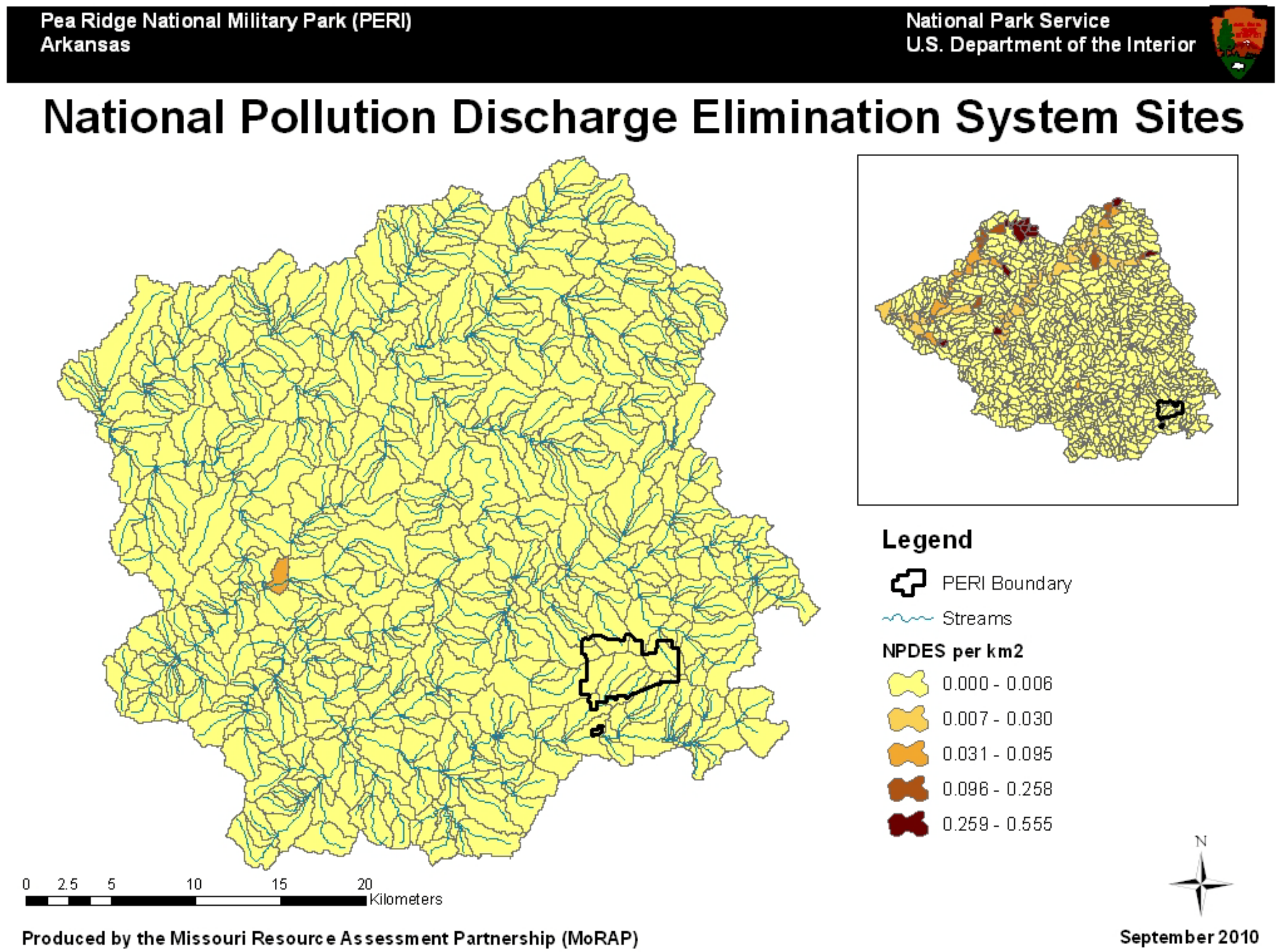

Figure A-25. Density of National Pollution Discharge Elimination System (NPDES) sites above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

