WORKING TO CLOSE THE RESEARCH-IMPLEMENTATION GAP: A CONSERVATION ASSESSMENT OF THE UPPER OCONEE SUBBASIN IN GEORGIA, USA TO IDENTIFY PARCELS FOR EASEMENT RECRUITMENT

by

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(Under the Direction of Laurie Fowler)

ABSTRACT

Private land conservation is becoming increasingly important as economic incentives expand and evidence of ecological significance of private land accumulates. Ensuring the transfer of ecological knowledge derived from scientific research to conservation practitioners is imperative for closing the research – implementation gap. I addressed this gap locally with a conservation assessment of the Upper Oconee subbasin in Northeast Georgia, driven by stakeholder input and Georgia policy. I analyzed nine conservation features with parcels and five acre block boundaries to evaluate the most efficient method for identifying Priority Parcels for easement recruitment by the Oconee River Land Trust and Athens Land Trust. Priority Parcels identified by summing block scores within parcels was the most efficient method. One-hundred one Priority Parcels were identified for easement recruitment. The results will be incorporated into the conservation planning strategies of the two land trusts and used in their easement recruitment campaigns.

INDEX WORDS: conservation, priority strategy, land trust, ecosystems services, georgia land conservation program, easement

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DEDICATION

I dedicate my thesis to the friends and spirit of the Georgia River Survey. May the bond of friendship we developed floating upon the enchanted bosoms of Georgia's rivers last our lifetimes and proliferate beyond. Thank you all for your inspirations!

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

THESIS OUTLINE

In this thesis, I describe how I modeled conservation features derived from existing scientific datasets at a landscape scale to identify conservation priority areas within a watershed, the Upper Oconee subbasin. By the phrase "conservation features", I am referring to natural elements valued as important by conservation stakeholders. The pragmatic goal of my thesis is to facilitate the transmission of scientific knowledge generated from research to conservation practitioners in a usable form. Metaphorically speaking, I want to build a bridge over the knowledge gap that exists between researchers and practitioners of conservation. Others have recently referred to this as the research – implementation gap (Knight et al. 2008). For the academic exercise of my thesis, I ask the broad question, "How does changing the size and shape of the analysis unit change the identified conservation priority areas spatially, both in location and area?" To answer this question, I chose to analyze the conservation features twice using parcel boundaries for a first run and five acre blocks for a second run. The parcels, or units of political boundaries, represented analysis units of non-uniform size or shape. In contrast, the five acre blocks represented analysis units of uniform size and shape, which more closely approximated the natural boundaries of the conservation features than did the parcels. Thus, the more specific question that I wanted to answer from this choice of analysis units was, "How do identified conservation priority areas differ when analyzing with a political unit versus an approximated natural unit?" I refer to these two approaches throughout my thesis as the parcel method and the block method.

I chose parcels as an analysis unit because the stakeholders for my project were land trusts. Land trusts hold conservation easements, which are contracts with landowners that protect land. Hence, this approach was efficient because it allowed for identifying the minimal number of landowners with relatively high conservation value land. I explain the role of land trusts and their relationship with land owners in further detail in a later section. The five acre block allowed for analysis at the subparcel (within parcel) and interparcel (transboundary) levels. This approach identified those lands with the highest value for conservation, regardless of political boundaries, which is important because ecological functions and wildlife do not necessarily adhere to political boundaries.

Chapter 1 is a review of the literature for private lands conservation, the Georgia Land Conservation Program, ecosystem services, and spatial priority strategies, as well as how these topics are relevant to my thesis. Chapter 2 reviews the methods used for modeling the conservation features in the Upper Oconee subbasin with both the parcel and five acre block units. In Chapter 3, I present the results of both of these methods and their respective identified conservation priority areas. In Chapter 4, I interpret the results and discuss the differences and similarities of the two approaches. Further, in Chapter 4 I summarize the information I gave to the land trusts for outreach to the identified landowners, as well as the possible implications of this project's research and outreach effort. Finally, Appendix D is the report that I presented to the land trusts in the form of a project summary.

INTRODUCTION

Multitudes of global and continental scale conservation priority-setting schemes exist to date (Brooks et al. 2006). While attracting large sums of funding and donor support (Myers & Mittermeier 2003), the scales and subsequent coarse resolution data of these models are too general for pragmatic on-the-ground conservation planning and implementation efforts (Margules & Pressey 2000). As an effort to assist with facilitating an operational-level plan, this thesis outlines development of a stakeholder-informed, regional conservation strategy, which involved working with conservation practitioners in the Upper Oconee subbasin of northeast Georgia (Figure 1.1). The Upper Oconee subbasin is not a region of high species richness and does not contain many documented rare species (GA DNR 2005); however, there are ecosystems and ecological functions highly valued by local watershed residents. Therefore, I modeled conservation features that encompass ecosystems and ecological functions identified as important by the conservation practitioners.

The conservation practitioners involved with the development of this thesis were the Oconee River Land Trust (ORTL) and Athens Land Trust (ALT), both of which operate in the Upper Oconee subbasin as 501(c)(3) non-profit land conservation organizations. The Oconee River Land Trust was formed in 1993 with the mission "to conserve natural lands to protect water quality, preserve wildlife habitat, and enhance the quality of our lives and those of future generations." They "are committed to preserving many different types of land including forests, river and stream corridors, wetlands, wildlife habitat, productive farms and timberland, historic sites and scenic views" (ORLT 2009). They currently own one property and hold 26 conservation easements on over 1900 acres of land. The Athens Land Trust was formed in 1994 with a mission "to promote quality of life through integration of community and the natural environment by preserving land, creating energy-efficient and affordable housing, and revitalizing neighborhoods" (ALT 2009). They currently hold 16 easements on over 800 acres of land.

While both land trusts are dedicated to preserving the natural environment, ORLT focuses more on traditional conservation values, such as water quality, wildlife habitat and corridors, and ALT focuses on preservation of farmlands and historic sites, which emphasize the cultural components of conservation. Due to the associated difficulties of spatially mapping cultural values, my thesis research caters more to the core mission of ORLT and the peripheral mission of ALT of preserving traditional conservation features associated with ecosystems and their ecological functions, as mentioned previously. The results presented in Chapter 3 demonstrate the different primary missions of the two land trusts, and how the current modeling process is biased towards the mission of ORLT.

The remaining portions of Chapter 1 are broken into four sections. Each of these sections consists of a review of the literature relevant to the thesis topic, and an explanation of how my thesis situates itself in the context of the topics. The first section covers the ecological importance and rising popularity of private land conservation. As a result of meetings with ORLT and ALT staff and board members, as well as conversations with Georgia Department of Natural Resources (DNR) personnel, we realized that the conservation features selected for the modeling process closely aligned with a subset of qualifying criteria found in state legislation regarding conservation values, the Georgia Land Conservation Program (GLCP). The GLCP is the topic of the second section. Further, as a consequence of a peripheral focus of on ecosystems and their ecological functions, it is relevant to define and briefly review ecosystem services, which is in section three. Finally, section four is a literature review of the history of spatial priority strategies for conservation since the early 1980s, which explores the roles of species richness indicators and biogeographic regions in the prioritization process. This final section also examines the trajectory of each of these roles as well as the popularity of contemporary modeling processes for conservation priorities, namely reserve selection algorithms.

PRIVATE LAND CONSERVATION

In the United States, motivating private landowners to engage in conservation is essential for successful protection of ecological processes and biodiversity (Merenlender et al. 2004; Rissman et al. 2007; Scott et al. 2001; Wilcove et al. 1996). Estimates of the distributions of threatened and endangered plant and animal species suggest that greater than 90% occur on private lands, while two-thirds of these species are estimated to have more than 60% of their habitat on such lands (GAO 1994; Groves et al. 2000). The United States public lands system was originally established in the early 20th century in areas having high recreational and/or aesthetic value and without commercial interest and human presence (Pressey 1994)[1]. These areas were not designated using biological parameters; thus, much of the currently held public lands do not protect regions of valuable ecological functions or high biodiversity. Using two criteria as proxies for biodiversity, elevation and soil productivity, Scott et al. (2001), found that the majority of U.S. nature reserves (i.e. national parks, national forests, designated wilderness areas, national wildlife refuges, Indian reservations, and county parks) are at high elevations in regions of low soil productivity. This is in contrast to the biogeographical distribution estimates of most species, which are found at low elevations on higher productivity soils (Scott et al. 2001). Additionally, Noss et al. (1995) observed that 126 ecosystems in the U.S. are in at least a threatened state, indicating loss of valuable ecosystem processes. This suggests that with less

[1] It is important to recognize that there was not always a lack of human presence in these areas. They were often inhabited by Native Americans (Spence 1999).

than 6% of the conterminous U.S. in nature reserves (Scott et al. 2001) that the majority of these ecosystems and their processes occur on private lands. Further, the 1973 Endangered Species Act (ESA) protects federally listed species from direct loss of life and habitat loss, but a paucity of legislation requiring the protection of ecological functions and/or biodiversity currently exists. Thus, the prevalence of these features on private lands and the scarcity of legislation afforded to their protection suggest that engaging private landowners with a voluntary, incentive-based route to conservation is critical.

The prevalent route for involving private landowners with conservation is through partnerships with land trusts, which are non-profit, non-governmental organizations (NGOs) that operate at scales ranging from the international and national level (e.g. The Nature Conservancy) to state (e.g. Georgia Land Trust) and local levels. Land trusts and private landowners enter into a contractual deed of conservation easement, defined as, "a voluntary legal agreement between a landowner and another party that restricts the development of a tract of land" in order to protect conservation values (Fowler 1998).[2] Essentially, a private landowner that enters into an easement agreement surrenders certain development rights to the property while maintaining legal ownership of the land. The terms of the easement are unique to each property. Hence, each easement agreement includes various restrictions and reservations of land use. Examples of rights that are often restricted include subdivision of the property, construction in sensitive areas, clear cutting of timber, and alteration of the topography. Examples of rights that are often reserved include hunting, farming, selective timber harvesting, and development in specific areas of the property.

[2] Land trusts also purchase property, called fee simple acquisition.

Requirements for receiving federal tax benefits for conservation easements stipulate meeting one of four conservation values as defined by Internal Revenue Code (IRC), Section 170 (h) (Table 1.1). State level qualifications for receiving state tax benefits for conservation easements are determined by Georgia legislation and the discretionary assessment of the Department of Natural Resources (DNR), but were formerly assessed by meeting one of the ten conservation purposes listed in Table 1.2[3]. Additionally, conservation easements must be held by qualified organizations, as defined in IRC, Section 170(h)(3). Land trusts normally meet this designation under law.

The majority of land trusts are run by volunteers and have limited or no professional staff; hence, landowners often initiate the easement process rather than land trusts that have identified the most environmentally sensitive lands within their jurisdiction. This is motivating the scientific community to provide practitioners of private land conservation with a stakeholder-informed, scientifically-driven model for recruiting easements. Another incentive is the rapid proliferation of land trusts across the U.S. over the past decade. Over the five year period 2000 – 2005, the number of land trusts registered with the Land Trust Alliance (LTA, a national-level umbrella organization for land trusts) increased by 32% to nearly 1700 organizations (LTA 2005). The acreage of land held under conservation easements by these organizations more than doubled in the same five-year period to 37 million acres (LTA 2005), which is nearly 2% of the conterminous U.S. land area using Scott et al.'s (2001) estimate of approximately 1.9 billion

[3] While this project was being conducted, the Georgia Legislature modified House Bill 1274 in April 2008. One of the modifications effectively changed the requirement for receiving tax benefits for a conservation easement from meeting at least one of the ten conservation purposes in Table 1.2 to a discretionary decision by GA DNR.

acres total. Considering nature reserves constitute only about 6% of the conterminous U.S., this percentage is significant (Scott et al. 2001).

Furthermore, both the U.S. Congress and many state legislatures have recognized the public benefit of private land conservation through easements by increasing the associated income and property tax incentives. Congress increased the tax deduction for the years 2006 – 2009 from 30% of adjusted gross income (AGI) over six years to 50% of AGI over 16 years (100% for ranchers and farmers) in August 2006, retroactive to January 1st of that year (IRC, Sec. 170(h)). At least 12 states currently offer tax incentives programs (Pentz 2007; Younge 2008). The 2006 Georgia Conservation Tax Credit Act (H.B. 1107) established Georgia's first state tax credit for landowners entering into conservation easements and was amended by H.B.1274 in 2008. The resulting incentives allow for a state tax credit of 25% of the fair market value of the easement up to $250,000 for individuals, $500,000 for corporations, and $1,000,000 for partnerships, applied over eleven years. A tax credit is different from a deduction in that the credit is a direct subtraction from taxes owed, rather than a deduction on taxable income, as with the federal incentives program. Local governments have joined the bandwagon by providing property tax reductions where the fair market value has been reduced because of the encumbrance on the property's value. These economic incentives programs indicate governmental recognition of the importance of private land conservation and have stimulated it since their inception (LTA 2005; Roe & McKay 2008). Thus, the need for projects that bridge the gap between scientific research and conservation practice are becoming increasingly important for private land conservation.

Yet another need is an assessment of conservation features currently protected by conservation easements. These data do not currently exist because published data are too aggregated (Merenlender et al. 2004). For land trusts and other conservation organizations to develop conservation strategies, a clear regional perspective of what is protected and how much of it is protected needs to be ascertained. Further, Rissman et al. (2007) undertook an analysis of 119 easements held by TNC and found that habitat disturbance and fragmentation are likely to occur on these tracts as a result of the terms of the easements, which can lead to the loss of ecological functions or species. Thus, the land trust community needs scientific research that informs easement recruitment, drafting, and management to prevent potential habitat fragmentation and loss of functions and species. An objective of this thesis is to provide ORLT and ALT with estimates of the modeled conservation features protected on existing easements and other conservation lands, which will help the land trusts develop a conservation strategy within a regional planning context.

GEORGIA LAND CONSERVATION PROGRAM

The Georgia Land Conservation Program (GLCP) was created in 2005. It provides state-funded grants and loans for fee simple acquisition or conservation easements to qualifying entities for approved land conservation projects. Eligible entities include cities, counties, the Georgia Forestry Commission (GFC), other state departments and agencies, and nongovernmental organizations, which may apply to the Georgia Environmental Facilities Authority (GEFA) with proposals for land conservation projects. Both GEFA and the Georgia Department of Natural Resources (DNR) review land conservation project proposals and make recommendations to the Georgia Land Conservation Council (GLCC), which makes the final decision regarding acceptance or denial of the proposal for funding.

Funding for the GLCP is available from two sources: 1) the Georgia Land Conservation Trust Fund, and 2) the Georgia Land Conservation Revolving Loan Fund. Grants from the Trust Fund are available to DNR, GFC, other state departments and agencies, cities, and counties.

Loans from the Revolving Loan Fund are available to cities, counties, and non-profit organizations, and are subject to interest rates set by GEFA. Money from either source must be used solely to defray the expenses of conservation land or conservation easements that meet the values defined in O.C.G.A. Sec 12-6A-2.

All three reviewing entities (GEFA, DNR, and GLCC), especially DNR, use scoring criteria that quantify the value of "conservation land" for each proposal as laid out by Georgia law (O.C.G.A Sec. 12-6A-1) (Table 1.2). As mentioned in the Introduction section, a subset of these ten scoring criteria were used in this thesis's modeling process to evaluate and rank lands in the Upper Oconee subbasin for conservation value. The conservation features and scoring procedure are reviewed in detail in Chapters 2 and 3.

As of February 2009, the GCLP has supported land conservation projects amounting to over 100,000 acres through grants, loans, and tax credits. Fifty-four of these projects have received grants and/or loans, while eighty-seven of them are recipients of Georgia state tax credits as described in the previous review section, totaling approximately 70,000 and 30,000 acres, respectively. These numbers indicate a significant positive impact on Georgia land conservation.

ECOSYSTEM SERVICES

Biodiversity has been the target of conservation efforts for at least two decades (Wilson et al. 1988). However, emphasizing the interdependency of ecological processes and human livelihood to area residents is important in addition to species richness indicators. The concept of ecosystem services recognizes this interdependency. It is not a new idea, dating from the early 1980s (Ehrlich & Mooney 1983), but has recently been popularized (Costanza et al. 1997; Daily 1997; Daily & Matson 2008; MEA 2005; Turner et al. 2007). As defined by the United Nations' Millennium Ecosystem Assessment, ecosystem services are those environmental "goods and services provided by nature for the benefit of human welfare" (MEA 2005). The idea of ecosystem services allows for acknowledging more than the "intrinsic" value of biodiversity by expanding the breadth of the conservation argument to include the "utilitarian" values of nature (Daily 1997; Egoh et al. 2007).

The MEA defines four broad categories of ecosystem services including: provisioning, regulating, supporting, and cultural services. Examples of these include food production and fresh water supply; erosion and flood regulation; primary production; and aesthetic and historic values, respectively. While this thesis does not attempt to quantify the value of the ecosystem services provided by specific ecological functions or ecosystems, the conservation features used in the modeling process are aligned with conservation values that resemble the aforementioned ecosystem services. These values include water quality, flood regulation, erosion regulation, and food production.

SPATIAL PRIORITY STRATEGIES FOR CONSERVATION

Unprecedented globalization rates, human disturbances of natural environments, population pressures on limited natural resources, and loss of critical habitat from land conversion to agricultural and urban areas have all led to development of multiple conservation planning schemes. Determining the best method or set of methods and the appropriate scale for achieving the most efficient and comprehensive conservation planning scheme is a challenging task. Conservation planners have developed strategic plans and classification schemes for more than three decades (Udvardy 1975). Many of these strategic plans emphasize spatial conservation options as well as temporal options (Brooks et al. 2006). Units of analysis range from species hotspots (Mittermeier 2004), measured by an area's species richness and/or species endemism to biogeographic or ecoregional models delineated by ecoclimatic characteristics and physiographic boundaries (Jepson & Whittaker 2002). Proponents of the biogeographic approach often cite the significance of protecting ecological functions that species depend on for survival (Olson & Dinerstein 2002). These are complex and complicated choices that conservation planners make when creating priority schemes. Further complications are associated with assessing the benefits and costs of opportunistic, or *ad hoc*, conservation (Knight & Cowling 2007) versus systematic, or planned, conservation efforts and action. Here, the focus is on systematic conservation planning, defined as any strategic method for spatially identifying priority areas for conservation. This is a more generalized definition than is associated with reserve selection algorithms (Margules & Pressey 2000), reviewed later.

Regardless of the obstacles, conservation efforts must proceed, although with caution and self-reflection, constantly updating methods and practices to achieve the goals of protecting diversity of genes, species, ecosystems, and natural processes. It is difficult to achieve these goals without acknowledging that the tree of conservation has roots that weave through multiple disciplines. Conservation is about managing human-environment interactions, and about understanding these practices and the associated tradeoffs between use of natural resources and conservation of resources and biodiversity at multiple levels (Agrawal & Redford 2006). Achieving these goals requires a multi-disciplinary, integrative approach, accomplished through collaboration of researchers from diverse backgrounds including: anthropology, biology, ecology, economics, geography, and others. With this recognition, this thesis is concentrated on the ecological component.

Biogeographical Representation

Following the save-species campaigns of the late 1970s and early 1980s focused on flagship species, conservation practitioners popularized a biogeographic approach and the importance of protecting ecosystems and critical habitat for their constituent species. One of the first attempts at standardizing a spatial framework for conservation planning was a World Conservation Union (IUCN) commissioned study (Udvardy 1975) that was comprised of two independent studies with similar paths: Dasmann (1973) and Udvardy (1969) (reviewed in Jepson & Whittaker 2002). It aims to classify communities by unique ecoclimatic features while maintaining taxonomic distinctiveness, which is achieved through developing a hierarchical system of classification for regional biogeographic realms and macro-scale biogeographic provinces.

Biogeographic realms are delineated by ecoclimatic factors that follow Clements and Shelford's biome system and taxonomic distinctiveness using Wallace's faunal regions (in Jepson & Whittaker 2002). As subunits of realms, biogeographic provinces are delineated by vegetation climax communities and arbitrary taxonomic differences of areas having 65%, or two-thirds, of their species in common. The IUCN commissioned further studies to operationalize the Dasmann-Udvardy system in Indonesia, as well as the Indo-Malayan and Afrotropical Realms (in Jepson & Whittaker 2002). The IUCN researchers developed a third tier in the hierarchy called biounits to capture the finer spatial scale for implementation. This third tier also included equal representation of habitat and taxonomic units, following the Dasmann-Udvardy system (Jepson & Whittaker 2002). A more recent biogeographic strategy by World Wildlife Fund blends the system above with the United States Forest Service's ecoregions (Omernik 1987) at the global level. This strategy produced the Global 200, the most irreplaceable ecoregions in the world (Olson & Dinerstein 2002).

Species Richness

In contrast to the ecoclimatic-driven models above, there are species-driven models. Early attempts at species priority-setting approaches were set by the World Conservation Union's

(IUCN) Species Survival Commission and the U.S. Endangered Species Office (Myers 1983). Beginning in 1988 with the publication of *Biodiversity* (Wilson et al. 1988), and the first prominent species priority-setting approach for conservation (Myers 1988), many regional and global level conservation strategies emphasized species richness and species endemism as the fundamental criteria by which to value conservation priorities.

The call for a prioritization scheme that follows a ranking system of species importance and threats of habitat loss was a relatively new concept that acknowledged the limited funding and personnel resources within conservation (Myers 1983, 1988). This methodological approach of developing a priority-ranking system of threatened species and including exceptional-value ecosystems was promulgated by Myers (1983). The tactic subtly called for the reorientation of conservation efforts from one focused on single species to one having a multispecies and systems-oriented emphasis, akin to the Dasmann – Udvardy system, but with more emphasis on species endemism numbers and threat levels. This call lead to a wave of changes and, ultimately, a paradigm shift in conservation planning efforts over the following two decades by reorienting the conservation agenda towards a spatially structured, hierarchical system of ranked geographic locations or conservation priority areas.

Reserve Selection Algorithms

Reserve site selection entails developing a strategy to protect the biodiversity of species, ecosystems, and/or natural processes, defined as conservation features, which have specific operational targets, or quantities of representation (Margules & Pressey 2000). From a biological perspective, the best practice for achieving efficient conservation is through a reserve selection algorithm, or iterative process, that minimizes the number or total area of sites needed to conserve the maximum representation of targets (Pressey & Nicholls 1989). As reviewed in

Pressey (2002), Kirkpatrick (1983) was the first to utilize an iterative method to maximize representation targets. Pressey reviews five other independent lines of thought that led to similar conclusions (Ackery & Vane-Wright 1984; Game & Peterken 1984; Margules et al. 1988; Rebelo & Siegfried 1990; Thomas & Mallorie 1985). The shared theme was efficient representation of targets through minimal redundancy in reserves, which was later coined complementarity (Vane-Wright et al. 1991). The popularity of reserve selection algorithms has grown rapidly, especially since the late 1990's (Figure 1.2). Pressey's (2002) review found 245 references in the Information Science Institute's (ISI) database mentioning reserve selection algorithm for the years 1980 - 2000. He did not publish specifics of his search term(s) for the database; hence, replication of his references was not possible. However, a search for "reserve selection" in ISI's Science Citation Index – Expanded for the years 1983 – 2008 found 463 references, extending the increasing trend shown by Pressey through 2006 (Figure 1.2). The year 2008 was not complete at the time of the search and may explain the low yield for that year.

While not able to draw any conclusions of its effects, an interesting side note worth mentioning is the release of the Environmental Systems Research Institute's (ESRI; Redlands, CA USA) first user-friendly GUI (graphical user interface), the ArcView GIS (geographic information system) software program in 1992. Many authors would agree that the advent of new technologies and software programs have strongly influenced conservation planning and practice (Brosius 2006; Brosius & Russell 2003; Hazen & Harris 2007; Olson et al. 2001). The year 1992 was the beginning of rapid growth of reserve selection algorithms in science (Figure 1.2).

Building upon the fundamental concept of complementarity, Pressey et al. (1993) added the components of flexibility and irreplaceability. Flexibility implies that there are alternative reserve networks or various site combinations for achieving conservation of representation targets, which allow managers and decision-makers alternative scenarios for implementing efficient conservation. Irreplaceability is a measure of a site's conservation value, indicating the relative importance of a particular site to a reserve network's achievement of its representation targets (Pressey et al. 1993). For example, a site with high irreplaceability likely contains a conservation feature not represented in other sites in the reserve network. Margules and Pressey (2000) expanded these concepts into an explicit six stage operational model for systematic conservation planning designed to protect biological diversity (Table 1.3). They emphasized two key components for any plan: 1) species representativeness, and 2) species persistence.

The popularity and influence of Pressey et al. (1993) and Margules and Pressey (2000) are clearly demonstrated by the number of citations of these seminal works as found in a search of ISI's Science Citation Index – Expanded database (Figure 1.3). The numbers of author-excluded citing references are 394 and 463, respectively. A search for the phrase "systematic conservation" in the ISI database further reveals the extended effects of Margules and Pressey's (2000) six-stage operational model on conservation planning (Figure 1.4).

Two fundamental concepts taken from these seminal works are irreplaceability, or measures of spatial conservation options, and vulnerability, or measures of temporal conservation options (Margules & Pressey 2000). Vulnerability was first recognized as important by Myers (1983) in his call for a priority-ranking strategy for species. Myers (1988; 2003) measured vulnerability using deforestation rates in his well-known global level analysis for biodiversity hotspots. These two concepts are in numerous spatial conservation planning models. Brooks et al. (2006) conceptualized a framework for nine global-level conservation assessments using one or both of these criteria (Figure 1.5). While not an exhaustive list, there are even more examples of regional level assessments that use these concepts (Cowling & Pressey 2003; Hughey et al. 2003; Kremen et al. 2008; Noss et al. 2002; O'Connor et al. 2003; Rodriguez & Young 2000; Shi et al. 2005; Smith et al. 2008; Wikramanayake et al. 1999).

In conclusion, systematic conservation planning has widened its vision from a single species-oriented perspective to a broader scope, which includes species richness and endemism, as well as the ecological functions harnessed in biogeographic areas, or ecoregions. This transition acknowledges the importance of ecosystems and ecological processes, and their critical role in the preservation and quality of life for all biota, including humans.

Through reviewing conservation priority modeling, I intended to demonstrate to the reader that I acknowledge the importance of this progression in priority modeling. I recognize the fundamental concepts of irreplaceability, vulnerability, complementarity, flexibility, and species richness as important to the priority process, though not explicitly included here. Steps 2 – 4 of Margules and Pressey's conservation planning process are the concentration of my thesis (Table 1.3). Further, the focus on the GLCP criteria affords the stakeholders (land trusts) potential opportunities to secure loans for acquisition of easements based on the identified priority areas. As reflected in the GLCP, areas with equal scores have equal potential for acquiring funds for conservation easement purchasing. Thus, I decided in the early planning phases to choose a scoring procedure over an iterative one, as found in selection algorithms. In addition to evaluating all parcels in the subbasin, I conducted a separate analysis of the conservation features currently protected by existing conservation lands. This provided the land trusts with the necessary information to achieve representation targets of specific features by placing the identified priority areas in a regional planning context. Finally, a database of results allows the land trusts flexibility in planning through provision of the relative cover for each conservation feature in each analysis unit.

Table 1.1: Conservation purposes as defined by Internal Revenue Code, Section 170(h)(4)(A). These four purposes are used to evaluate conservation easements for federal tax deduction requiremments.

Conservation Purposes
i. the preservation of land areas for outdoor recreation by, or the education of, the general public,
ii. the protection of a relatively natural habitat of fish, wildlife, or plants, or similar ecosystems,
iii. the preservation of open space (including farmland and forest land) where such preservation is – I. for scenic enjoyment of the general public, or II. pursuant to a clearly delineated Federal, State, or local governmental conservation policy, and will yield a significant public benefit, or
iv. the preservation of a historically important land area or a certified historic structure.

Table 1.2: Georgia Land Conservation Program Criteria. Ten criteria that define "conservation land" for Georgia policy. Each of the ten criteria is associated with a set of questions used for quantifying the conservation value of a land conservation project. Subsets of the questions for the seven criteria boxed in red were used in the conservation modeling process in this thesis.

Georgia Land Conservation Program Criteria
1. Water quality protection for rivers, streams, and lakes;
2. Flood protection;
3. Wetlands protection;
4. Reduction of erosion through protection of steep slopes, areas with erodible soils and stream banks;
5. Protection of riparian buffers and other areas that serve as natural habitat and corridors for native plant and animal species;
6. Protection of prime agricultural and forestry lands;
7. Protection of cultural sites, heritage corridors, and archaeological and historic resources;
8. Scenic protection;
9. Provision of recreation in the form of boating, hiking, camping, fishing, hunting, running, jogging, biking, walking, and similar outdoor activities; and
10. Connection of existing or planned areas contributing to the goals set out in this paragraph (O.C.G.A. Sec. 12-6A-1).

Table 1.3: An operational six stage model of systematic conservation planning summarized from Margules and Pressey (2000).

Six Stages of Systematic Conservation Planning
1. Measure and Map Biodiversity
2. Identify Planning Region Conservation Goals
3. Review Existing Reserves
4. Select Additional Reserves
5. On-the-ground Implementation
6. Management and Monitoring of Reserves

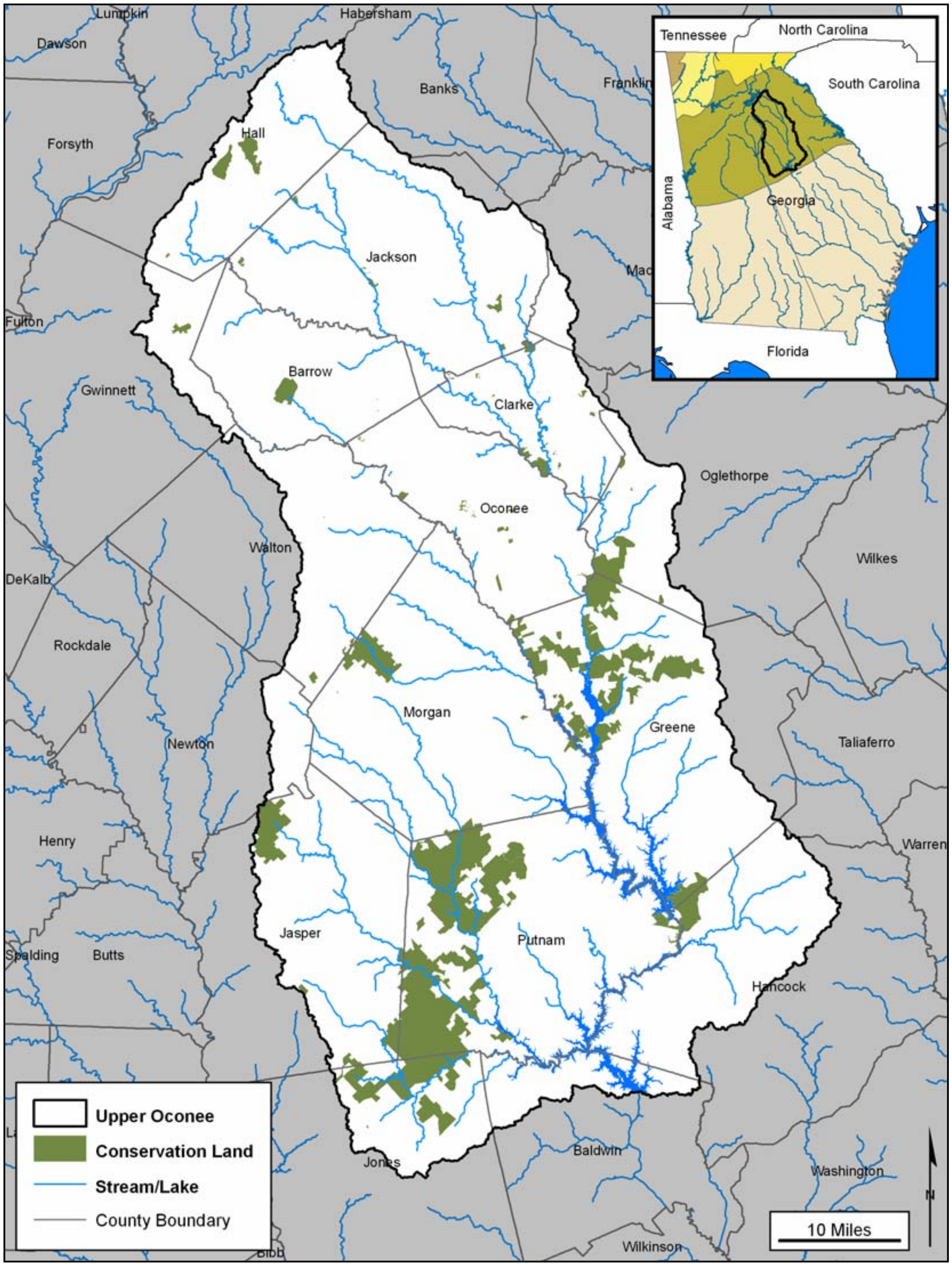

Figure 1.1: Study Region. Upper Oconee subbasin of the Piedmont Physiographic Province and Southeastern Conifer and Broadleaf Forest Ecoregion in Northeast Georgia.

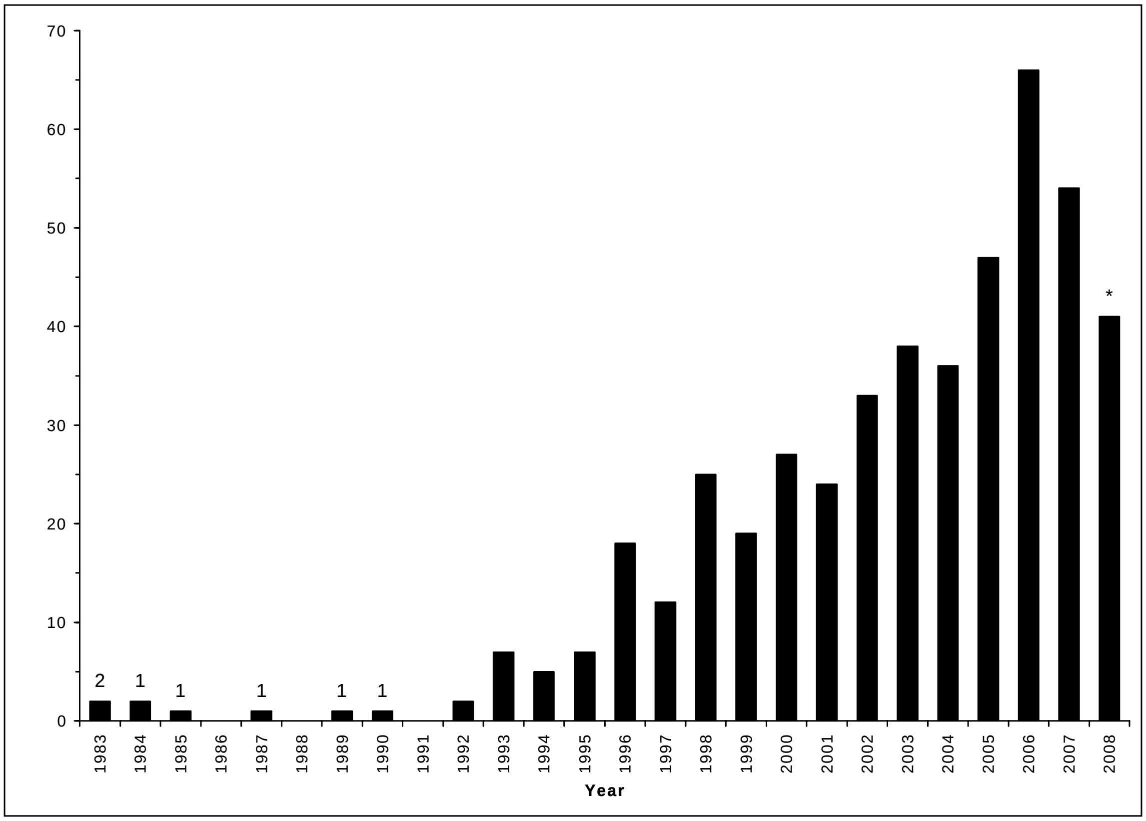

Figure 1.2: A database search for the phrase "reserve selection" in the Information Science Institute's Science Citation Index - Expanded on November 28th, 2008 showing the number of publications per year since 1983. Numbers above years indicate seven publications not found in database search that are taken from Pressey (2002). Game and Peterken (1984) is the first publication found using the phrase "reserve selection" in the database search. *2008 is incomplete.

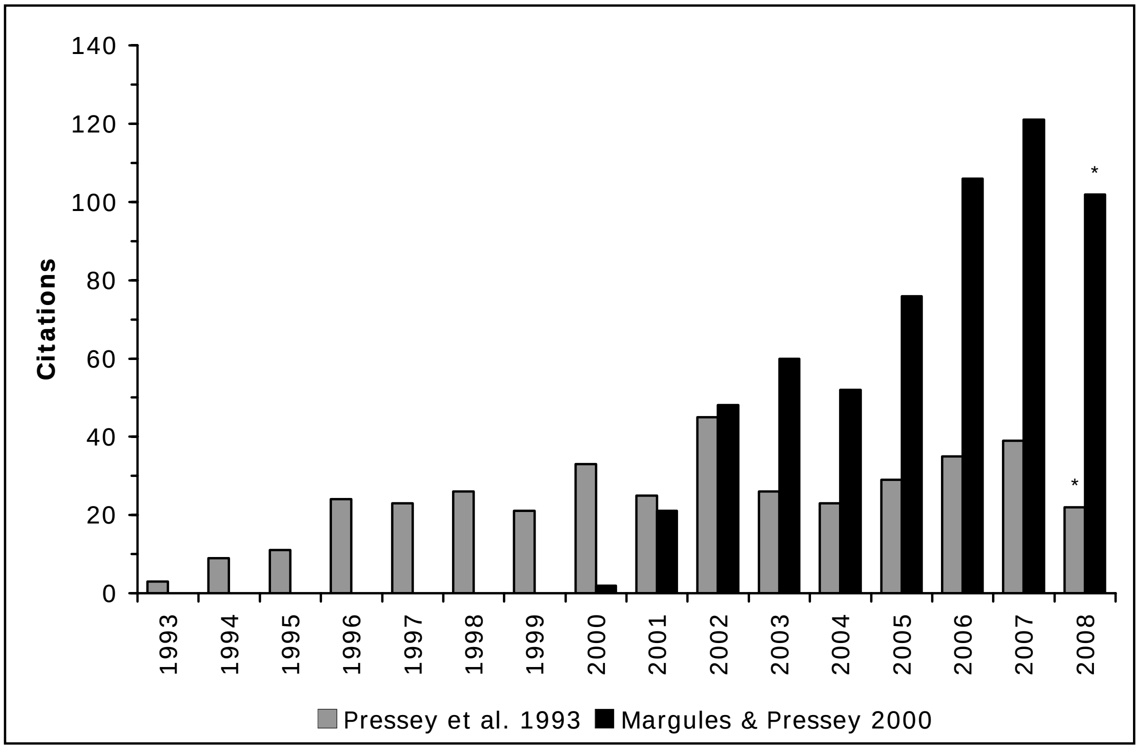

Figure 1.3: Author excluded citations of Pressey et al. (1993) and Margules and Pressey (2000) found in a database search of the Information Science Institute's Science Citation Index - Expanded on November 28th, 2008. Totals are 394 and 588, respectively. *2008 is incomplete.

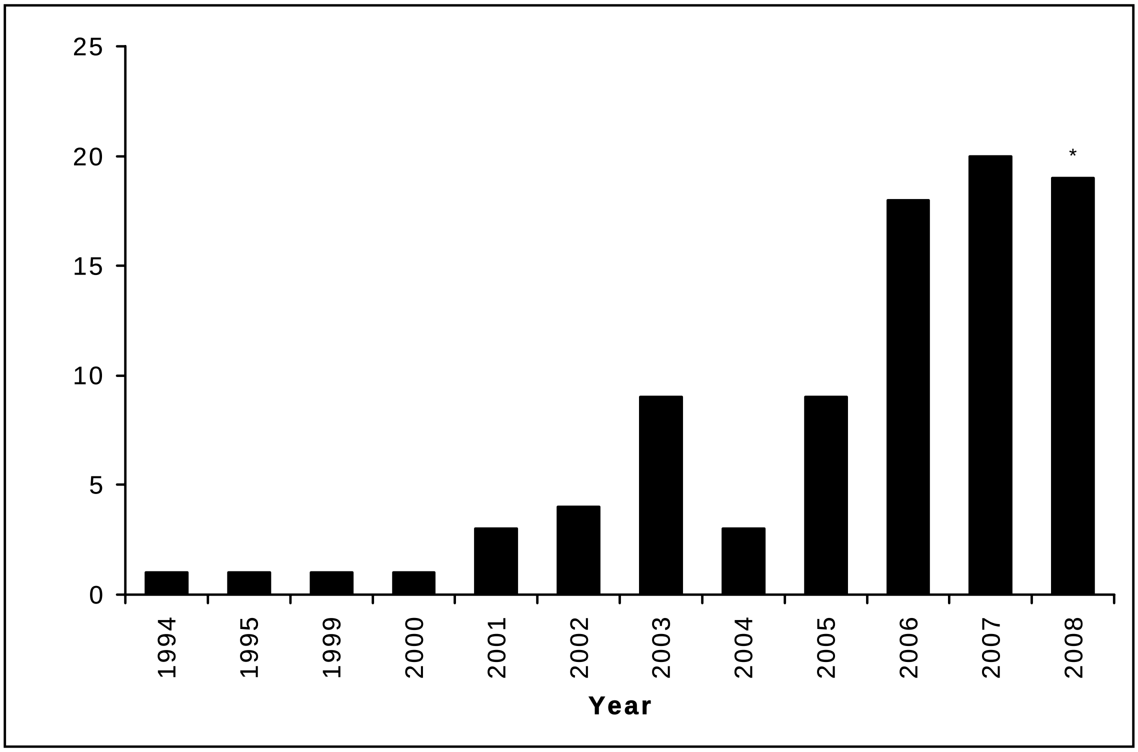

Figure 1.4: A database search of the phrase "systematic conservation" in the Information Science Institute's Science Citation Index - Expanded on November 29th, 2008. 89 references were found. *2008 is incomplete.

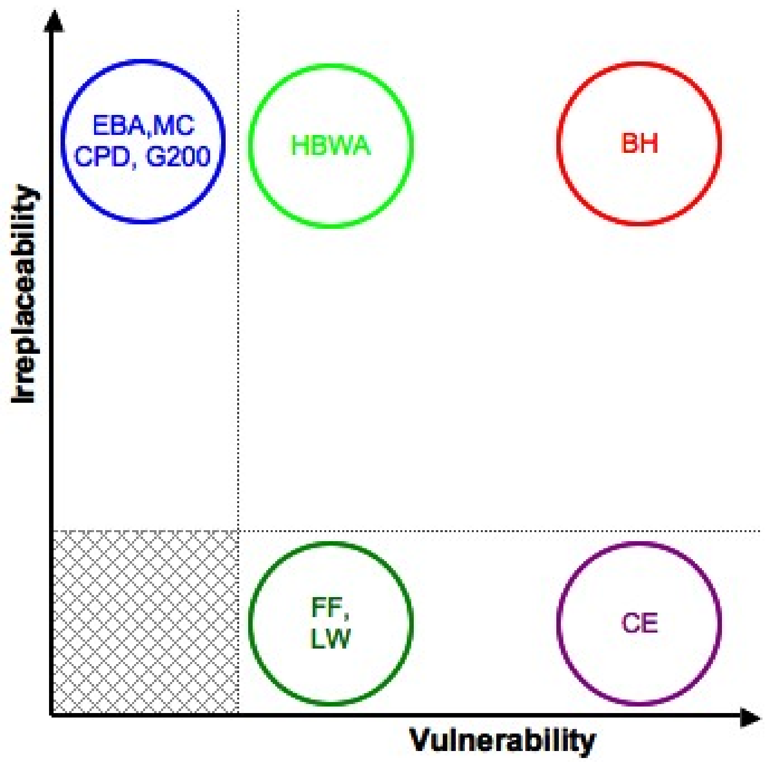

Figure 1.5: Conceptual framework of irreplaceability and vulnerability for nine global conservation priority strategies modified from Brooks et al. (2006). Strategies below the irreplaceability dashed line do not include irreplaceability criteria. Strategies to the left of the vulnerability dashed line do not include vulnerability criteria. CE = Crisis Ecoregions, BH = Biodiversity Hotspots, EBA = Endemic Bird Areas, CPD = Centres of Plant Diversity, MC = Megadiversity Countries, G200 = The Global 200 Ecoregions, HBWA = High Biodiversity Wilderness Areas, FF = Frontier Forests, LW = Last of the Wild.