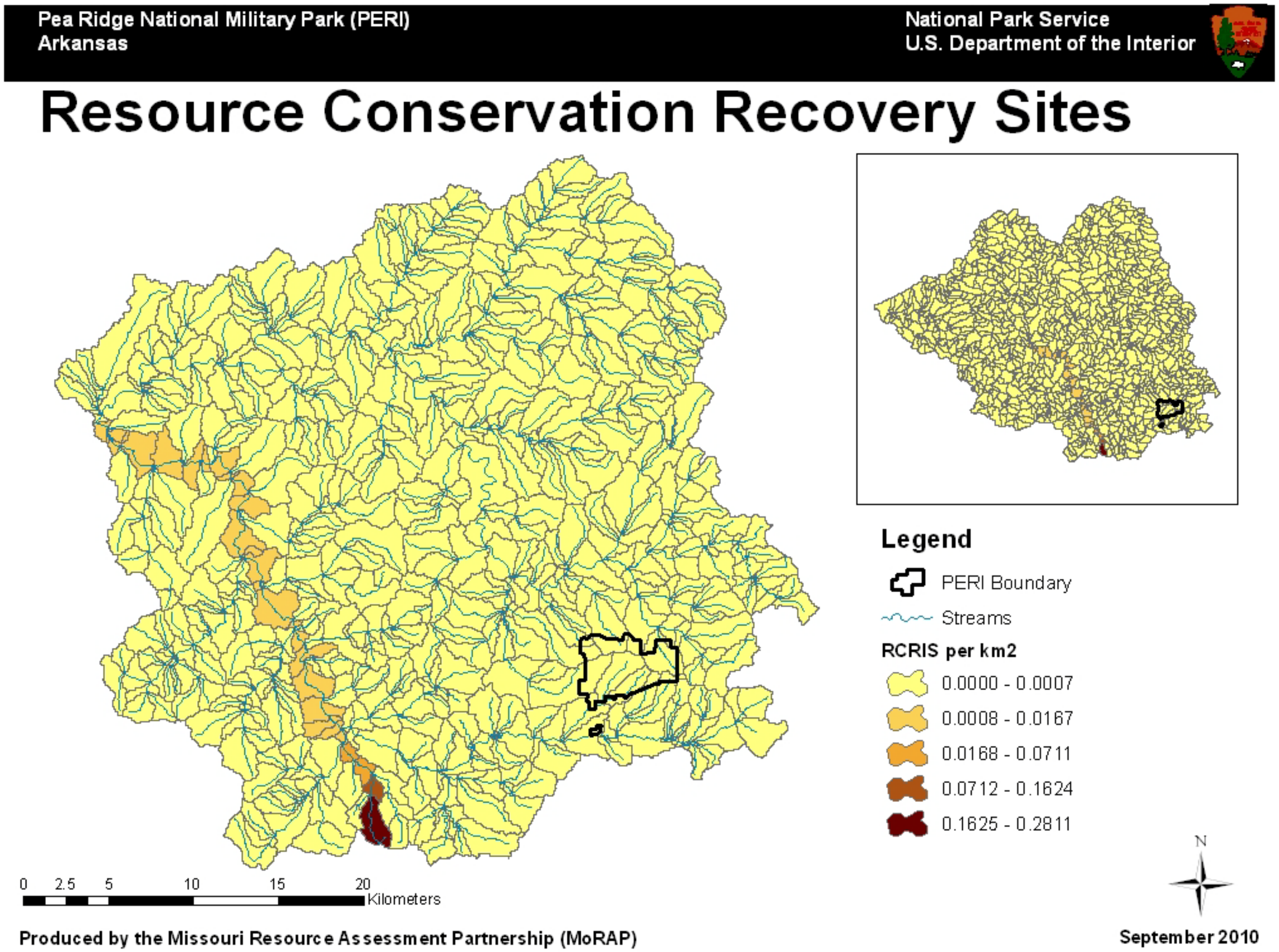

Figure A-26. Density of Resource Conservation Recovery sites above every stream segment in the HUC 10 and HUC 8 (inset) for PERI.

Appendix B Summary of References for Current and Target Conditions for Each Attribute/Indicator

Reporting Unit / Resource Type / Attribute	Data/Information Sources	Reference/Target Conditions
Park-wide		
Vegetation		
Landscape composition	Vegetation cover types were mapped from high resolution aerial imagary, potential vegetation, and soil map units	Targets based on professional judgement. Generally fewer patches of larger size are desirable.
Land use/Land cover	Vegetation cover types were assigned to three classes: natural, successional, and cultural	Targets based on professional judgement with the goal of increasing the area of natural vegetation while decreasing successional vegetation.
Breeding bird community	Peitz, D.G. 2009. Bird monitoring at Pea Ridge National Military Park, Arkansas 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/194. National Park Service, Fort Collins, Colorado.	Targets represent 2008 baseline data collection. The goal is to maintain or enhance the breeding bird community.
White-tailed deer	http://science.nature.nps.gov/im/units/htln/library/Wildlife/Deer/PERI_Deer_2005_2010_r.pdf	Peer reviewed literature reports that the ecological carrying capacity for deer is 8 indifividuals/km^2 Tilghman, Nancy G. 1989. Impacts of White-tailed Deer on forest regeneration in northwestern Pennsylvania. J. Wildlife Management 53(3):524-532.
Invasive exotic plant impact	Young, C.C, J.T. Cribbs, J.L. Haack, and H.J. Etheridge. 2007. Invasive exotic plant monitoring at Pea Ridge National Military Park: Year 1 (2006). Natural Resource Technical Report NPS/HTLN/NRTR—2007/019. National Park Service, Fort Collins, Colorado.	Targets are based on professional judgement, and focus on reducing, or not allowing further expansions, in the numbers and foliar cover of invasive plant speices within the park.
Air quality		
Ozone	Five-year average of the annual 4th-highest 8-hour ozone concentration from interpolated data between 2004 - 2008. See:http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm	EPA standard of < 75ppb established in 2008
Atmoshperic deposition	Five-year average concentration from interpolated data between 2004 - 2008. See:http://www.nature.nps.gov/air/Maps/AirAtlas/IM_materials.cfm	NPS (2007a) reports that wet deposition amounts of less than 1 kg/ha/yr do not cause ecosystem harm.
Bottomland forest		
Landscape Composition	Vegetation cover types were mapped from high resolution aerial imagary, potential vegetation, and soil map units	Targets based on professional judgement. Generally fewer patches of larger size are desirable.
Land Use/Land Cover	Vegetation cover types were assigned to three classes: natural, successional, and cultural	Targets based on professional judgement with the goal of increasing the area of natural vegetation while decreasing successional vegetation.

Reporting Unit

Resource Type

Attribute	Data/Information Sources	Reference/Target Conditions
Semi-natural grassland reporting unit		
Landscape Composition	Vegetation cover types were mapped from high resolution aerial imagary, potential vegetation, and soil map units	Targets based on professional judgement. Generally fewer patches of larger size are desirable.
Land Use/Land Cover	Vegetation cover types were assigned to three classes: natural, successional, and cultural	Targets based on professional judgement with the goal of increasing the area of restorede prairie with native warm-season grasses and forbs and fewer shrubs and vines.
Diversity and herbacous guild composition	Habitat data from Peitz, D.G. 2009. Bird monitoring at Pea Ridge National Military Park, Arkansas 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/194. National Park Service, Fort Collins, Colorado.	Professional judgement was used to set targets for the upland grasslands with the goal of increasing the cover of native warm-season grasses and forbs, and decreasing the cover of shrubs and vines. Professional Judgement was informed by community descriptions in Appendix C.
Dry woodland reporting unit		
Landscape Composition	Vegetation cover types were mapped from high resolution aerial imagary, potential vegetation, and soil map units	Targets based on professional judgement. Generally fewer patches of larger size are desirable.
Land Use/Land Cover	Vegetation cover types were assigned to three classes: natural, successional, and cultural	Targets based on professional judgement with the goal of increasing the area of natural vegetation while decreasing successional vegetation.
Structural class	Habitat data from Peitz, D.G. 2009. Bird monitoring at Pea Ridge National Military Park, Arkansas 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/194. National Park Service, Fort Collins, Colorado.	Professional judgement was used to set targets for the woodland. Professional Judgement was informed by community descriptions in Appendix C, and: Canopy cover and basal area from Nelson (2005) and Missouri Forest and Woodland Natural Community Profiles (http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed: 10/15/2010). Stem density range of values from Jenkins, S.E., R. Guyette, and A.J. Rebertus. 1997. Vegetation-site relationships and fire history of savanna-glade-woodland mosaic in the Ozarks. Pages 184-201 in S.G. Pallardy, R.A. Cecich, H.E. Garrett, and P.S. Johnson, editors. Proceedings of 11th Central Hardwood Forest Conference. General Technical Report NC-188. U. S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.