CHAPTER 2

METHODS FOR MODELING CONSERVATION FEATURES AND IDENTIFYING CONSERVATION PRIORITY AREAS

For the conservation assessment of the Upper Oconee subbasin, I chose nine conservation features that stakeholders identified as important and that could be mapped with the ArcGIS Desktop software (ESRI, Redlands, CA). I created or acquired the eleven datasets used for evaluating the conservation features, as necessary (Table 2.1). The scale (1:100,000) and subsequent accuracy of the coarsest datasets allowed for analysis units equal to or greater than five acres. As mentioned in Chapter 1, two types of analysis units were used to evaluate the conservation features: 1) parcels, and 2) five acre blocks (see Figure 2.1 for parcels ≥ 5 acres). I describe the methods for assessing the conservation features for both of these analysis units, and for identifying conservation priority areas in this chapter. Finally, to clarify terminology usage, anytime I refer to Priority Parcels by Parcel (PPP), I am referencing the parcel method results. This is in contrast to parcels identified as priorities via the block method, which are specifically called Priority Parcels by Block (PPB).

A target in conservation priority modeling typically refers to a goal or set of goals for the conservation features that are being modeled. These goals indicate a specific number of a species or a set geographical area to be identified for protection. As this model does not examine species numbers or their distributions, I identified an areal target for protection of 2.75% of the subbasin's area, which is 80.22 square miles. I chose this areal target because it would, if protected, raise the total area protected in the subbasin to 10%, an internationally recognized goal for the global protected area conservation network (IUCN 1992).

To identify these priority areas, I developed an additive model by assigning each analysis unit a score from a modified set of subcriteria drawn from the ten GLCP criteria (also refered to as factors in the GLCP document) previously used for evaluating land conservation projects (Table 1.2). The nine conservation features of this model, their scoring categories, and the associated GLCP criteria/factors (in abbreviated form) are shown in Table 2.2. In the following section, Conservation Features, I describe the methods for creating the nine conservation feature layers in Table 2.2 from the layers in Table 2.1, and justify the modifications to some of the original GCLP subcriteria. Further, I describe how I modeled each of these conservation feature layers to identify conservation priority areas in the subsequent section, Feature Modeling. In the final section of this chapter, Model Parameter Evaluation, I describe the methods for assessing the influence of each model parameter (which compose the conservation features) on the model outputs, as well as parameter correlations. I analyzed all features with ArcGIS Desktop 9.2 and three extensions: Spatial Analyst, Hawth's Analysis Tools (Beyer 2004) and ArcHydro 9.

CONSERVATION FEATURES

Input Layer 1: Natural Vegetation

Using Spatial Analyst, I combined the 2005 Georgia Land Use Trends (GLUT) forest classes (deciduous (41), evergreen (42), mixed (43), and forested wetland (91)) and used the higher class resolution of the 1998 GAP Analysis Project (GA GAP) land cover (Kramer et al. 2003) "natural vegetation" classes (i.e. rock outcrop (34), mesic hardwood (410), submesic hardwood (411), hardwood forest (412), xeric hardwood (413), xeric pine (423), xeric mixed pine-oak (432), mixed pine-hardwood (434), bottomland hardwood (900)) to exclude highly managed forest (i.e. 1998 open loblolly-shortleaf pine (422) and loblolly-shortleaf pine forest (440)) from my natural vegetation layer (Figure 2.2; see GA DNR 2005 for more detail on managed versus natural vegetation in the 1998 land cover data). The combination of the two natural vegetation layers removed these managed forest types from the 2005 forest layer, providing a more accurate depiction of the natural vegetation desirable for conservation. The natural vegetation scoring categories for the analysis units were taken directly from the GLCP criterion for natural vegetation cover under "Factor 1: Water Quality Protection for Rivers, Streams, and Lakes" with no modifications (GLCP 2009; Table 2.2).

Input Layer 2: Average Impervious Surface Cover of HUC 12 Subwatersheds

I assessed the percent impervious area within each United States Geological Survey (USGS) Hydrologic Unit Code (HUC) 12 subwatershed in the Upper Oconee from the 2005 GLUT dataset (Figure 2.3). Analysis units that had their centroid in these subwatersheds were then ranked accordingly per the four scoring categories in Table 2.2 for this conservation feature. Impervious surface cover was the only layer of the nine conservation features that was used as a negative indicator for conservation. In other words, lower percent imperviousness in the subwatershed resulted in a higher score for each analysis unit.

The impervious surface indicator was developed following the GLCP criterion under "Factor 1: Water Quality Protection…" as with natural vegetation cover (GLCP 2009). However, I made three modifications to the GLCP criterion. First, I used more recent 2005 GLUT data instead of 2001 National Land Cover Data for impervious cover estimates. Second, I chose HUC 12 hydrologic units over HUC 10 units because of their smaller size (420 km^2 versus 70 km^2 average for 10 and 12, respectively) and finer detail when summarizing percent impervious within a watershed. I chose smaller HUC 12 units over larger HUC 10 units to maintain the landscape context afforded by a watershed level extent on impervious surface cover, but to minimize the potential devaluing of analysis units many miles from urban centers. Third, I changed the break points for each category to adjust for ecologically significant breaks in watershed impervious cover. Arnold and Gibbons (1996) show watersheds with greater than 10% impervious cover are impacted. Thus, I modified original GLCP scoring category break points from 0.5, 2.0, and 5.0% to break points of 5.0 and 10.0%. Others show supporting evidence of watershed impervious surface cover of five percent or less as negatively affecting some sensitive species (Seth Wenger, Laurie Fowler, and Bud Freeman, *pers. comm.*), but the 2005 GLUT dataset has an accuracy of five percent, which prevents analysis at lower percentages.

Input Layer 3: 100-Year Flood Zones

I selected 100-year flood zone vector polygons from the Federal Emergency Management Agency's (FEMA) Q3 Digital Flood Insurance Rate Map (DFIRM) dataset (Figure 2.4). Flood zone data were unavailable for Greene, Hancock, Jasper, and Putnam Counties; hence, analysis units in these counties were not evaluated for this feature. The four scoring categories in Table 2.2 were taken directly from the GLCP criterion for flood zones under "Factor 2: Flood Protection" (GLCP 2009).

Input Layer 4: Headwater Streams

I extended the USGS National Hydrography Dataset (NHD) high resolution (1:24,000) stream network using USGS 30m National Elevation Data (NED) and a sixteenth mile catchment minimum in ArcHydro, because USGS stream lines have been shown to be an underestimate of actual headwater occurrences (Colson et al. 2008). Further, I assessed stream order in ArcHydro. I designated all first and second order streams as Headwater Streams (Figure 2.5). The four categories in Table 2.2 were used to score Headwater Streams in each analysis unit, which adheres to the GLCP criterion under "Factor 2: Flood Protection" (GLCP 2009).

Input Layer 5: Wetlands

I reclassified 2005 GLUT wetland data (forested wetland (91)) into a binary raster of wetlands and no wetlands for the Upper Oconee (Figure 2.6). The four scoring categories in Table 2.2 were modified from the GLCP criterion for wetland cover under "Factor 3: Wetlands Protection" (GLCP 2009). GLCP scoring categories are: imperiled and ecologically significant wetlands, ecologically significant wetlands, and wetlands, from high to low score. The 2005 GLUT land cover dataset that was available does not include identifiers for imperilment or ecological significance. Instead, I calculated the percentage of wetlands within each analysis unit (parcel or five acre block) and used the flood zone scoring categories to rank wetlands, as these two conservation features were considered to provide similar ecological functions such as water purification and filtration.

Input Layer 6: Steep Slopes

I calculated the percent slopes using USGS NED 30m DEM data and recoded them into steep slopes (≥ 20%) and not steep slopes (< 20%; Figure 2.7). Slopes ≥ 20% are referred to as Steep Slopes, henceforth. No modifications were made to the original GLCP criterion under "Factor 4: Reduction of Erosion through Protection of Steep Slopes, Areas with Erodable Soils, and Stream Banks" (GLCP 2009).

Input Layer 7: Georgia Wildlife Action Plan Priority Areas

I combined High Priority Watersheds (HPW) and Potential Conservation Opportunity Areas (PCOA) from the Georgia Wildlife Action Plan (GA WAP) to identify state conservation priority areas that were present in analysis units (GA DNR 2005; Figure 2.8). These areas were identified by a team of experts from DNR and other universities and state agencies. The experts chose these areas using occurrence of state species of concern, large intact natural vegetated habitat, and watershed level characteristics (GA DNR 2005). The sum total score for an analysis unit falling within HPWs and PCOAs was eight, which is higher than for any other conservation feature (five), because HPWs and PCOAs were not exclusive criteria, as with the other features' score categories (Table 2.2). I scored analysis units according to the criterion for this layer in Table 2.2 following the GLCP criterion under "Factor 5: Protection of Riparian Buffers and other Areas that Serve as Natural Habitat and Corridors for Native Plant and Animal Species" (GLCP 2009).

Input Layer 8: Prime Farmland Soils

I extracted a GIS vector polygon layer of those lands with prime farmland soils from 2001 NRCS SSURGO data (Figure 2.9). Data were not available for Greene and Hancock Counties; hence, analysis units were not evaluated for prime farmland soils in these counties. I did not include prime forestry lands as this designation required consultation with, and potentially field site visits by, the Georgia Forestry Commission under GLCP criterion, "Factor 6: Protection of Prime Agricultural and Forestry Lands" (GLCP 2009).

Input Layer 9: Landscape Connectivity

I created a composite corridor raster for landscape connectivity to both 2003 conservation lands in the GA DNR dataset and to 2005 PCOAs from the GA WAP (Figure 2.10). Two least cost distance rasters were generated using conservation lands and PCOAs as potential source populations, and recoded 2005 GLUT land cover and impervious surface data as cost rasters. The first cost distance raster was generated from GLUT land cover data, which were reclassed as: high passability (0) (from rock outcrop (34), deciduous (41), mixed (43), forested wetland (91), and wetland (93)); moderate passability (5) (from beach (7), open water (11), clear-cut and sparse (31), evergreen (42), row crops and pastures (81)); and low passability (20) (from low intensity urban (22) and high intensity urban (24)). The second cost distance raster was generated from the impervious surface data with values that ranged from low – high passability (0 – 20 = 0 – 100% cover, respectively), and indicated those areas with relatively high impervious surface cover as greater costs, which made roads and highways contiguous low passability zones in the final corridor raster.

I assessed the connectivity of each analysis unit to its neighbors by classifying units into three natural categories with Jenk's Optimization (natural breaks), which seeks to minimize within class and maximize among class standard deviations. I chose the three categories to follow the relative index as described by the GLCP criterion under "Factor 10: Connection of Existing or Planned Areas Contributing to the Goals Set Out in this Paragraph" (GLCP 2009), where the goals refer to: landscape connectivity, recreational connectivity, and regional and local conservation plans.

FEATURE MODELING

Parcel Method

For the parcel method, I collected county parcel data from the Northeast Georgia and Middle Georgia Regional Development Centers as well as Gwinnett County's Planning Department. Parcel data ranged from 2005 – 2007. Due to the data accuracy limitation mentioned above, I analyzed parcels greater than or equal to five acres that were not in the GA DNR 2003 conservation lands database. This resulted in analyzing 34,024 parcels of the 214,941 parcels in the Upper Oconee subbasin (Figure 2.1). It should be noted that there are errors in the parcel dataset, which are a result of assimilating parcel datasets from 18 counties. Errors include overlap, gaps, and double counting of some parcels. It would have been too time consuming to attempt to correct for these errors. However, I took precautions to ensure accuracy of the parcels in the final results by visually inspecting the Priority Parcels and comparing their boundaries and other available data (e.g. Parcel ID, acreage, etc.) with tax assessor data online (http://www.gaassessors.com).

The percentage of four of the nine conservation features within each parcel boundary was assessed for all parcels using Hawth's Analysis Tools' *Polygon in Polygon Analysis* tool for vector polygon shapefiles and *Zonal Stats ++* tool for rasters. I assessed the connectivity of each analysis unit to its neighbors with *Zonal Stats ++* tool and parcels were then assigned to one of the three Jenk's natural categories for passability: high, moderate, or low. Mileage of headwater streams for each parcel was assessed with Hawth's Analysis Tools' *Sum Line Lengths in Polygon* tool. I scored parcels with their centroids in GA WAP Priority Areas and in HUC 12 subwatersheds with a presence/absence criteria and respective scores from the score chart (Table 2.2). Nine layers of parcels scored for these nine conservation features were used in an additive model (Figures 2.2 – 2.10). The output was called the Baseline Model, with a range of possible scores for parcels from 1 – 48.

Additionally, a tenth parameter for parcels ranked parcel size into three categories of 5 – 99, 100 – 499, and ≥ 500 acres (Figure 2.11). The category break points were modified from the GLCP criterion of eligible acres for a conservation land project under Factor 6 (GLCP 2009). First, the parcel method assumes 100% of the parcel is available for conservation easement or fee purchase. Second, the category break points were adjusted from 100, 500, and 1000 acres to five, 100, and 500 acres because the lands trusts had not previously acquired tracts or easements on tracts over 1,000 acres. Thus, the break point of 1,000 acres would likely undervalue parcels within the land trusts' prior operational ranges of < 1 – 500 acres. These size categories were used to correct for area differences among parcels, described below.

A five acre parcel and a 500 acre parcel both with 50% natural vegetation cover are not of equal conservation value. As a corrective measure for parcel size variation, an Area-weighted Multiplicative (AWM) Model was run. This model is the product of the Baseline Model scores for parcels multiplied by the area-weighted factors of one, three, and five, mentioned above. The possible scores for parcels in the AWM Model range from 1 – 240. The reason that the range of possible scores has a minimum of one and not zero for both the Baseline and AWM Models is due to a score of ≥ 1 for the Landscape Connectivity feature (Table 2.2). The Priority Parcels by Parcel (PPP) were determined to be those with the highest scores that met the areal target of 2.75% of the subbasin.

Five Acre Block Method

I created the five acre block analysis units by casting a fishnet over the subbasin in ArcGIS and selecting those blocks that had their centroid in the subbasin. This resulted in 373,208 five acre blocks. The 100-year flood zone vector shapefile was converted to a 10m raster grid. Average percent cover for five of the nine conservation features for the blocks was computed using Spatial Analyst's *Zonal Stats* tool. I assessed the average connectivity value for each five acre block to its neighbors using Spatial Analyst's *Zonal Stats* tool and classified them into the three Jenk's categories for passability: low, moderate, and high. I calculated headwater stream mileage for all blocks using Hawth's Analysis Tools *Sum Line Lengths in Polygons Tool* and created raster grid with the headwater stream mileage values. I assigned blocks with their centroid in HUC 12 subwatersheds the appropriate percent impervious surface cover and scored them accordingly. Finally, five acre blocks with ≥ 50% GA WAP Priority Areas were considered located in a Priority Area.

As with the parcel method, identification of the parcels within or containing the highest scoring five acre blocks is necessary to facilitate the land trusts contacting landowners. An area-weighted score for each of the 214,941 parcels of the Upper Oconee subbasin was determined by summing the scores of all five acre blocks within each parcel. The highest scoring parcels, or Priority Parcels by Block (PPB), that met the 2.75% areal target for the subbasin were identified and compared with the PPP from the parcel method.

Further, as mentioned in Chapter 1, knowledge of currently protected features in a landscape context is important when developing a conservation plan. To evaluate landscape context of protected versus non-protected conservation features of interest, I assessed currently held land trust easements and existing conservation lands in the GA DNR 2003 dataset for the Upper Oconee subbasin using the scoring chart (Table 2.2). Finally, to provide the results of these analyses to the land trust staff in a usable format, I created a ©Microsoft Excel database and GeoPDFs by ©TerraGo Technologies (http://www.terragotech.com). The Excel database includes all of the results for each conservation feature for all analyzed parcels, easements, and conservation lands. I created GeoPDFs with the Map2PDF for ArcGIS extension by ©TerraGo Technologies. GeoPDFs are multilayer, geospatially-referenced PDFs capable of containing GIS layer attribute information. They are readable in the free ©Adobe Reader with the GeoPDF Toolbar also available from ©TerraGo Technologies.

MODEL PARAMETER EVALUATION

The nine conservation features can also be referred to as model parameters. The only feature that is not exactly the same as its model parameter is the GA WAP Priority Area feature. This feature is composed of two subfeatures, or model parameters, which are the Potential Conservation Opportunity Areas (PCOA) and High Priority Watersheds (HPW) from the Georgia Wildlife Action Plan. In order to evaluate the influence that each model parameter had on the outcome of both the parcel and five acre block methods, I performed a series of analyses with an n-1 approach, where n equals the total set of model parameters (n=11 for parcels and n=10 for five acre blocks). To accomplish this, I excluded each parameter from the model one at a time (n-1). Priority areas were then identified for each n-1 subset of n parameters for both methods. To facilitate comparison and relative parameter weight in each method, I calculated a community similarity index for each n-1 run and compared each with the total of n parameters. I used Sorensen's Similarity Index treating priority areas for parcels and blocks as "species", and each subset of n-1 parameters as a "community." Sorensen's Similarity Index follows as:

$$Ssi = 2C / A + B$$

where, C = shared number of species;

A = number of species from community 1;

B = number of species from community 2.

However, while 2.75% of the subbasin was the areal target for identifying priority areas, an area-correction factor was necessary to account for differences among totals from each n-1 subset, or "community." The unique total area for each n-1 subset was a result of many analysis units sharing the same score and the target area being bracketed within this score set. Developing a criterion to decide which analysis units with the same scores should be included over others was deemed unneccesary, and in the case of parcels, not possible because they vary in size. For example, choosing a cutoff score of 120 may select too large of an area, but choosing a score of

125 may select too small of an area. If there is no score between 120 and 125, then deciding which analysis units from the 120 score set should be included to meet the areal target would be tedious and subjective. To correct for this variation in area of each n-1 subset, I modified the Sorensen Similarity Index equation by correcting for area:

$$Ssa = (2C * Area_C) / (A*Area_A + B*Area_B)$$

where, C = shared number of priority areas;

$Area_C$ = total area of shared priority areas;

A = number of priority areas from n parameter output;

$Area_A$ = total area of priority areas from baseline output;

B = number of priority areas from n-1 parameter output;

$Area_B$ = total area of priority areas from n-1 parameter output.

Finally, in addition to the above series of processes and analyses, I calculated a Pearson's *r* correlation coefficient with the statistical program R (2009) for the binary form of eight model parameters and continuous form for the two continuous parameters (impervious surfaces and connectivity) to quantify the strength and direction of the linear relationship between any two parameters. Pearson's *r*:

$$r = \text{cov}(x, y) / (\alpha_x * \alpha_y)$$

where, cov (x, y) = covariance of variables x and y;

α_x = standard deviation of variable x;

α_y = standard deviation of variable y.

In the following chapter, I present the results of the modeling for the nine conservation features. Priority areas both from the parcel and five acre block methods are identified and compared and the results of the sensitivity analyses are presented.

Table 2.1: GIS Data Layers. Layers used for creating conservation feature layers, their sources, scales, and years. Abbreviations: UGA NARSAL (University of Georgia Natural Resources Spatial Analysis Lab), GLUT (Georgia Land Use Trends), FEMA Q3 DFIRM (Federal Emergency Management Agency Q3 Digital Flood Insurance Maps), USGS NED (United States Geological Survey National Elevation Dataset), DNR WAP (Department of Natural Resources, Wildlife Action Plan), NRCS SSURGO (Natural Resources Conservation Science, Soil Survey Geographic Database).

GIS Data Layer	*Data Source*	*Scale*	*Year*
Stream Order	Created in a GIS	1:100K	1999
Natural Vegetation	UGA NARSAL GAP & GLUT	1:100K	2005
Impervious Surface Cover	UGA NARSAL GLUT	1:100K	2005
Floodplains	FEMA Q3 DFIRM	1:24K	2001
Wetlands	UGA NARSAL GLUT	1:100K	2005
Terrain Slope	USGS NED	1:100K	1999
Potential Conservation Opportunity Areas	GA DNR WAP	1:100K	2005
High Priority Waters	GA DNR WAP	1:100K	2005
Prime Farmlands	NRCS SSURGO	1:24K	2001
Connectivity	Created in a GIS	1:100K	2005
Parcels	Counties & RDC	1:24K	2005 - 07

Table 2.2: Conservation feature score chart. Nine conservation features and their seven associated conservation values. Criteria used in scoring categories are drawn from the GLCP criteria, though some are modified (see text). Abbreviations: HUC (Hydrologic Unit Code); GA WAP (Georgia Wildlife Action Plan); PCOA (Potential Conservation Opportunity Area); HPW (High Priority Watershed).

Conservation Value	*Conservation Feature*	*Score*			
		5	3	1	0
Water Quality Protection	Natural Vegetation Cover (%)	75 – 100	50 – 74	25 – 49	0 – 24
	Impervious Surface Cover of HUC 12 Subwatershed (%)	< 5	5 – 10	-	≥ 1
Flood Protection	100-Year Flood Zone Cover (%)	≥ 50	25 – 49	1 – 24	< 1
	Headwater Streams (mi.)	≥ 1	0.5 – 0.9	0.1 – 0.4	< 0.1
Wetland Protection	Wetland Cover (%)	≥ 50	25 – 49	1 – 24	< 1
Erosion Reduction	Steep Slopes (%)	≥ 50	25 – 49	1 – 24	< 1
Habitat Protection	GA WAP Priority Area	PCOA	HPW	-	-
Agricultural Land Protection	Prime Agricultural Soils (%)	≥ 66	33 – 65	5 – 32	< 5
Landscape Connectivity	Connectivity to Conservation Lands & PCOAs	High	Moderate	Low	-

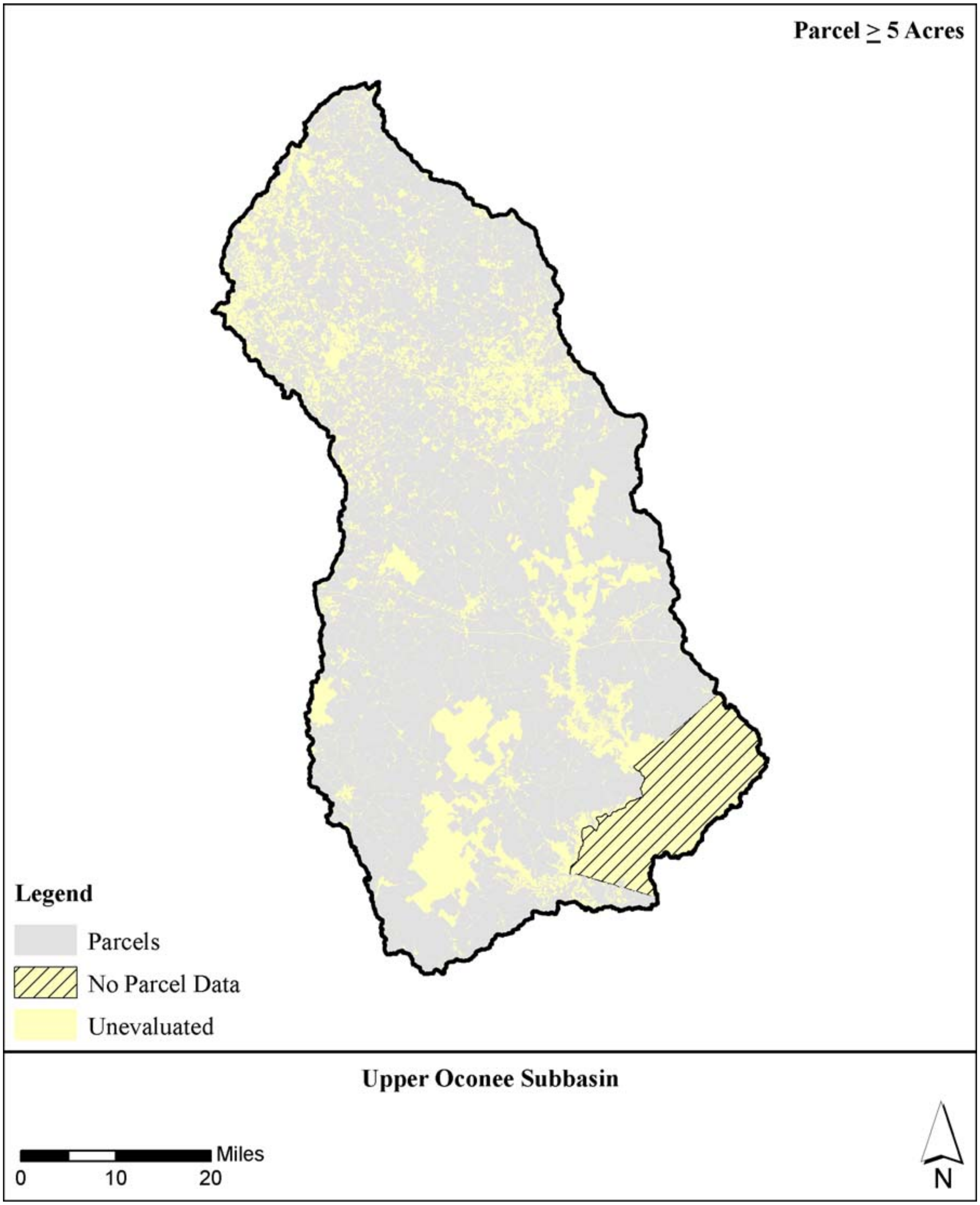

Figure 2.1: Parcels analyzed with parcel method. Extent of parcels (grey area) five acres or greater that were analyzed in the model, excluding conservation lands. No parcel data were available for Hancock County in the SE corner. Parcel dates range from 2005 to 2007.

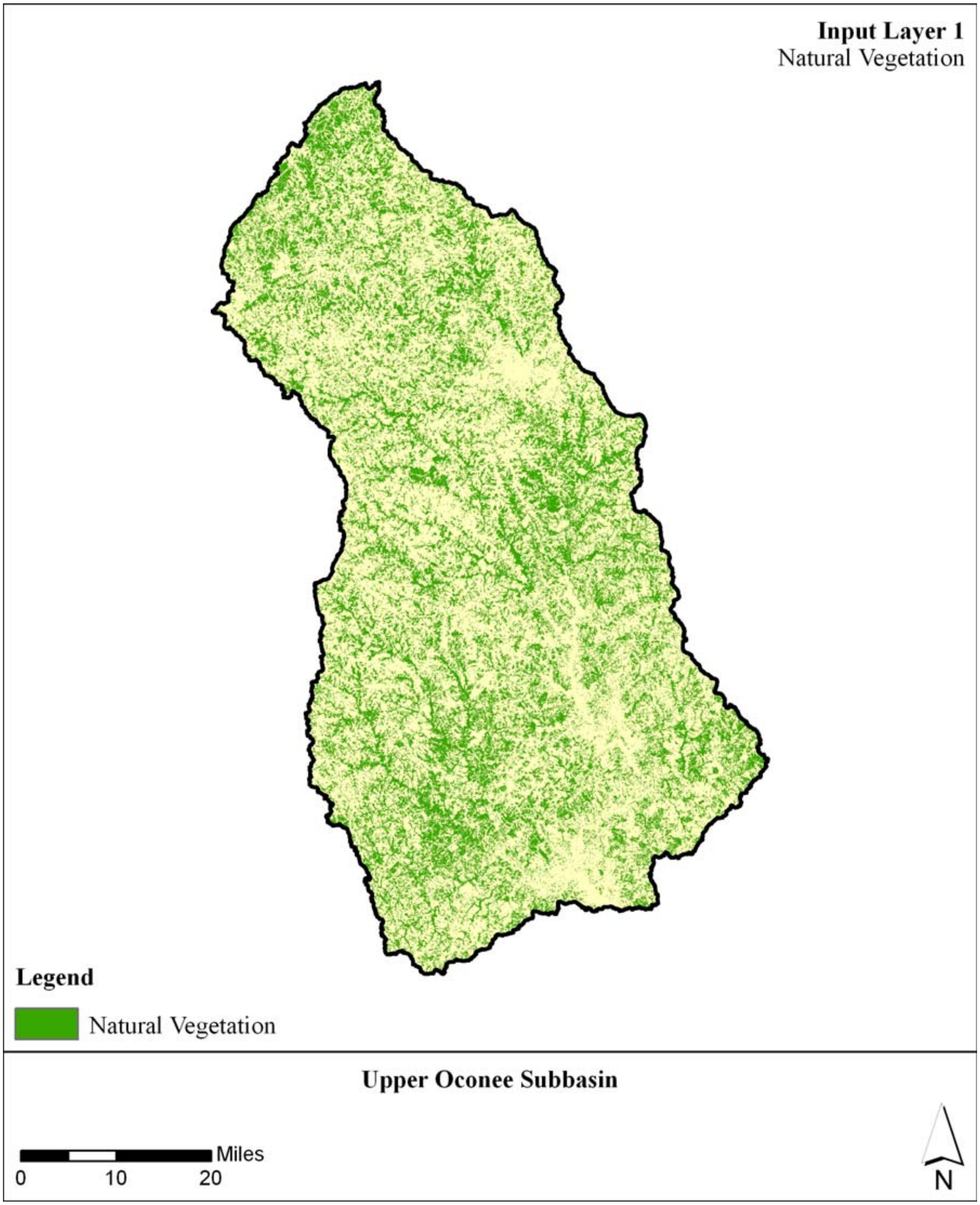

Figure 2.2: Natural vegetation. Binary map of estimated 2005 natural vegetation derived from overlay of recoded 1998 GA GAP and 2005 GLUT land cover datasets.

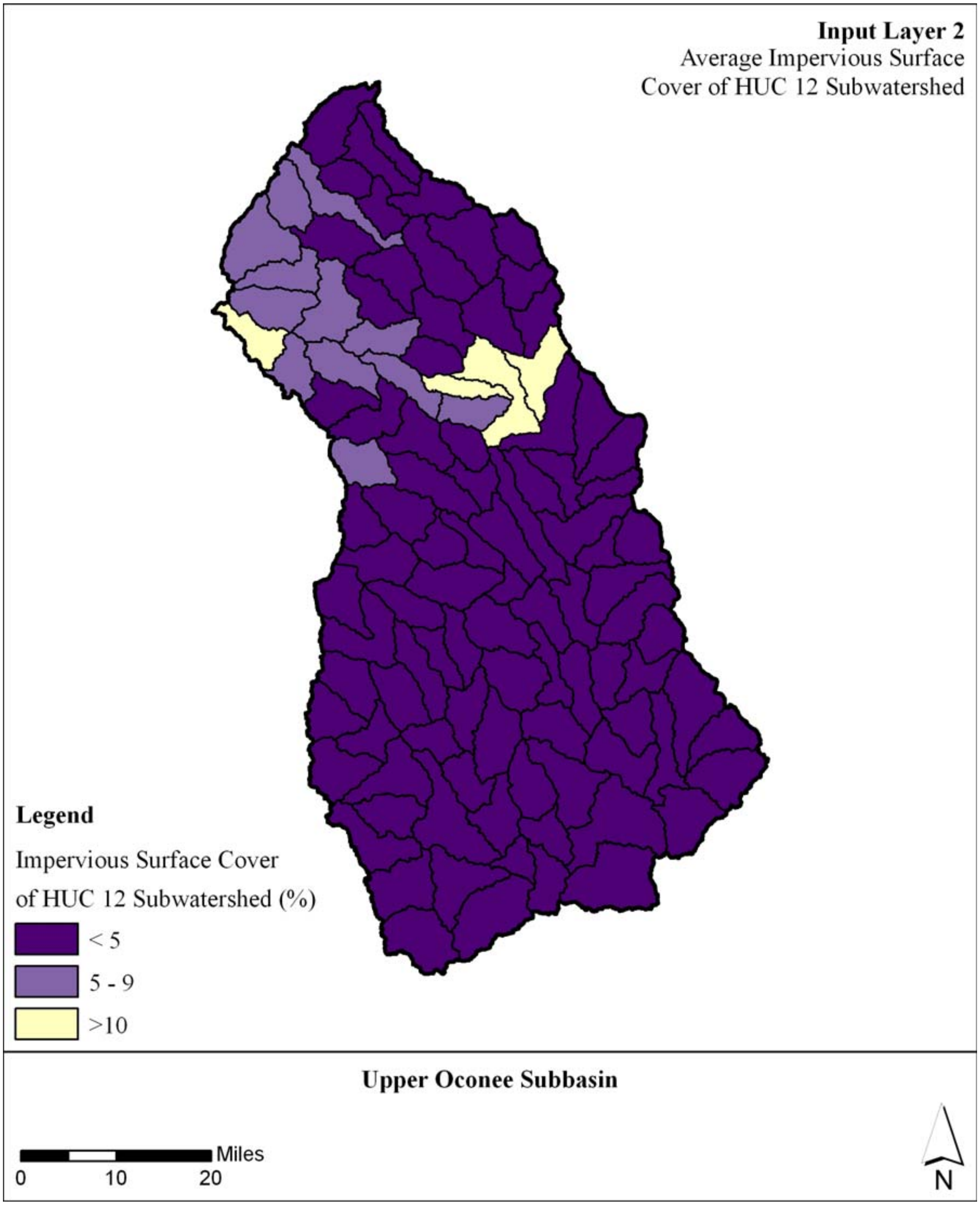

Figure 2.3: Average impervious surface cover of HUC 12 subwatersheds. Map of 2005 GLUT impervious surface cover averaged by USGS HUC 12 subwatersheds and classified into three categories.

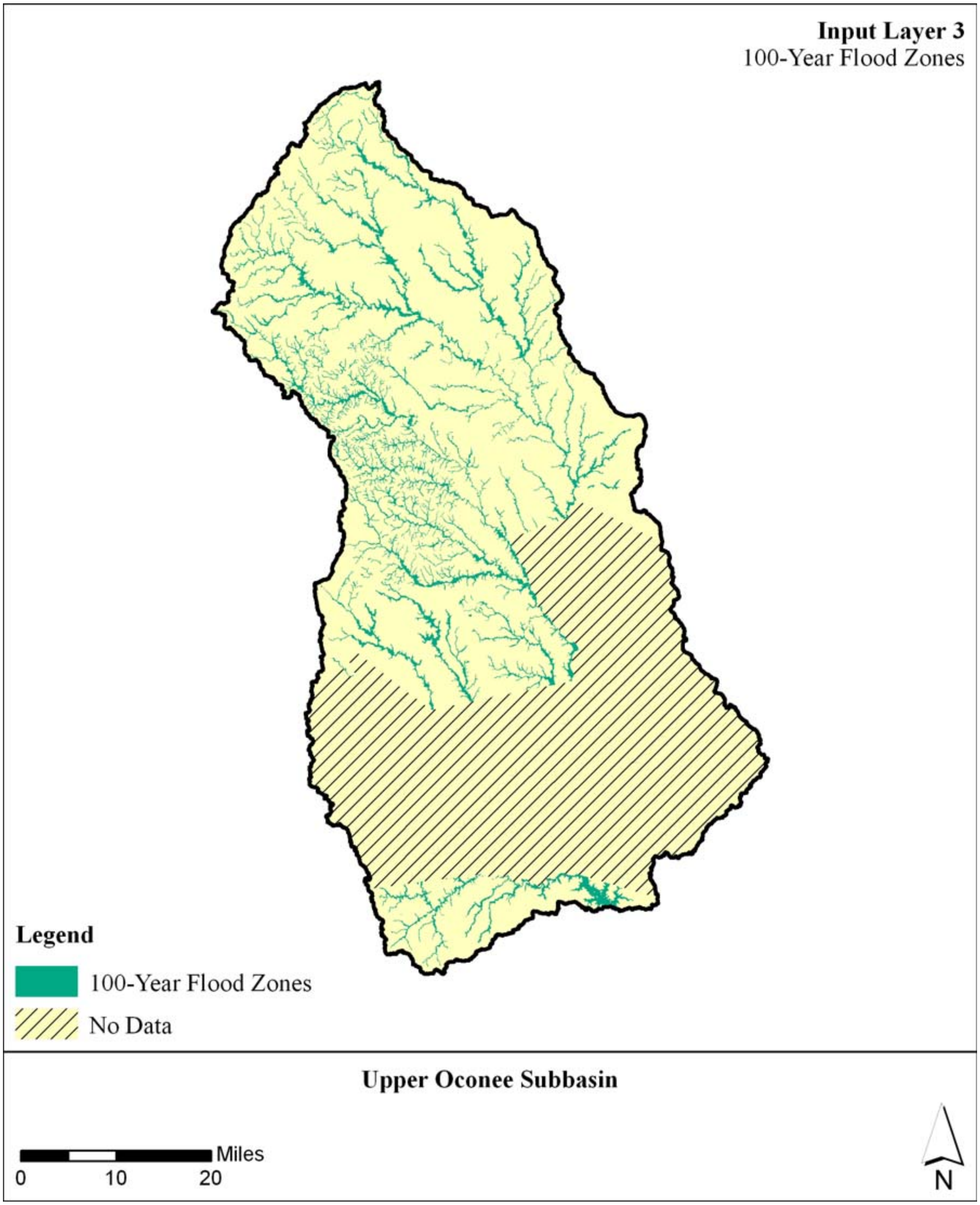

Figure 2.4: 100-year flood zones. 100-year flood zones extracted from FEMA's Q3 DFIRM dataset. No data were available for Greene, Hancock, Jasper, and Putnam Counties.

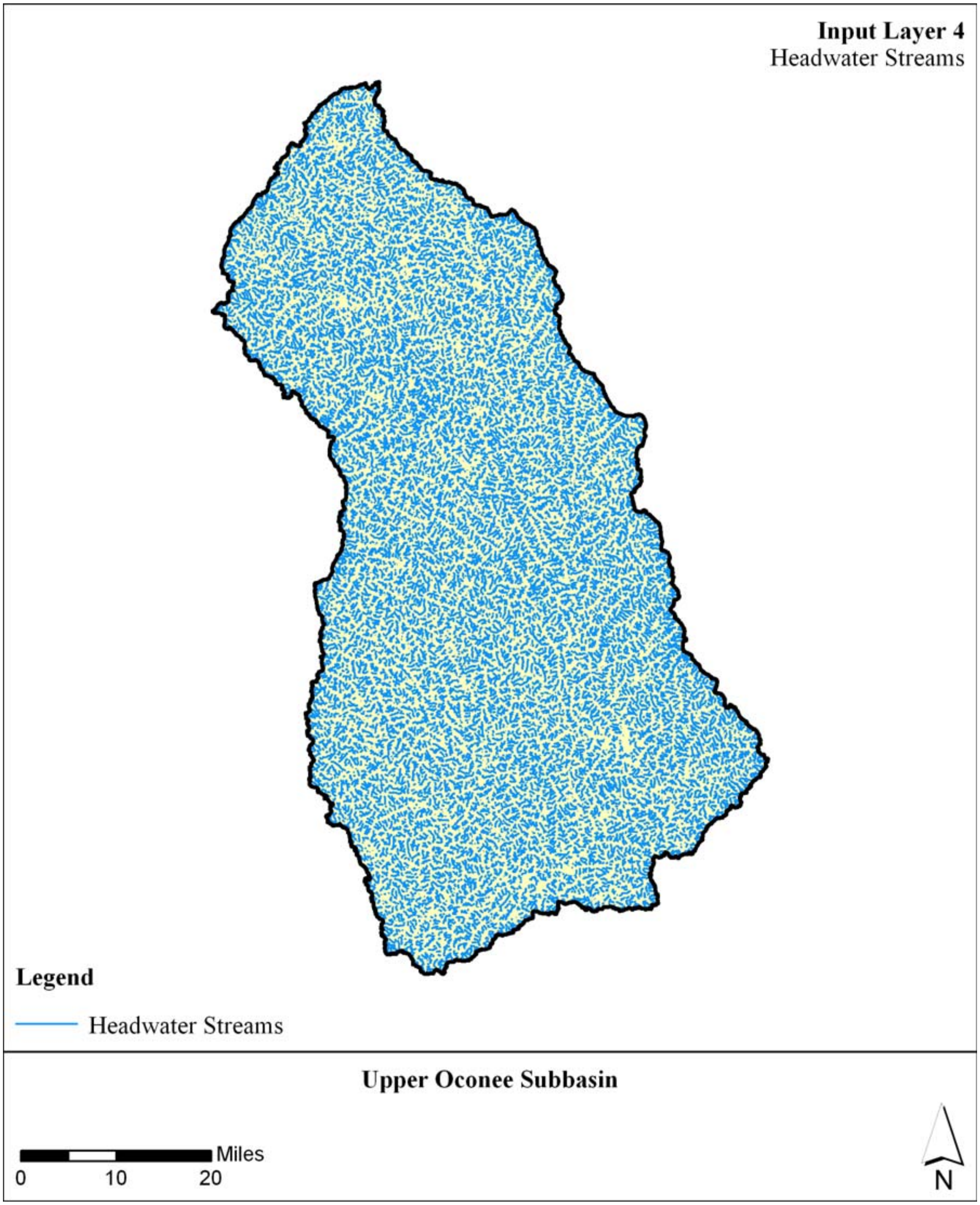

Figure 2.5: Headwater streams. First and second order streams identified in Arc Hydro using USGS NHD 1:24K stream lines and USGS NED 30m DEM and a sixteenth mile catchment minimum.

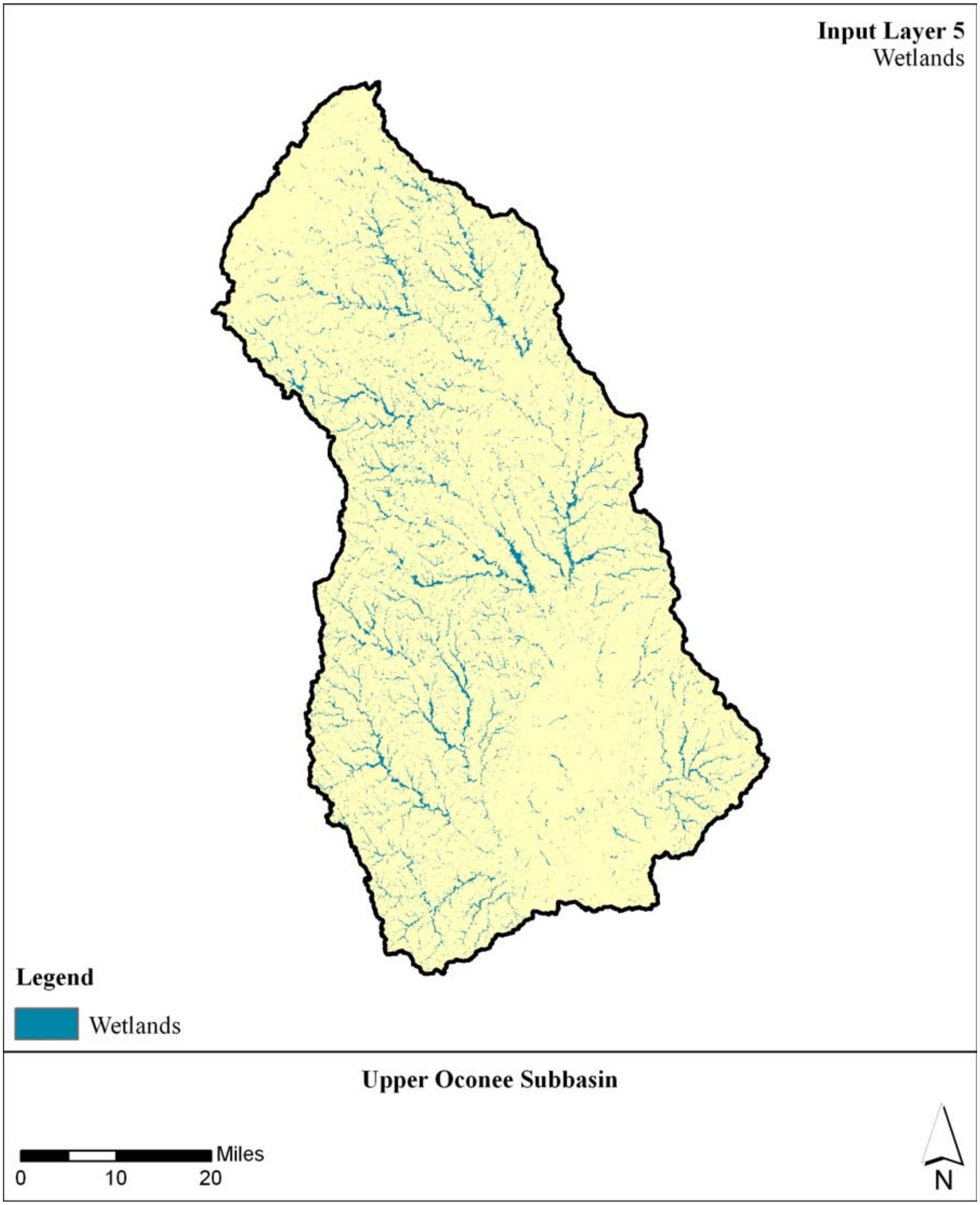

Figure 2.6: Wetlands. A binary map showing the distribution of forested wetlands as identified in the 2005 GLUT land cover dataset.