Reporting Unit

Resource Type

Attribute	Data/Information Sources	Reference/Target Conditions
Cover type	Habitat data from Peitz, D.G. 2009. Bird monitoring at Pea Ridge National Military Park, Arkansas 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/194. National Park Service, Fort Collins, Colorado.	The lower limit of oak composition was multiplied by the lower limit of total basal area. The upper limit of oak composition was multiplied by the uppder limit of total basal. Proportional range of oak species composition (0.65-0.80) and range of total basal area for the reporting unit from Nelson (2005) and Missouri Forest and Woodland Natural Community Profiles (http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed: 10/15/2010).
		The lower limit of hickory composition was multiplied by the lower limit of total basal area. The upper limit of hickory composition was multiplied by the uppder limit of total basal. Proportional range of oak species composition (0.15-0.30) and range of total basal area for the reporting unit from Nelson (2005) and Missouri Forest and Woodland Natural Community Profiles (http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed: 10/15/2010).
Regeneration	Habitat data from Peitz, D.G. 2009. Bird monitoring at Wilson's Creek National Battlefield, Missouri 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/195. National Park Service, Fort Collins, Colorado.	Professional judgement was used to set targets for the woodland. Professional Judgement was informed by community descriptions in Appendix C, and: Jenkins, S.E., R. Guyette, and A.J. Rebertus. 1997. Vegetation-site relationships and fire history of savanna-glade-woodland mosaic in the Ozarks. Pages 184-201 in S.G. Pallardy, R.A. Cecich, H.E. Garrett, and P.S. Johnson, editors. Proceedings of 11th Central Hardwood Forest Conference. General Technical Report NC-188. U. S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota. Rice, E.L., and W.T. Penfound. 1955. An evaluation of the variable-radius and paired-tree methods in the Blackjack-Post Oak forest. Ecology 36:315-320.
Herbacous guild composition	Habitat data from Peitz, D.G. 2009. Bird monitoring at Wilson's Creek National Battlefield, Missouri 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/195. National Park Service, Fort Collins, Colorado.	Cover of native grass and forbs from Nelson (2005) and Missouri Forest and Woodland Natural Community Profiles (http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed: 10/15/2010) weighted by areal extent of type, and professional judgement. Total woody cover (understory) from Missouri Forest and Woodland Natural Community Profiles
Structure	Habitat data from Peitz, D.G. 2009. Bird monitoring at Pea Ridge National Military Park, Arkansas 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/194. National Park Service, Fort Collins, Colorado.	Height of canopy from Nelson (2005) and Missouri Forest and Woodland Natural Community Profiles (http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed: 10/15/2010). Weighted by areal extent of different woodland types. To be measured as average over all upland woodlands.

Reporting Unit Resource Type Attribute	Data/Information Sources	Reference/Target Conditions
Typic woodland reporting unit		
Landscape Composition	Vegetation cover types were mapped from high resolution aerial imagary, potential vegetation, and soil map units	Targets based on professional judgement. Generally fewer patches of larger size are desirable.
Land Use/Land Cover	Vegetation cover types were assigned to three classes: natural, successional, and cultural	Targets based on professional judgement with the goal of increasing the area of natural vegetation while decreasing successional vegetation.
Structural class	Habitat data from Peitz, D.G. 2009. Bird monitoring at Pea Ridge National Military Park, Arkansas 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/194. National Park Service, Fort Collins, Colorado.	Professional judgement was used to set targets for the woodland. Professional Judgement was informed by community descriptions in Appendix C, and: Canopy cover and basal area from Nelson (2005) and Missouri Forest and Woodland Natural Community Profiles (http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed: 10/15/2010). Stem density range of values from Jenkins, S.E., R. Guyette, and A.J. Rebertus. 1997. Vegetation-site relationships and fire history of savanna-glade-woodland mosaic in the Ozarks. Pages 184-201 in S.G. Pallardy, R.A. Cecich, H.E. Garrett, and P.S. Johnson, editors. Proceedings of 11th Central Hardwood Forest Conference. General Technical Report NC-188. U. S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.
Cover type	Habitat data from Peitz, D.G. 2009. Bird monitoring at Pea Ridge National Military Park, Arkansas 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/194. National Park Service, Fort Collins, Colorado.	The lower limit of oak composition was multiplied by the lower limit of total basal area. The upper limit of oak composition was multiplied by the uppder limit of total basal. Proportional range of oak species composition (0.65-0.80) and range of total basal area for the reporting unit from Nelson (2005) and Missouri Forest and Woodland Natural Community Profiles (http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed: 10/15/2010).
		The lower limit of hickory composition was multiplied by the lower limit of total basal area. The upper limit of hickory composition was multiplied by the uppder limit of total basal. Proportional range of oak species composition (0.15-0.30) and range of total basal area for the reporting unit from Nelson (2005) and Missouri Forest and Woodland Natural Community Profiles (http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed: 10/15/2010).