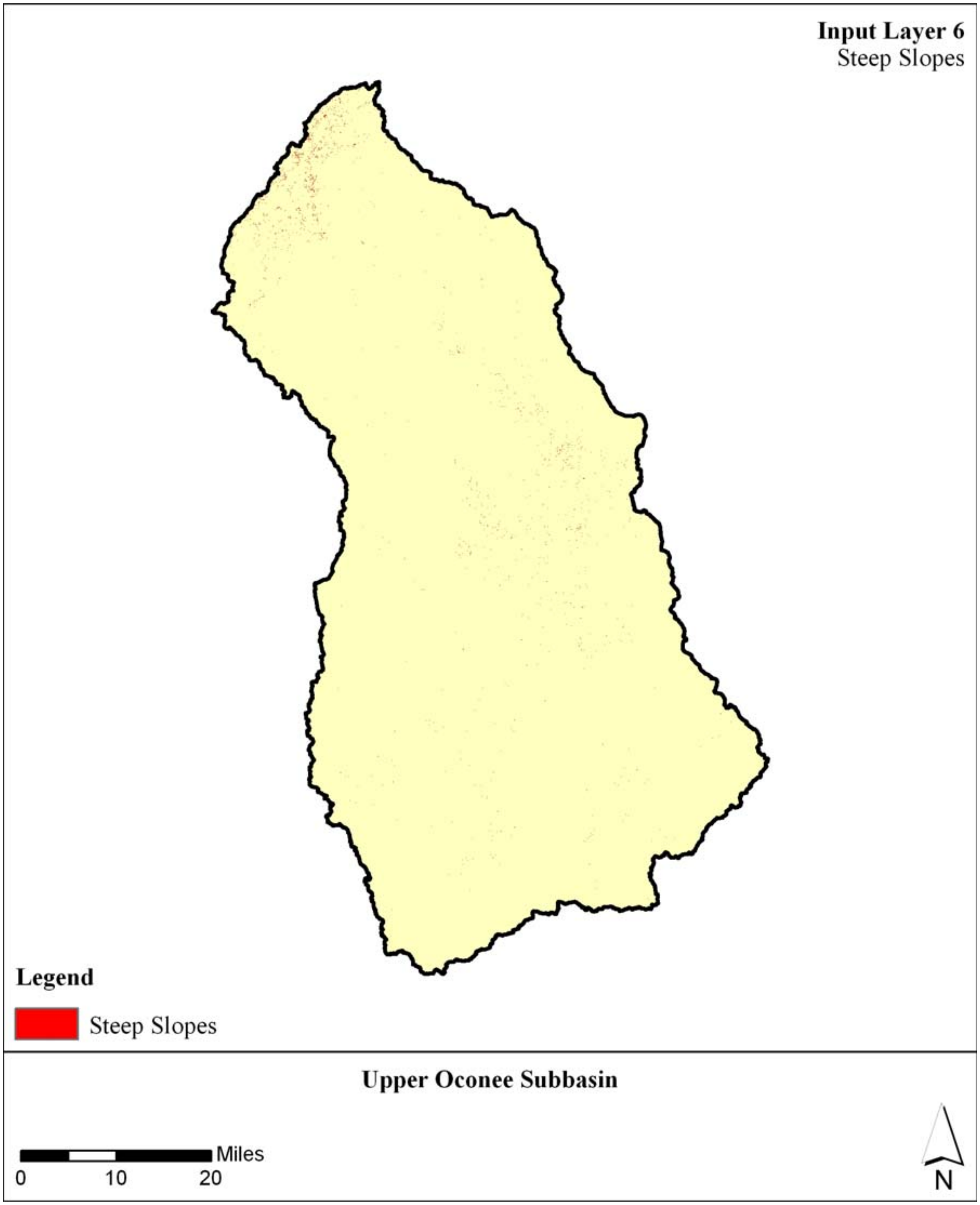

Figure 2.7: Steep slopes. Binary map showing locations of areas with steep slopes (≥20% gradient) derived from USGS 30m DEM data.

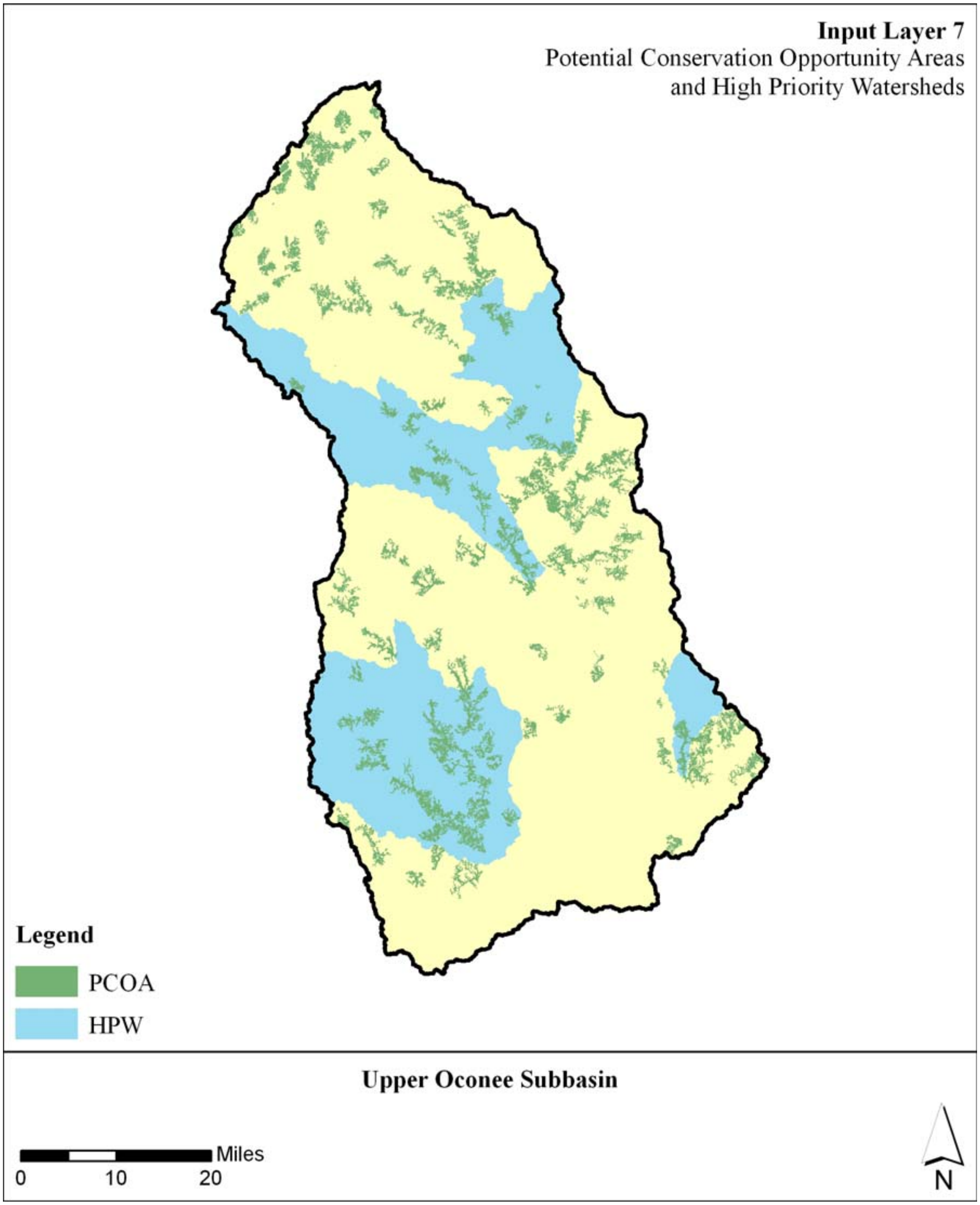

Figure 2.8: Georgia Wildlife Action Plan priority areas. Potential Conservation Opporunity Areas (PCOA) and High Priority Watersheds identified in the 2005 Georgia Wildlife Action Plan.

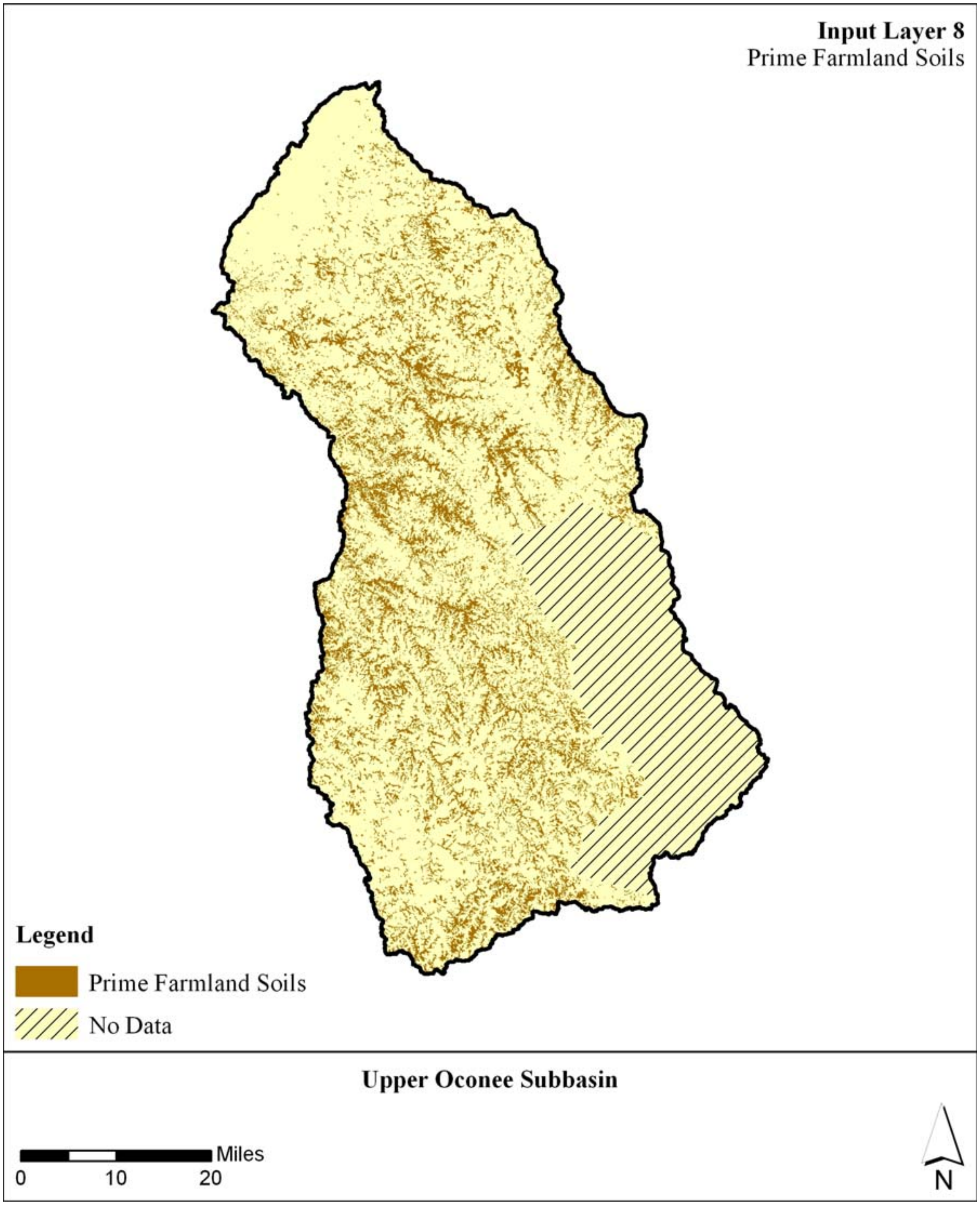

Figure 2.9: Prime farmland soils. Soils identified as having prime farmland potential in the NRCS SSURGO dataset. No data were available for Greene and Hancock Counties.

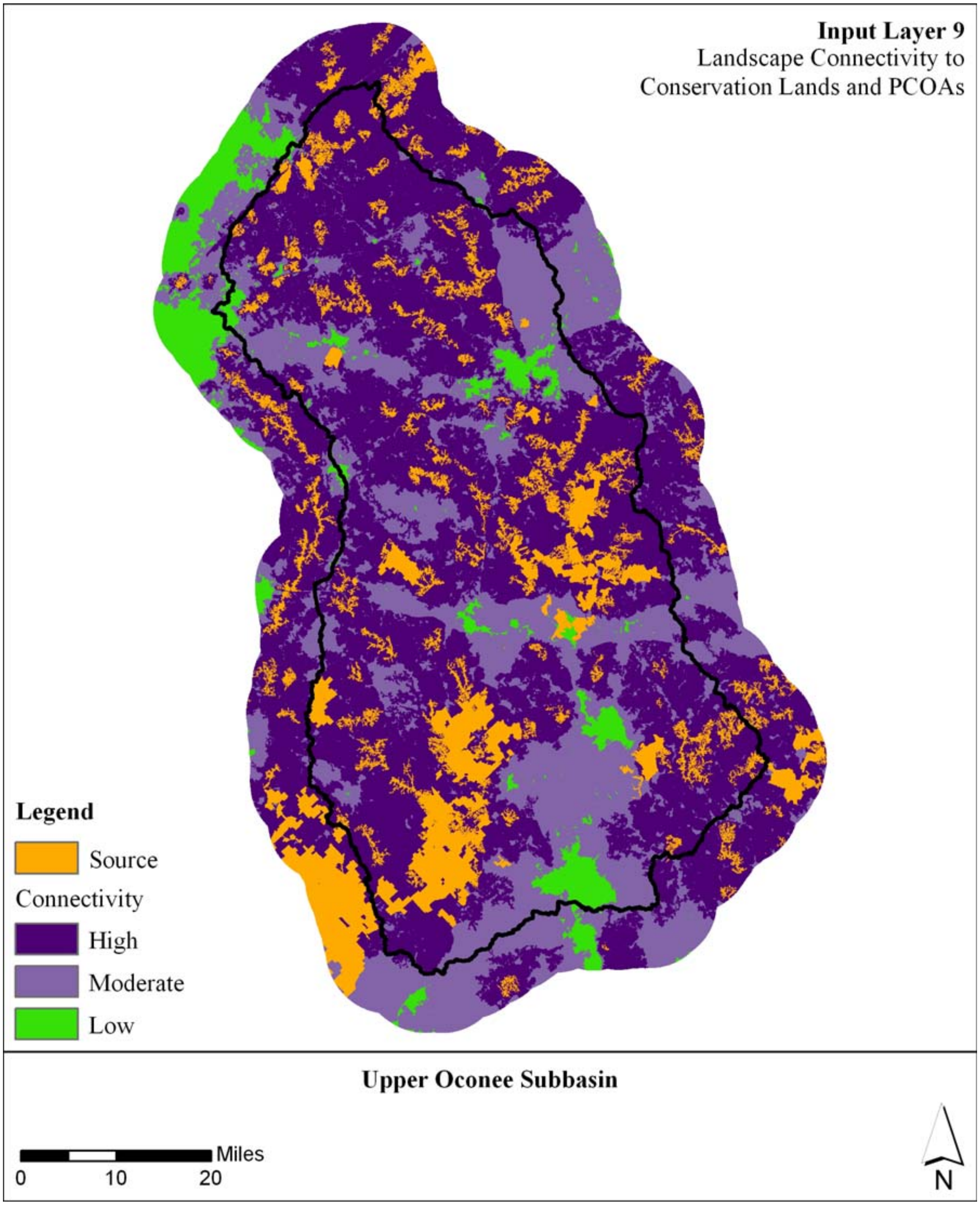

Figure 2.10: Landscape connectivity. Three Jenk's classifications of relative landscape connectivity to 2003 GA DNR conservation lands and 2005 GA WAP PCOAs (Figure 2.8) extended 10 kilometers beyond subbasin. Recoded 2005 GLUT land cover and impervious surface data were used to identify costs.

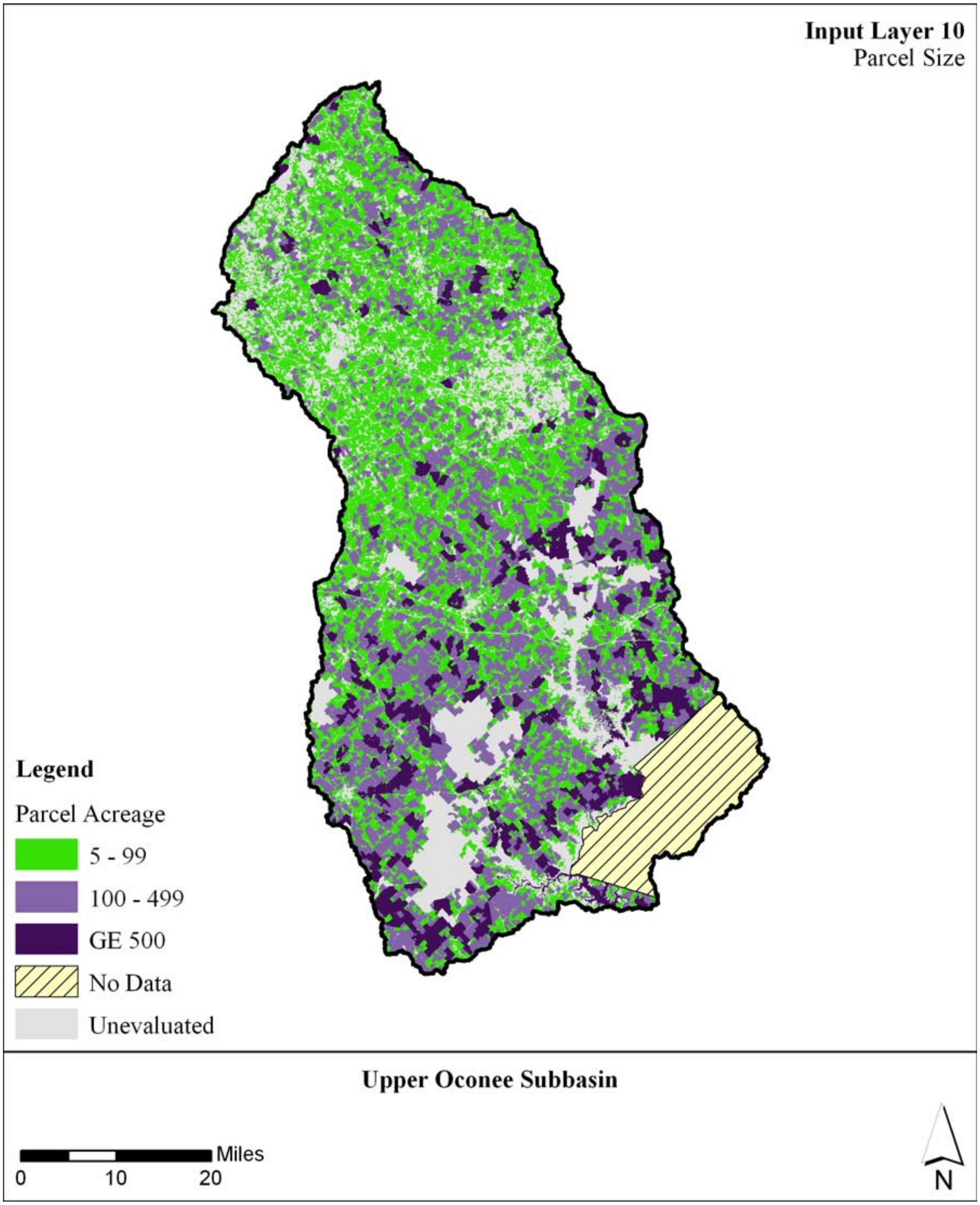

Figure 2.11: Parcel method parcel sizes. Three size categories for parcels used as area-weighting factors in the modeling process. No data were available for Hancock County. Conservation lands are whited out.

CHAPTER 3

RESULTS OF TWO METHODS FOR IDENTIFYING CONSERVATION PRIORITY AREAS

In this chapter, I present the results of two methods for modeling conservation features in the Upper Oconee subbasin. I used parcel boundaries as the analysis unit for the first method, and five acre blocks for the second method to perform a conservation assessment of the subbasin. The two approaches allowed comparison of political units and "natural" units (approximated by the five acre blocks) for identifying conservation priority areas. The overarching objective was to identify parcels with high value conservation land, and subsequently to notify local land trusts to promote implementation of the assessment.

Of the Upper Oconee subbasin's 2,917 mi^2, natural vegetation covers 30% of the watershed. The total impervious surface cover is 2.3%, with the northwest region containing the highest coverage and the southwest region having the lowest coverage. One-hundred year flood zones cover 9.7% of the 1,802 mi^2 for which digitized data were available. The USGS NHD stream network for the Upper Oconee measures approximately 6,630 miles. The stream network calculated using a GIS extended this mileage by 3,140 miles to approximately 9,770 miles. Of these, 4,929 miles were first order streams and 2,271 miles were second order streams. This means that headwater streams as calculated here, extended 7,200 miles, which is 74% of all streams in the subbasin. Wetlands cover 4.8%, and steep slopes extend over 0.2% of the subbasin. From the Georgia WAP, PCOAs cover 8.4% and HPWs represent 29% of the subbasin's extent. Finally, prime farmland soils cover 19% of the 2,400 mi^2 for which data were available.

Figure 3.1 shows the percentage of each feature protected in the Upper Oconee subbasin's 211.5 mi^2 of conservation lands for eight of the conservation features. For example, protection is afforded for 35.6 mi^2 of the 875 mi^2 of natural vegetation in the subbasin, or 4.1%. Subwatershed impervious surface cover is not included in Figure 3.1 because it was used as a negative indicator and is not desirable in protected areas. Landscape connectivity was categorical and was not included in Figure 3.1 either. GA WAP Priority Areas were subdivived into their subfeatures, PCOAs and HPWs for Figure 3.1.

PARCEL METHOD EVALUATION

The following results present the spatial distribution of scores and score means for each of the analyzed conservation features by parcel. Spatial distributions of scores by parcel (excluding conservation lands) for all nine conservation feautures are shown in Output Layers 1 – 9 (Figures 3.2 – 3.10). Table 3.1 shows the potential score and actual mean scores for each conservation feature. Potential scores are important to consider when comparing mean scores, as the highest and lowest scores as well as the number of score categories will both have an effect on the mean value.

Parcel Baseline Model scores ranged from 1 – 35 with a mean score of 14.2 (Figure 3.11). Area-weighted Multiplicative Model scores ranged from 1 – 160, with a mean of 17.7 (Figure 3.12). The areal target for priority area identification was defined as 2.75%, which would increase the total protected area within the subbasin to 10%. This threshold was reached by selecting the top 70 highest scoring as Priority Parcels because they facilitated capturing this area (Figure 3.13). These 70 parcels comprised 3.09% of the Upper Oconee subbasin. Scores ranged from 115 – 160. An alternative set of priority parcels would have included the 59 highest scoring parcels, but they would cover only 2.64% of the subbasin. These parcels' scores ranged from 120 – 160.

Taken together, these 70 parcels encompass 35.6 mi^2 of natural vegatation; 9.4 mi^2 of 100-year flood zones; 222 miles of headwater streams; 9.4 mi^2 of wetlands; 180 acres of steep slopes; 26.7 mi^2 of PCOAs; 47.2 mi^2 of HPWs; and 30.2 mi^2 of prime farmland soils. All parcels are greater than 500 acres and located in an area identified as having a high landscape connectivity value. Figure 3.1 shows the potential percentage increase in protected area for eight of the conservation features for the Upper Oconee subbasin if the 70 Priority Parcels were under easement. PCOAs and HPWs are shown to illustrate their independent contributions to the GA WAP Priority Area conservation feature. The smallest potential percentage increase in protected area is for natural vegatation at 42%, followed by headwater streams at 43%. Protected area for 100-year flood zones and prime farmland soils would increase by nearly 130%. The potential increase of protected area for the other conservation features ranges from 51 – 68%.

BLOCK METHOD EVALUATION

The total number of five acre block units analyzed was 372,208. Mean scores for five acre blocks for each conservation feature are shown in Table 3.1. Block Baseline Model scores ranged from 1 – 38 with a mean score of 13.2 (Figure 3.14). To meet the areal target, 11,877 Priority Blocks were selected with a score range of 24 – 38 and a mean score of 31 (Figure 3.15). These blocks comprised 92.8 mi^2, or 3.18% of the subbasin. An alternative set of blocks that would have met the areal target consisted of 9,124 units, which was 71.3 s mi^2. This set's scores ranged from 25 – 38. As with the parcel method, the larger set was chosen in order to capture the areal target.

The Priority Blocks encompassed 78.8 mi^2 of natural vegetation; 49.7 mi^2 of 100-year flood zones; 409 miles of headwater streams; 47.3 mi^2 of wetlands; 288 acres of steep slopes; from the Georgia WAP, 58.7 mi^2 of PCOAs and 49.7 mi^2 of HPWs; and 7.7 mi^2 of prime farmland soils. Potential percentage increases from the currently protected area for each conservation feature varied broadly from 32% for prime farmland soils to as much as 710% for 100-year flood zones (Figure 3.16).

The 11,877 blocks consisted of 2,482 contiguous patches, ranging in size from individual five acre units to one patch larger than 1,900 acres. The mean patch size was 23.9 acres. These 2,482 patches intersected 6,382 parcels. Jenk's optimization was used to divide these patches into nine natural categories by size in order to identify the largest contiguous patches (Figure 3.17). The top three categories consisted of 13 contiguous patches from 560 – 1,940 acres and intersected 510 parcels. The top two categories, a subset of the top three, was comprised of eight contiguous patches of 750 – 1,940 acres and intersected 313 parcels. The top category consisted of one patch at 1,940 acres, which intersected 97 parcels.

Land trusts work with landowners; therefore, identifying the parcels that were the highest scoring, even with the block method, was necessary. An area-weighted score was calculated by summing the block scores within each parcel for 214,941 parcels in the subbasin. There were 101 Priority Parcels by Block (PPB), which were identified by summing block scores within parcels, and then selecting those that met the threshold of 2.75% of the subbasin (Figure 3.18). They ranged from 106 – 1,594 acres and covered 83.14 mi^2, which is 2.85% of the subbasin. This number of parcels allowed capturing the areal target. They encompassed 37.1 mi^2 of natural vegetation; 196 miles of headwater streams; 16.3 mi^2 of 100-year flood zones; 12.9 mi^2 of wetlands; 96 acres of steep slopes; 30.8 mi^2 of PCOAs; 36.4 mi^2 of HPWs; and 11.8 mi^2 of prime farmland soils. Figure 3.19 shows the potential percentage increase for conservation features if the PPB were under easement or other protected status. Potential percentage increase in protected area for these features in the subbasin ranged from 30% for steep slopes to over 230% for 100-year flood zones.

METHOD COMPARISON

Of the 101 Priority Parcels by Block, 37 were shared with the 70 Priority Parcels by Parcel (Figure 3.20). The shared area was 46.7 mi^2. Forty-three of the 101 PPB were ≥ 500 acres, indicating that six of these 43 were additional to those identified by the parcel method, which were all over 500 acres. Due to the non-normal distribution of the scores from the two parcel datasets, I ran a non-parametric statistical hypothesis test (Wilcoxon Signed-Rank Test) on the 32,648 shared parcel scores. This tested the null hypothesis that score distributions would be the same among the two parcel datasets. The null hypothesis was rejected ($p < 0.0001$), indicating that the score distributions were not the same. The difference between the two priority parcel datasets resided in the 55 remaining parcels of the PPB, which were in the 100 – 500 acre size class.

I also ran the Wilcoxon test on the scores of a sample subset of 7,630 random points from the parcel dataset and the block dataset. The null hypothesis was rejected ($p<0.0001$), indicating that the score distributions for parcels and blocks were not the same. However, Pearson's *r* for spatial correlation of 10,000 random points of binary values from the Priority Parcels by Parcel and Priority Blocks, or political vs natural boundaries, was equal to 0.23, indicating a relatively low positive correlation.

To facilitate comparison of identified priority areas, Figure 3.21 shows the percentage of each conservation feature found within each of the three priority area datasets: 1) PPP, 2) Priority

Blocks, and 3) PPB. Priority Blocks contained higher percentages for all features analyzed except for Prime Farmland Soils (Figure 3.21). PPP contained 13.5% of Priority Blocks, where as PPB contained 21% of Priority Blocks, indicating greater efficiency than PPP at capturing Priority Blocks. Further, the most signicant contribution of the comparitive analysis relates to the realization that to protect the highest conservation value land identified using five acre blocks, in other words the Priority Blocks, 6,382 landowners, and thus, easements would be needed. By focusing recruitment efforts on the PPB, 21% of this high conservation value land could be protected by contacting just 101 landowners, and thus, monitoring only as many easements.

EASEMENT EVALUATION

At the time of analysis, ORLT and ALT had 20 and 14 easements and fee simple holdings in the Upper Oconee subbasin covering 1,314 and 638 GIS-calculated acres, respectively. Easements from both land trusts were found to be representing at least some quantity of all seven non-categorical conservation features. ORLT's holdings were calculated to be protecting: 636 acres of natural vegetation; 424 acres of 100-year flood zones; eight miles of headwater streams; 377 acres of wetlands; two acres of steep slopes; from the GA WAP, 342 acres of PCOAs, and 808 acres in HPWs; and 69 acres of prime farmland soils. ALT's holdings were calculated to be protecting: 223 acres of natural vegetation; 23 acres of 100-year flood zones; 33 acres of wetlands; four acres of steep slopes; from the GA WAP, 23 acres of PCOAs, and 340 acres in HPWs; and 158 acres of prime farmland soils. Figure 3.22 shows the total acreage of eight conservation features, organized by land trust. PCOAs and HPWs are subdivided from the GA WAP Priority Area conservation feature for Figure 3.22.

MODEL PARAMETER EFFECTS

Model parameters were not considered to be highly correlated (Table 3.2). The strongest correlations were among the Natural Vegetation and PCOA parameters, as well as the 100_year Flood Zone and Wetland parameters (r = 0.419 and r = 0.405, respectively). The area-corrected Sorenson Similarity Indices (Ssa) for each n-1 subset of model parameters for both parcel and block methods of analysis are shown in Figure 3.23. PCOAs and HPWs are shown separetely to show their independent effects on the GA WAP Priority Area conservation feature. For the parcel method, the most influential parameter was the GA WAP priority area parameter, and the least influential was the headwater streams parameter.

The landscape connectivity feature in the parcel method did not change the PPP identified using the areal target. The Ssa for the parcel Baseline Model compared with the parcel AWM Model was 0.34, indicating that the area multiplication factor had the strongest effect on the identified Priority Parcels. Figures A.1 – A.11 in Appendix A show the spatial change in Priority Parcels for each n-1 subset of model parameters, including the area multiplication factor's spatial similarity compared with the parcel Baseline Model.

The relative strength of each parameter for the block method was different in order of strength, but the conservation feature with the most effect was the same. The most influential parameter was the GA WAP priority area parameter and the least influential was the steep slopes parameter.

Figures B.1 – B.10 in Appendix B show the spatial change in Priority Blocks for each n-1 subset of model parameters for the block method.

Table 3.1: Parcel and block score means. This table shows the same conservation values and features as Table 2.2. The data shown are potential scores for analysis units (i.e. what a unit could have scored) along with mean scores for both parcels and five acre block units. Potential Conservation Opportunity Areas (PCOA) are from the Georgia Wildlife Action Plan (GA WAP).

Conservation Value	*Conservation Feature*	*Potential Score*	*Mean Parcel Score*	*Mean Block Score*
Water Quality Protection	Natural Vegetation Cover	0, 1, 3, 5	1.11	1.29
	Impervious Surface Cover of HUC 12 Subwatershed	0, 3, 5	4.41	4.77
Flood Protection	100-Year Flood Zone Cover	0, 1, 3, 5	0.52	0.40
	Headwater Streams	0, 1, 3, 5	0.59	0.09
Wetland Protection	Wetland Cover	0, 1, 3, 5	0.45	0.35
Erosion Reduction	Steep Slopes	0, 1, 3, 5	0.04	0.02
Habitat Protection	GA WAP Priority Area	0, 3, 5, 8	1.49	1.31
Agricultural Land Protection	Prime Farmland Soils	0, 1, 3, 5	1.17	0.93
Landscape Connectivity	Connectivity to Conservation Lands & PCOA	1, 3, 5	4.12	4.37

Table 3.2: Pearson's *r* values for model parameters. This table shows the correlation coefficients (Pearson's *r*) for the ten model parameters that were used to define the nine conservation features analyzed in the model. Values were calculated in the R statistical program from parameter values at 10,000 randomly generated points (2009). Potential Conservation Opportunity Areas (PCOA) from the Georgia Wildlife Action Plan (WAP) and natural vegetation parameters had the strongest correlation ($r = 0.419$), and were closely followed by 100-Year Flood Zones and Wetlands ($r = 0.405$). HPW = high priority watershed from the Georgia WAP. Values calculated from a subset of 6180* and 8269** random points due to data extent.

Model Parameter	*Natural Vegetation*	*Average IS by HUC 12*	**100-Year Flood Zones*	*Headwater Streams*	*Wetlands*	*Steep Slopes*	*PCOA*	*HPW*	*** Prime Farmland Soils*	*Landscape Connectivity*
Parameter	1	2	3	4	5	6	7	8	9	10
1	1.000	-0.054	0.167	0.086	0.265	0.034	0.419	0.021	-0.202	-0.249
2	-0.054	1.000	-0.037	-0.016	-0.043	0.028	-0.040	0.093	-0.020	0.255
3	0.122	0.047	1.000	0.041	0.314	-0.008	0.093	-0.012	-0.103	-0.029
4	0.086	-0.016	0.055	1.000	0.051	-0.004	0.028	0.001	-0.037	-0.019
5	0.265	-0.043	0.405	0.051	1.000	-0.007	0.157	0.037	-0.099	-0.101
6	0.034	0.028	-0.013	-0.004	-0.007	1.000	0.035	-0.020	-0.017	-0.022
7	0.419	-0.040	0.133	0.028	0.157	0.035	1.000	0.043	-0.112	-0.242
8	0.021	0.093	0.020	0.001	0.037	-0.020	0.043	1.000	0.014	-0.072
9	-0.179	0.028	-0.124	-0.035	-0.088	-0.014	-0.100	0.049	1.000	0.138
10	-0.249	0.255	-0.043	-0.019	-0.101	-0.022	-0.242	-0.072	0.162	1.000

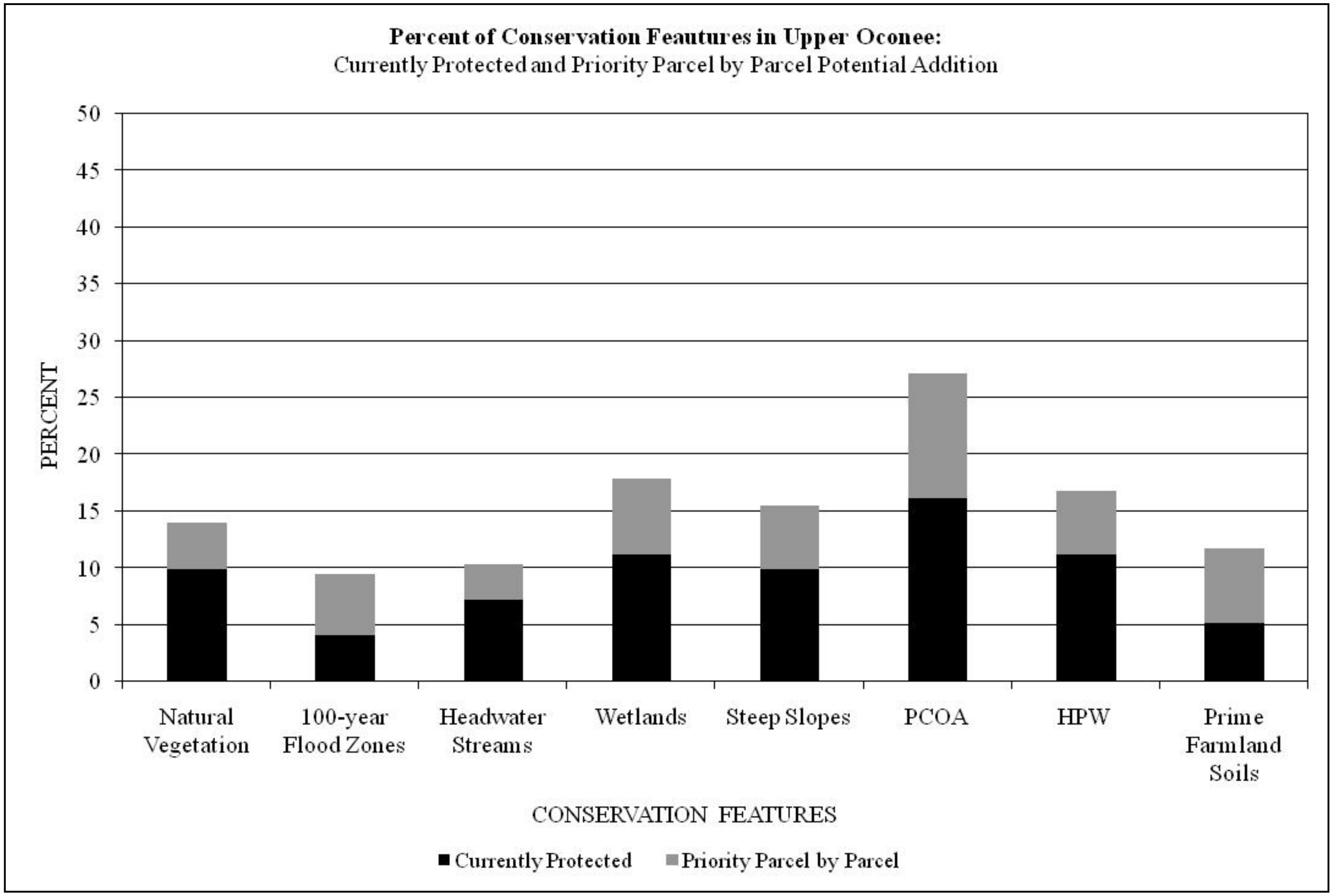

Figure 3.1: Potential conservation addition of Priority Parcels by Parcel. This graph shows the potential percentage increase in protected area that would occur for each conservation feature if the Priority Parcels by Parcel were under easement. PCOA = Potential Conservation Opportunity Area and HPW = High Priority Watershed from the Georgia Wildlife Action Plan.

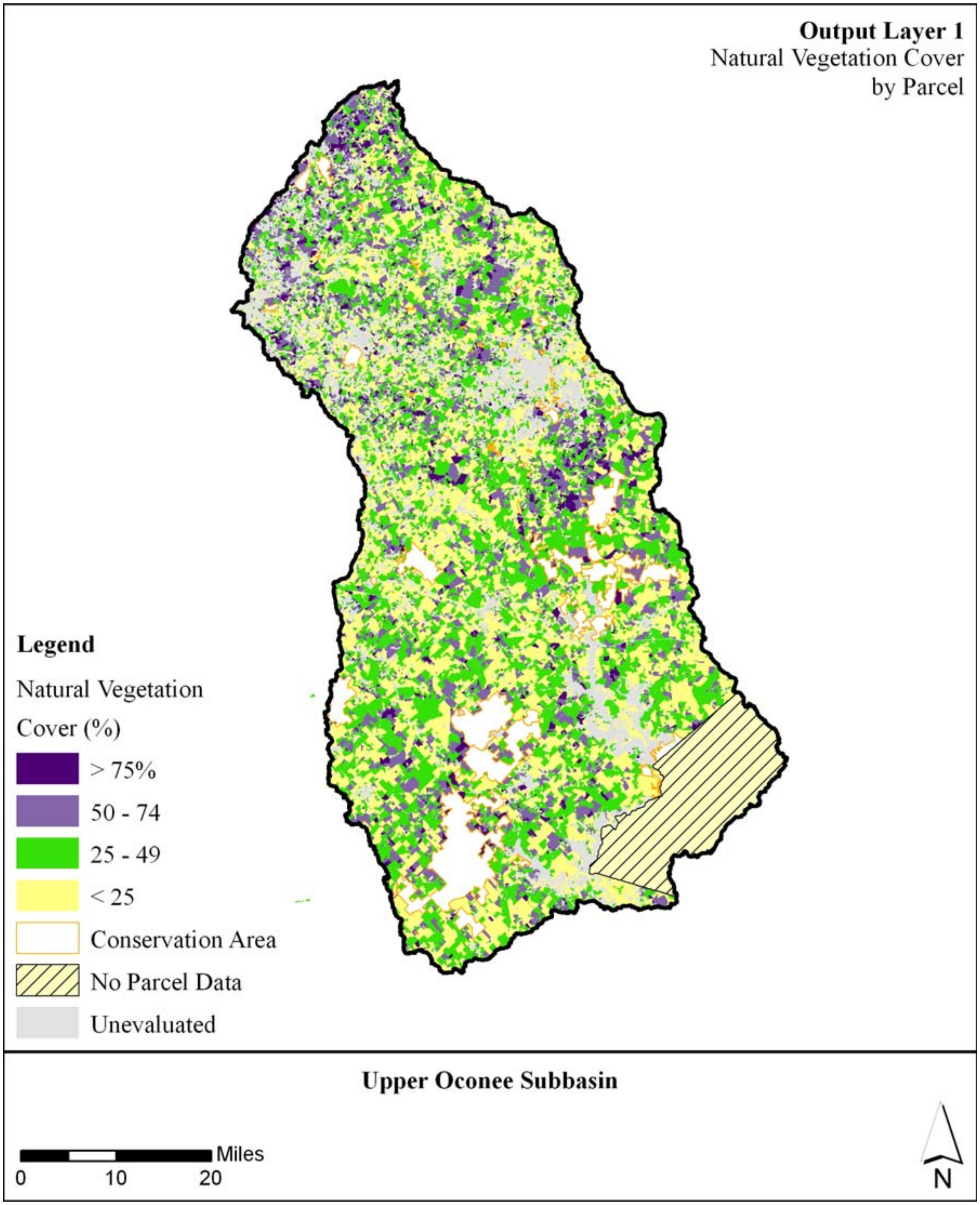

Figure 3.2: Percent natural vegetation cover by parcel. The four categories were used for scoring parcels. Table 2.2 shows the scores.

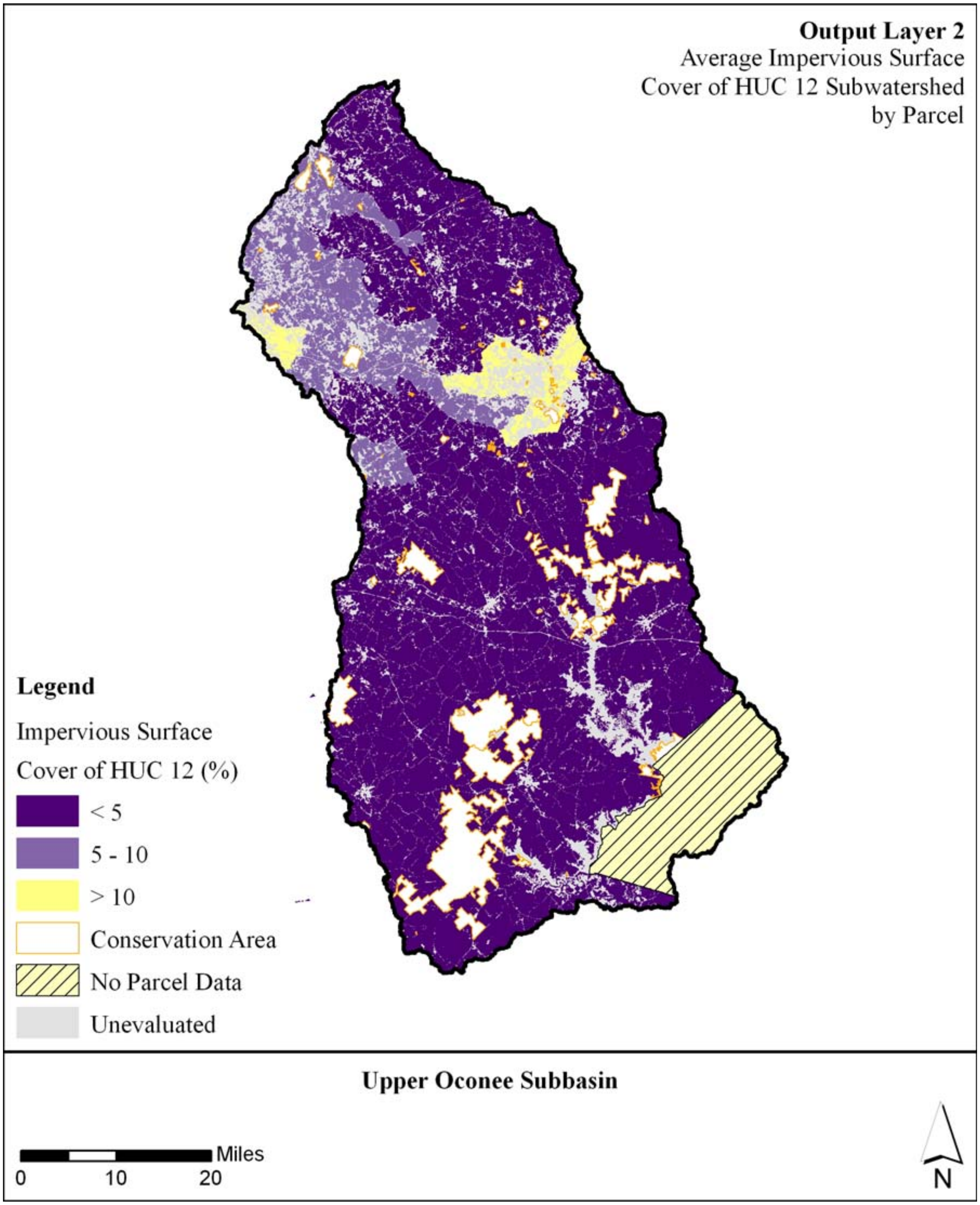

Figure 3.3: Percent average impervious surface cover of HUC 12 subwatershed by parcel. The three scoring categories were used for scoring parcels. Scores are shown in Table 2.2.

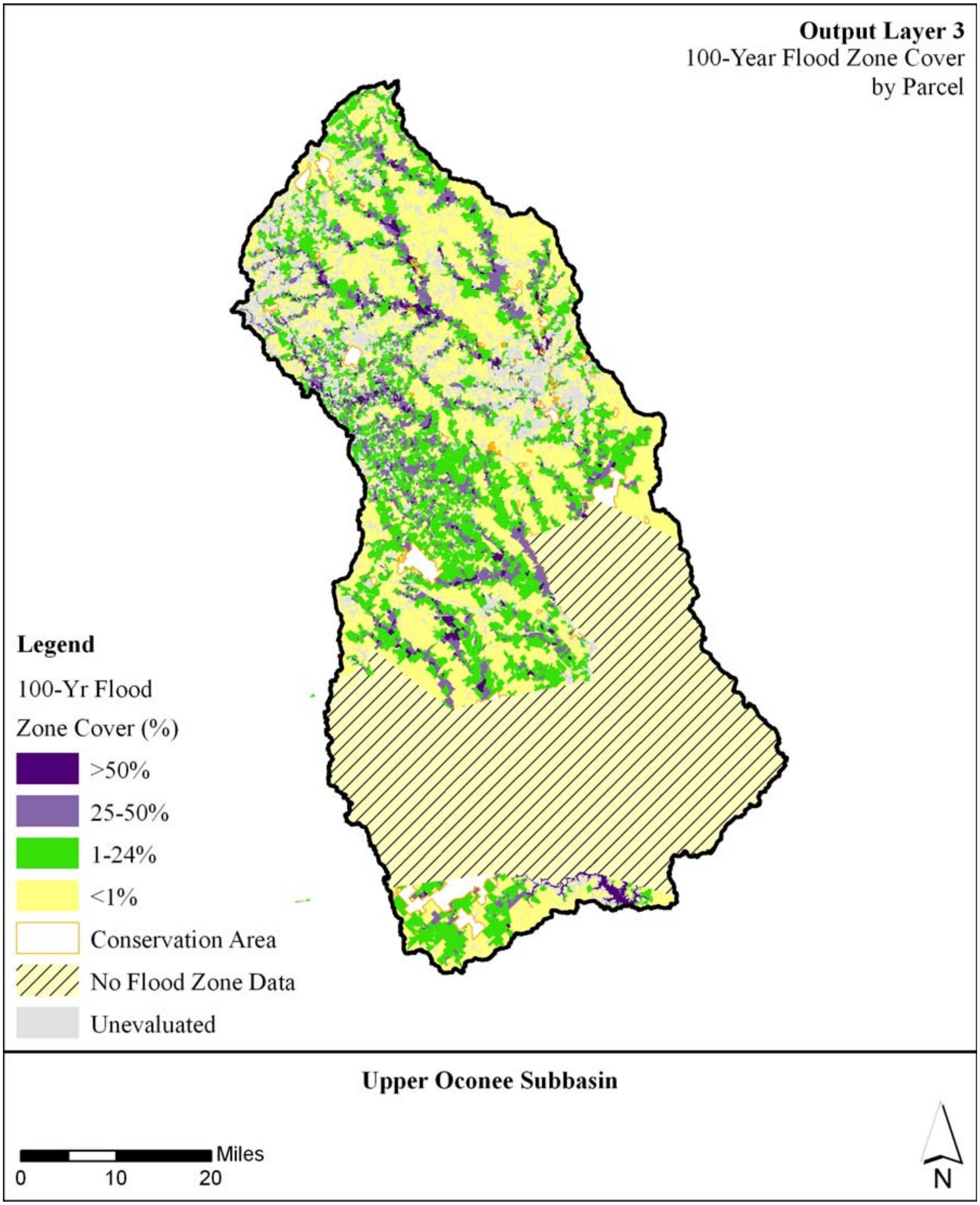

Figure 3.4: Percent 100-year flood zone cover by parcel. The four categories were used for scoring parcels. Scores are shown in Table 2.2.

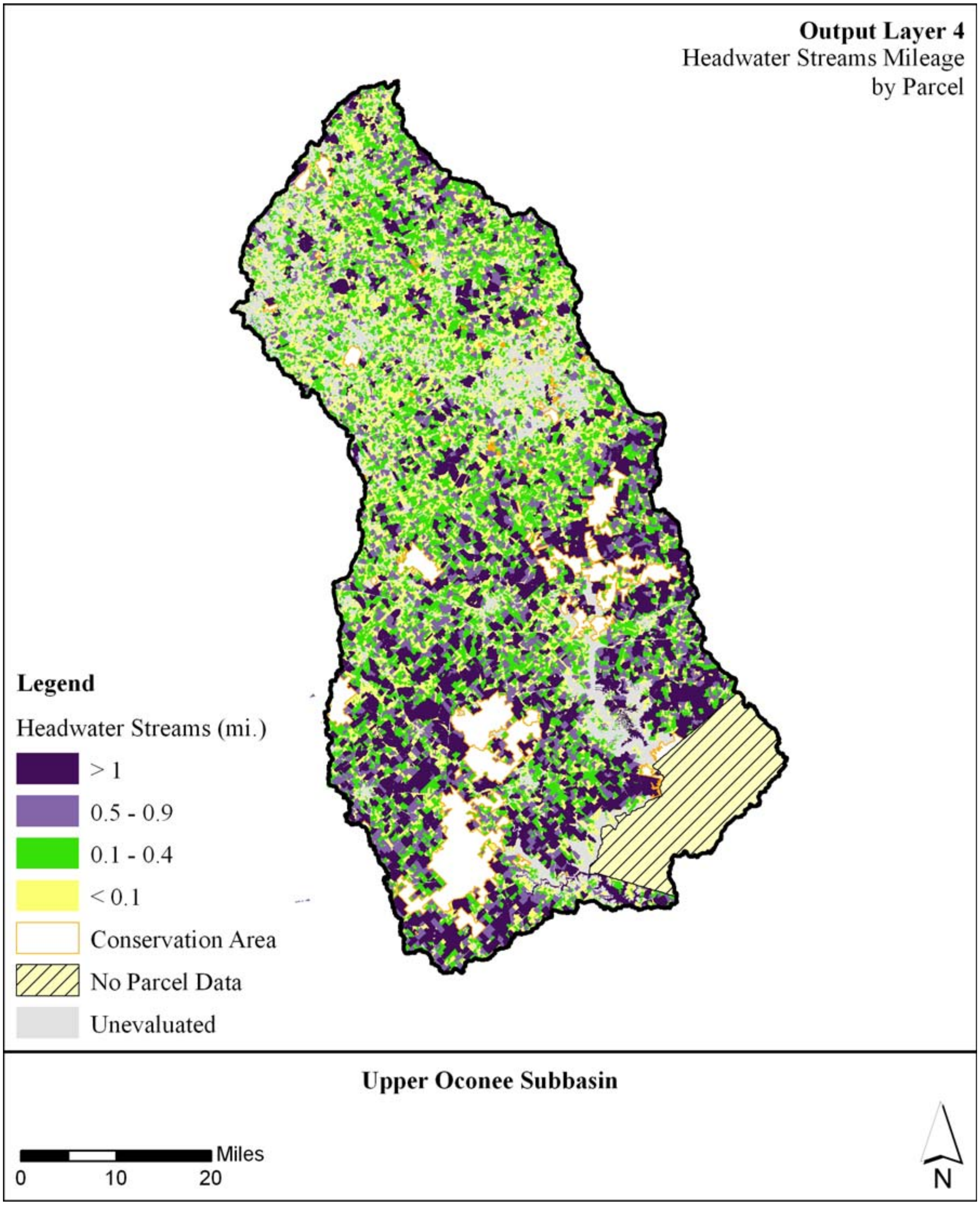

Figure 3.5: Mileage of headwater streams by parcel. The four categories were used for scoring parcels. Scores are shown in Table 2.2.

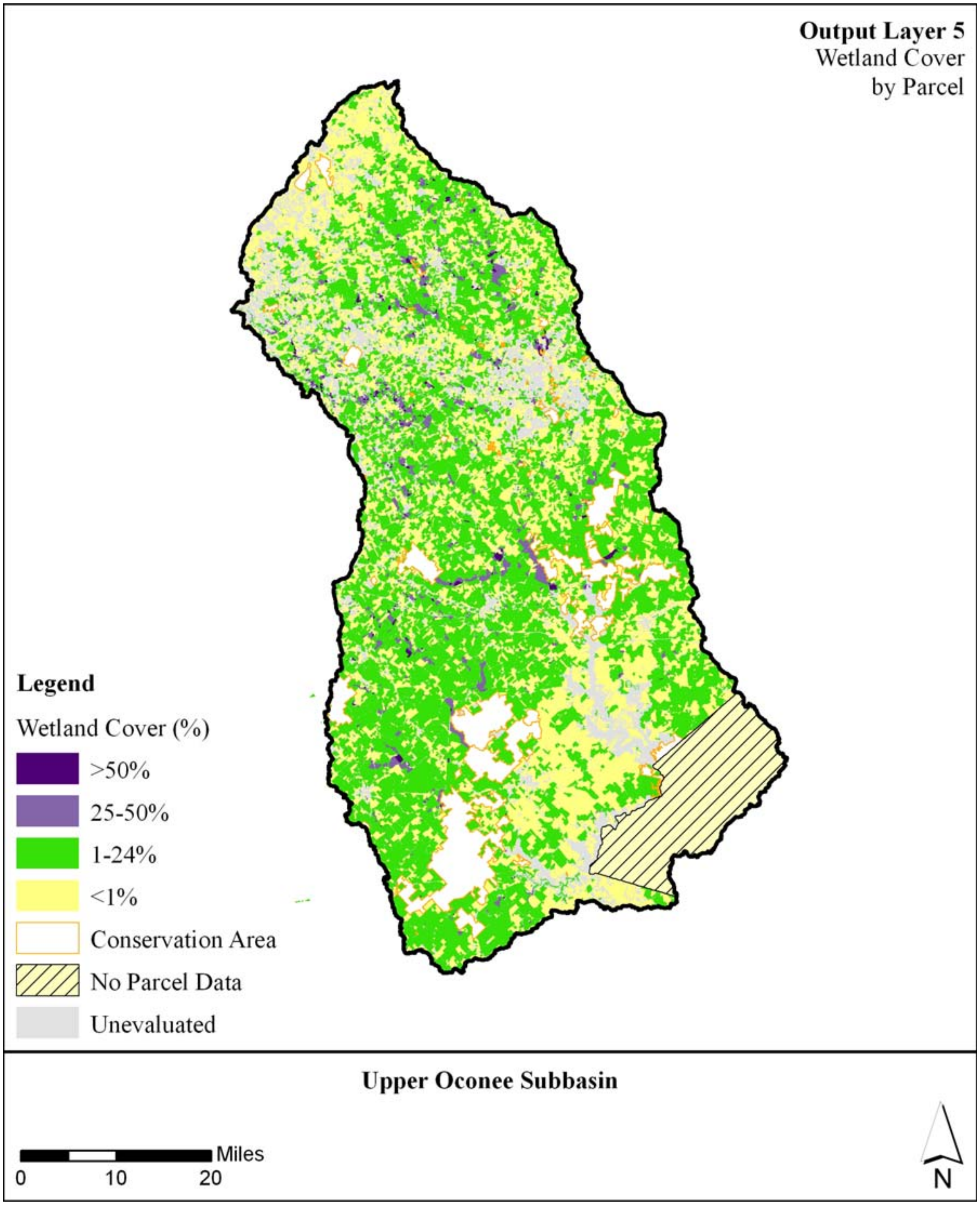

Figure 3.6: Percent wetland cover by parcel. The four categories were used for scoring parcels. Scores are shown in Table 2.2.

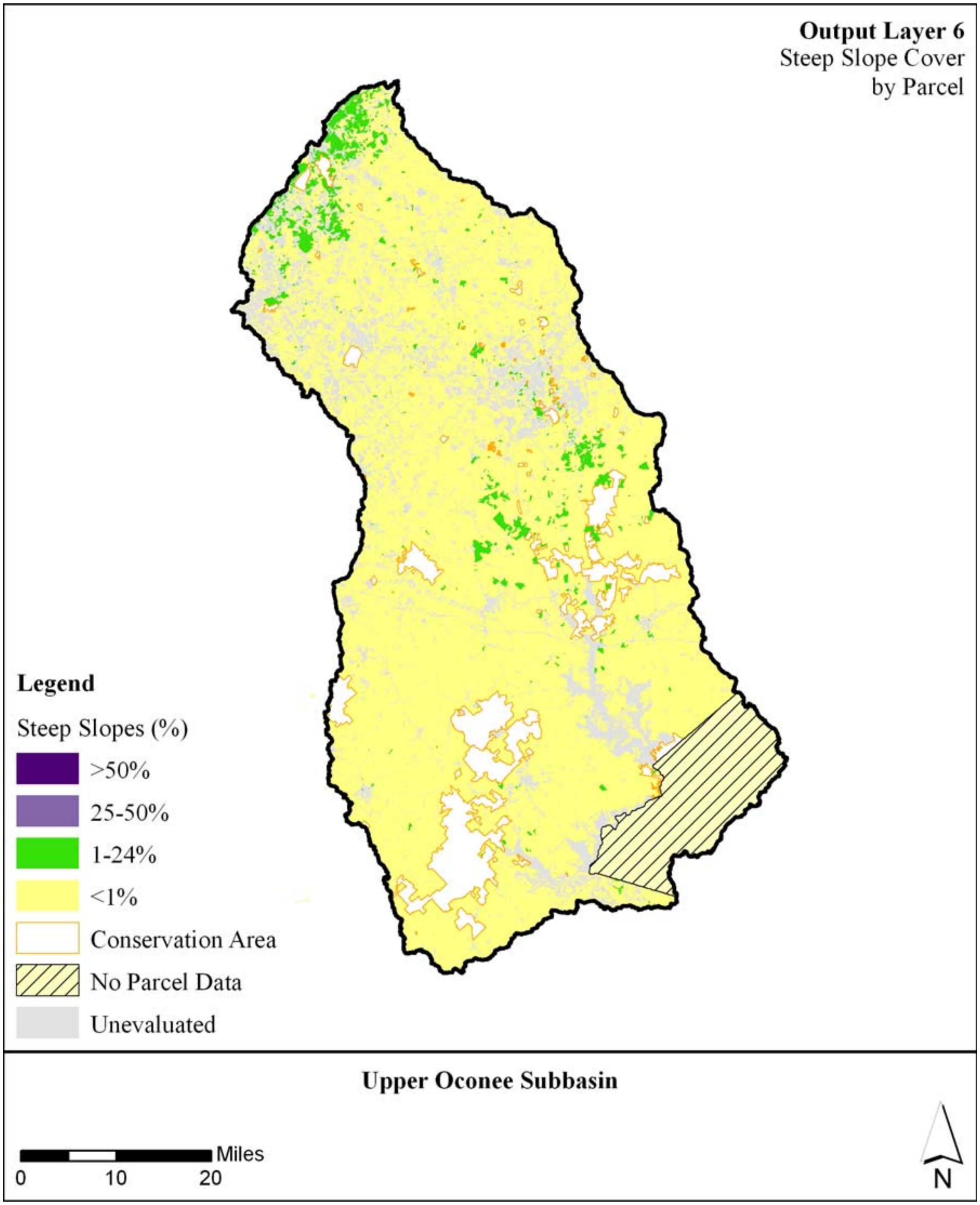

Figure 3.7: Percent steep slopes cover by parcel. The four categories were used for scoring parcels. Scores are shown in Table 2.2.

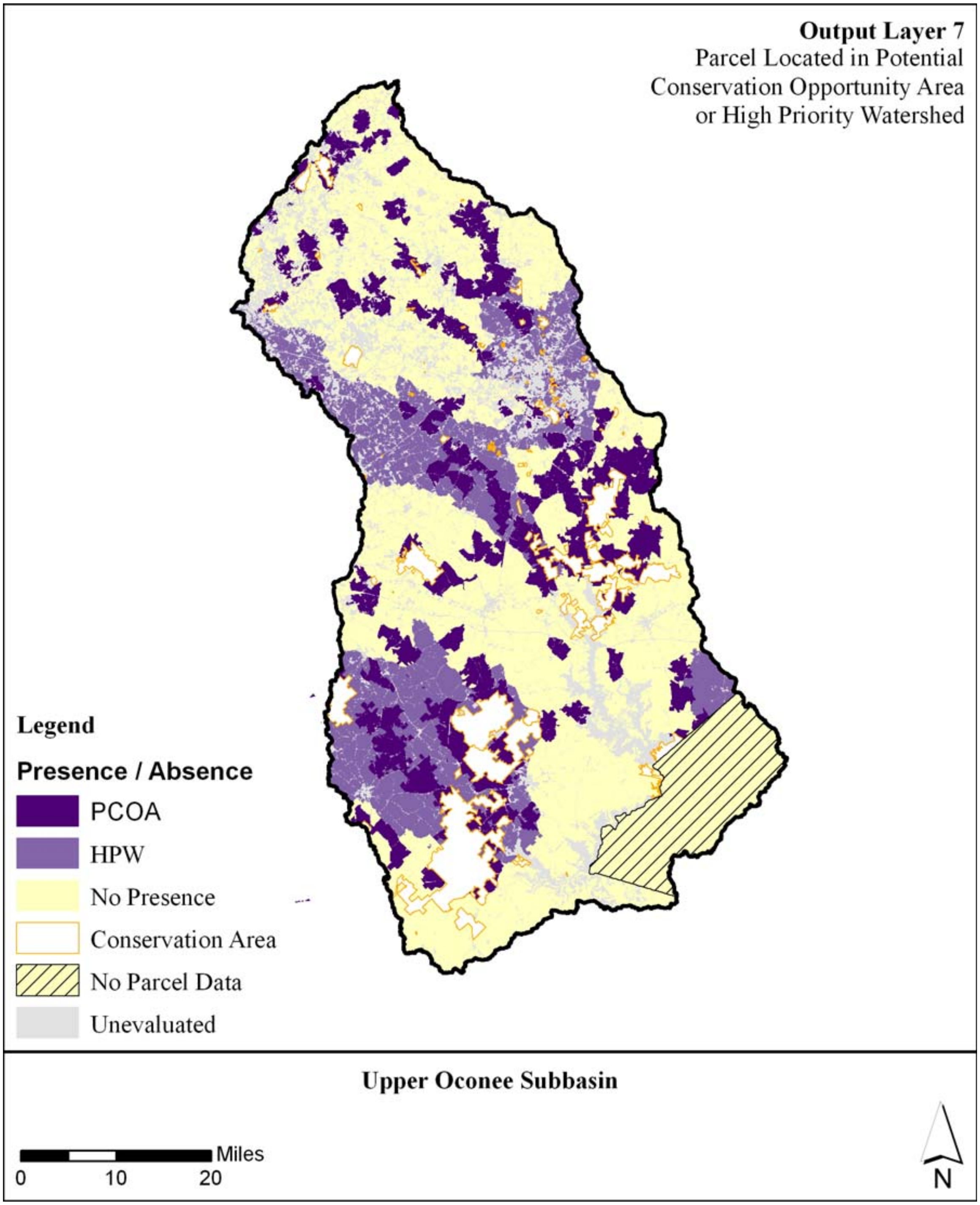

Figure 3.8: Parcels containing Georgia Wildlife Action Plan priority areas. The two categories were used for scoring parcels. Scores are shown in Table 2.2. PCOA = Potential Conservation Opportunity Areas and HPW = High Priority Watersheds.

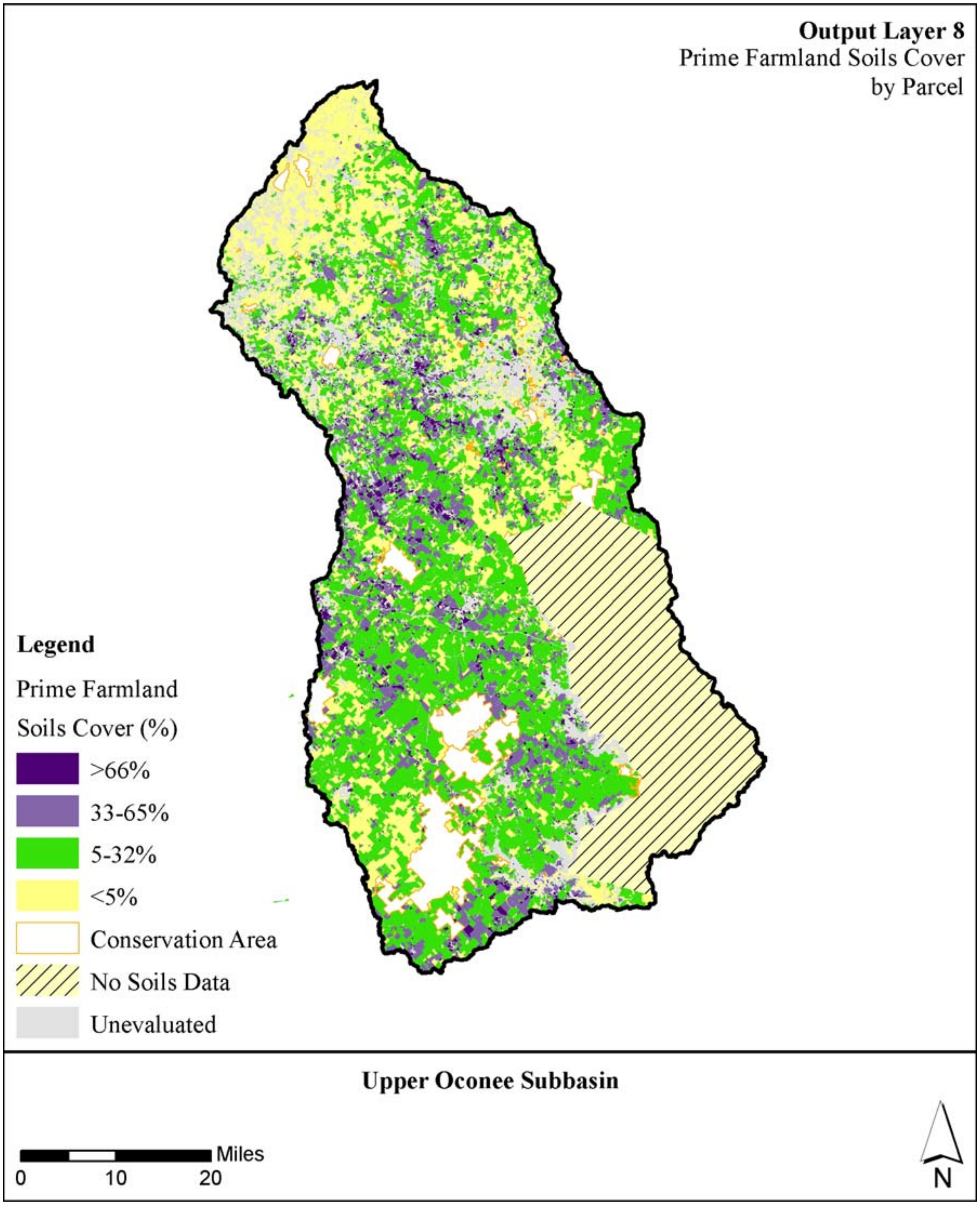

Figure 3.9: Percent prime farmland soils cover by parcel. The four categories were used for scoring parcels. Scores are shown in Table 2.2.

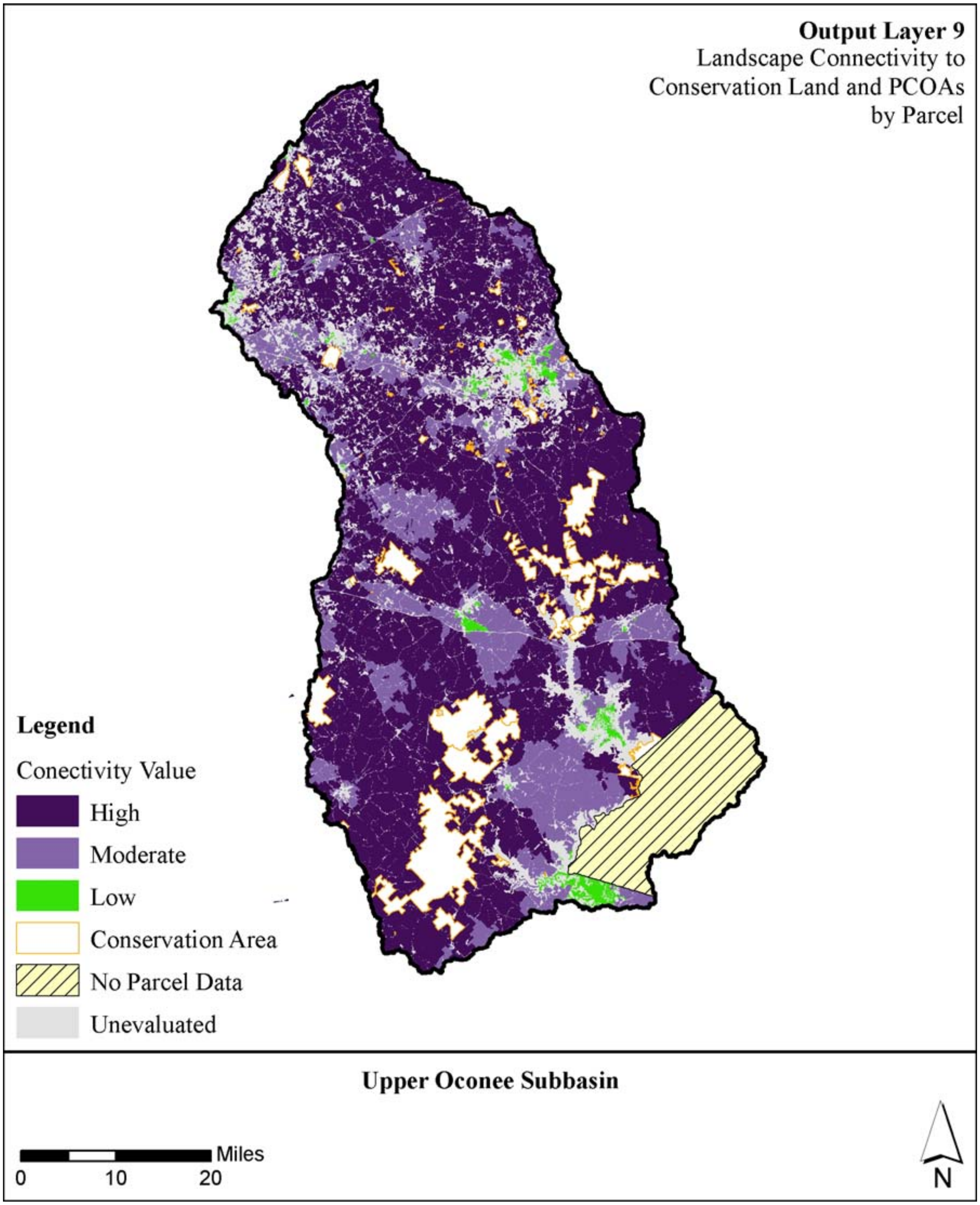

Figure 3.10: Landscape connectivity categories by parcel. The four categories were used for scoring parcels. Scores are shown in Table 2.2. PCOA = Potential Conservation Opportunity Area from Georgia Wildlife Action Plan.

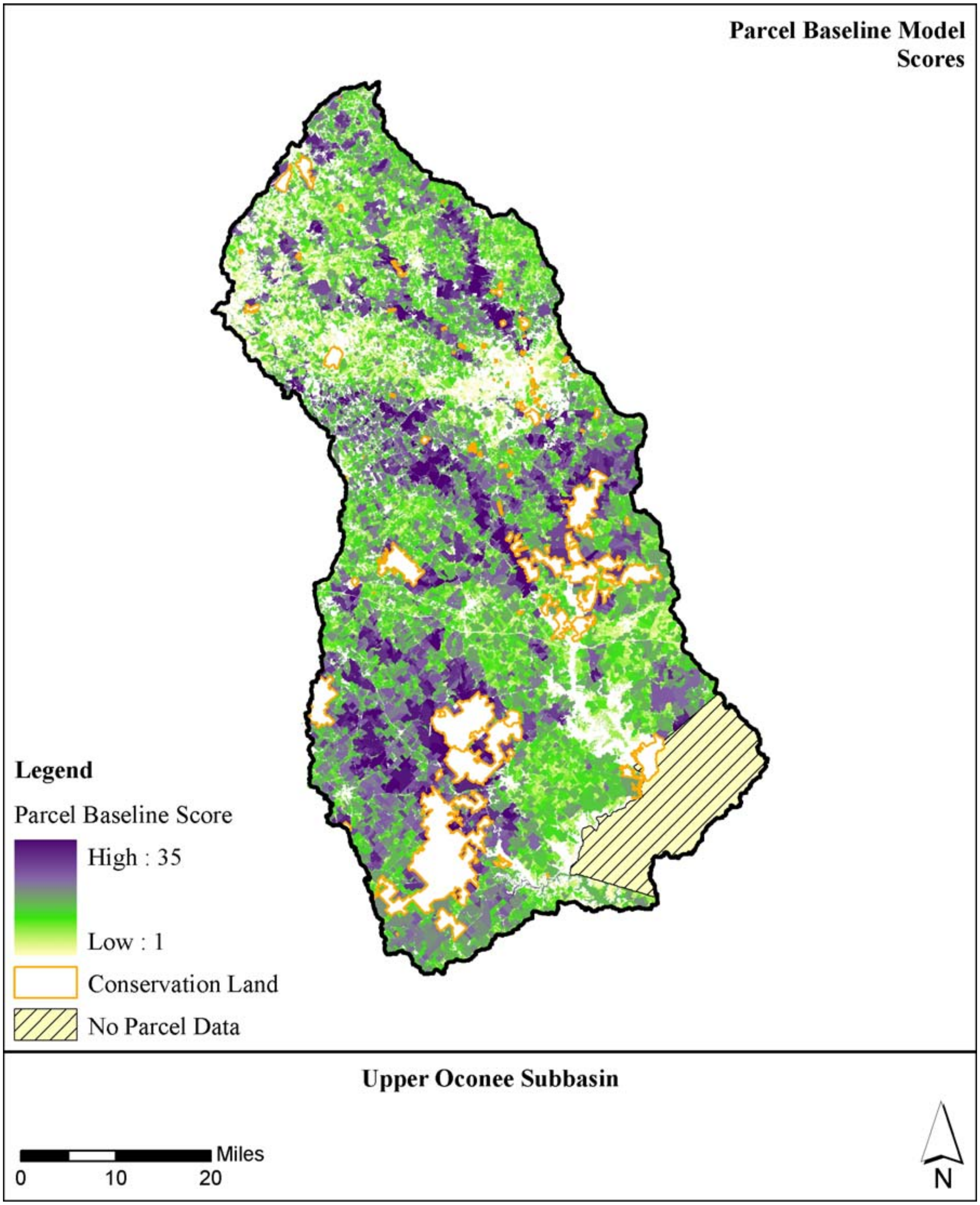

Figure 3.11: Parcel Baseline Model scores. This map shows the spatial distribution of parcels scores not corrected for area in the Upper Oconee subbasin. High scores equate to relative high conservation values.

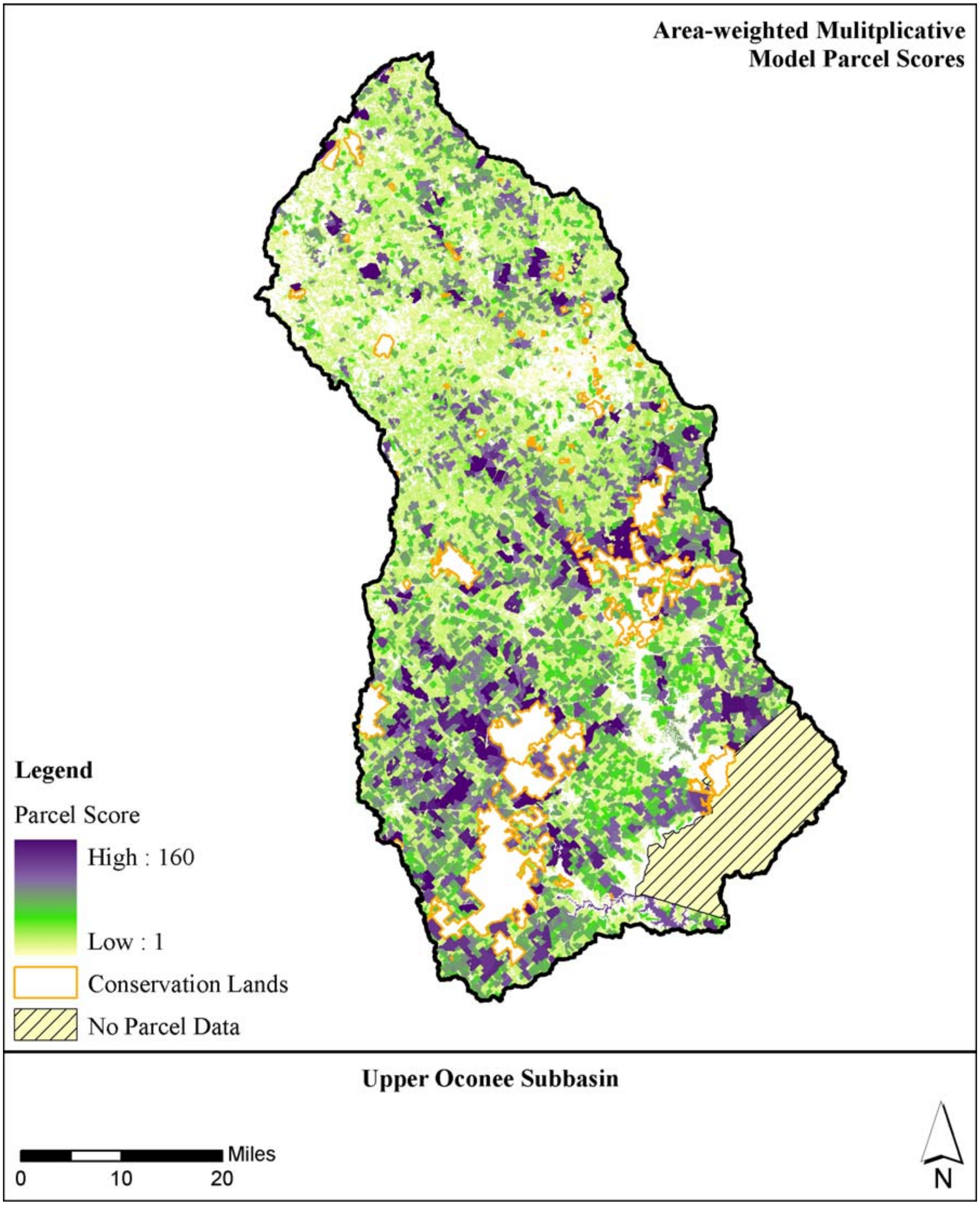

Figure 3.12: Parcel Area-weighted Multiplicative Model scores. This map shows the spatial distribution of area-corrected parcel scores in the Upper Oconee subbasin. High scores equate to relative high conservation values.

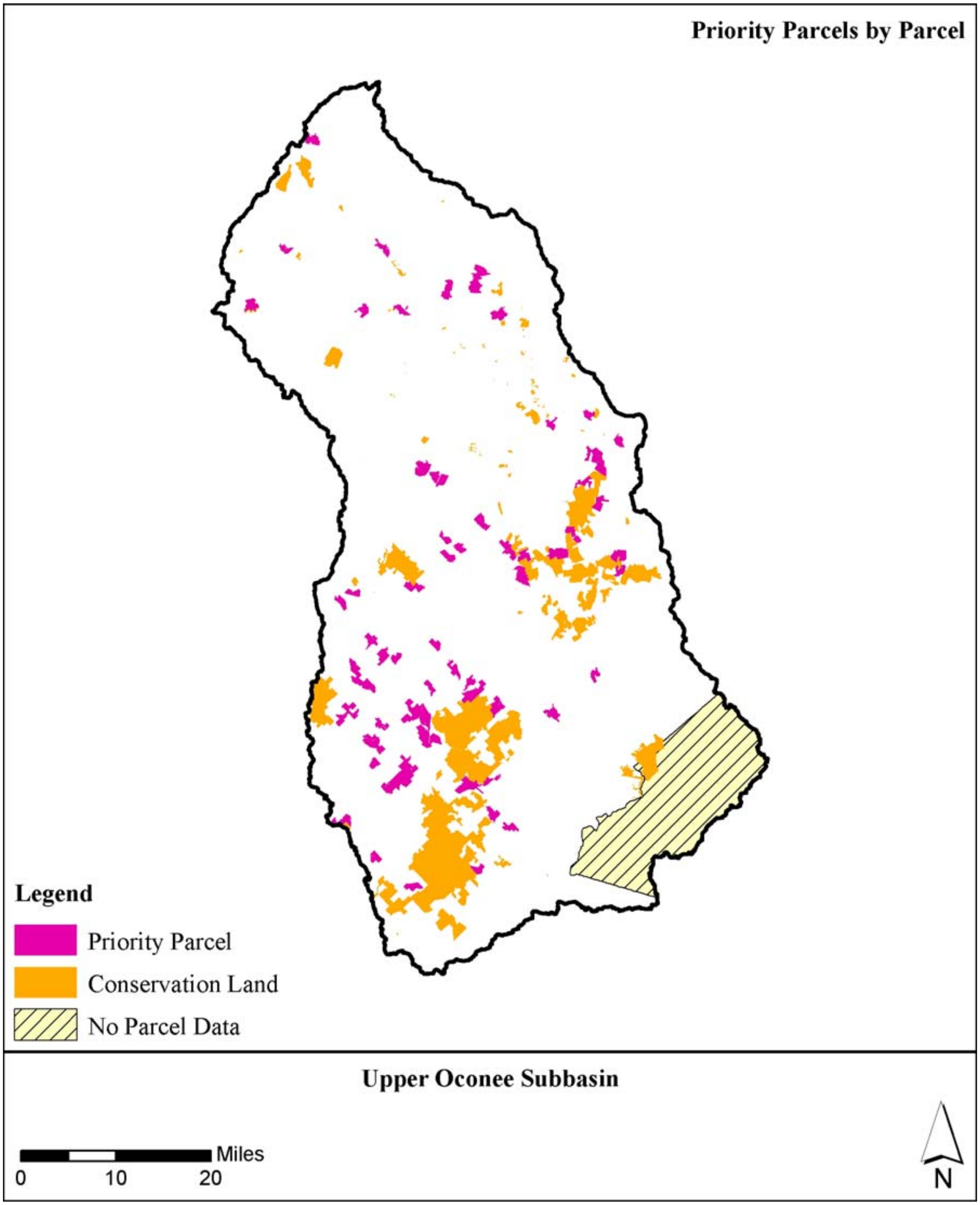

Figure 3.13: Priority Parcels by Parcel. This map shows the location and distribution of the highest scoring 70 parcels identified for high conservation value by the parcel method.

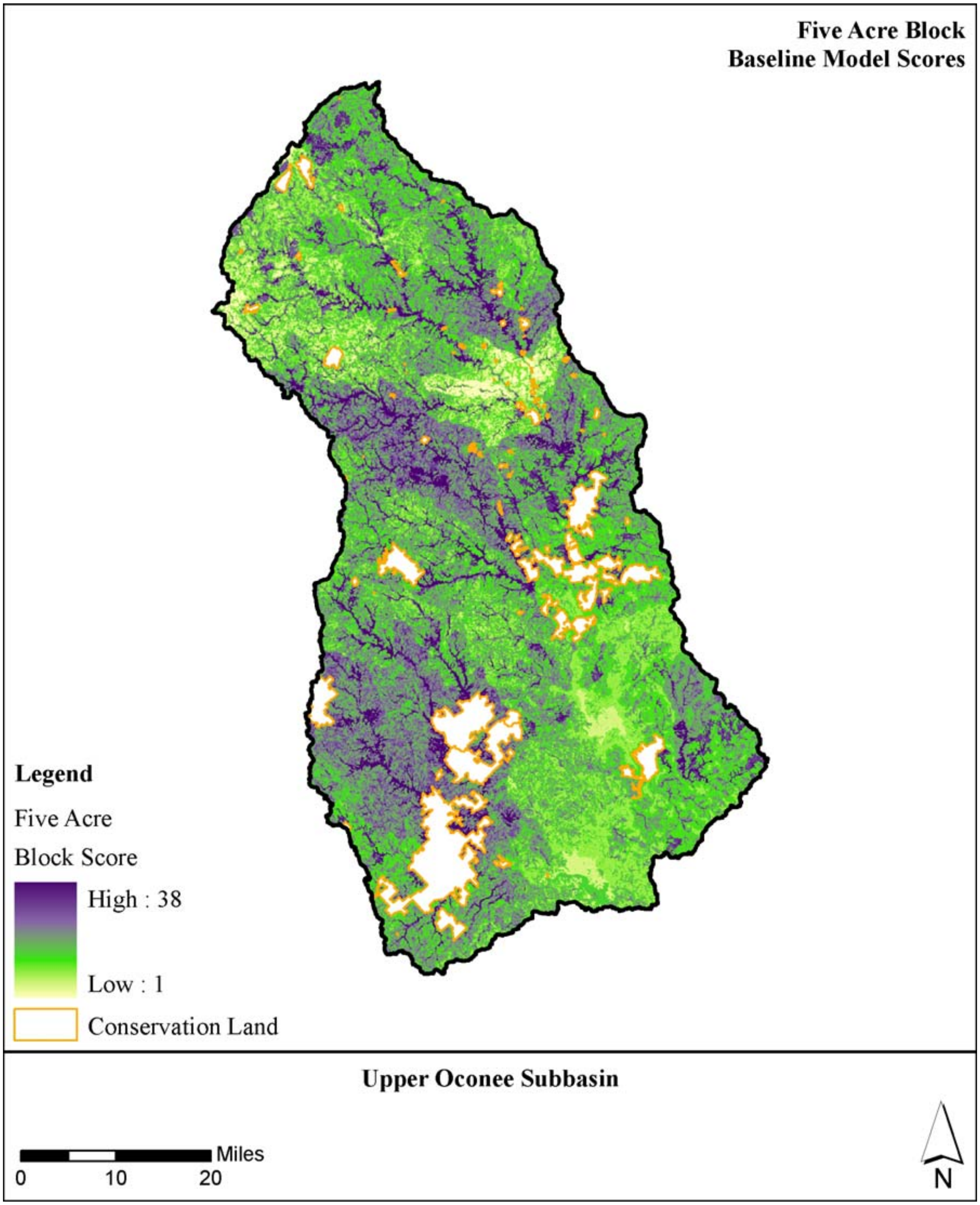

Figure 3.14: Block Baseline Model scores. This map shows the spatial distribution of five acre block scores in the Upper Oconee subbasin. High scores equate to relative high conservation values.