Reporting Unit

Resource Type

Attribute	Data/Information Sources	Reference/Target Conditions
Regeneration	Habitat data from Peitz, D.G. 2009. Bird monitoring at Wilson's Creek National Battlefield, Missouri 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/195. National Park Service, Fort Collins, Colorado.	Professional judgement was used to set targets for the woodland. Professional Judgement was informed by community descriptions in Appendix C, and: Jenkins, S.E., R. Guyette, and A.J. Rebertus. 1997. Vegetation-site relationships and fire history of savanna-glade-woodland mosaic in the Ozarks. Pages 184-201 in S.G. Pallardy, R.A. Cecich, H.E. Garrett, and P.S. Johnson, editors. Proceedings of 11th Central Hardwood Forest Conference. General Technical Report NC-188. U. S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota. Rice, E.L., and W.T. Penfound. 1955. An evaluation of the variable-radius and paired-tree methods in the Blackjack-Post Oak forest. Ecology 36:315-320.
Herbacous guild composition	Habitat data from Peitz, D.G. 2009. Bird monitoring at Wilson's Creek National Battlefield, Missouri 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/195. National Park Service, Fort Collins, Colorado.	Cover of native grass and forbs from Nelson (2005) and Missouri Forest and Woodland Natural Community Profiles (http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed: 10/15/2010) weighted by areal extent of type, and professional judgement. Total woody cover (understory) from Missouri Forest and Woodland Natural Community Profiles
Structure	Habitat data from Peitz, D.G. 2009. Bird monitoring at Pea Ridge National Military Park, Arkansas 2008 status report. Natural Resource Technical Report NPS/HTLN/NRTR—2009/194. National Park Service, Fort Collins, Colorado.	Height of canopy from Nelson (2005) and Missouri Forest and Woodland Natural Community Profiles (http://mdc4.mdc.mo.gov/Documents/17524.doc, accessed: 10/15/2010). Weighted by areal extent of different woodland types. To be measured as average over all upland woodlands.

Reporting Unit / Resource Type / Attribute	Data/Information Sources	Reference/Target Conditions
Pratt Creek and Winton Spring Branch (water quality only)		
Fish community		
Composition	2009 unpublished data following - Dodd, H.R., D.G Peitz, G.A. Rowell, D.E. Bowles, and L.M. Morrison. 2008. Protocol for Monitoring Fish Communities in Small Streams in the Heartland Inventory and Monitoring Network. Natural Resource Report NPS/HTLN/NRR - 2008/052. National Park Service, Fort Collins, Colorado. Justus, B.G., and J.C. Peterson. 2005b. The fishes of Pea Ridge National Military Park, Arkansas, 2003. Scientific Investigations Report 2005-5129. National Park Service, U.S. Geological Survey, Reston, Virginia.	2007 data serves as baseline with the goal to maintain or improve the fish community. Sowa, S.P., D.D. Diamond, R. Abbitt, G. Annis, T. Gordon, M.E. Morey, G.R. Sorensen, and D. True. 2005. A gap analysis for riverine ecosystems of Missouri. U.S. Geological Survey, National Gap Analysis Program, Columbia, Missouri.
Condition	2009 unpublished data following - Dodd, H.R., D.G Peitz, G.A. Rowell, D.E. Bowles, and L.M. Morrison. 2008. Protocol for Monitoring Fish Communities in Small Streams in the Heartland Inventory and Monitoring Network. Natural Resource Report NPS/HTLN/NRR - 2008/052. National Park Service, Fort Collins, Colorado.	Reference condition is based on peer reviewed index in: Dauwalter, D.C., E.J. Pert, and W.E. Keith. 2003. An index of biotic integrity for fish assemblages in Ozark Highland streams of Arkansas. Southeastern Naturalist 2:447-468.
Water quality (medians)	Moore, N., and K. Keaton. Undated. Water quality study: Pea Ridge National Military Park Fall <http://faculty.nwacc.edu/lsuchy/Water Quality At Pea Ridge Military Park (Main Report).pdf>. Accessed 14 March 2011. 2009 Unpublished data following Bowles, D. E., M. H. Williams, H. R. Dodd, L. W. Morrison, J. A. Hinsey, C. E. Ciak, G. A. Rowell, M. D. DeBacker, J.L. Haack. 2008. Monitoring Protocol for Aquatic Invertebrates of Small Streams in the Heartland Inventory & Monitoring Network. Natural Resource Report NPS/HTLN/NRR—2008/042. National Park Service, Fort Collins, Colorado.	Reference conditions based on State of Missouri recommendations in: Brown, D., and J. Czarnezki. Undated. Missouri streams fact sheet-chemical monitoring. Missouri Department of Conservation, Jefferson City, Missouri. http://www.mostreamteam.org/Documents/Fact%20Sheets/17767.pdf