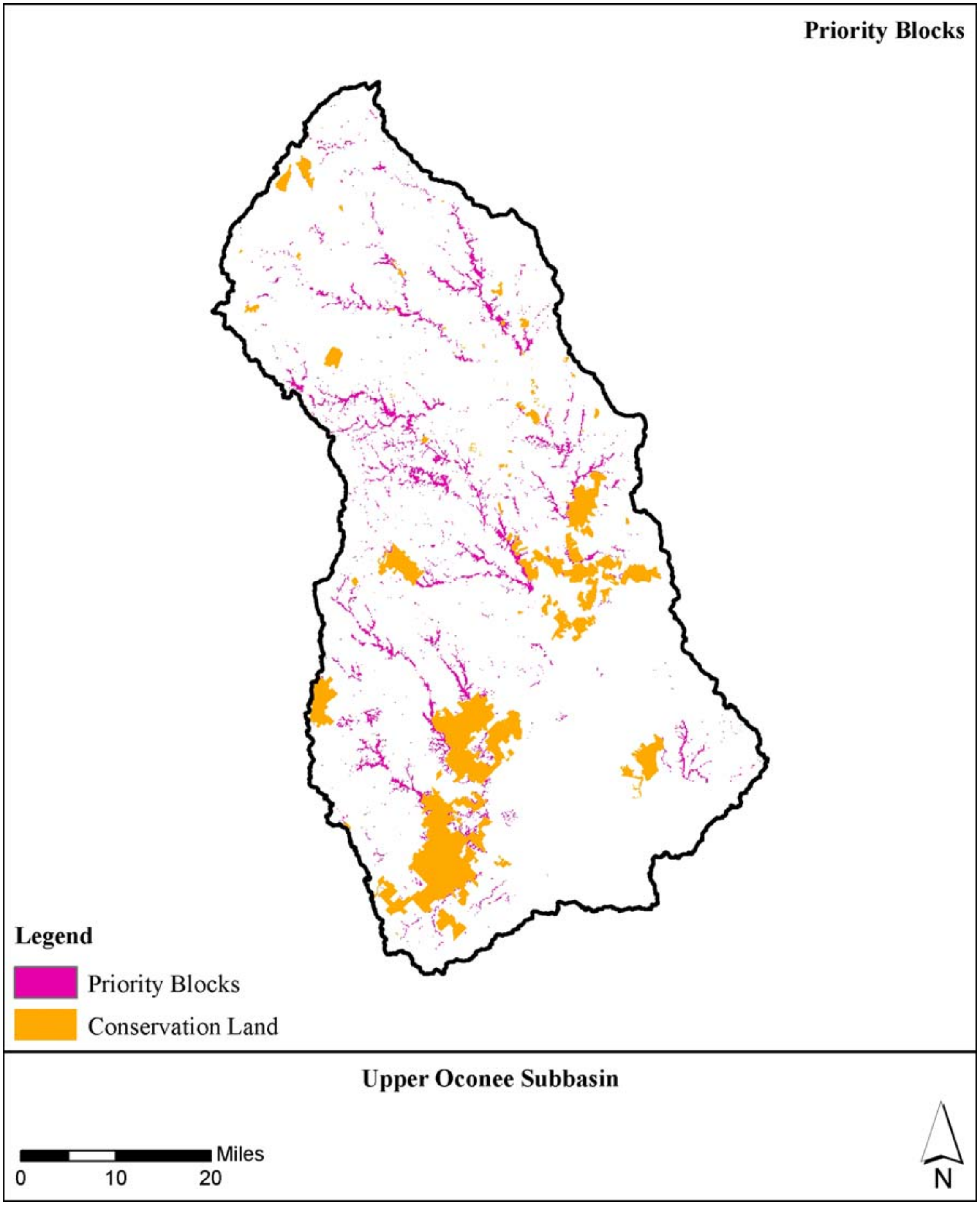

Figure 3.15: Priority Blocks. This map shows the location and distribution of the priority blocks identified as having relatively high conservation value in the five acre block method. Priority Blocks cover 92.8 square miles, which is 3.18 percent of the subbasin.

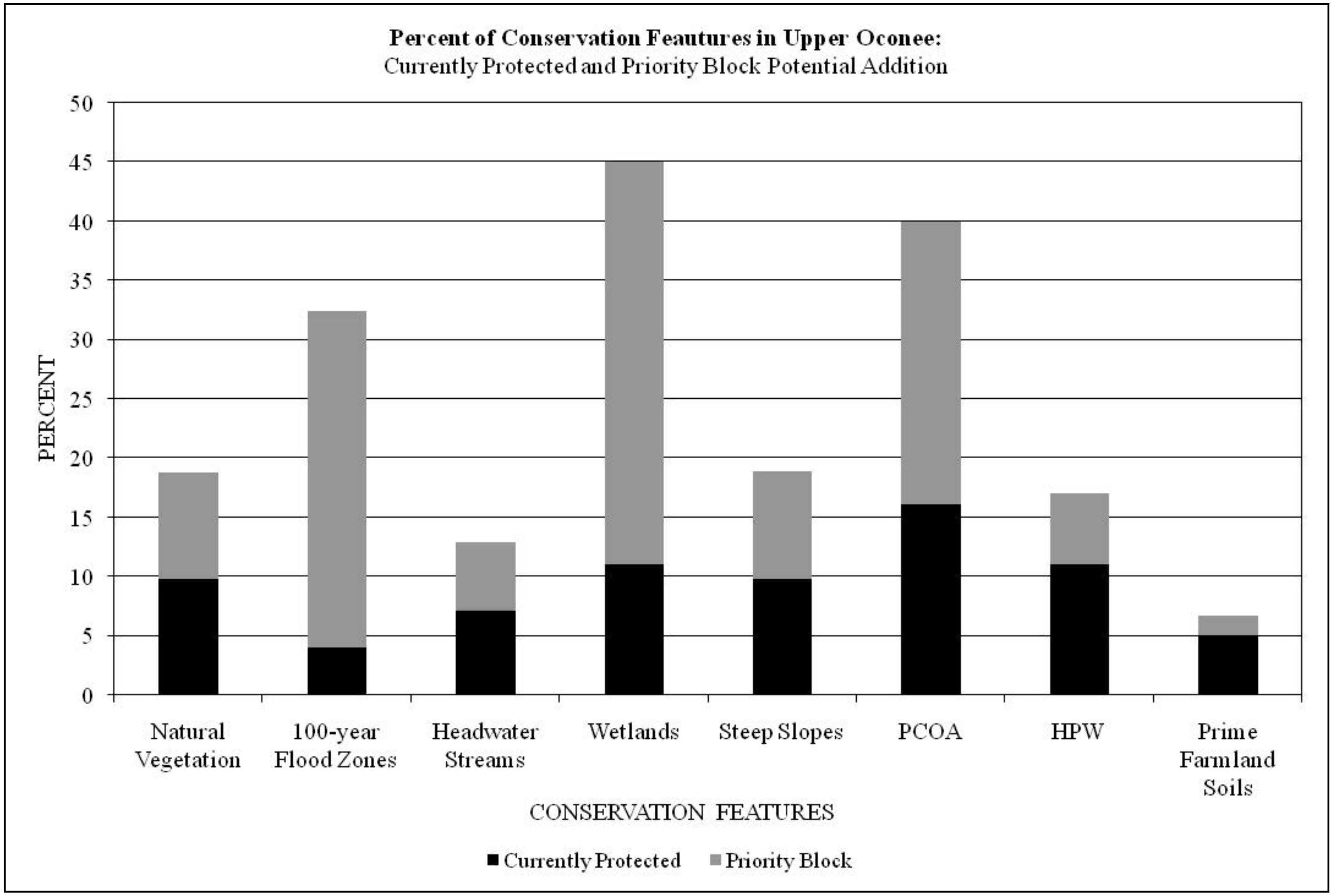

Figure 3.16: Potential conservation addition of Priority Blocks. This graph shows the potential percentage increase in protected area that would occur for each conservation feature if the Priority Blocks were under easement or other protected status. PCOA = Potential Conservation Opportunity Areas and HPW = High Priority Watersheds from the Georgia Wildlife Action Plan.

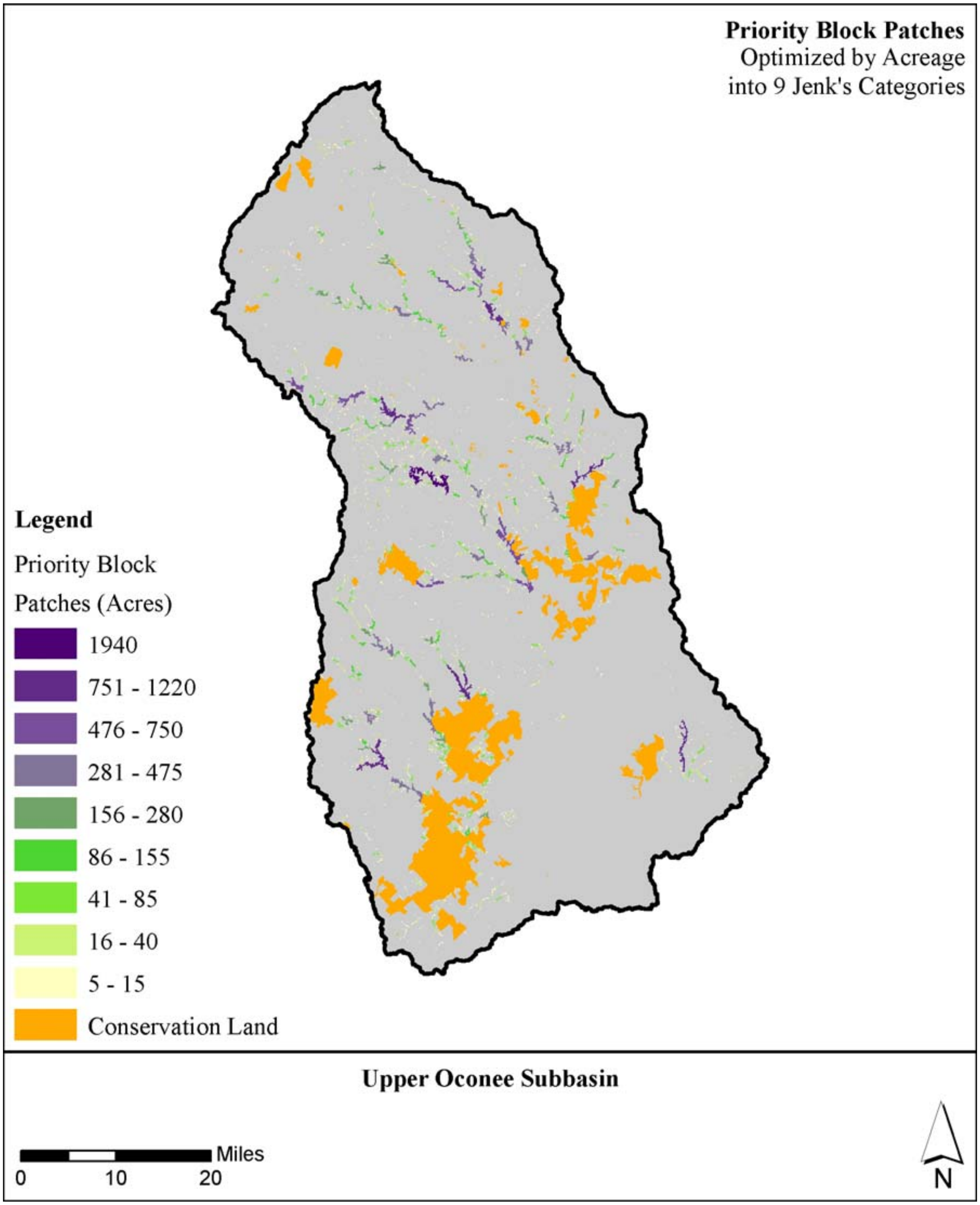

Figure 3.17: Ranked patches of contiguous blocks. This map shows the spatial distribution of patch sizes for the five acre block method. Patches are classed into nine natural categories using Jenk's Optimization.

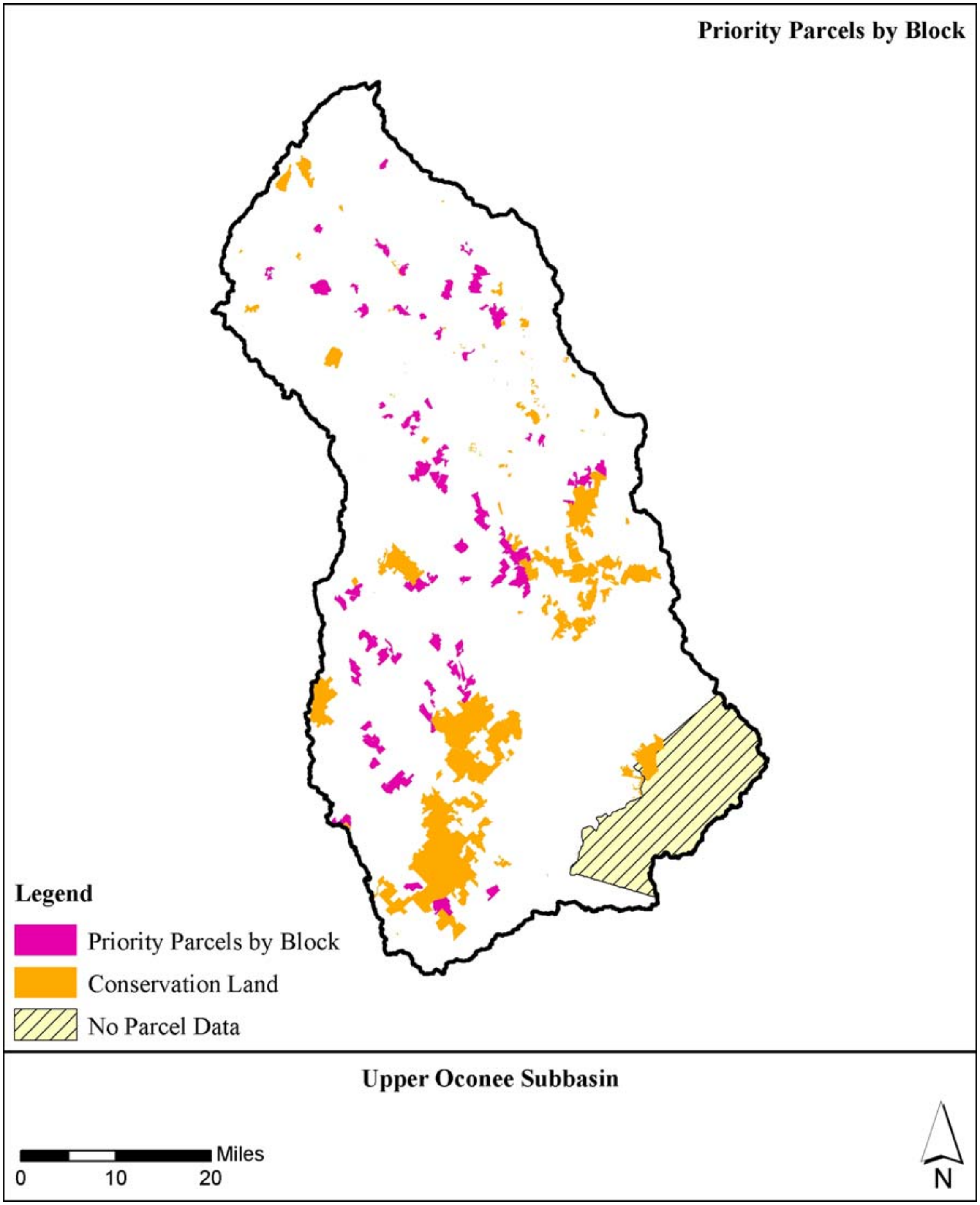

Figure 3.18: Priority Parcels by Block. This map shows the location and distribution of parcels identified as having relatively high conservation value using the five acre block method by summing the blocks within each parcel. The 101 parcels cover 83.1 square miles, which is 2.85 percent of the Upper Oconee subbasin.

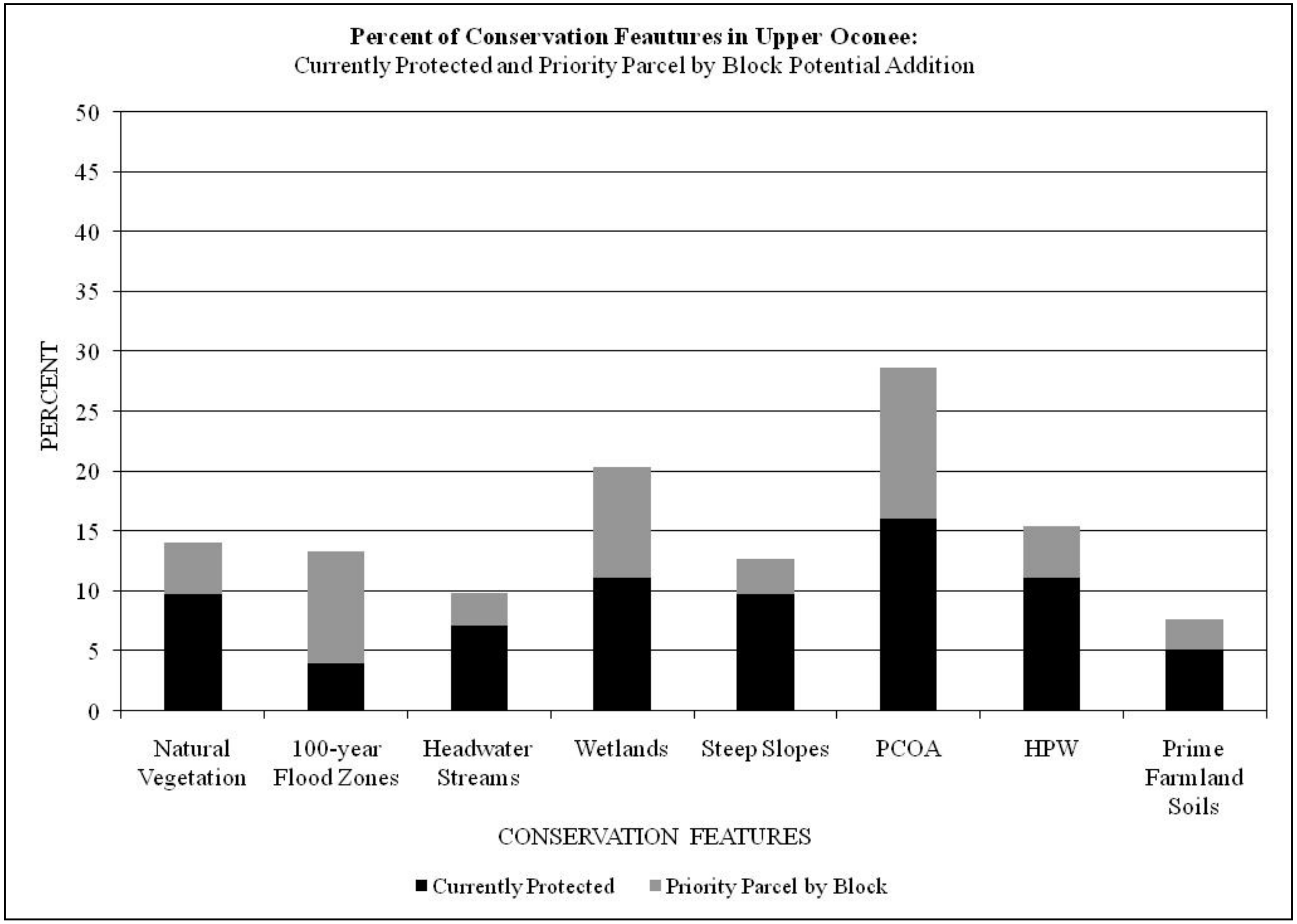

Figure 3.19: Potential conservation addition of Priority Parcels by Block. This graph shows the potential percentage increase in protected area that would occur if the Priority Parcels by Block were under easement or other protected status. PCOA = Potential Conservation Opportunity Areas and HPW = High Priority Watersheds from the Georgia Wildlife Action Plan.

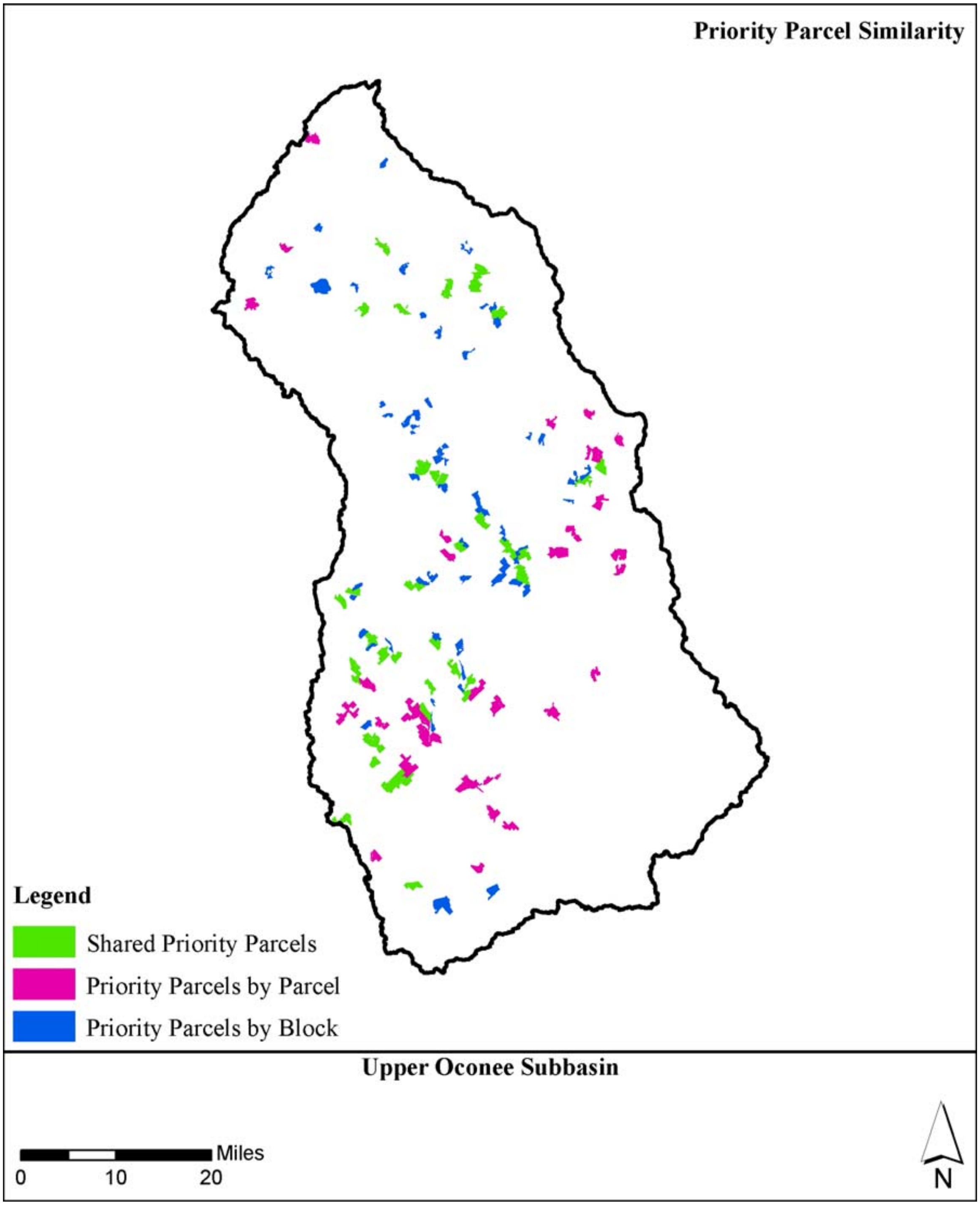

Figure 3.20: Spatial similarity of Priority Parcels identified by parcel and by block. This map shows the spatial similarity of priority parcels from the parcel and block methods. Of the 101 priority parcels by block and the 70 priority parcels by parcel, 37 were shared. These comprised 46.7 square miles. Sorensen similarity index equaled 0.23.

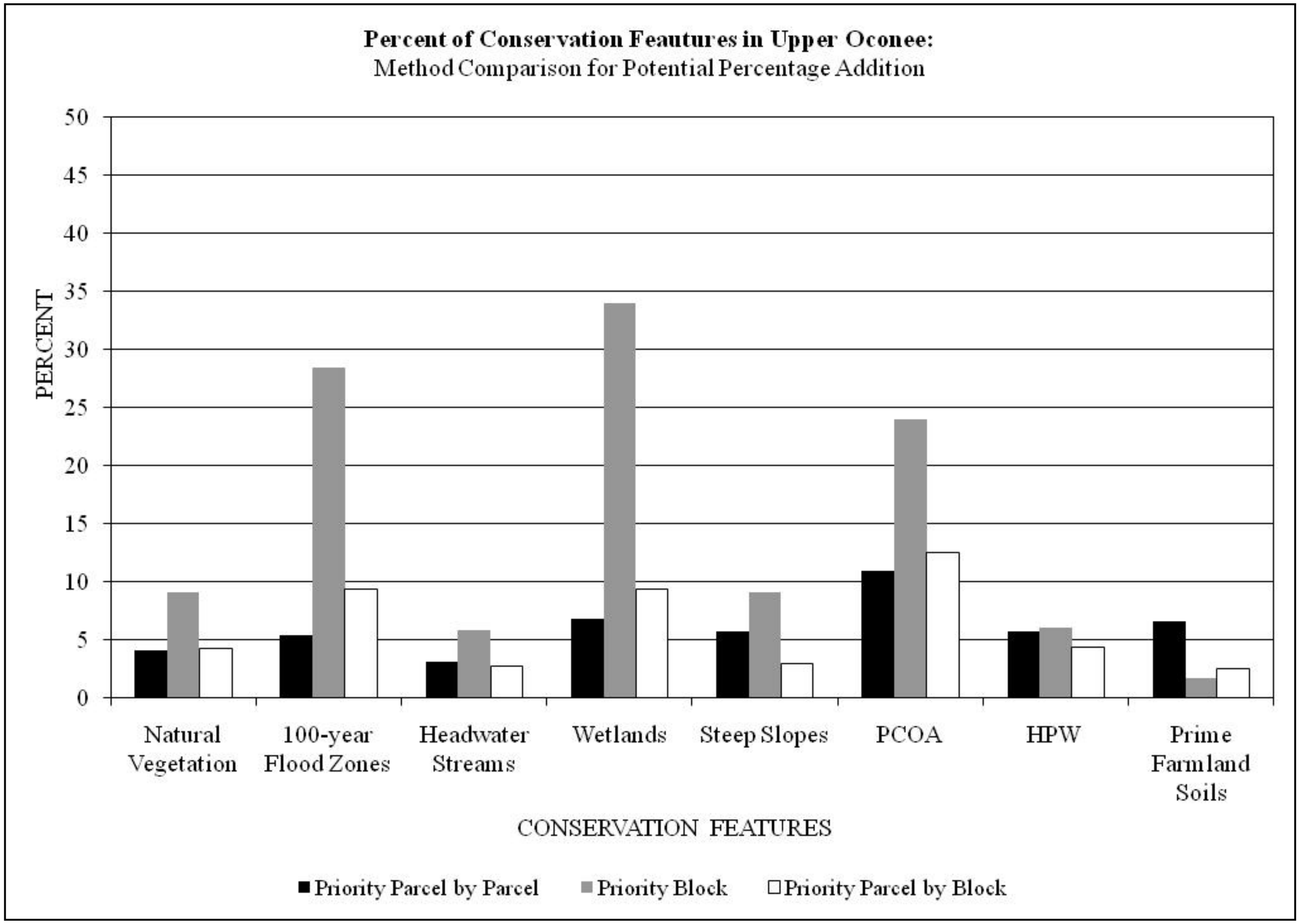

Figure 3.21: Method comparison for potential conservation addition of priority areas. This graph compares the potential percentage conservation addition for each feature for Priority Parcels by Parcel, by Block, and Priority Blocks. PCOA = Potential Conservation Opportunity Areas and HPW = High Priority Watersheds from the Georgia Wildlife Action Plan.

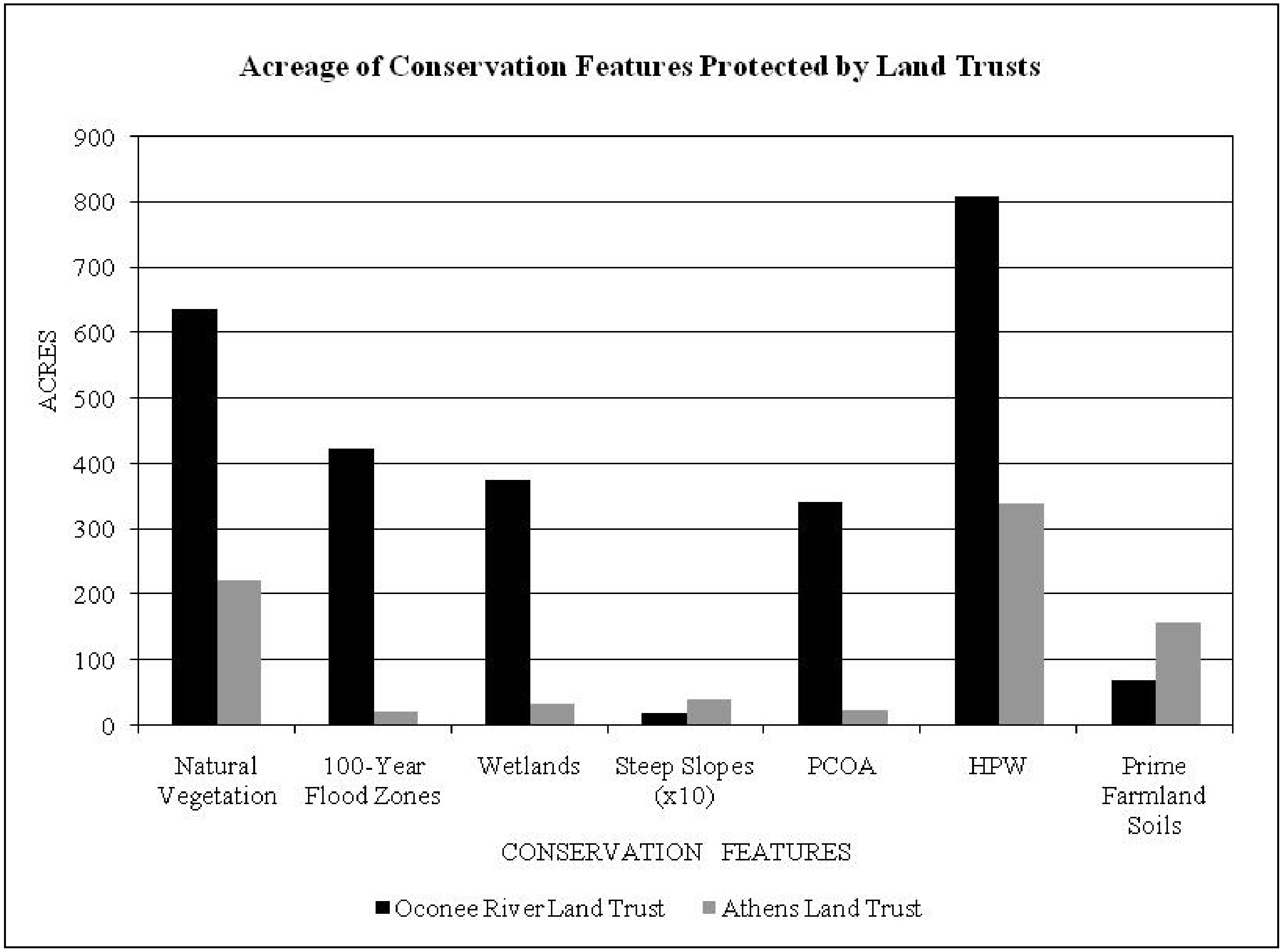

Figure 3.22: Conservation features protected by land trusts. This graph shows the acreage of six of the conservation features protected by Oconee River Land Trust and Athens Land Trust. The subcomponents for the Georgia Wildlife Action Plan Priority Areas are shown as Potential Conservation Opportunity Areas (PCOA) and High Priority Watersheds (HPW).

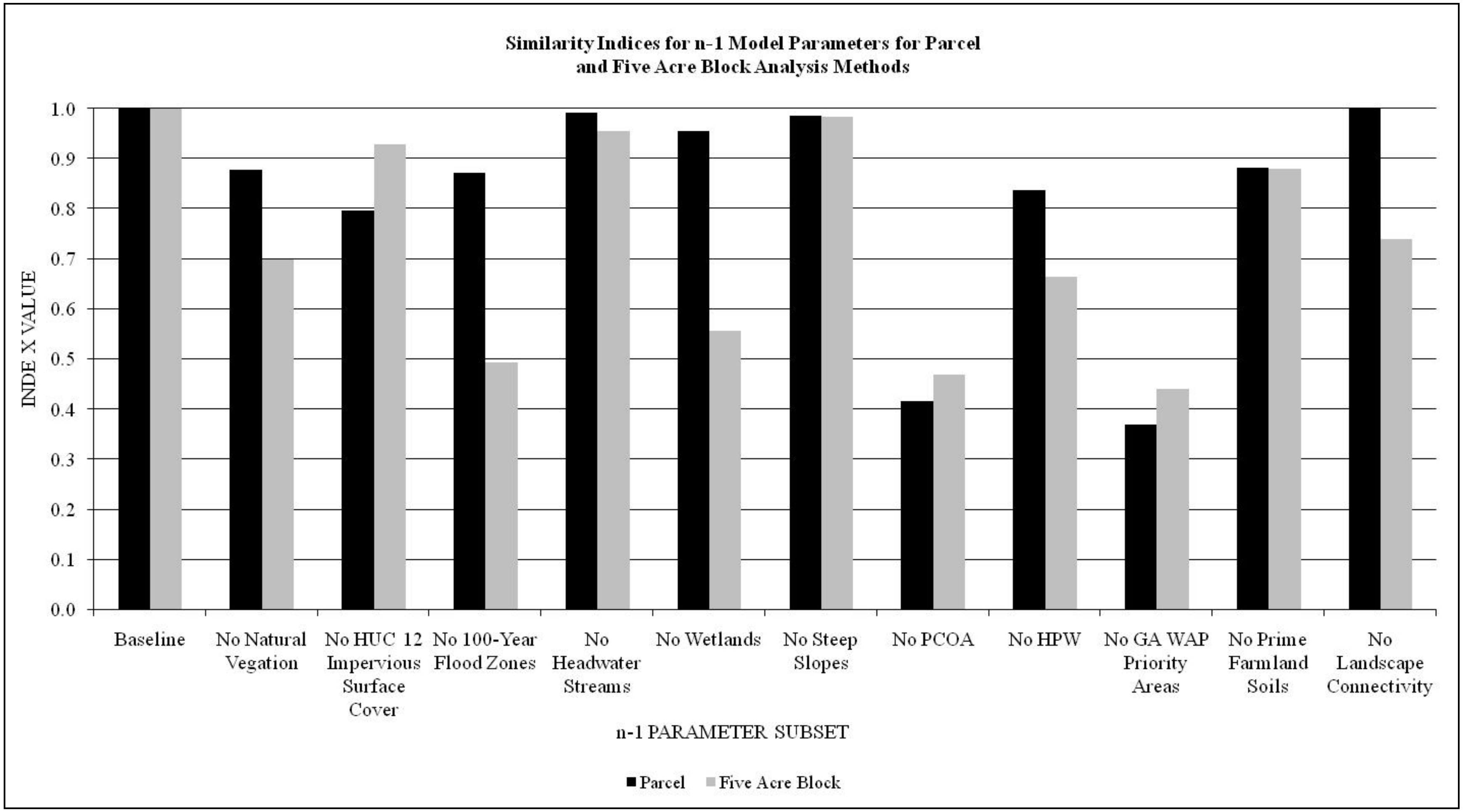
Similarity Indices for n-1 Model Parameters for Parcel and Five Acre Block Analysis Methods
INDE X VALUE
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Baseline
No Natural Vegation
No HUC 12 Impervious Surface Cover
No 100-Year Flood Zones
No Headwater Streams
No Wetlands
No Steep Slopes
No PCOA
No HPW
No GA WAP Priority Areas
No Prime Farmland Soils
No Landscape Connectivity
n-1 PARAMETER SUBSET
Parcel
Five Acre Block

Figure 3.23: Method comparison of similarity indices for model parameters. This graph shows the effect of each model parameter on the model output. A lower index value indicates a stronger effect on the model outputs. Each paired set of values represents the similarity of the model without the listed parameter to the Baseline Model (at left). For the parcel method, baseline means the Area-weighted Multiplicative (AWM) Model outputs, not "baseline" as mentioned in the text. The subcomponents for the Georgia Wildlife Action Plan Priority Areas are shown as Potential Conservation Opportunity Areas (PCOA) and High Priority Watersheds (HPW).

CHAPTER 4

DISCUSSION

To reiterate the goals of my thesis, I wanted: 1) to facilitate the sharing of scientific knowledge with conservation practitioners in an easily comprehended and usable format; and 2) to compare the usage of political boundary analysis units against approximated natural boundary analysis units (parcels versus five acre blocks) for identifying conservation priority areas. With the first goal, I intended to fulfill a pragmatic application for my thesis, ascribing to a philosophy that the production of knowledge from my thesis should extend beyond my own edification as an academic. I followed a more academic trajectory with my second goal through critical inquiry into methods of landscape ecology. For this goal (or question as it is stated in the first chapter), I analyzed the consequences of changing the patterns and scales of the analysis units on the identification of conservation priority areas. Further, I inquired how anthropogenic influences on the landscape might become discernible through correlation of priority areas identified from both political and natural boundaries. In this chapter, I discuss how I achieved the second goal mentioned above, followed by how I presented the results to the land trusts, the aim of the first goal. I feel that this order of explanation is necessary, because the pragmatic goal requires understanding the results and limitations of the model's prioritization process. I start by explaining the significance of the conservation features to the model, and follow this with a comparison of the results from the parcel and block methods. I then discuss the limitations of the modeling process before discussing the format that I used to present the results to the land trusts. Finally, to restate my note on terminology from Chapter 2, Priority Parcels by Parcel (PPP) refer to those identified via the parcel method and Priority Parcels by Block (PPB) indicate those from the block method.

ACADEMIC INQUIRY

Conservation Feature Significance

I evaluated each model parameter's relative weight, or significance, in the model with the Sorensen Similarity Index. As indicated by the similarity indices, the Georgia Wildlife Action (GA WAP) Priority Area feature (and in particular the subfeature of Potential Conservation Opportunity Areas (PCOA)) was the most influential parameter for both the parcel and block methods (Figure 3.23). This occurred because I weighted the model toward the GA WAP Priority Areas by having two subfeatures that were not exclusive of each other. This feature had a possible score of eight compared with only five for all of the other features; hence, any parcel or block within both a PCOA and an HPW would score eight points (Table 3.1, *Possible Scores*). Further, of the 27 parcels that were lost from the PPP by exclusion of this feature, 19 of them fell in High Priority watersheds (HPW) and all of them scored as presemt in a PCOA.

The weighting of the GA WAP Priority Areas was important for two reasons. First, I intended to extend the assessment made by GA DNR (2005) in the GA WAP, which evaluated large, 100 ha tracts of critical wildlife habitat and species of concern. I did this by targeting other conservation values that encapsulate critical ecological functions. Second, as of 2009 the GA DNR became the decision-making entity for the newly revised GLCP, which has been renamed the Georgia Conservation Tax Credit Program (GCTCP; Appendix C). In other words, the GA DNR is the sole certifying agency for tax credit applications, and for evaluating the legal designation of "conservation land" using more general criteria than the GLCP by following the values outlined in the GCTCP (Appendix C). Hence, the emphasis was intentional, though with ostensibly further reaching consequences now that the GA DNR is the decision-maker for applications to the GCTCP.

Further, for Upper Oconee subbasin residents, the argument to identify conservation values that are associated with ecological functions in addition to those values identified by GA DNR is logical. Numerous studies have associated the user-based ecosystem services rendered by ecological functions as critical for inclusion to conservation assessments and planning (Chan et al. 2006; Daily & Matson 2008; Egoh et al. 2007). However, the areal target of 2.75% (10% total) for the subbasin was a guideline. It does not indicate whether this percentage would be a sufficient quantity to sustain the critical ecological functions that supply ecosystem services needed by human and wildlife residents.

Natural and Political Boundaries

The model results show that there is moderate correlation among priority areas identified by the parcel and block methods ($r = 0.57$). However, the score distributions are not the same for either the area-weighted parcel scores versus the block scores (Wilcoxon Signed-Rank Test, $p<0.0001$), nor the area-weighted parcel scores (parcel method) versus block-summed parcel scores (block method; Wilcoxon Signed-Rank Test, $p<0.0001$). The reason that the score distributions are not the same relates to the area-weighting step for the parcel method. The simple classifying of areas into just three categories, which have broad ranges, undervalues parcels that are in the upper ranges of each size class. The result is a trimodal distribution of scores from the parcel method. For example, for two parcels of 99 acres and 101 acres with equivalent percentages and presence/absence criteria for all conservation features, the model values the smaller parcel three times less (using multiplication factors of 1 and 3, respectively).

The same holds true for a parcel of 400+ acres and one just over 500 acres, except that the value difference is on the order of one and two-third times less (i.e. factors of 3 and 5, respectively).

I chose these three size categories and their respective multipliers from the GLCP criteria. One major difference, however, in the way that I used the size factors (i.e., 1, 3, and 5) is that I multiplied total parcel scores by them, instead of adding the points to the total score. This inadvertently caused the trimodal score distribution and subsequent devaluing of parcels in the upper ranges, as explained earlier. I conclude from these results that, if the area-weighting categories for the parcel method were more finite and numerous (i.e. more than just multipliers of 1, 3, and 5 for three size categories), the r value would increase, as would the likelihood of the score distributions being the same for the Wilcoxon tests.

The reason for the different "area-weighting" methods (i.e. multiplying versus adding) of my model and the GLCP criteria relate to different intentions. I use "area-weighting" liberally here, since the GLCP criteria did not correct for area with an even application over parcel size ranges either. In other words, parcels near the low end and near the high end of very broad size categories were valued equally. For example, a parcel of 501 acres would be equally valued to one of 999 acres, assuming all feature percentages and presence/absence criteria were the same (using the GLCP size categories mentioned in the methods section). This is acceptable for valuing a parcel for a decision process, but not for ranking it among other parcels. Hence, I expose a fundamental difference in my goal and the goal of DNR in using the GLCP criteria for valuing parcels. I was ranking parcels and attempting to identify those with the highest relative value for conservation. DNR was using the GLCP criteria as an informative and quantitative guide in a decision-making process for valuing individual parcels. However, this process for DNR has changed since the new 2009 GCTCP legislation throws out the score chart that previously guided the process, and affords them an executive decision based on descriptive, rather than quantitative, criteria (Appendix C). My hope is that the change in legislation results in a greater likelihood of applications for the Priority Parcels being accepted by the GCTCP.

The most convincing argument for the use of natural boundaries when identifying conservation priority areas is demonstrating the differences in efficiency relating to land area. By efficiency here, I mean that for an equal area of land, it is possible to capture a greater percentage (or quantity) of the conservation features using natural boundaries. As an example, if the Priority Blocks came under protected status, the percentage of protected 100-year flood zones and PCOAs in the Upper Oconee would increase by more than 20% and wetlands by more than 30%. These are high percentages compared with increases of 100-year flood zones and wetlands for the PPP and PPB of about 5% and 10%, respectively (Figure 3.22). Thus, for my analysis of the Upper Oconee, acquiring the 92.8 mi^2 of Priority Blocks would be the most efficient route regarding the ratio of quantity of conservation features to land area needed.

However, for the land trusts, this route would require contacting over 6,300 landowners and potentially monitoring and managing the numerous resulting easement holdings. Even contacting just those landowners that fall within the largest contiguous patch of 1,940 acres identified by the block model would require drafting 97 recruitment letters. Thus, a more efficient approach for the land trusts is to maximize the ratio of quantity of conservation features to landowners they need to contact. This approach minimizes the demand on already limited personnel hours for the land trusts and maximizes the possible returns relative to energy spent. Thus, contrasting with the Priority Blocks simulating a natural boundary perspective and an approach with high land area efficiency, a focus on the political boundaries of the Priority Parcels increases the personnel efficiency while maintaining respectable target quantities of conservation features for the efforts of practitioners. For example, there are 70 and 101 landowners identified in the PPP and PPB, respectively, compared with the greater than 6,300 landowners identified by the Priority Blocks. While acquisition of easements on these Priority Parcels would not increase the percentage of protected conservation features nearly as dramatically as would easements in the Priority Plocks, the recruitment and monitoring efforts would be tremendously lower. The potential percentage increase in protected area for conservation features using the PPB approaches ranges from 30% (steep slopes) to a rather large 232% (100-year flood zones; Figure 3.22). All of the results and reasons presented thus far led me to conclude that the Priority Parcels by Block are the most informative and efficient means for identifying landowners to contact.