Appendix C Descriptions of Pre-European Vegetation Communities for Pea Ridge National Military Park, Arkansas

Descriptions of Pre-European Vegetation Communities for Pea Ridge National Military Park

Lee F. Elliott, Missouri Resource Assessment Partnership
27 April 2010

Primarily associated with the Typic Woods and Forest Reporting Unit
Dominant Species: black oak/post oak-hickory
General Historical Vegetation: dry-mesic slope woodland
Site Type: Slope forest (>20% slopes)
Ecological System: Ozark-Ouachita Dry-Mesic Oak Forest
Description: Woodlands over cherty substrates are dominated by *Quercus velutina* (black oak), *Quercus alba* (white oak), *Quercus stellata* (post oak), and *Carya alba* (mockernut hickory). The canopy is relatively closed (canopy cover of 70 to 100%) at a height of 30 to 90 feet, with a basal area between 60 and 100 sq. ft./acre. Sites over limestone substrate may have *Quercus muehlenbergii* (chinquapin oak) and *Fraxinus quadrangulata* (blue ash) or *Fraxinus americana* (white ash) as codominants. The shrub canopy has a cover of 10 to 40%, with species such as *Rhus aromatica* (fragrant sumac), *Vaccinium* spp. (blueberries), *Parthenocissus quinquefolia* (Virginia creeper), and *Ceanothus americana* (New Jersey tea). Species such as *Sideroxylon lanuginosum* (gum bumelia), *Juniperus virginiana* (eastern redcedar) and *Frangula caroliniana* (Carolina buckthorn) are more likely to be encountered on limestone substrates. Herbaceous cover may range from 40 to 80% cover with species such as *Schizachyrium scoparium* (little bluestem), *Andropogon gerardii* (big bluestem), *Bouteloua curtipendula* (sideoats grama), *Sorghastrum nutans* (yellow Indiangrass), *Dalea* spp. (prairie clovers), *Desmodium* spp. (ticktrefoils), *Lespedeza* spp. (lespedezas), *Dichanthelium* spp. (panic grasses), and *Helianthus hirsutus* (hairy sunflower). On sites with limestone substrate, species such as *Muhlenbergia sobolifera* (rock muhly), *Taenidia integerrima* (yellow pimpernel), *Lithospermum canescens* (hoary puccoon), *Astragalus distortus* (Ozark milkvetch), and *Astragalus crassicarpus* var. *trichocalyx* (groundplum milkvetch) are more commonly encountered.

Primarily associated with the Dry Woodland Reporting Unit
Dominant Species: post oak-blackjack oak/hickory
General Historical Vegetation: dry oak woodland
Site Types: Linker fine sandy loam (high landscape positions), Mountainburg very stony sandy loam, Enders very stony loam (over sandstone or shale)
Ecological System: Ozark-Ouachita Dry Oak Woodland
Description: Canopy of these woodlands range in cover from 30 to 80 percent, canopy height is typically 20 to 60 feet in height, and basal area is relatively low (30 to 70 sq. ft./acre). The overstory is dominated by *Quercus stellata* (post oak), *Quercus marilandica* (blackjack oak), *Carya texana* (black hickory), and *Quercus velutina* (black oak). *Quercus alba* (white oak) and occasionally *Quercus falcata* (southern red oak) may be present. Shrub cover is relatively low (less than 40% canopy cover) and is composed of species such as *Rhus aromatica* (fragrant

sumac), *Vaccinium pallidum* (lowbush blueberry), *Amelanchier arborea* (common serviceberry), *Ceanothus americanus* (New Jersey tea), and stunted members of the overstory canopy. The herbaceous cover may be variable, from 30 to 90% cover, sometimes with rocky ground and lichens conspicuous. In areas with deeper soil, the herbaceous layer is dominated by species such as *Schizachyrium scoparium* (little bluestem), *Danthonia spicata* (poverty grass), *Carex* spp. (sedges), and forbs such as *Clitoria mariana* (butterfly pea), *Desmodium rotundifolium* (prostrate tick trefoil), *Solidago hisipida* (hairy goldenrod), and *Cunila origanoides* (common dittany).

Primarily associated with the Semi-natural Grassland Reporting Unit
Dominant Species: post oak-bluestem
General Historical Vegetation: flatwoods
Site Types: Taloka silt loam
Ecological System: Ozark-Ouachita Dry Oak Woodland
Description: This open woodland is characterized by a subsurface soil layer of reduced permeability leading to brief periods of flooding during rainy periods, followed by extended dry periods. The overstory is often open (cover between 30 and 80%), relatively short (30 to 50 feet in height), and with a basal area between 30 and 70 sq. ft/acre. The overstory is typically dominated by *Quercus stellata* (post oak), though *Quercus marilandica* (blackjack oak) and *Carya texana* (black hickory) may also be present. The shrub/understory is poorly developed (less than 40% cover) and contains species such as *Rubus* spp. (blackberries) and *Toxicodendron radicans* (eastern poison ivy). The herbaceous canopy may be dense and dominated by grasses and sedges, particularly *Schizachyrium scoparium* (little bluestem). *Cinna arundinacea* (sweet woodreed), *Carex* spp. (sedges), *Juncus interior* (inland rush), and *Symphyotrichum patens* (late purple aster) are among the many other species that may be present.

Primarily associated with the Bottomland Forest Reporting Unit
Dominant Species: red oak/sugar maple-white oak/bitternut hickory
General Historical Vegetation: floodplain forest
Site Types: Britwater gravelly silt loam, Elsah soils, Jay silt loam, Secesh gravelly silt loam, low mesic slopes
Ecological System: Ozark-Ouachita Mesic Hardwood Forest
Description: These forests have an almost closed canopy (90 to 100% canopy closure) to a height of 80 to 110 feet and a basal area from 90 to 110 sq. ft./acre. The overstory canopy is dominated by a variety of species including *Quercus rubra* (northern red oak), *Acer saccharum* (sugar maple), *Quercus alba* (white oak), *Carya cordiformis* (bitternut hickory), and *Carya ovata* (shagbark hickory). Other canopy species include *Quercus shumardii* (Shumard's oak), *Tilia americana* (American basswood), *Juglans nigra* (black walnut), and *Gymnocladus dioicus* (Kentucky coffeetree). An understory is present to a height of 5 to 25 feet of saplings of the overstory as well as *Asimina triloba* (pawpaw), *Aesculus glabra* (Ohio buckey), *Ulmus rubra* (slippery elm), *Carpinus caroliniana* (American hornbeam), and *Diospyros virginiana* (common persimmon). Shrubs are also present with a cover from 30 to 60% and include species such as *Lindera benzoin* (spicebush), *Staphylea trifolia* (American bladdernut), *Corylus americana* (American hazelnut), and *Toxicodendron radicans* (eastern poison ivy). The herbaceous layer is diverse, with a canopy cover between 30 and 70%. Numerous species may be encountered in the herbaceous layer, including *Laportea canadensis* (Canadian woodnettle), *Erigenia bulbosa* (harbinger of spring), *Cardamine concatenata* (cutleaf toothwart), *Erythronium albidum* (white

fawnlily), *Enemion biternatum* (eastern false rue anemone), *Arisaema dracontium* (green dragon), *Trillium* spp. (trilliums), numerous ferns, and other numerous others.