Further, addressing the second goal, I predicted that anthropogenic influences may become discernible when comparing the parcel and block methods. In other words, patterns of individual landowner's land management practices may be noticeable. An indication of support for this prediction would be a high spatial correlation for Priority Parcels and Priority Blocks. If land management practices were very different among landowners, the priority areas I would expect to locate with both the parcel and block methods should correlate more highly. For example, a landowner who practiced selective or no timber harvesting would likely rank higher for the model than one who practiced clear cutting. However, as I showed previously, the correlation between these two methods' priority areas was only moderate ($r = 0.57$). Further, the only conservation feature in the model that landowners have direct control over is the natural vegetation cover. Land management practices can also affect the presence of PCOAs, but this is limited to property owners with large tracts of land, preferably ≥ 100 hectares and with a State listed species of concern. Thus, for these reasons, I conclude that my model is not predictive of landowners' land management practices.

Model Limitations

Aside from the limitation already mentioned, which relates to correlating land management practices and priority areas, I present a few other limitations to the model and results in this section. A true accuracy assessment would benefit the model results. In other words, empirical measurements of the conservation features on a random selection of the priority parcels during a site visit would be beneficial. However, due to time and financial constraints I conducted visual assessments with 2007 National Agriculture Imagery Program (NAIP) images, and determined that all Priority Parcels by Block appear correctly scored. Moreover, ORLT board members agreed with the relative scoring of their easements, which helps to strengthen the predictions, as they are experienced field staff and expert biologists with onsite knowledge of their easement holdings. Further restrictions relate to the use of 30m land cover data, which limited the minimum analysis unit (i.e. parcel and block) size to five acres. This effectively undervalues urban green spaces and planning for their acquisition, since many urban parcels are of less than five acres.

Other limitations in the model include the missing 100-year flood zone and prime farmland soils data, which may have skewed the results. However, a few of the Priority Parcels are in areas where the absent data would be located (11 and two in counties missing 100-year flood zone and prime farmland soils data, respectively); thus, some of the highest-ranking parcels may be even more strongly implicated for conservation action, were the data included. Additionally, although I explicitly chose to increase the number of headwater streams beyond the USGS 1:24K streams based on the findings of Colson et al. (2008), this estimation may have spatially misidentified and/or wrongly quantified headwater streams as a result of the low accuracy of the 30m NED, leading to a misrepresentation of features contained within parcels. Ground truthing to assess the stream accuracy would be beneficial; however, time and financial constraints limit such endeavors.

Further, impervious cover could be a positive indicator for need of conservation action by indicating more intense development in the subwatershed, and thus a higher threat to remaining natural areas of relatively high conservation value. This is the concept of vulnerability mentioned in Chapter 1 (Margules & Pressey 2000). Other measures that predict parcel development likelihood or pressure (e.g. topography, municipal growth directions and rates, proximity to amenities) would be valuable in assessing the urgency for conservation action in some areas. Finally, the land trusts' budget constraints relating to easement costs as well as land owner preferences (e.g. willingness to donate) and interest in conservation are not accounted for in this model (Polasky et al. 2001; Strager & Rosenberger 2007). Despite these limitations, this model provides ORLT and ALT with information to proactively and efficiently recruit easements on lands with valuable conservation features.

PRAGMATIC APPLICATION

Context-Dependent Planning

Context-dependent planning for conservation is essential to an efficient and effective strategy for preserving and protecting natural resources (Kiesecker et al. 2007; Rissman et al. 2007). By context-dependent, I am referring to the idea that in order to be efficient with efforts, conservation practitioners and organizations must have knowledge of the quantity and extent of conservation features currently protected. Evaluating this information against what features are most in need of protection will vastly improve the efficiency of conservation efforts. Due to the variability of feature protection inherent in conservation easements, Rissman et al. (2007) called for a more detailed assessment of easement contributions in a regional context. As part of my research, I quantitatively assessed the nine conservation features from the model for current easement holdings for ORLT and ALT in the Upper Oconee subbasin (Figure 3.22). Further, I assessed these same features within existing protected areas to promote regional planning by the two land trusts (Figure 3.19). Moreover, this ultimately allows the land trusts to develop an easement recruitment strategy for protection of these conservation features with organizational, as well as regional quantitative targets in mind. However, the next step will be to review current agreements to ensure the legal protection of these features on the land trusts' easements.

Conservation Planning and Implementation

To accomplish the first goal of pragmatic application of my thesis research, I presented ORLT and ALT with a report in the form of a project summary (Appendix D). This report succinctly, and in non-technical language, explained the processes described heretofore in my thesis for identifying conservation priority areas and parcels as well as the landowners of such properties in the Upper Oconee subbasin. The report briefly reviews the decisions for selecting the conservation features that I analyzed in the model. I also explain the rationale for choosing the GLCP criteria as a guideline for the model parameters and score indices. Critical to the report, I discuss the limitations of the analyses relating to the accuracy of the input data. Further, aside from the visual assessments I made with 2007 NAIP aerial imagery, I strongly encourage field verification before any acquisition processes are begun. The only exception to the field verification recommendation is determining the identified landowners' interest via a solicitation letter.

In order to facilitate implementation of any conservation assessment, a good conservation plan must have, and create if necessary, a strategic method for contacting affected individuals. In the case of working with land trusts, an avenue or format for contacting landowners is imperative. During the course of my research, UGA law students in the Odum School of Ecology's Environmental Law Practicum began working with ORLT to draft a formal letter for contacting the owners of the Priority Parcels. They also suggested an informal gathering of the landowners with the land trust staff and board members. Such a gathering could potentially facilitate a sense of community among the landowners and foster a relationship between the landowners and the land trusts.

Finally, it is fundamental to empower the land trusts to use this conservation assessment of the Upper Oconee subbasin, and to turn conservation planning into implementation. I presented a final report to the land trusts in both a hard copy and digital version of the project summary described above. The digital version came in the format of GeoPDFs, which are geospatially referenced PDF files, containing attribute data from a GIS (http://www.terragotech.com/). Additional project deliverables in the digital version included: 1) a 1:24,000 digital map of each Priority Parcel with parcel boundaries and associated conservation feature values, five acre block scores, 2007 NAIP aerial imagery, and 2005 GLUT land cover; 2) all available Priority Parcel information from each county's tax assessor website (http://www.gaassessors.com); and 3) an Excel database of all analyzed conservation features for over 34,000 parcels in the Upper Oconee. A significant side-benefit of this study is providing the land trusts access to the entire database of values for the features analyzed in all parcels, which allows them to visit potential easement sites with *a priori* knowledge.

CONCLUSIONS

In conclusion, it is important to recognize that any prioritization process necessarily chooses to value one set of parameters at the expense of others. For example, in this model I did not evaluate cultural heritage sites, viewsheds, and agricultural lands (although partially encapsulated through the prime farmland soils parameter), thereby denying representation to these valuable historical, scenic, and vital landscape features. This is not to discredit this modeling process. My intention here is to make end users of this and other priority models aware that priority schemes cannot consider all features of conservation value. Researchers choose parameters with stakeholders to answer one set of questions as accurately as possible. There is no model that can capture the breadth of values and features needing protection. Conservation modelers and practitioners are wise to keep these thoughts in mind throughout all phases of assessment, planning, and implementation of conservation strategies.

REFERENCES

Ackery, P. R., and R. I. Vane-Wright 1984. Milkweed butterflies, their cladistics and biology : being an account of the natural history of the Danainae, a subfamily of the Lepidoptera, Nymphalidae. British Museum (Natural History), London & Ithaca, NY.

Agrawal, A., and K. Redford. 2006. Poverty, Development, And Biodiversity Conservation: Shooting in the Dark? Ann Arbor MI **48109**:647-5948.

ALT. 2009. http://www.athenslandtrust.org accessed February 8, 2009.

Arnold, C. L., and C. J. Gibbons. 1996. Impervious Surface Coverage: The Emergence of a Key Environmental Indicator. Journal of the American Planning Association **62**:243-258.

Beyer, H. L. 2004. Hawth's Analysis Tools for ArcGIS, Available at http://www.spatialecology.com/htools.

Brooks, T. M., R. A. Mittermeier, G. A. B. da Fonseca, J. Gerlach, M. Hoffmann, J. F. Lamoreux, C. G. Mittermeier, J. D. Pilgrim, and A. S. L. Rodrigues. 2006. Global biodiversity conservation priorities. Science **313**:58-61.

Brosius, J. P. 2006. Seeing Communities: Technologies of visualization in conservation in G. W. Creed, editor. The seductions of community : emancipations, oppressions, quandaries. School of American Research; James Currey, Santa Fe Oxford.

Brosius, J. P., and D. Russell. 2003. Conservation from Above: An Anthropological Perspective on Transboundary Protected Areas and Ecoregional Planning. Journal of Sustainable Forestry **17**:39-66.

Chan, K. M. A., M. R. Shaw, D. R. Cameron, E. C. Underwood, and G. C. Daily. 2006. Conservation planning for ecosystem services. Plos Biology **4**:2138-2152.

Colson, T., J. Gregory, J. Dorney, and P. Russell. 2008. Topographic and Soil Maps Do Not Accurately Depict Headwater Stream Networks. National Wetlands Newsletter. Environmental Law Institute, Washington D.C.

Costanza, R., R. dArge, R. deGroot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. Oneill, J. Paruelo, R. G. Raskin, P. Sutton, and M. vandenBelt. 1997. The value of the world's ecosystem services and natural capital. Nature **387**:253-260.

Cowling, R. M., and R. L. Pressey. 2003. Introduction to systematic conservation planning in the Cape Floristic Region. Biological Conservation **112**:1-13.

Daily, G. C. 1997. Nature's services : societal dependence on natural ecosystems. Island Press, Washington, DC.

Daily, G. C., and P. A. Matson. 2008. Ecosystem services: From theory to implementation. Proceedings of the National Academy of Sciences **105**:9455-9456.

Dasmann, R. F. 1973. A system for defining and classifying natural regions for the purposes of conservation. World Conservation Union, Morges, Switzerland.

Egoh, B., M. Rouget, B. Reyers, A. T. Knight, R. M. Cowling, A. S. van Jaarsveld, and A. Welz. 2007. Integrating ecosystem services into conservation assessments: A review. Ecological Economics **63**:714-721.

Ehrlich, P. R., and H. A. Mooney. 1983. Extinction, Substitution, and Ecosystem Services. BioScience **33**:248-254.

Fowler, L. 1998. A Landowner's Guide: Conservation easements for natural resource protection. Georgia Land Trust Service Center.

GA DNR. 2005. A Comprehensive Wildlife Conservation Strategy for Georgia. Wildlife Resources Division.

Game, M., and G. F. Peterken. 1984. Nature Reserve Selection-Strategies in the Woodlands of Central Lincolnshire, England. Biological Conservation **29**:157-181.

GAO. 1994. Endangered Species Act: Information on Species Protection on Nonfederal lands. U. S. General Accounting Office, Washington, D.C.

GLCP. 2009. GLCP Project Scoring and Evaluation Criteria. DNR.

Groves, C. R., R. L. S. Kutner, D. M. Storms, M. P. Murray, J. M. Scott, M. Schafale, A. S. Weakley, and R. L. Pressey. 2000. Owning up to our responsibilities: who owns lands important for biodiversity. Pages xxv, 399 p. in B. A. Stein, L. S. Kutner, J. S. Adams, Nature Conservancy (U.S.), and Association for Biodiversity Information., editors. Precious heritage : the status of biodiversity in the United States. Oxford University Press, Oxford ; New York.

Hazen, H. D., and L. M. Harris. 2007. Limits of territorially-focused conservation: a critical assessment based on cartographic and geographic approaches. Environmental Conservation **34**:280-290.

Hughey, K. F. D., R. Cullen, and E. Moran. 2003. Integrating economics into priority setting and evaluation in conservation management. Conservation Biology **17**:93-103.

IUCN. 1992. Protected Areas of the World: A Review of National Systems. IUCN, Gland, Switzerland and Cambridge , UK.

Jepson, P., and R. J. Whittaker. 2002. Ecoregions in Context: a Critique with Special Reference to Indonesia. Conservation Biology **16**:42-57.

Kiesecker, J. M., T. Comendant, T. Grandmason, E. Gray, C. Hall, R. Hilsenbeck, P. Kareiva, L. Lozier, P. Naehu, A. Rissman, M. R. Shaw, and M. Zankel. 2007. Conservation easements in context: a quantitative analysis of their use by The Nature Conservancy. Frontiers in Ecology and the Environment **5**:125-130.

Kirkpatrick, J. B. 1983. An Iterative Method for Establishing Priorities for the Selection of Nature Reserves - An Example from Tasmania. Biological Conservation **25**:127-134.

Knight, A. T., and R. M. Cowling. 2007. Embracing opportunism in the selection of priority conservation areas. Conservation Biology **21**:1124-1126.

Knight, A. T., R. M. Cowling, M. Rouget, A. Balmford, A. T. Lombard, and B. M. Campbell. 2008. Knowing but not doing: Selecting priority conservation areas and the research-implementation gap. Conservation Biology **22**:610-617.

Kramer, E., M. J. Conroy, M. J. Elliot, E. A. Anderson, W. R. Burnback, and J. Epstein. 2003. The Georgia Gap Analysis Project. University of Georgia and USGS, Athens, GA.

Kremen, C., A. Cameron, A. Moilanen, S. J. Phillips, C. D. Thomas, H. Beentje, J. Dransfield, B. L. Fisher, F. Glaw, T. C. Good, G. J. Harper, R. J. Hijmans, D. C. Lees, E. Louis, Jr., R. A. Nussbaum, C. J. Raxworthy, A. Razafimpahanana, G. E. Schatz, M. Vences, D. R. Vieites, P. C. Wright, and M. L. Zjhra. 2008. Aligning Conservation Priorities Across Taxa in Madagascar with High-Resolution Planning Tools. Science **320**:222-226.

LTA. 2005. National Land Trust Census Report. Land Trust Alliance, Washington D.C.

Margules, C. R., A. O. Nicholls, and R. L. Pressey. 1988. Selecting networks of reserves to maximise biological diversity. Biological Conservation **43**:63-76.

Margules, C. R., and R. L. Pressey. 2000. Systematic conservation planning. Nature **405**:243-253.

MEA 2005. Ecosystems and human well-being : synthesis. Island Press, Washington, DC.

Merenlender, A. M., L. Huntsinger, G. Guthey, and S. K. Fairfax. 2004. Land trusts and conservation easements: Who is conserving what for whom? Conservation Biology **18**:65-75.

Mittermeier, R. A. 2004. Hotspots revisited. CEMEX, Mexico City.

Myers, N. 1983. A priority-ranking strategy for threatened species? The Environmentalist **3**:97-120.

Myers, N. 1988. Threatened biotas: "Hot spots" in tropical forests. The Environmentalist **8**:187-208.

Myers, N. 2003. Biodiversity hotspots revisited. Bioscience **53**:916-917.

Myers, N., and R. A. Mittermeier. 2003. Impact and acceptance of the hotspots strategy: Response to Ovadia and to Brummitt and Lughadha. Conservation Biology **17**:1449-1450.

Noss, R. F., C. Carroll, K. Vance-Borland, and G. Wuerthner. 2002. A multicriteria assessment of the irreplaceability and vulnerability of sites in the Greater Yellowstone Ecosystem. Conservation Biology **16**:895-908.

Noss, R. F., E. T. LaRoe III, and J. M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of the loss and degradation. U.S. Department of the Interior, National Biological Service, Washington, D.C.

O'Connor, C., M. Marvier, and P. Kareiva. 2003. Biological vs. social, economic and political priority-setting in conservation. Ecology Letters **6**:706-711.

Olson, D. M., and E. Dinerstein. 2002. The Global 200: Priority ecoregions for global conservation. Annals of the Missouri Botanical Garden **89**:199-224.

Olson, D. M., E. Dinerstein, E. D. Wikramanayake, N. D. Burgess, G. V. N. Powell, E. C. Underwood, J. A. D'Amico, I. Itoua, H. E. Strand, J. C. Morrison, C. J. Loucks, T. F. Allnutt, T. H. Ricketts, Y. Kura, J. F. Lamoreux, W. W. Wettengel, P. Hedao, and K. R. Kassem. 2001. Terrestrial ecoregions of the worlds: A new map of life on Earth. Bioscience **51**:933-938.

Omernik, J. M. 1987. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers **77**:118-125.

ORLT. 2009. http://www.orlt.org accessed February 8, 2009.

Pentz, D. 2007. State Conservation Tax Credits: Impact and Analysis. Conservation Resource Center.

Polasky, S., J. D. Camm, and B. Garber-Yonts. 2001. Selecting biological reserves cost-effectively: An application to terrestrial vertebrate conservation in Oregon. Land Economics **77**:68-78.

Pressey, R. L. 1994. Ad Hoc Reservations - Forward or Backward Steps in Developing Representative Reserve Systems. Conservation Biology **8**:662-668.

Pressey, R. L. 2002. The first reserve selection algorithm - a retrospective on Jamie Kirkpatrick's 1983 paper. Progress in Physical Geography **26**:434-441.

Pressey, R. L., C. J. Humphries, C. R. Margules, R. I. Vanewright, and P. H. Williams. 1993. Beyond Opportunism - Key Principles for Systematic Reserve Selection. Trends in Ecology & Evolution **8**:124-128.

Pressey, R. L., and A. O. Nicholls. 1989. Efficiency In Conservation Evaluation - Scoring Versus Iterative Approaches. Biological Conservation **50**:199-218.

R. 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Rebelo, A. G., and W. R. Siegfried. 1990. Protection of Fynbos Vegetation - Ideal and Real-World Options. Biological Conservation **54**:15-31.

Rissman, A. R., L. Lozier, T. Comendant, P. Kareiva, J. M. Kiesecker, M. R. Shaw, and A. M. Merenlender. 2007. Conservation easements: Biodiversity protection and private use. Conservation Biology **21**:709-718.

Rodriguez, L. O., and K. R. Young. 2000. Biological diversity of Peru: Determining priority areas for conservation. Ambio **29**:329-337.

Roe, C., and F. McKay. 2008. 2008 Survey of Land Trusts Operating in the Southeastern United States: Land Protection and Readiness for Accreditation. Land Trust Alliance, Southeast Program.

Scott, J. M., F. W. Davis, R. G. McGhie, R. G. Wright, C. Groves, and J. Estes. 2001. Nature reserves: Do they capture the full range of America's biological diversity? Ecological Applications **11**:999-1007.

Shi, H. U. A., A. Singh, S. Kant, Z. Zhu, and E. Waller. 2005. Integrating Habitat Status, Human Population Pressure, and Protection Status into Biodiversity Conservation Priority Setting. Conservation Biology **19**:1273-1285.

Smith, R. J., J. Easton, B. A. Nhancale, A. J. Armstrong, J. Culverwell, S. D. Dlamini, P. S. Goodman, L. Loffler, W. S. Matthews, A. Monadjem, C. M. Mulqueeny, P. Ngwenya, C. P. Ntumi, B. Soto, and N. Leader-Williams. 2008. Designing a transfrontier conservation landscape for the Maputaland centre of endemism using biodiversity, economic and threat data. Biological Conservation **141**:2127-2138.

Spence, M. D. 1999. Dispossessing the wilderness : Indian removal and the making of the national parks. Oxford University Press, New York.

Strager, M. P., and R. S. Rosenberger. 2007. Aggregating high-priority landscape areas to the parcel level: An easement implementation tool. Journal of Environmental Management **82**:290-298.

Thomas, C. D., and H. C. Mallorie. 1985. Rarity, species richness and conservation: Butterflies of the Atlas Mountains in Morocco. Biological Conservation **33**:95-117.

Turner, W. R., K. Brandon, T. M. Brooks, R. Costanza, G. A. B. da Fonseca, and R. Portela. 2007. Global conservation of biodiversity and ecosystem services. Bioscience **57**:868-873.

Udvardy, M. D. F. 1969. Dynamic zoogeography, with special reference to land animals. Van Norstrand Reinhold, New York.

Udvardy, M. D. F. 1975. A classification of the biogeographical provinces of the world. World Conservation Union, Morges, Switzerland.

Vane-Wright, R. I., C. J. Humphries, and P. H. Williams. 1991. What to protect?--Systematics and the agony of choice. Biological Conservation **55**:235-254.

Wikramanayake, E. D., E. Dinerstein, J. G. Robinson, K. U. Karanth, A. Rabinowitz, D. Olson, T. Mathew, P. Hedao, M. Conner, G. Hemley, and D. Bolze. 1999. Where can tigers live in the future? A framework for identifying high-priority areas for the conservation of tigers in the wild. Pages 255-272. Riding the tiger : tiger conservation in human-dominated landscapes. Zoological Society of London; Cambridge University Press, London; Cambridge; New York.

Wilcove, D. S., M. J. Bean, R. Bonnie, and M. McMillan. 1996. Rebuilding the Ark: Toward a More Effective Endangered Species Act for Private Land. Environmental Defense Fund, Washington, D.C.

Wilson, E. O., F. M. Peter, National Academy of Sciences (U.S.), and Smithsonian Institution. 1988. Biodiversity. National Academy Press, Washington, D.C.

Younge, C. L. 2008. Conservation Easement Tax Credits in Environmental Federalism. Yale Law Journal. Pocket Part 218 **117**.

APPENDIX A

PRIORITY AREA SPATIAL SIMILARITY FOR THE PARCEL METHOD

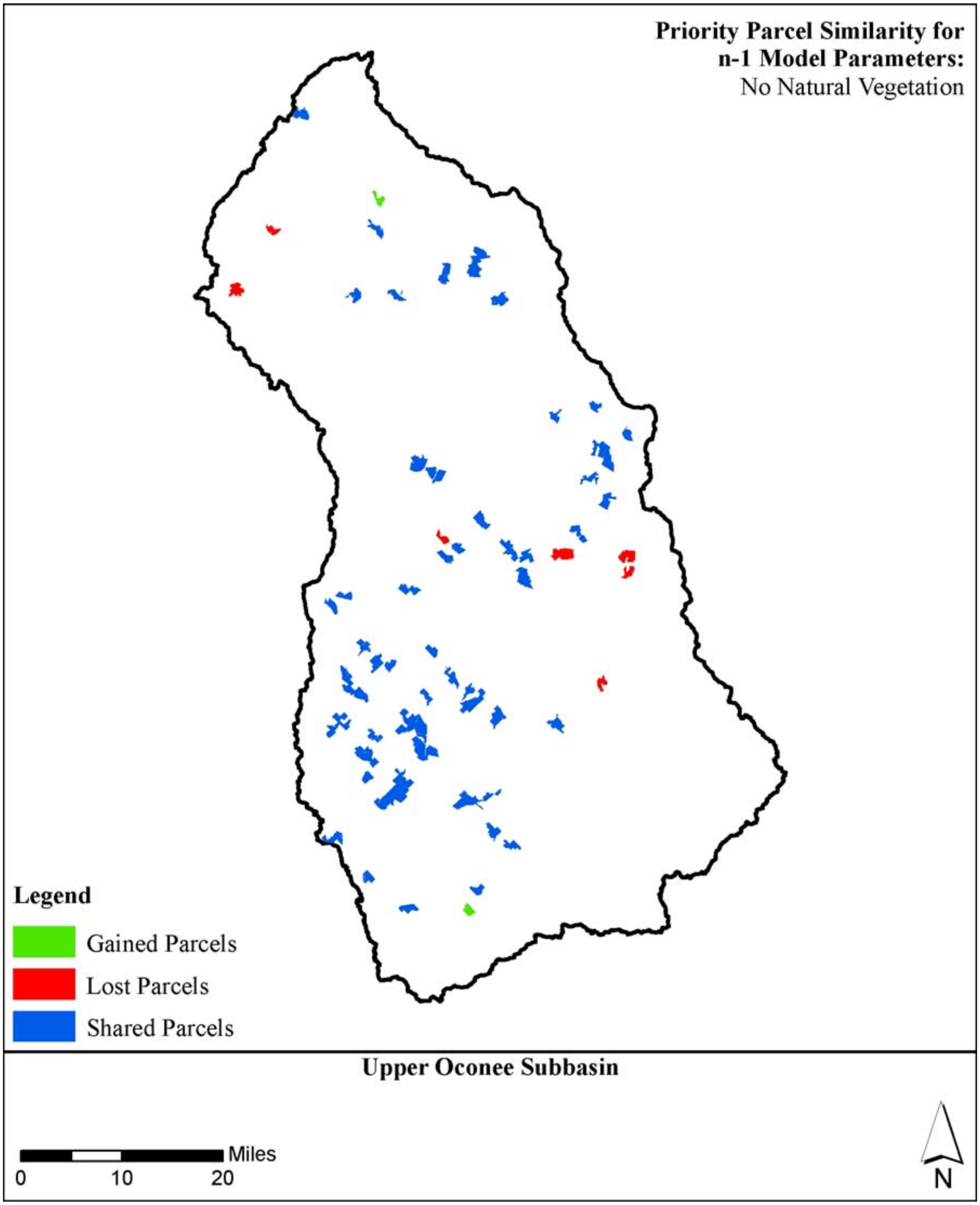

Figure A.1: Spatial similiarity for Priority Parcels by Parcel minus the Natural Vegetation parameter.

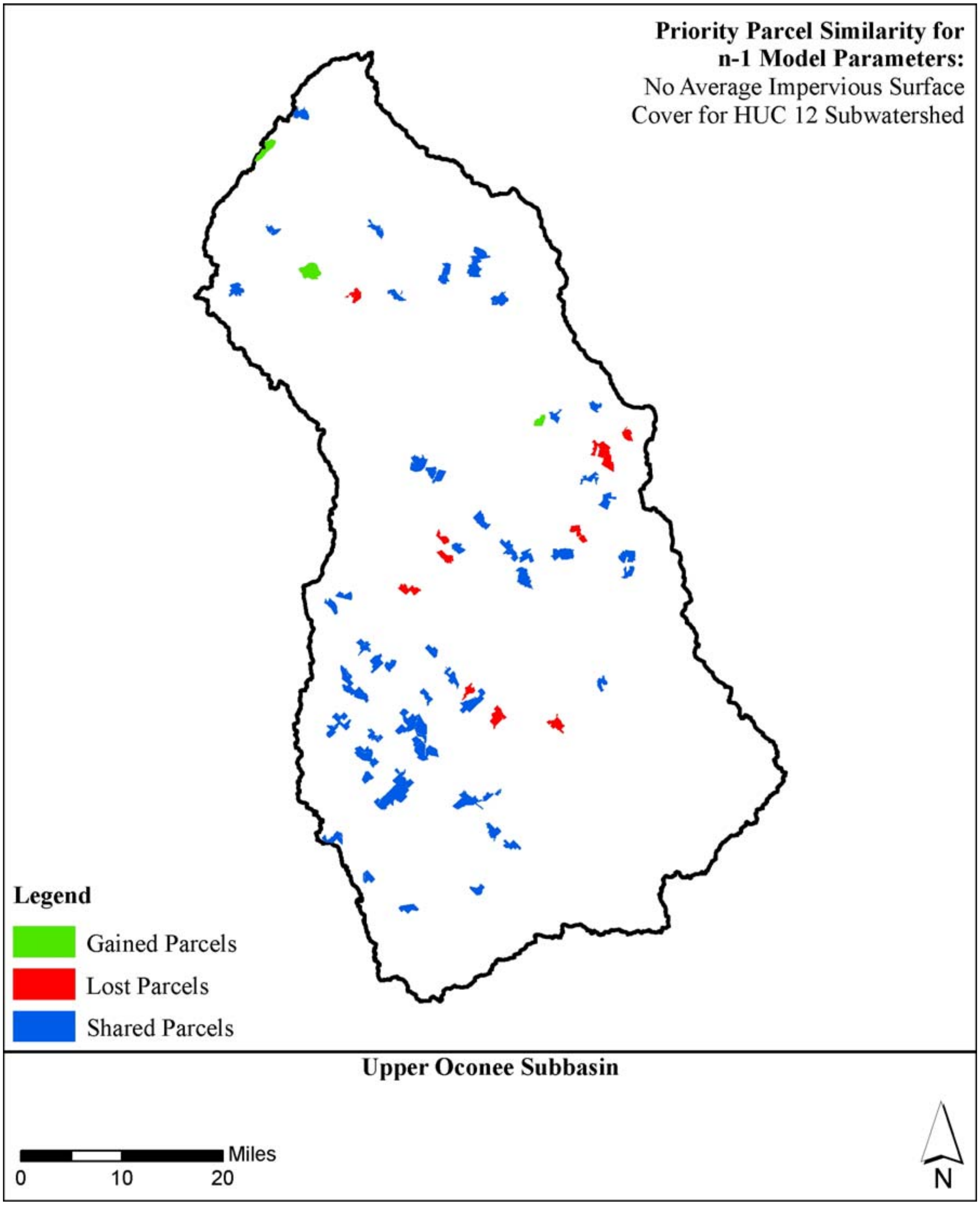

Figure A.2: Spatial similiarity for Priority Parcels by Parcel minus the Average Impervious Surface Cover for HUC 12 Subwatersheds parameter.

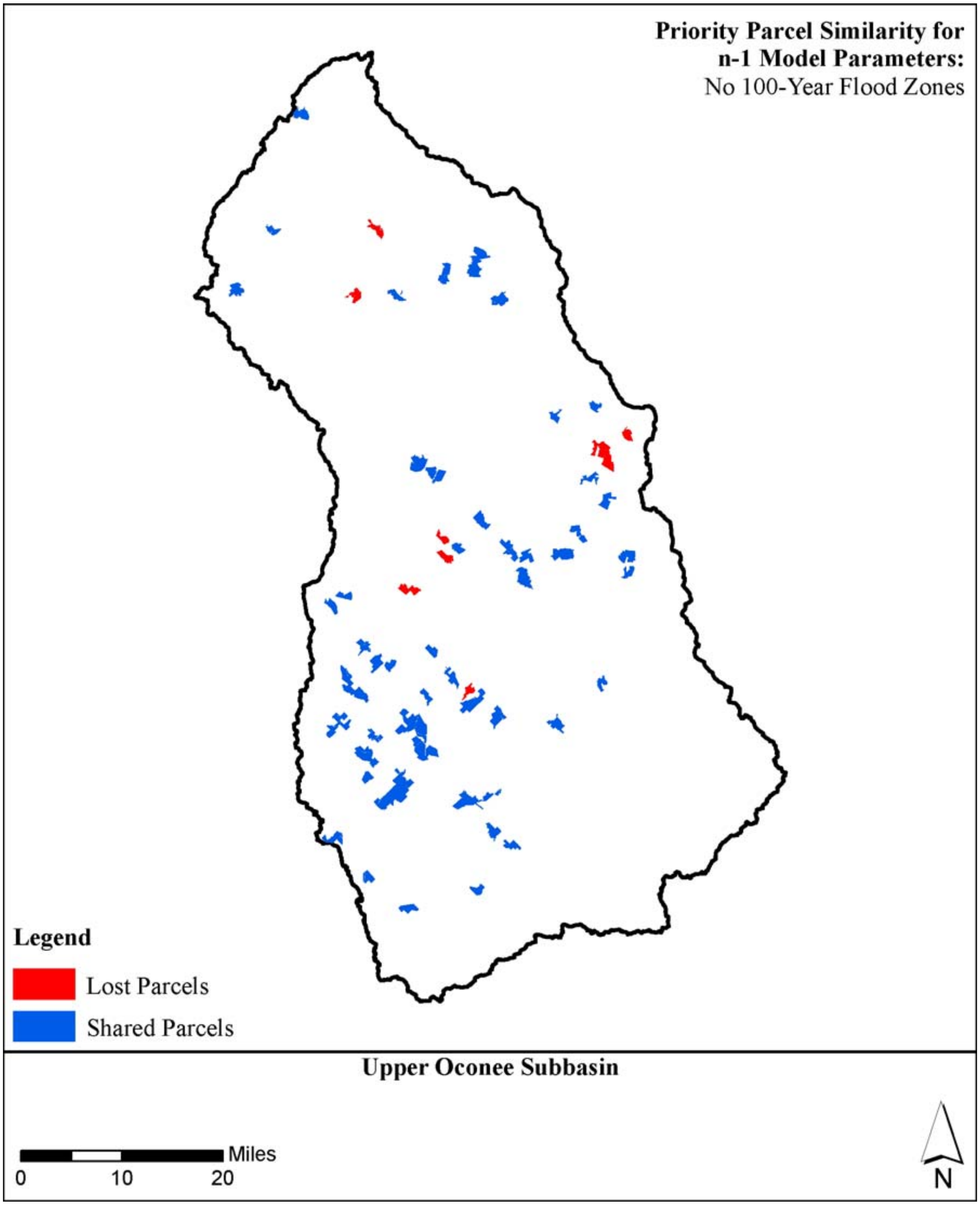

Figure A.3: Spatial similiarity for Priority Parcels by Parcel minus the 100-Year Flood Zones parameter.

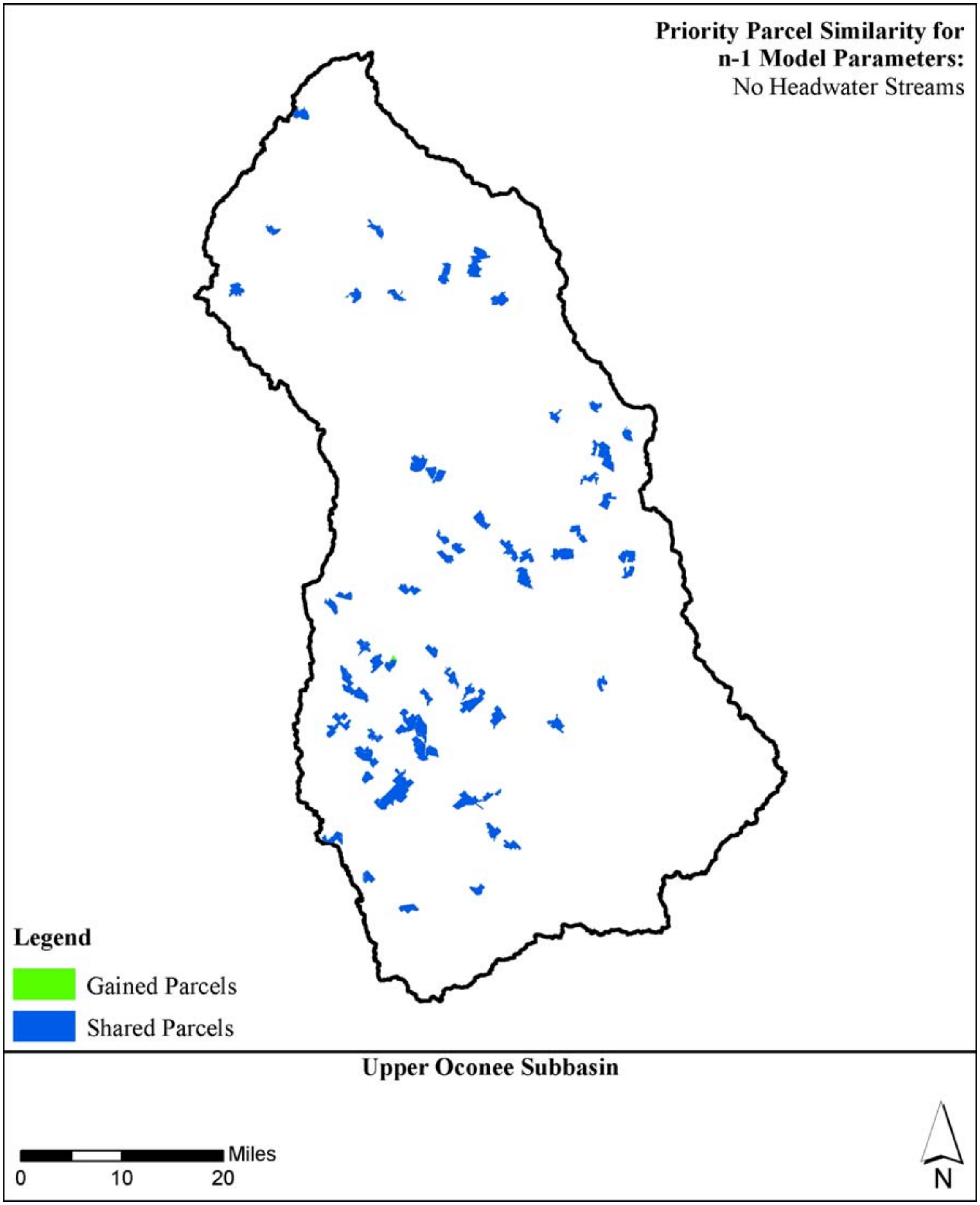

Figure A.4: Spatial similiarity for Priority Parcels by Parcel minus the Headwater Streams parameter.

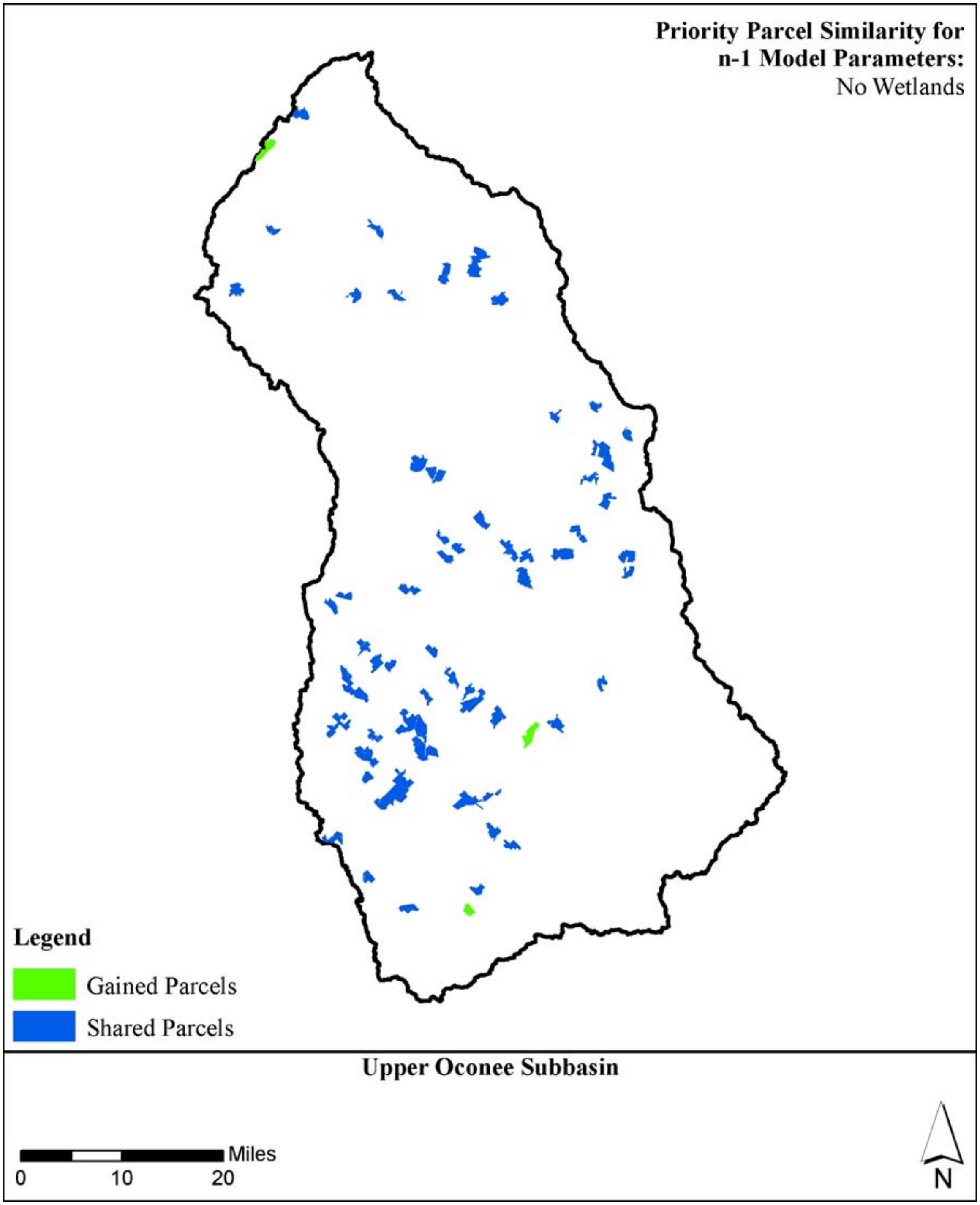

Figure A.5: Spatial similiarity for Priority Parcels by Parcel minus the Wetlands parameter.

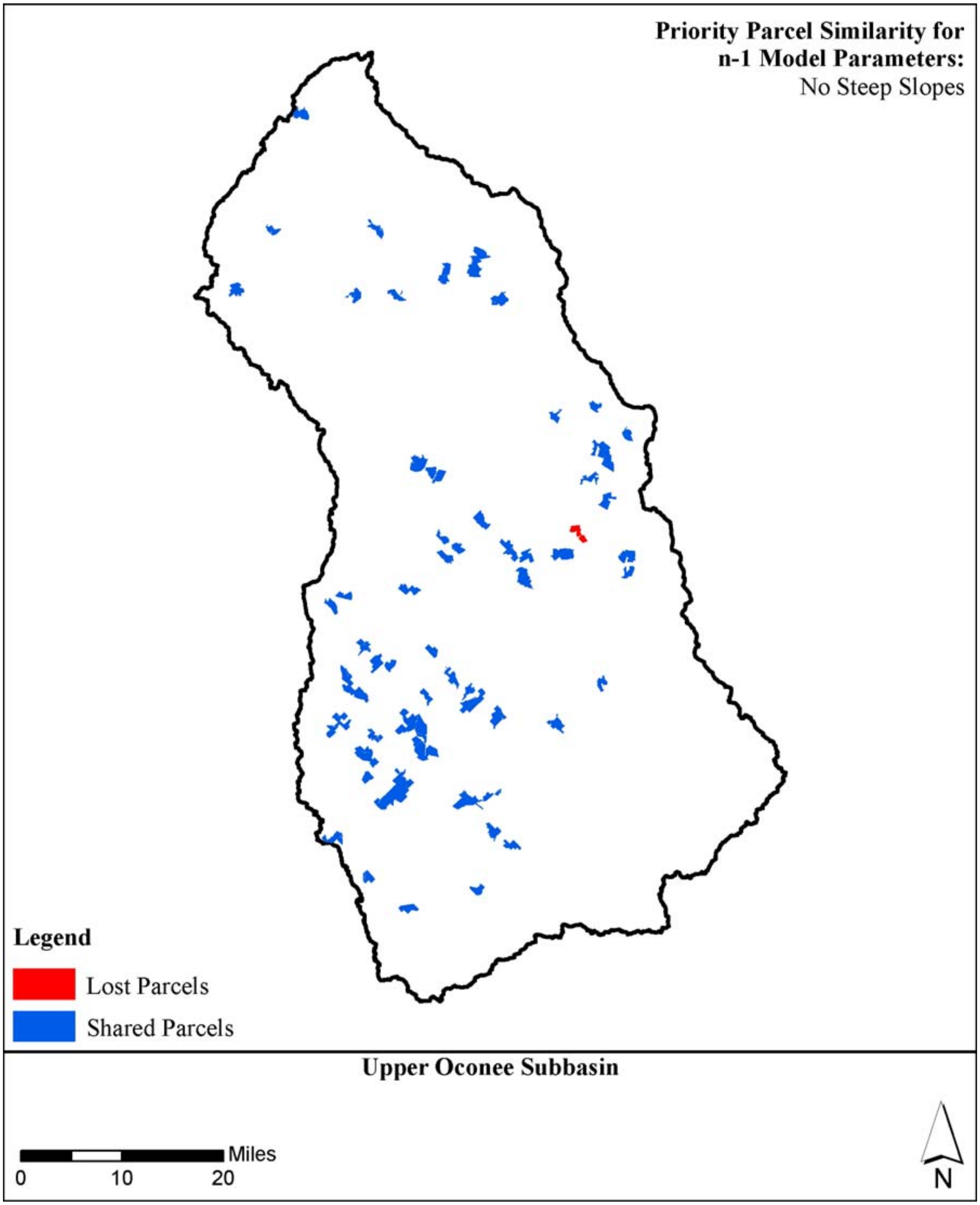

Figure A.6: Spatial similiarity for Priority Parcels by Parcel minus the Steep Slopes parameter.