Primarily associated with the Typic Woods and Forest and Semi-natural Grassland Reporting Unit
Dominant Species: white oak/post oak-black oak/hickory
General Historical Vegetation: dry-mesic oak woodland
Site Types: Cane loam, Captina silt loam, Cherokee silt loam, Enders very gravelly loam, Enders very stony loam (over limestone, less steep), Johnsburg silt loam, Mayes silty clay loam, Nixa very gravelly silt loam, Noark very gravelly silt loam, Pearidge silt loam, Summit silty clay, Tonti gravelly silt loam, Linker fine sandy loam (at lower landscape positions)
Ecological System: Ozark-Ouachita Dry-Mesic Oak Forest
Description: This forest with a relatively closed canopy (70 to 100% canopy cover) may have a canopy reaching to 70 to 100 feet in height and a basal area between 80 and 100 sq. ft./acre. Dominant species of the overstory are *Quercus alba* (white oak), *Quercus velutina* (black oak), and *Carya alba* (mockernut hickory). Other canopy species that may be present are *Quercus muehlenbergii* (chinquapin oak) and *Quercus stellata* (post oak). The cover of the sapling/shrub layer varies from 30 to 60% cover and is often dominated by species such as *Rhus aromatica* (fragrant sumac), *Cornus florida* (flowering dogwood), *Frangula caroliniana* (Carolina buckthorn), *Parthenocissus quinquefolia* (Virginia creeper), *Vitis* spp. (grapes), *Vaccinium pallidum* (lowbush blueberry), and *Vaccinium arboreum* (farkleberry), the latter two species more likely in soils over sandstone. Other shrub species that may be present include *Ceanothus americanus* (New Jersey tea), *Vitis aestivalis* (summer grape), and *Amorpha canescens* (leadplant). The herbaceous layer has a cover from 60 to 90% and often contains more forbs than the drier post oak woodlands. Species dominant in the herbaceous layer include *Schizachyrium scoparium* (little bluestem), *Andropogon gerardii* (big bluestem), *Carex* spp. (sedges), *Desmodium nudiflorum* (nakedflower ticktrefoil), *Desmodium marilandicum* (smooth small-leaf ticktrefoil), *Desmodium glutinosum* (pointedleaf ticktrefoil), and *Amphicarpaea bracteata* (American hogpeanut). *Monarda bradburiana* (eastern beebalm), *Helianthus hirsutus* (hairy sunflower), *Solidago ulmifolia* (elm-leaved goldenrod), *Silene virginica* (fire pink), *Maianthemum racemosum* (feathery false lily of the valley), and *Geranium maculatum* (spotted geranium) may also be common.

Primarily associated with the Typic Woods and Forest Reporting Unit
Dominant Species: white oak/red oak-black oak/sugar maple
General Historical Vegetation: mesic slope forest
Site Types: Clarksville extremely gravelly silt loam, Noark very gravelly silt loam (both on steep slopes)
Ecological System: Ozark-Ouachita Mesic Hardwood Forest
Description: This forest has a relatively closed canopy (70 to 100% canopy cover) with canopies reaching to 100 feet in height and basal areas ranging from 80 to 100 sq. ft./acre. Dominant species include *Quercus alba* (white oak), *Quercus rubra* (northern red oak), *Acer saccharum* (sugar maple), *Quercus velutina* (black oak), *Carya ovata* (shagbark hickory) and *Carya cordiformis* (bitternut hickory). Other canopy species include *Quercus muehlenbergii* (chinquapin oak), *Carya alba* (mockernut hickory), and *Quercus shumardii* (Shumard’s oak).

The understory and shrub canopy varies from 30 to 60% and contains saplings of the overstory species in addition to such species as *Cercis canadensis* (eastern redbud), *Asimina triloba* (pawpaw), *Lindera benzoin* (spicebush), *Corylus americana* (American hazelnut), *Carpinus caroliniana* (American hornbeam), and *Cornus florida* (flowering dogwood). The herbaceous layer is variable (from 30 to 60% cover) and contains numerous forbs, along with grass such as *Elymus virginicus* (Virginia wildrye) and *Chasmanthium latifolium* (Indian woodoats), and *Carex* spp. (sedges).

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