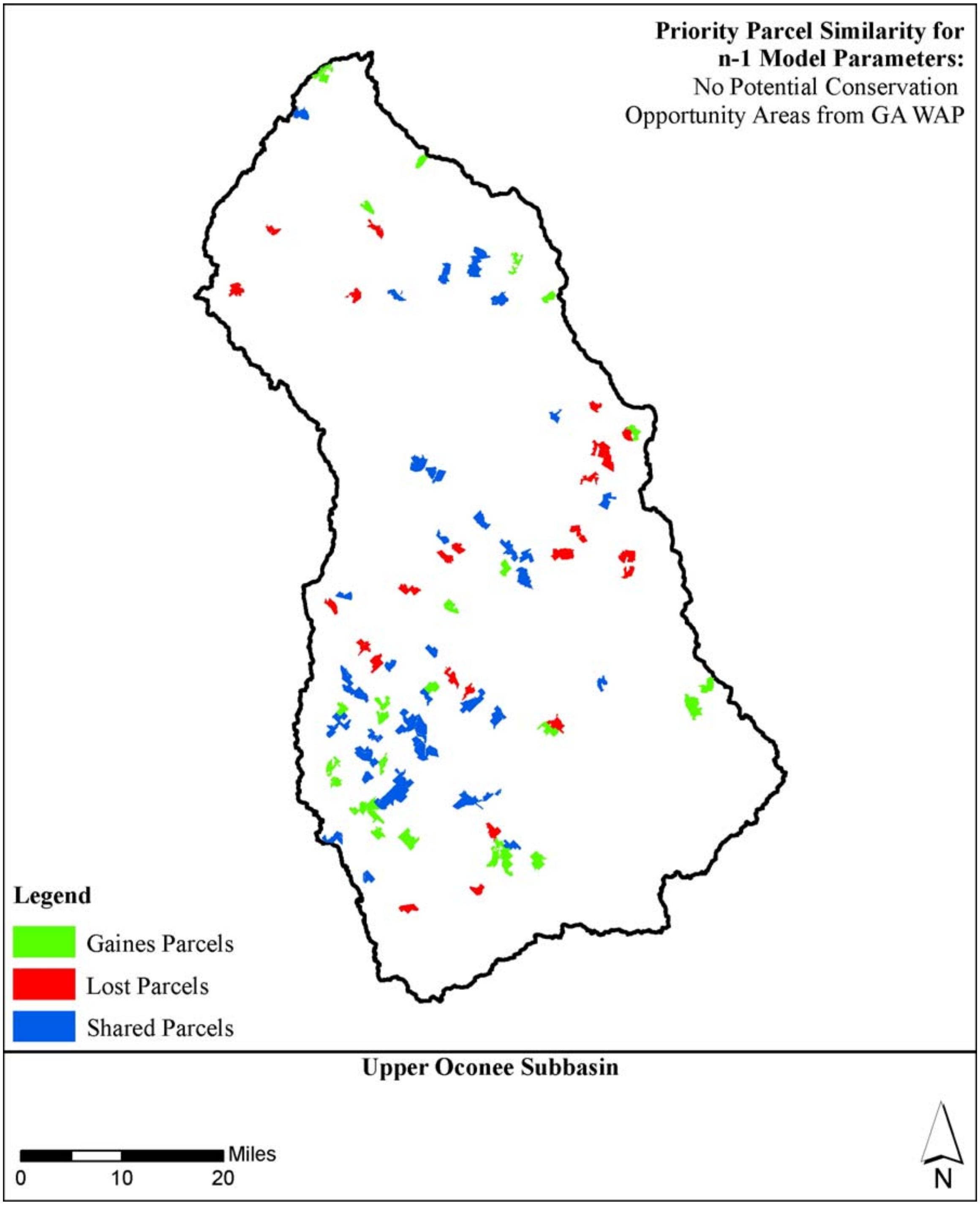

Figure A.7: Spatial similiarity for Priority Parcels by Parcel minus the Potential Conservation Opportunity Areas parameter from the Georgia Wildlife Action Plan.

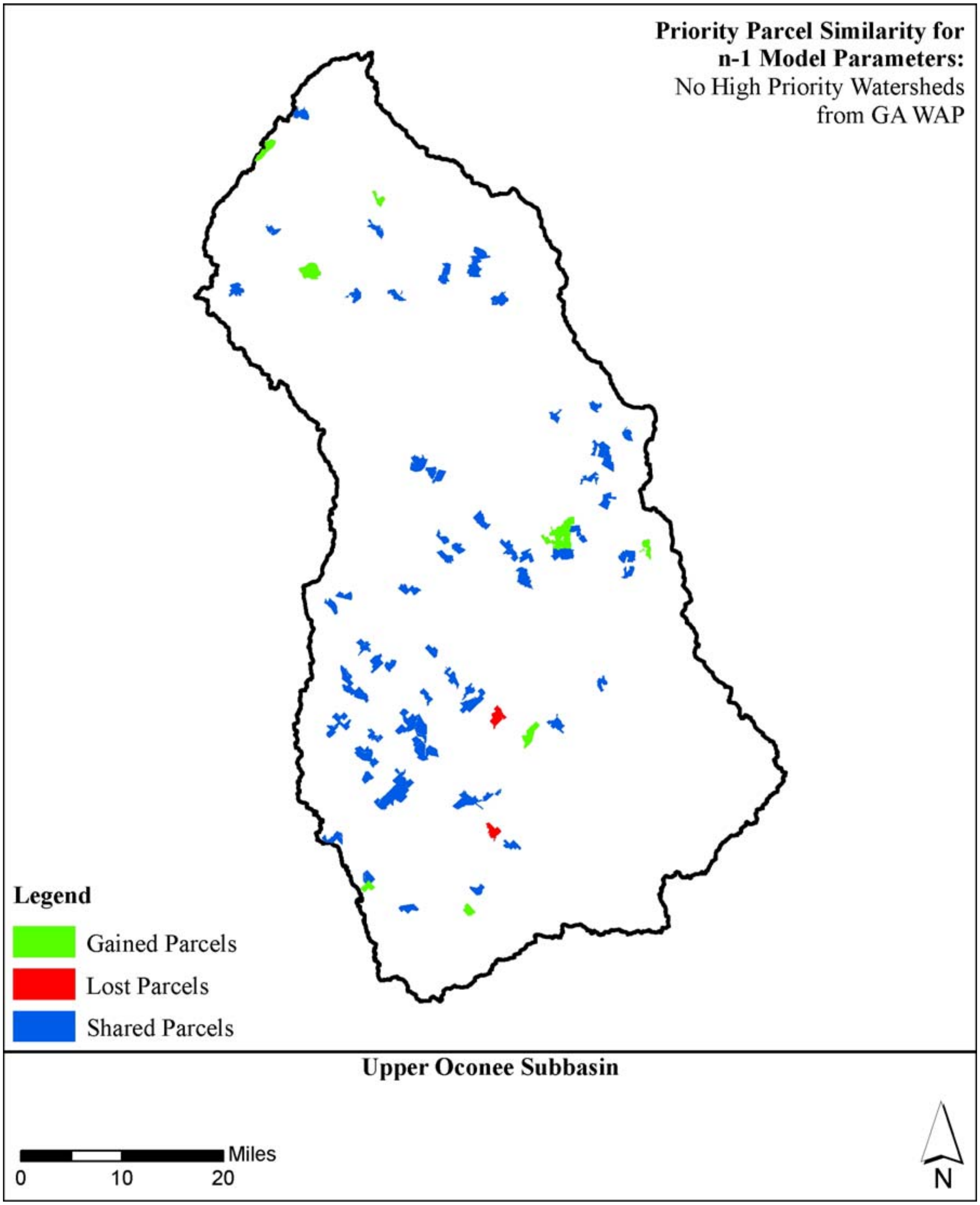

Figure A.8: Spatial similiarity for Priority Parcels by Parcel minus the High Priority Watersheds parameter from the Georgia Wildlife Action Plan.

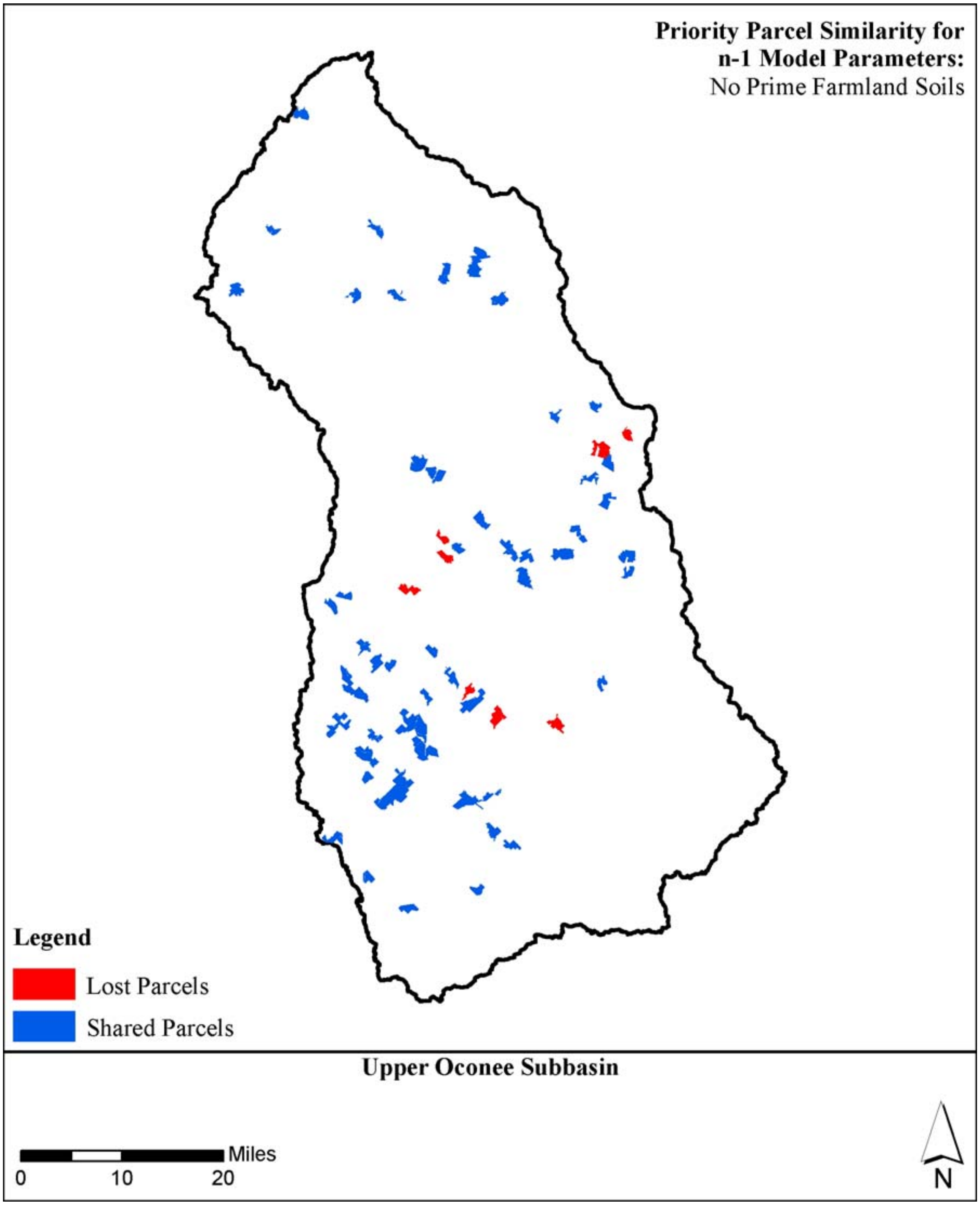

Figure A.9: Spatial similiarity for Priority Parcels by Parcel minus the Prime Farmland Soils parameter.

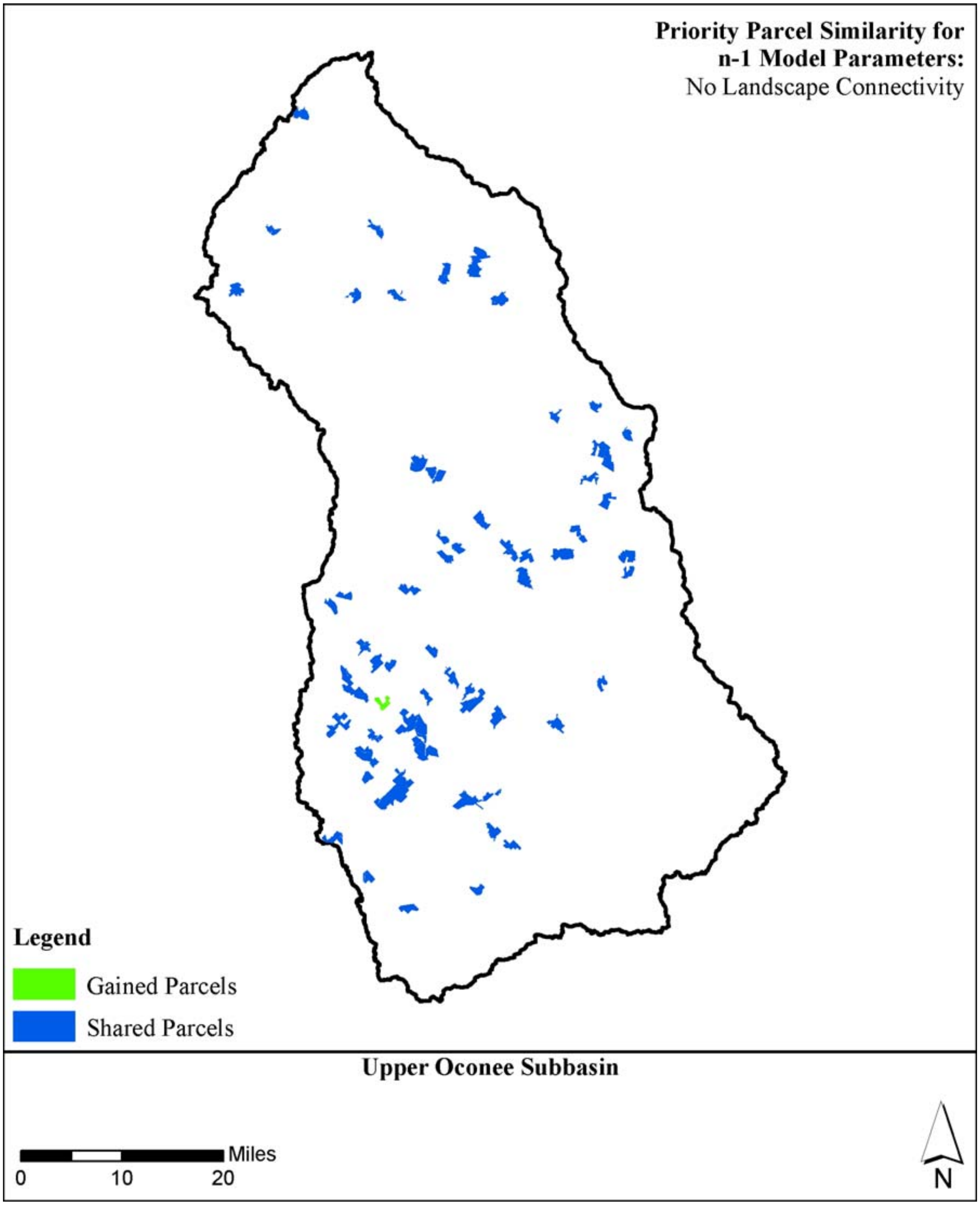

Figure A.10: Spatial similiarity for Priority Parcels by Parcel minus the Landscape Connectivity parameter.

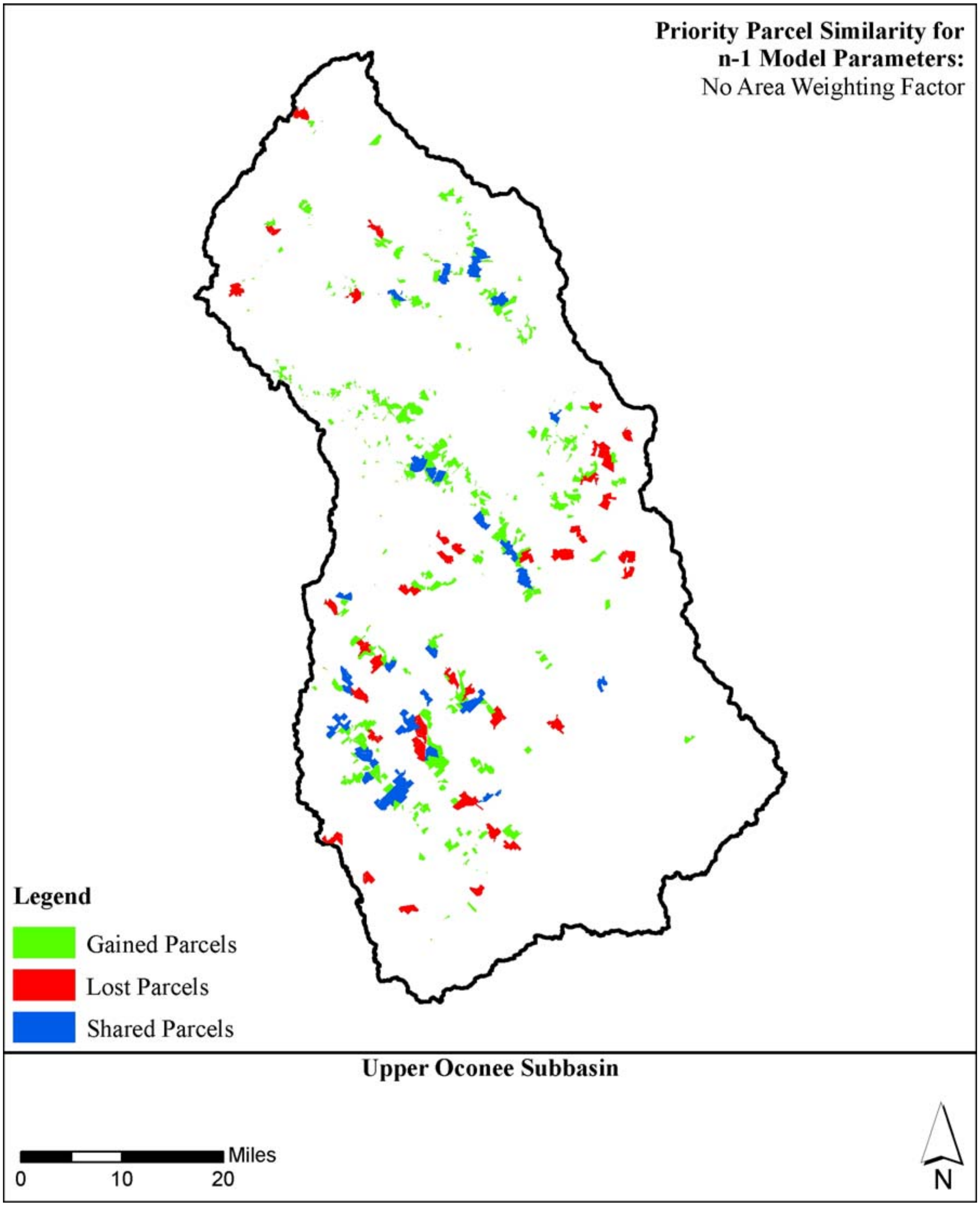

Figure A.11: Spatial similiarity for Priority Parcels by Parcel minus the Area-weighting Factor parameter.

APPENDIX B

PRIORITY AREA SPATIAL SIMILARITY FOR THE FIVE ACRE BLOCK METHOD

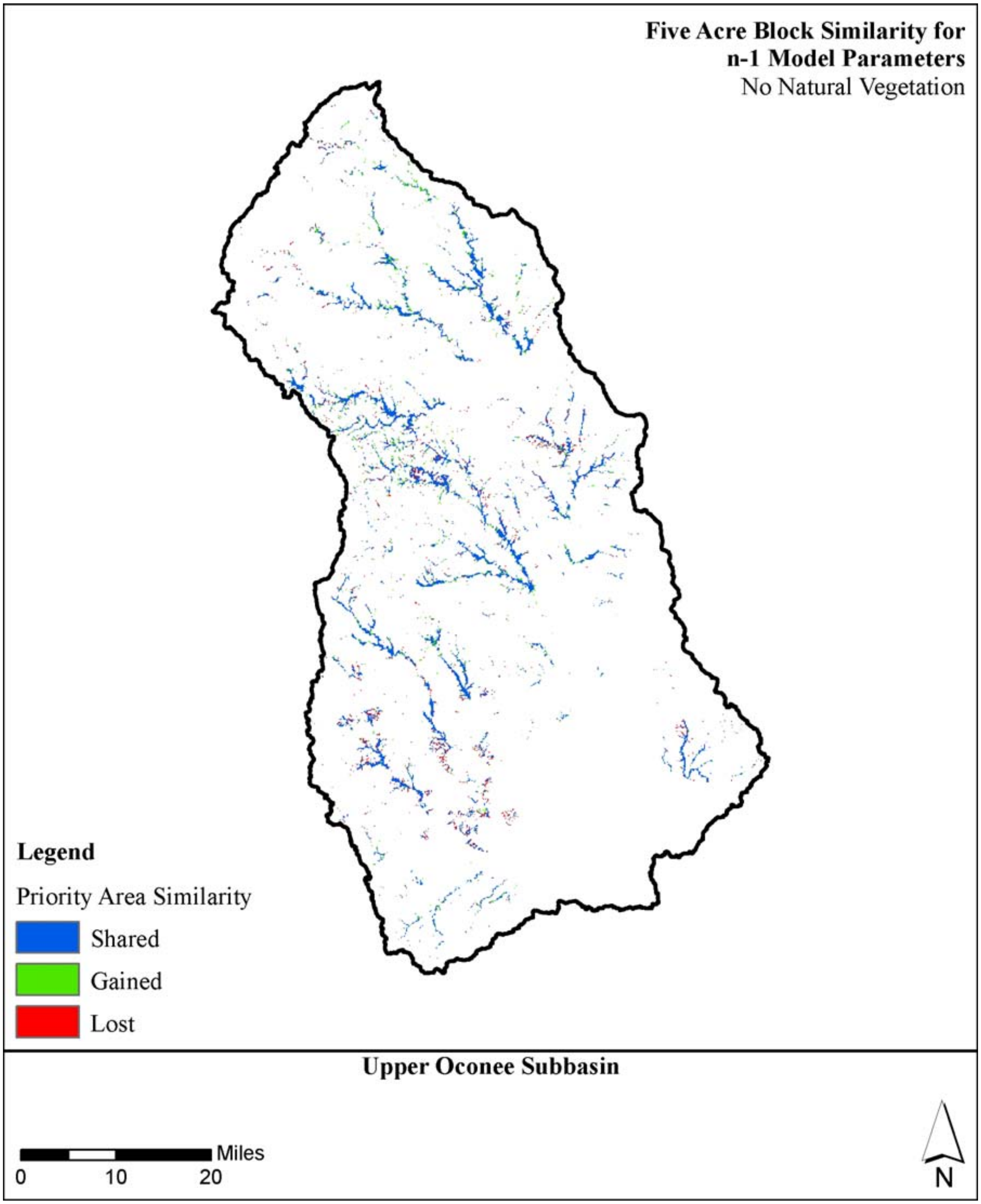

Figure B.1: Spatial similiarity for Priority Blocks minus the Natural Vegetation parameter.

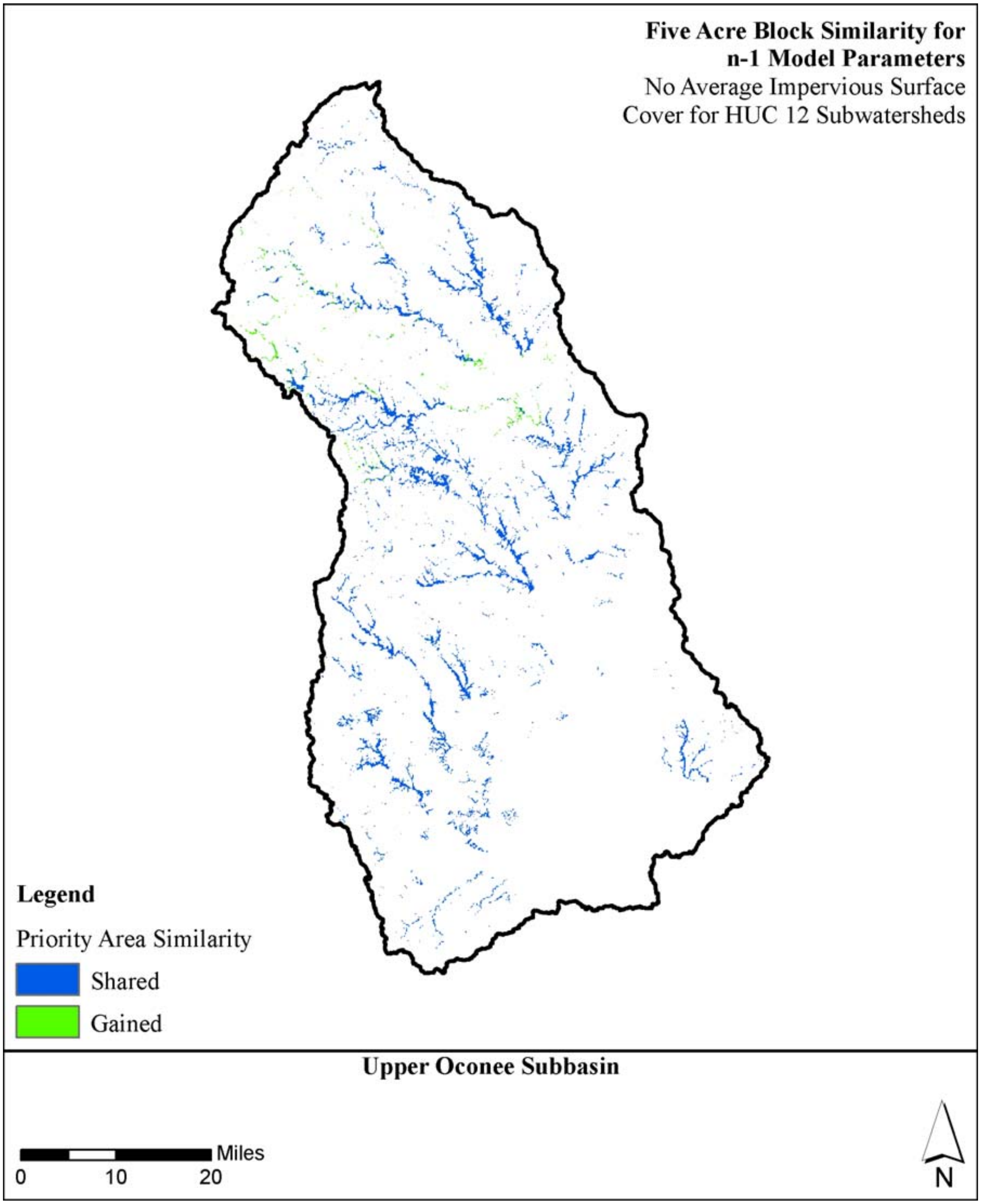

Figure B.2: Spatial similiarity for Priority Blocks minus the Average Impervious Surface Cover for HUC 12 Subwatersheds parameter.

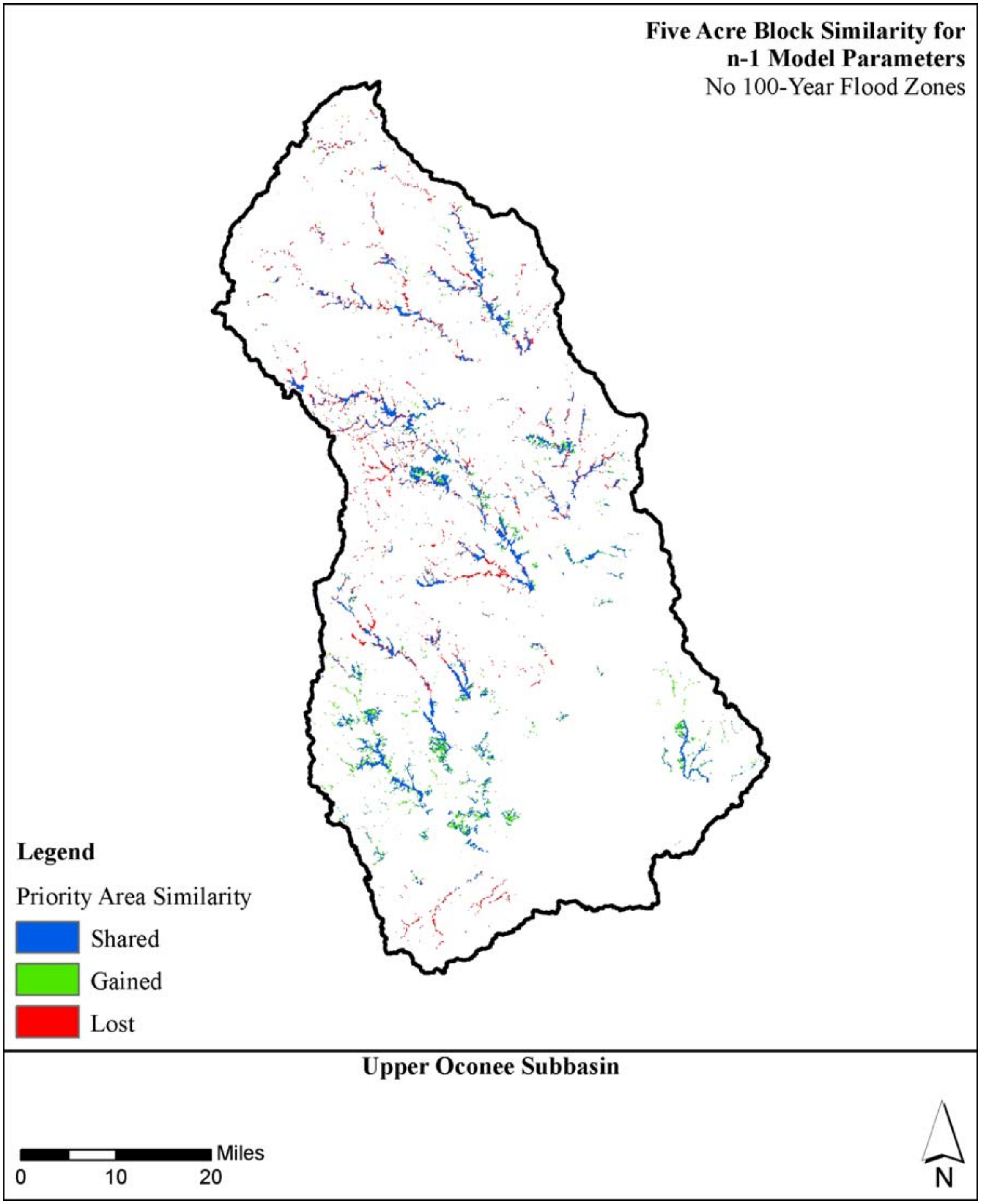

Figure B.3: Spatial similiarity for Priority Blocks minus the 100-Year Flood Zones parameter.

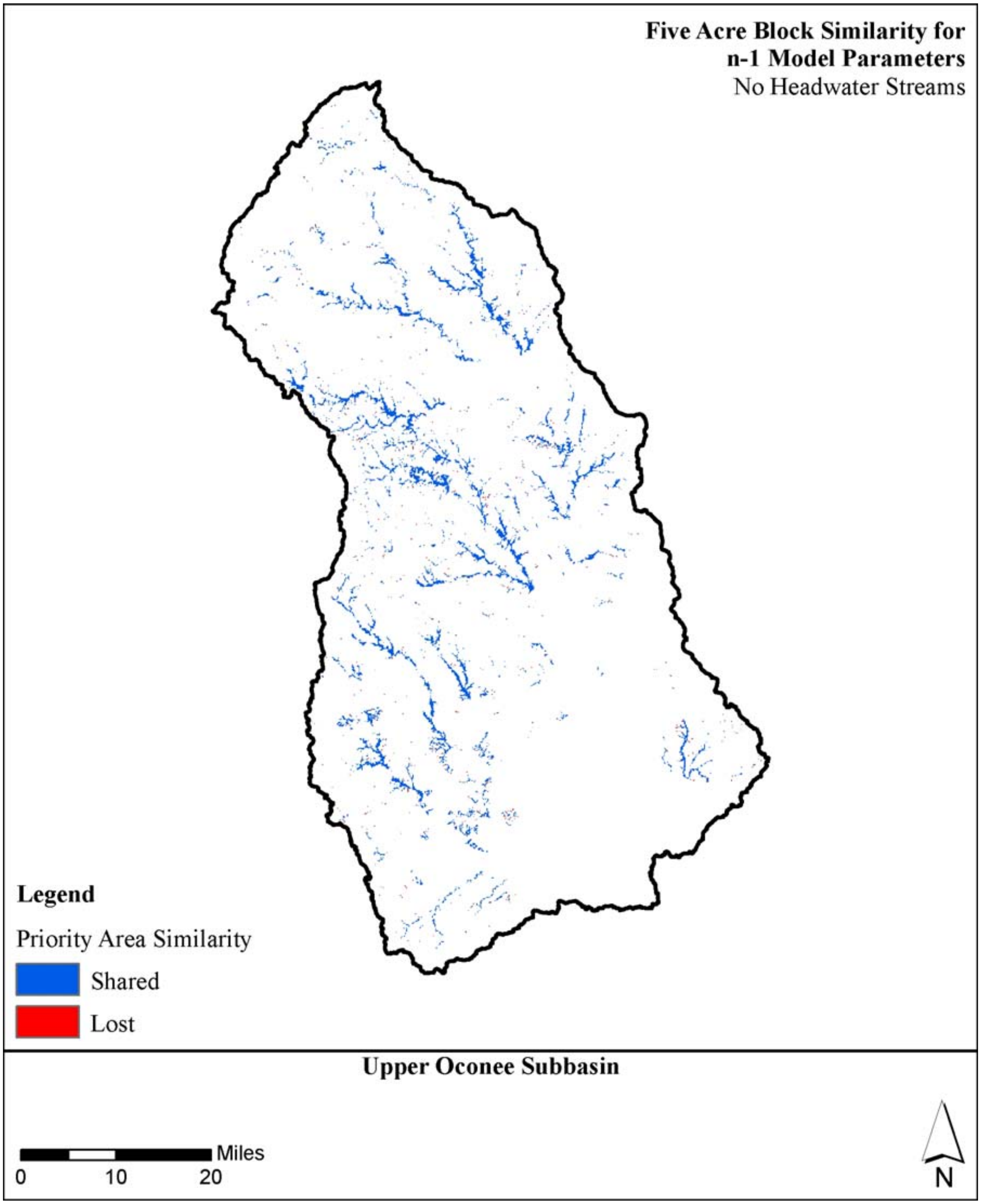

Figure B.4: Spatial similiarity for Priority Blocks minus the Headwater Streams parameter.

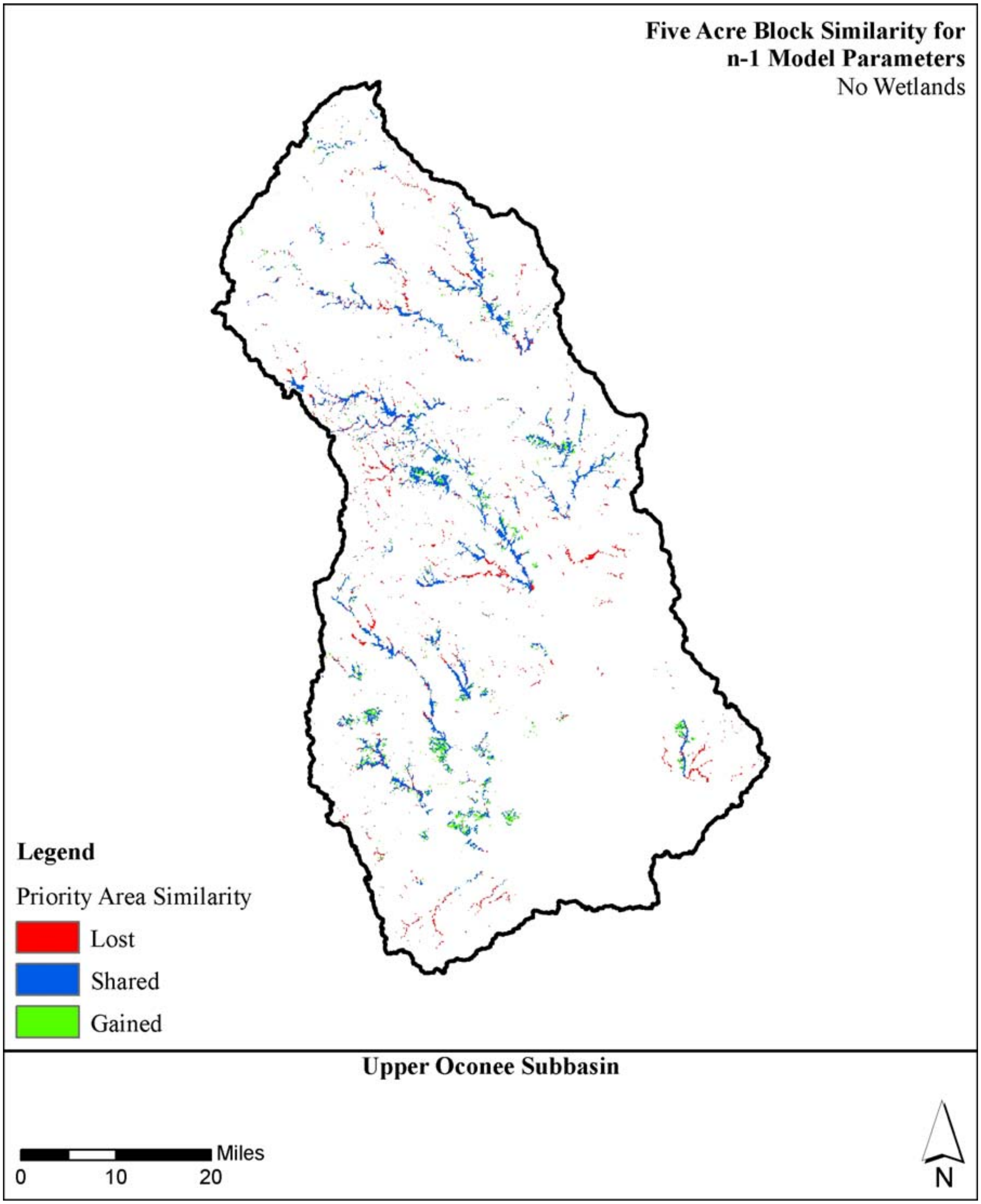

Figure B.5: Spatial similiarity for Priority Blocks minus the Wetlands parameter.

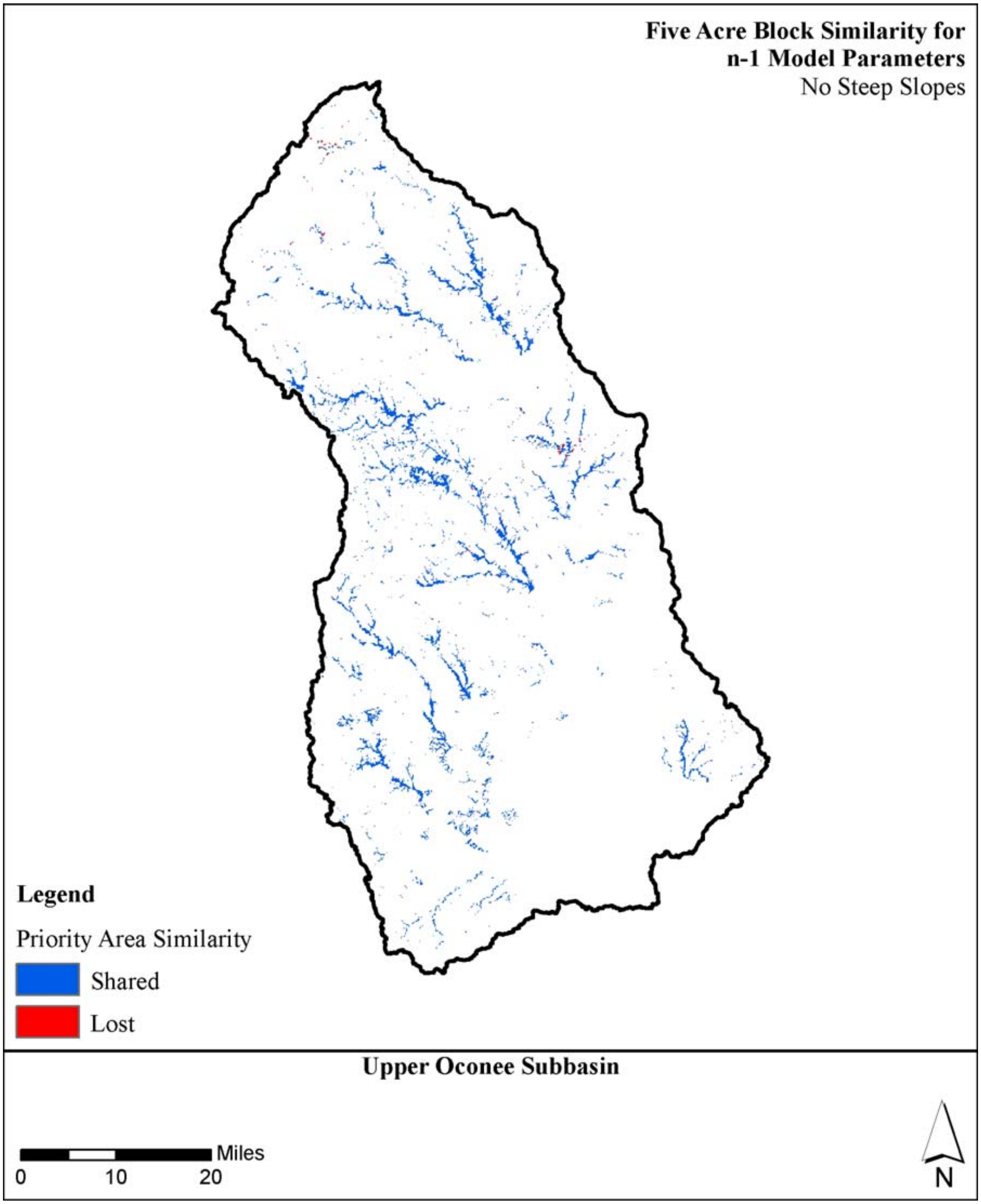

Figure B.6: Spatial similiarity for Priority Blocks minus the Steep Slopes parameter.

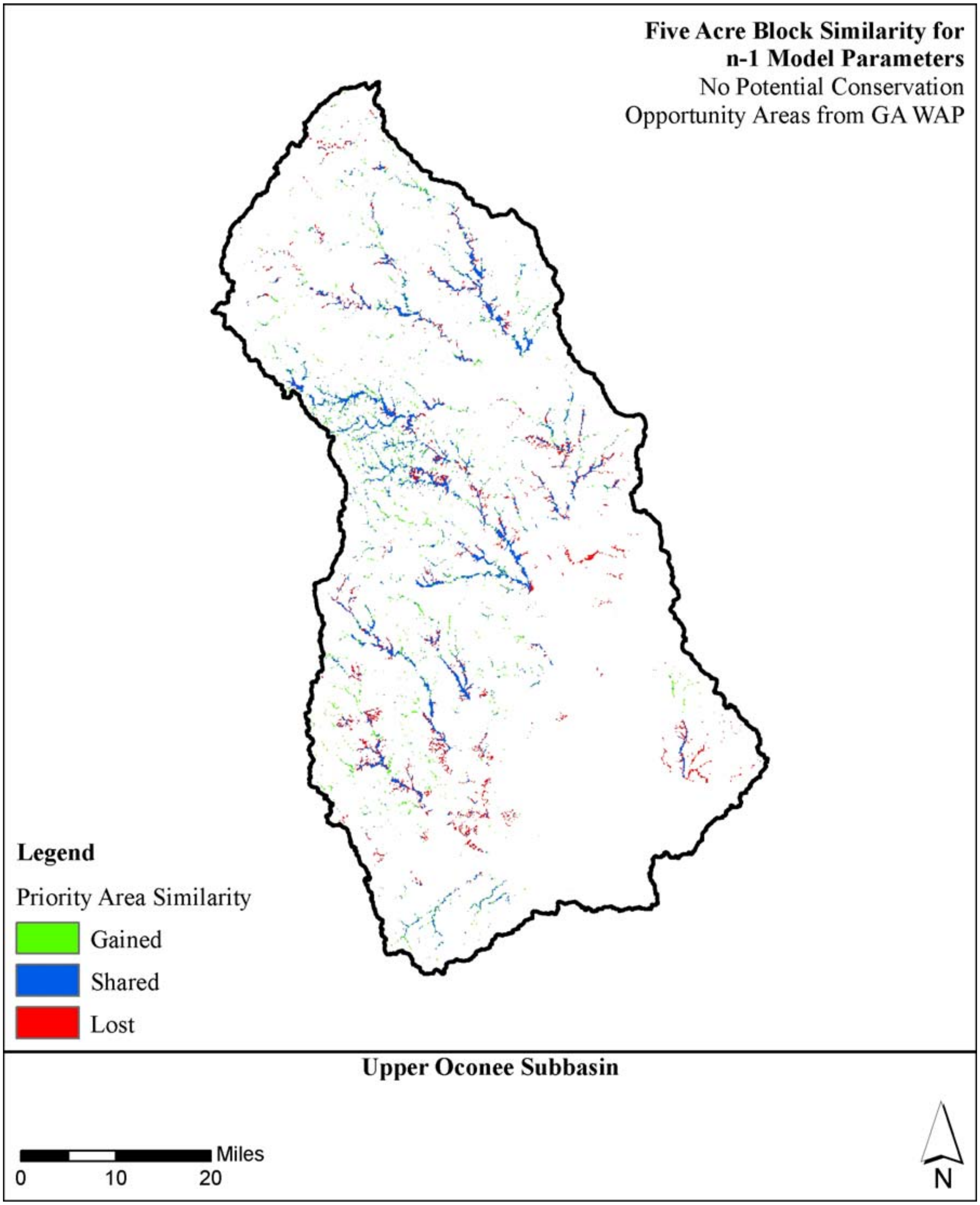

Figure B.7: Spatial similiarity for Priority Blocks minus the Potential Conservation Opportunity Areas parameter from the Georgia Wildlife Action Plan.

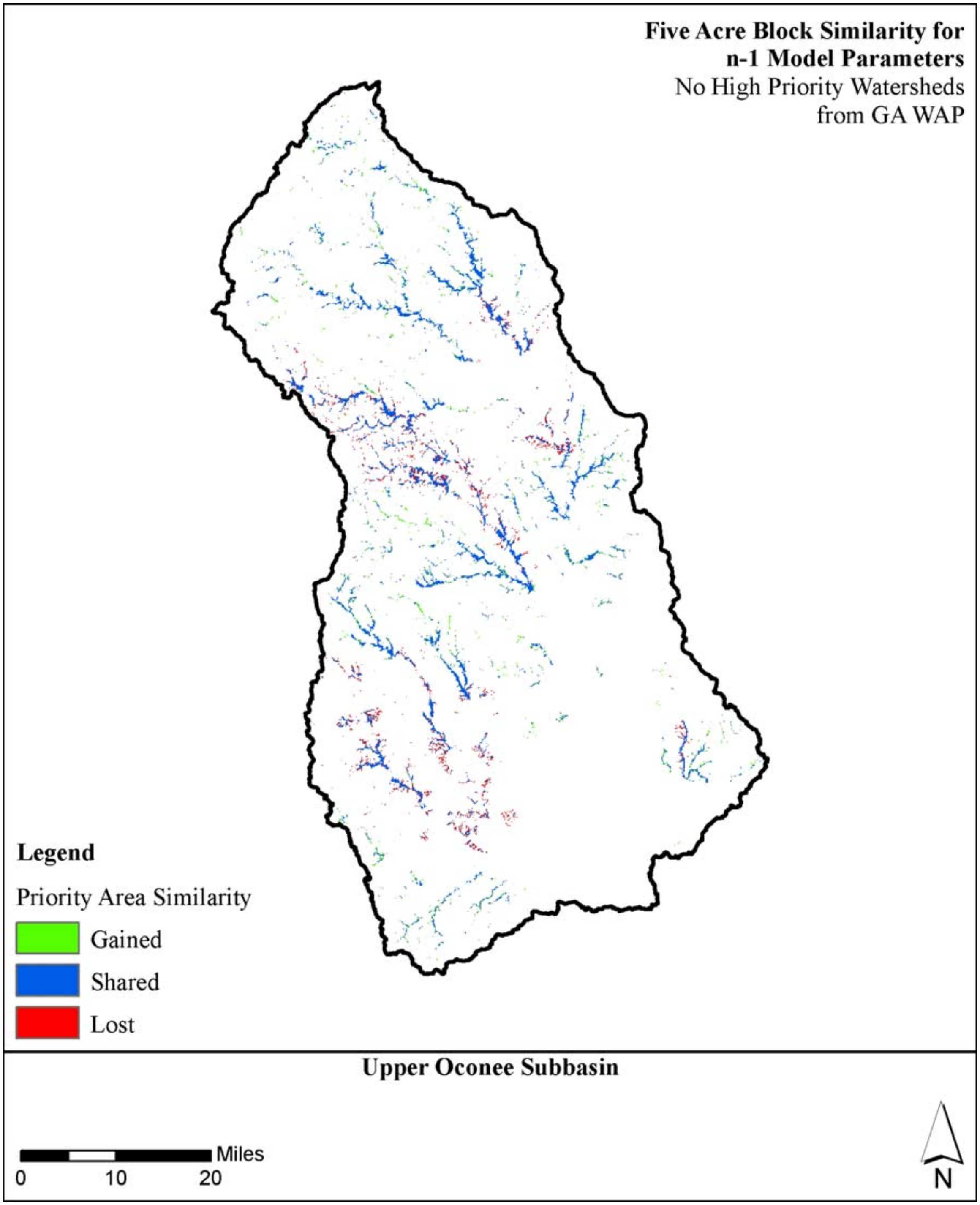

Figure B.8: Spatial similiarity for Priority Blocks minus the High Priority Watersheds parameter from the Georgia Wildlife Action Plan.

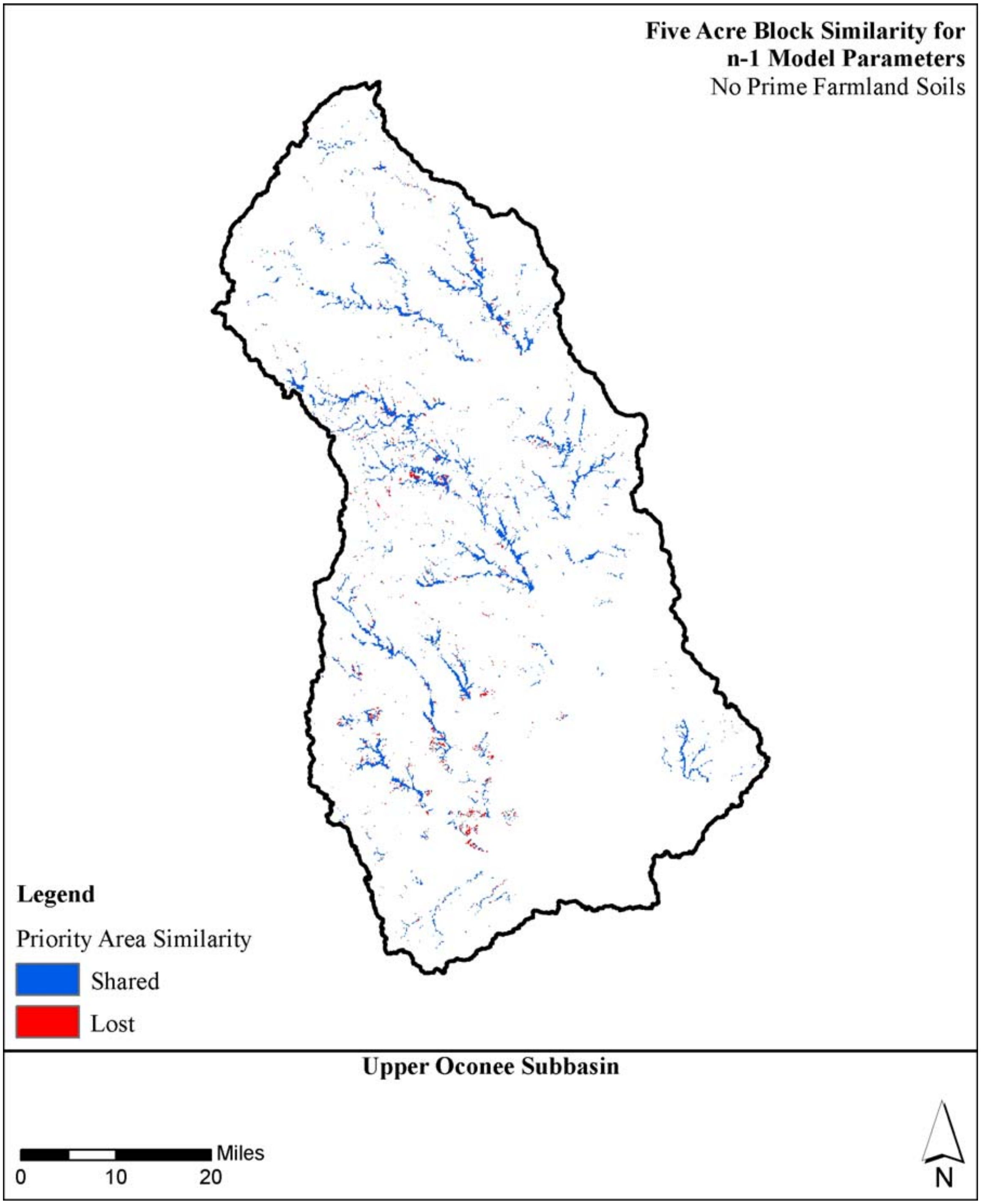

Figure B.9: Spatial similiarity for Priority Blocks minus the Prime Farmland Soils parameter.

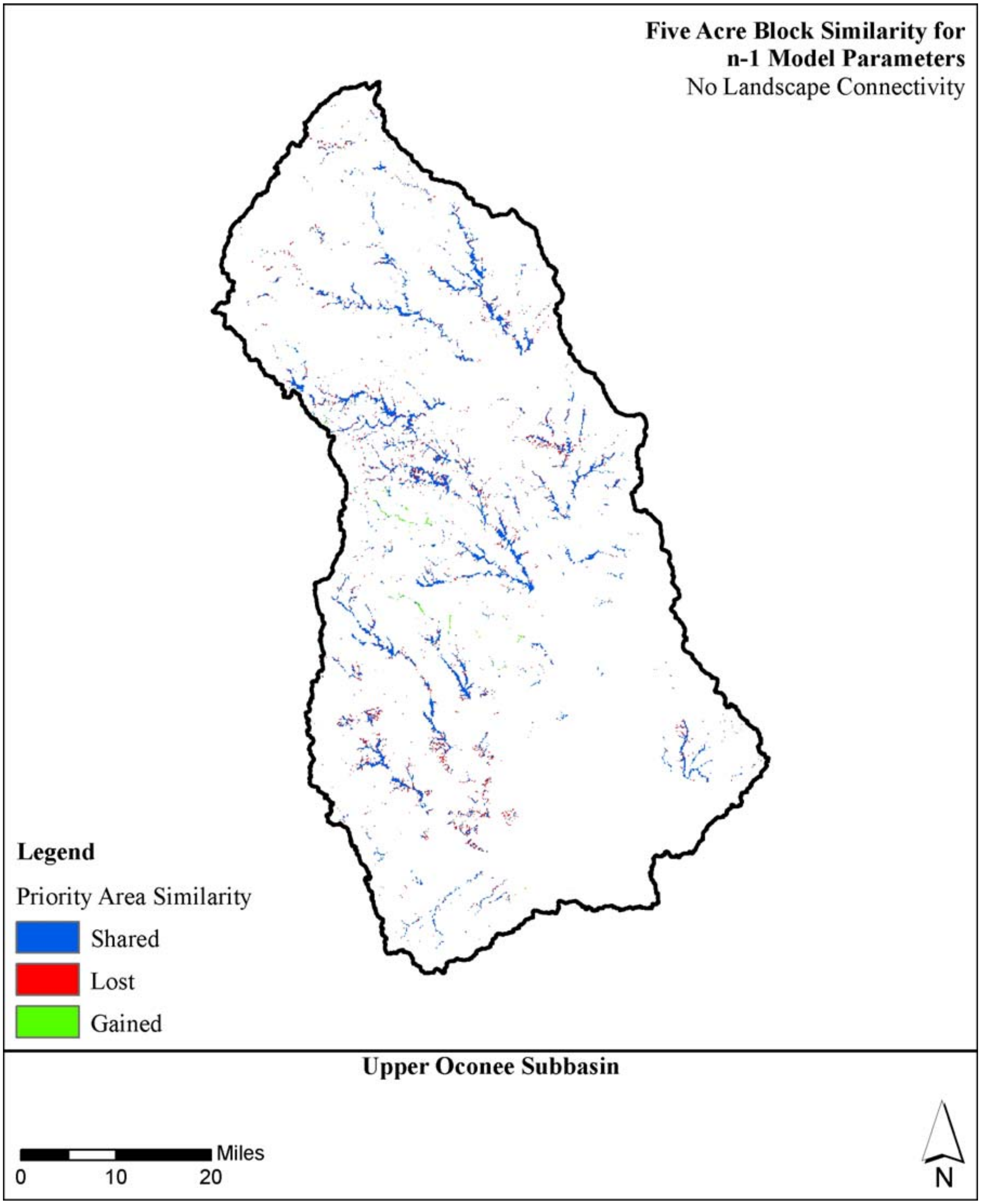

Figure B.10: Spatial similiarity for Priority Blocks minus the Landscape Connectivity parameter.

APPENDIX C

GEORGIA CONSERVATION TAX CREDIT PROGRAM: CHAPTER 391-1-6

CONSERVATION TAX CREDIT REGULATIONS

RULES OF GEORGIA DEPARTMENT OF NATURAL RESOURCES

CHAPTER 391-1-6

GEORGIA CONSERVATION TAX CREDIT PROGRAM

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391-1-6-.01 Purpose and Scope

(1) To provide for state income tax credits with respect to qualified donations of real property for conservation purposes and to provide for authority of the Department of Natural Resources to provide conditions, limitations, and exclusions for the Georgia Conservation Tax Credit Program

(2) The Department of Natural Resources shall be the certifying agency by:

(a) determining that property donated under this program is a Qualified Donation of Conservation Land; and

(b) providing an official certification form to the donor of Conservation Land that qualifies the donor for a state income tax credit.

391-1-6-.02 The Name of the Program

The program shall be referred to as the Georgia Conservation Tax Credit Program (GCTCP).

391-1-6-.03 Definitions

(1) “Applicant” means a Georgia taxpayer, either individual, partnership, corporation, professional association, limited liability company, or other entity, who makes, or contemplates making, a Qualified Donation to a Qualified Organization.

(2) “Certification” means final determination by the Department that an Applicant has made a Qualified Donation of Conservation Land.

(3) “Conservation Easement” means a non-possessory interest of a holder in real property as defined in O.C.G.A. § 44-10-2 (1).

(4) “Conservation Land” means Permanently Protected land and water, or interests therein, that is in its undeveloped, natural state or that has been developed only to the extent consistent with, or is restored to be consistent with, one or more of the following conservation purposes as defined below:

(a) Protection of water quality through the conservation of land containing a substantial amount of 100-year floodplain or containing streams, rivers, springs, marshlands, or natural wetlands, and which have a Permanently Protected vegetated buffer, such buffer being no less than 100 feet wide as measured from the edge of the water body or wetland and wherein no landdisturbing activities, timber harvest, or agricultural operations will occur;

(b) Reduction of erosion through the conservation of land containing a substantial amount of steep slopes of greater than 25% that will be protected from soil-disturbing activities;

(c) Protection of wildlife habitat through the conservation of high priority plants, animals, and habitats as defined by Georgia's Comprehensive Wildlife Conservation Strategy dated August 31, 2005, a copy of which can be obtained on the web at www.gadnr.org/cwcs or from the Wildlife Resources Division of the Department of Natural Resources 2070 U.S. Hwy. 278, SE, Social Circle, GA 30025 (Tel: 770-918-6400);

(d) Maintenance of prime farmland and forestry land managed according to current Best Management Practices as defined by the Georgia Soil and Water Conservation Commission and/or the Georgia Forestry Commission. Such properties must consist of a minimum of ten (10) contiguous acres and be used for production of timber products, crops, or livestock;

(e) Provision of compatible, low-infrastructure naturalresource based outdoor recreation as described in Georgia's Statewide Comprehensive Outdoor Recreation Plan 2008-2013, a copy of which can be obtained on the web at www.gastateparks.org or from the Georgia State Parks & Historic Sites Division of the Department of Natural Resources at 2 Martin Luther King, Jr. Dr., Suite 1352 East, Atlanta, GA 30334 (Tel: 404-656-2770), through the protection of land which is accessible for substantial and regular use by the general public at little or no cost;

(f) Provision of habitat or recreational connectivity through the protection of land contiguous with existing Conservation Lands, or with local, state, or federal lands managed primarily for natural habitat and which are open to the general public; and

(g) Protection of land with significant archaeological and/or historic sites, listed in or eligible for the Georgia Register of Historic Places either individually, or as a contributing building or land area within a historic district.

(5) "Department" means the Department of Natural Resources.

(6) "Permanent Protection" and "Permanently Protected" mean the protection of land and water resources as defined in O.C.G.A. § 12-6A-2 (10).

(7) "Pre-Certification" means preliminary determination by the Department that an Applicant's proposed Qualified Donation meets the criteria for Conservation Land.

(8) "Qualified Donation" means the fee simple conveyance of

100 percent of all right, title, and interest in the entire property, either by full donation or a discounted sale below Fair Market Value, or an interest in property which qualifies as a Conservation Easement, which has been accepted by a Qualified Organization and which has been permanently protected. The following types of properties and easements are specifically not eligible as qualified donations under this program:

(a) Any real property which is used for or associated with the playing of golf, or other high-infrastructure recreational facility;

(b) Any real property which is otherwise required to be dedicated open space pursuant to local governmental regulations or ordinances or to increase building density levels; and

(c) Except as otherwise provided in O.C.G.A. § 48-7-29.12 (d)(2), only one qualified donation may be made on a property that was part of a larger parcel under the same ownership in the prior year.

(9) "Qualified Organization" means the federal government, state, a county, a municipality, or a consolidated government of this state; or a bona fide charitable nonprofit organization qualified under the Internal Revenue Code. To be a Qualified Organization, a charitable nonprofit organization must:

(a) Be authorized to do business in Georgia and, if required, be currently registered with the Georgia Secretary of State;

(b) Have received tax-exempt status as a charity under section 501c(3) of the Internal Revenue Code of 1986 as stated in a Determination Letter provided by the Internal Revenue Service;

(c) Meet the requirements of section 1.170A-14(c) of the Internal Revenue Code of 1986, and therefore have the power to acquire, hold, or maintain land or interests in land; and

(d) Have adopted the Land Trust Alliance's *Land Trust Standards and Practices (2004)*, a copy of which can be obtained from www.lta.org, as guidelines for the organization's operations.

391-1-6-.04 Application for Pre-Certification and Certification

(1) Application forms for Pre-Certification or Certification may be obtained from the Department. The Applicant shall submit the completed application to the Department with all attachments necessary to provide sufficient information for review and evaluation.

(2) The Department shall review all completed Pre-Certification applications and shall make a preliminary determination as to whether or not the proposed donation is a Qualified Donation of Conservation Land. The Applicant shall be notified of this determination by letter within 60 days of receipt of the application. The Department shall reject Pre-Certification applications that are incomplete, incorrect, or do not meet the definition of Conservation Land, including applications where the

conservation easement does not provide for Permanent Protection as required in this chapter. If the Department rejected the Pre-Certification application because it was incomplete or incorrect, the Applicant may resubmit the Pre-certification application with revised or corrected information for consideration by the Department.

(3) Application for Certification of a donation may be made only after the property transaction has been completed and recorded by deed or other method to assure Permanent Protection. The Department shall review all completed Certification applications and shall make a determination as to whether or not the donation is a Qualified Donation of Conservation Land. The Applicant will be notified of this determination, including the reason for rejection, if applicable, by letter within 90 days of receipt of the application. The Department shall reject Certification applications that are incomplete, incorrect, or are not Qualified Donations of Conservation Land, including applications where the conservation easement does not provide for Permanent Protection as required in this chapter. If the Department rejected the Certification application because it was incomplete or incorrect, the Applicant may resubmit the application with revised or corrected information for consideration by the Department.

(4) A final determination by the Department on a Certification

application shall be subject to review and appeal under Chapter 13 of Title 50, the Georgia Administrative Procedure Act. To contest the Department's final determination, an applicant must file a petition for a hearing within thirty (30) calendar days after issuance of notice of the Department's final determination. A petition for hearing must be in writing and must comply with all applicable requirements set forth in Rules 391-1-2-.03, 391-1-2-.04 and 391-1-2-.05. The date upon which a petition for hearing is deemed to be filed with the Department is determined in accordance with Rule 391-1-2-.04. The failure of an applicant to file a petition for hearing within thirty (30) calendar days after issuance of notice of the Department's final determination shall operate as a waiver of the applicant's right to contest the determination and the determination shall become the final decision of the Department in accordance with O.C.G.A. § 50-13-19.

391-1-06-.05 Monitoring and Reporting Requirements

(1) Holders of Conservation Easements certified under this program shall annually monitor the Conservation Easement to assure that the terms are maintained and shall prepare an annual monitoring report. The Department may request a copy of annual monitoring reports at any time. A Qualified Organization that fails to submit requested annual monitoring reports shall not be eligible to be a Qualified Organization until they are in compliance with

this rule.

(2) The Department shall annually submit to its Board a status report of the GCTCP.

By Authority of O.C.G.A 48-7-29.12.

APPENDIX D

PROJECT SUMMARY

Upon reading an article in *Frontiers in Ecology and the Environment* in Spring 2007 (Keisecker et al.), the Lyndhurst Foundation put forth the idea to the University of Georgia's River Basin Center to assist the Oconee River Land Trust (ORLT) of Athens, GA with an assessment of their current holdings. In addition to assessing current holdings, another goal was to assist the land trust with the development of an easement recruitment campaign through identification of landowners with lands of high conservation value. Subsequently, Athens Land Trust (ALT) was brought on board. After funding was secured through the Georgia Forestry Commission's Urban and Community Forestry Grant for a graduate research assistant, I was brought on board to perform the outlined tasks. Through meetings and conversations with the representatives of both land trusts (from ORLT: Steffney Thompson; Chris Canalos, and Clint Moore; and from ALT: Laura Hall, Alfie Vick, and Lara Mathas), Georgia Department of Natural Resources (DNR) biologists (Chris Canalos and Matt Elliot), Land Trust Alliance's Southeast Regional Office Director Chuck Roe, and many others including UGA faculty and graduate students, I determined a project pathway.

In the meetings with the land trusts, they identified nine conservation features of importance to their missions of protecting wildlife and ecosystems, especially ecosystems harnessing ecological functions that effect water quality and quantity. These included: 1) natural vegetation cover, 2) low watershed impervious surface cover, 3) 100-year flood zones, 4) headwater streams, 5) wetland cover, 6) steep slopes, 7) Georgia Wildlife Action Plan (WAP) priority areas,

8) prime farmland soils, and 9) landscape connectivity to existing conservation areas. Georgia WAP priority areas included: 1) Potential Conservation Opporunity Areas (PCOA), which are large areas of intact natural vegetation of ≥ 100 hectares, or if smaller are reported to have state listed species of concern, and 2) High Priority Watersheds (HPW), which were identified by a team of experts. After hearing the full set of features, Chris Canalos and Matt Elliot suggested using the Georgia Land Conservation Program (GLCP) criteria as a set of predetermined and accepted guidelines for evaluating these features. Stakeholders chose the Upper Oconee subbasin as the study site to emphasize the importance of hydrologic connectivity and influence on water quality and quantity. The subbasin is 2,917 mi^2 and approximately 21% of the surface area of the larger Altamaha River basin.

After the meetings, I moved forward with these ideas and began acquiring all of the necessary data from numerous resources. These included: the Georgia GIS Clearinghouse for land cover[1], 100-year flood zone[2], and soils data[3], USGS data servers for hydrologic and elevation features, and multiple Regional Development Centers for parcel data. Parcel data were needed to identify landowners with the highest value conservation lands. Following data collection, I processed these raw data sets into nine GIS layers that became the conservation features used in the modeling process. I assessed each of these layers at the scale of five acre block analysis units over the extent of the subbasin for percentage cover (for areal layers, i.e. features 1, 3, 5, 6, and 8 above), mileage (for headwater streams), and presence/absence (for categorical criteria, i.e. features 2 and 7 above). I then scored the five acre blocks for each of the nine layers based on their calculated values by applying the GLCP criteria. I added each of the

[1] Originally from Natural Resources Spatial Analysis Lab's 2005 Georgia Land Use Trends data.
[2] Originally from Federal Emergency Management Agency's Q3 Digital Flood Insurance Rate Maps.
[3] Originally from Natural Resources Conservation Service Soil Survey Geographic database.

scored feature layers together to create a composite map showing areas of relative conservation value by five acre blocks. Finally, I summed the scored five acre blocks within parcels to create a map of area-weighted parcel scores, which allowed me to identify the parcels with the highest value conservation lands. I selected the 101 highest scoring parcels to be the Priority Parcels for the land trusts to focus easement recruitment efforts on (Figure 1).

Additionally, I assessed the extent of these features (minus the two categorical ones) in the subbasin, the percent that is currently protected on all management types of conservation lands (including the easements), and the potential addition to the percentage protected that would be afforded by having conservation easements on the Priority Parcels (Figure 2). This final step is critical not only because it affords a regional conservation planning perspective of what is protected versus what is not, but it also allows the land trusts to evaluate their organizational goals for protection of these conservation features. At the time of analysis, ORLT and ALT had 20 and 14 easements and fee simple holdings in the Upper Oconee subbasin covering 1,314 and 638 GIS-calculated acres, respectively. Easements from both land trusts were found to be representing at least some quantity of the seven non-categorical conservation features. ORLT's holdings were calculated to be protecting: 636 acres of natural vegetation; 424 acres of 100-year flood zones; eight miles of headwater streams; 377 acres of wetlands; two acres of steep slopes; from the Georgia WAP, 342 acres of PCOAs, and 808 acres in HPWs; and 69 acres of prime farmland soils. ALT's holdings were calculated to be protecting: 223 acres of natural vegetation; 23 acres of 100-year flood zones; 33 acres of wetlands; four acres of steep slopes; from the Georgia WAP, 23 acres of PCOAs, and 340 acres in HPWs; and 158 acres of prime farmland soils. These results are summarized in Figure 3. The majority of both land trusts' easements were located in areas identified by this model as having high connectivity to existing conservation lands and/or large tracts of natural vegetation (i.e. PCOAs).

Finally, the importance of presenting usable results to the land trusts' staff is imperative for bridging the research – implementation gap in conservation efforts. First, in addition to the process above and following the same steps as with the five acre block analysis units, I analyzed all parcels ≥5 acres for the conservation features, amounting to over 34,000. The results are in an Excel database, which will provide the land trusts with access to knowledge about parcels prior to visiting potential easements sites. This database also includes all of this information for all existing conservation lands, easements broken down by land trusts, and specifically the 101 Priority Parcels. Further, I created a digital database of 26 user-friendly, geospatially-referenced PDF maps, called GeoPDFs (www.terragotech.com), that allow access to much of the data in spatial form for the Priority Parcels. These GeoPDF maps are accessed through hyperlinks from one subbasin-wide PDF file. A sample GeoPDF map is shown as a screenshot in Figure 4. Atribute information for the Priority Parcels, roads, and streams is available by selecting them with a tool from a free Adobe Reader extension called TerraGo Desktop. Land cover data from 2005, aerial imagery from 2007, and five acre block scores are also available in these GeoPDFs as layers, which can be turned on or off.

I have shown through the results of this project that the Oconee River Land Trust and the Athens Land Trust are protecting lands with conservation values, many of them with high conservation values. Further, I have outlined a process for using existing scientific datasets in conservation assessments, the results of which are then presented in usable formats for conservation practitioners to apply to their planning strategies. The overall goal of which is to further the conservation agenda of preserving wildlife, ecosystems, and ecological functions.

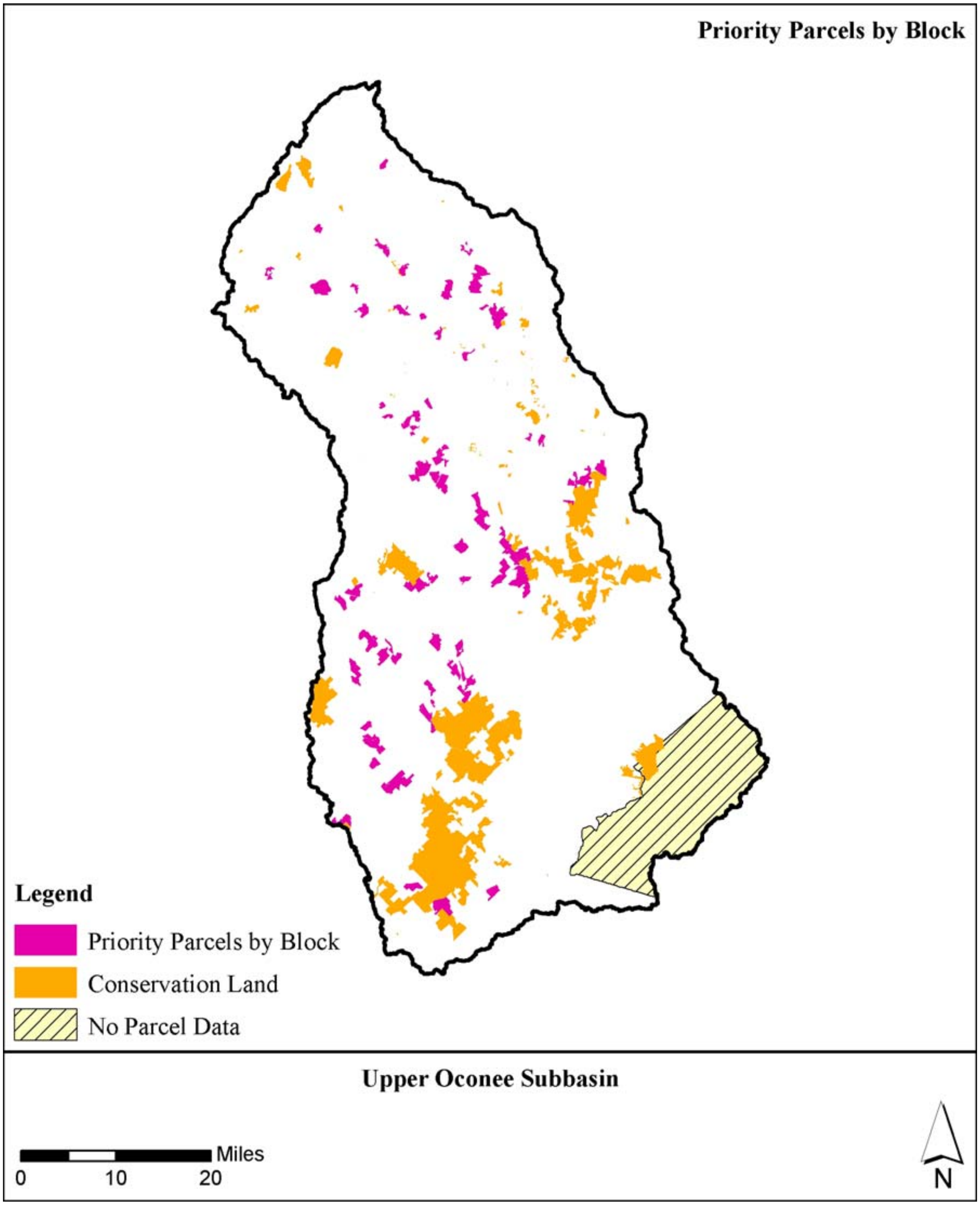

Figure D.1: Priority Parcels. This map shows the location and distribution of parcels identified as having relatively high conservation value using the five acre block method by summing the blocks within each parcel. The 101 parcels cover 83.1 square miles, which is 2.85 percent of the Upper Oconee subbasin.

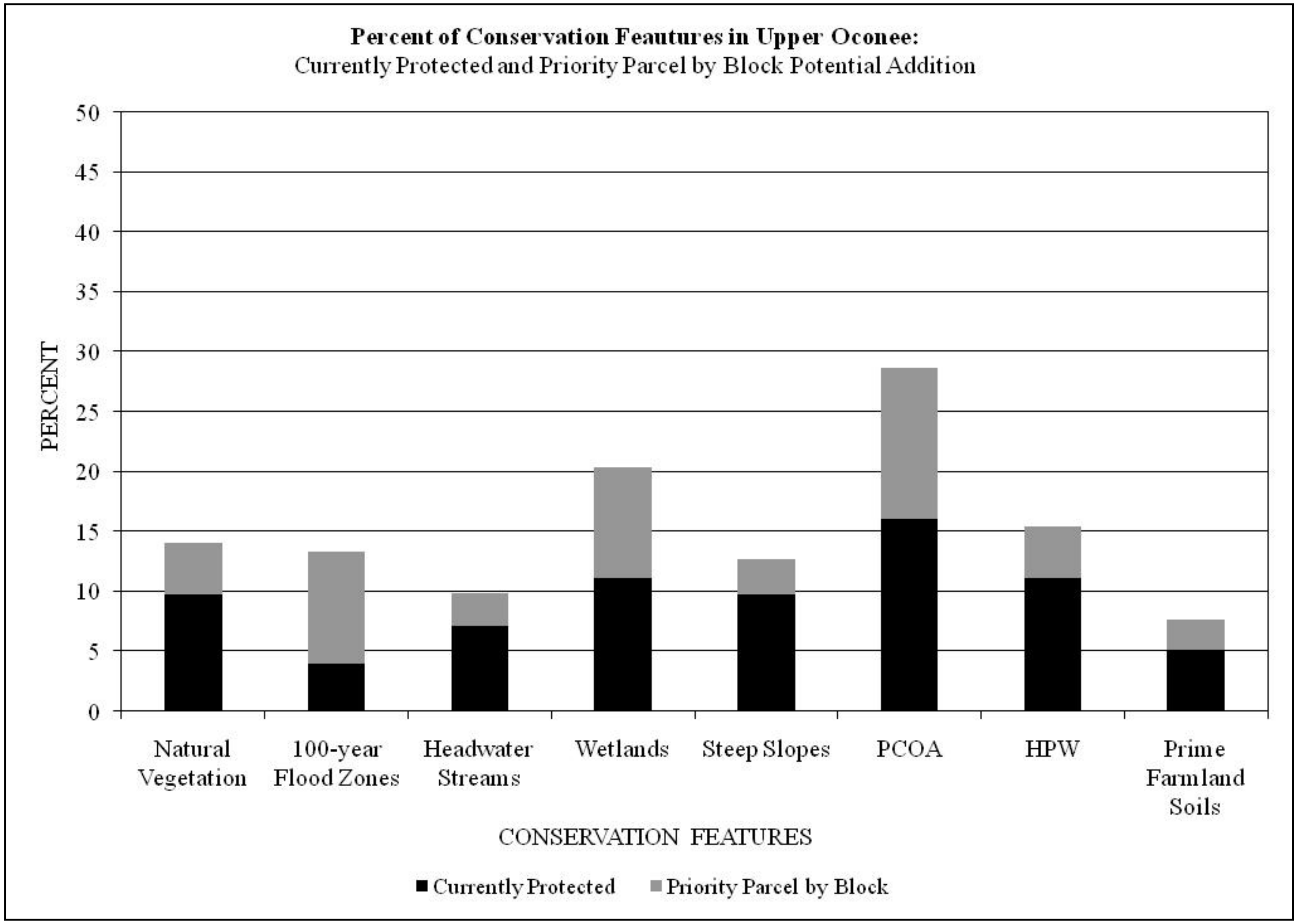

Figure D.2: Features protected compared with potential addition by Priority Parcels. This graph shows the percentage of conservation features protected by existing conservation lands, as well as the potential percentage increase in protected area that would occur if the Priority Parcels were under easement or other protected status. PCOA = Potential Conservation Opportunity Areas and HPW =

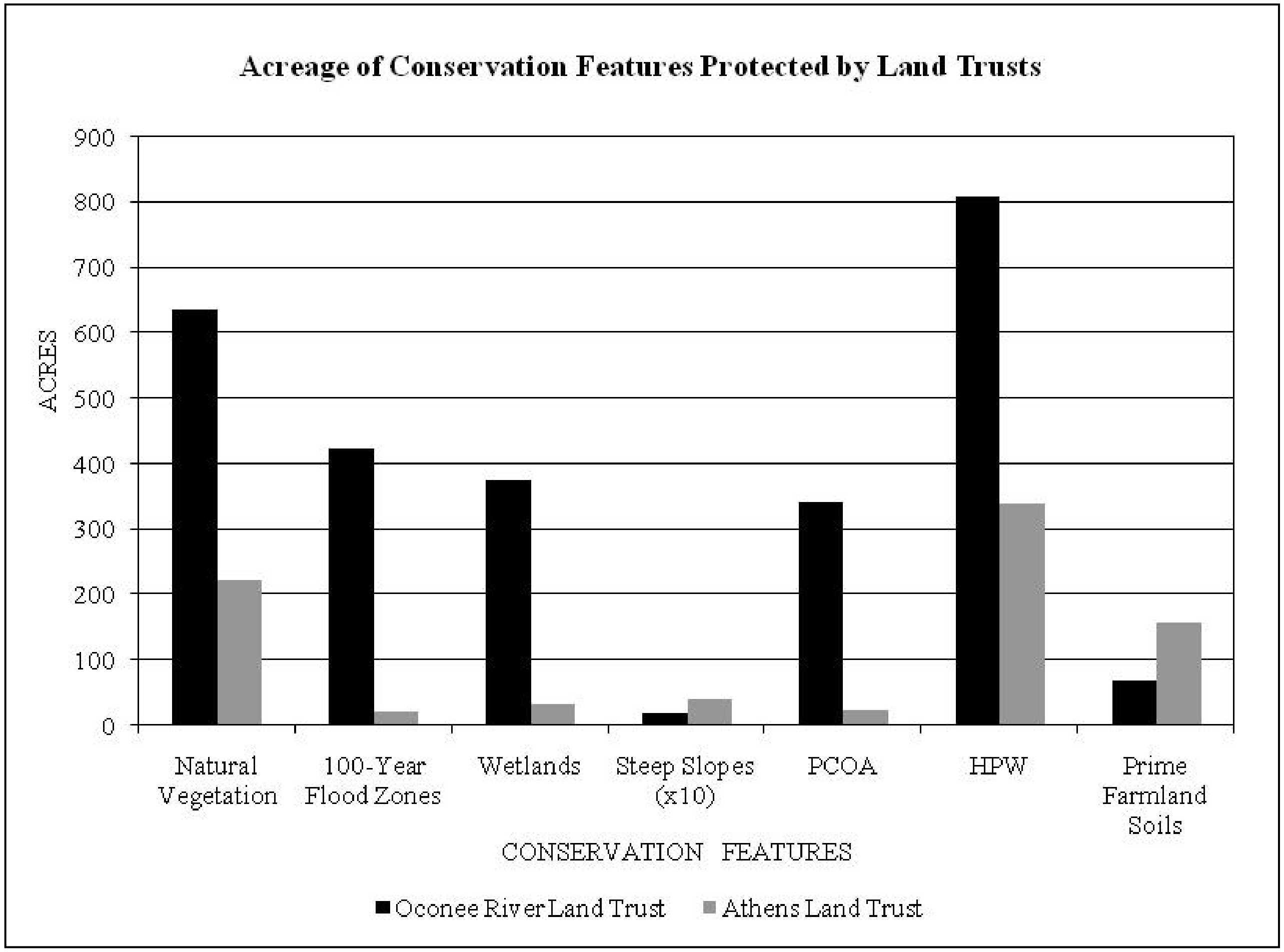

Figure D.3: Conservation features protected by land trusts. This graph shows the acreage of six of the conservation features protected by Oconee River Land Trust and Athens Land Trust. The subcomponents for the Georgia Wildlife Action Plan Priority Areas are shown as Potential Conservation Opportunity Areas (PCOA) and High Priority Watersheds (HPW).

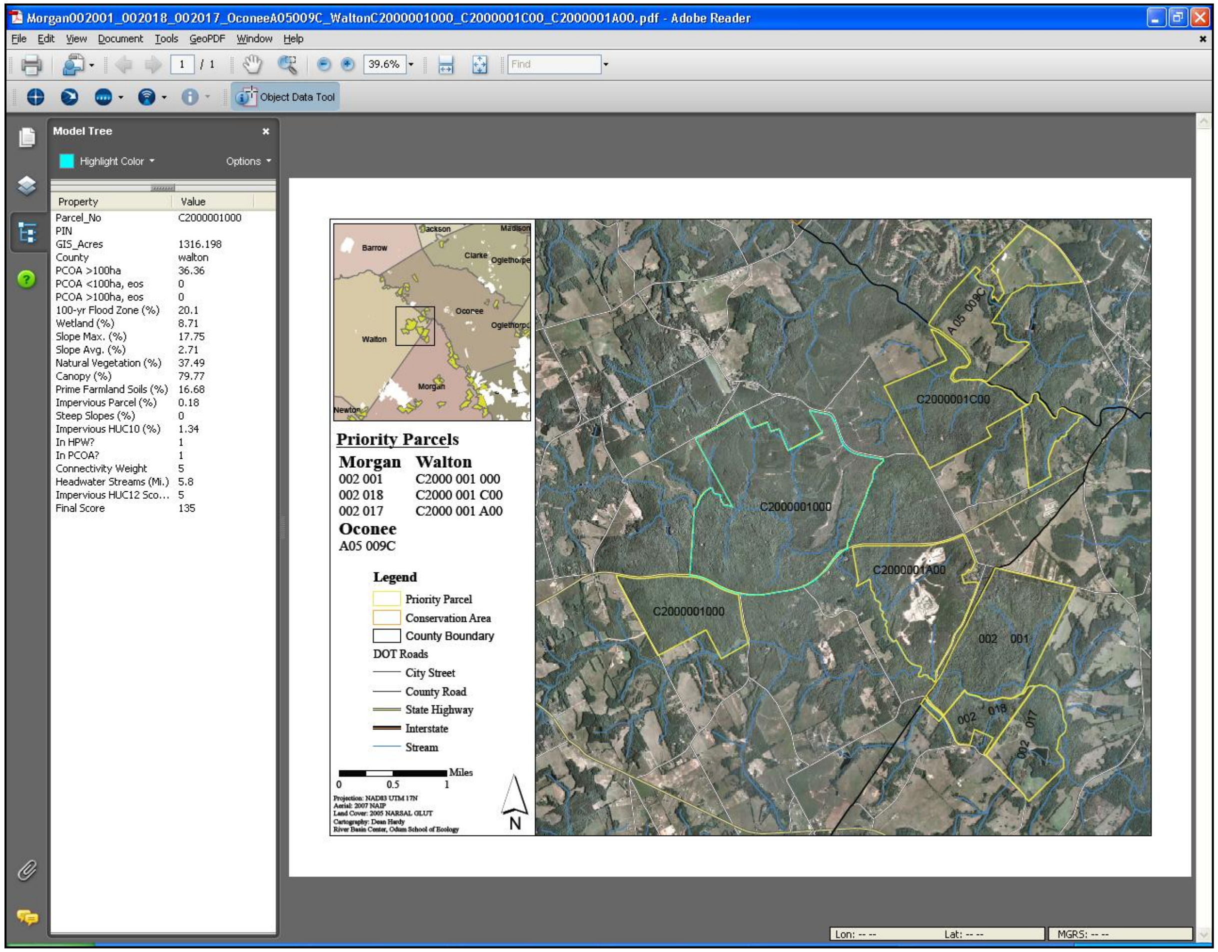

Figure D.4: Sample GeoPDF map. It is showing one Priority Parcel highlighted (light blue) and its associated information to the left in the column. Information is available for parcels, streams, and roads by clicking on them. Layers can be turned on and off. Below the 2007 aerial image are two other layers consisting of: 1) scores for five acre blocks and 2) 2005 land cover data.

APPENDIX E

IDENTIFYING AND PRIORITIZING POTENTIAL CONSERVATION SITES IN THE UPPER OCONEE SUBBASIN[1]

[1] Hardy D. and L. Fowler. 2009. *Proceedings of the Georgia Water Resources Conference*. April 25 – 27, 2009. The University of Georgia. Reprinted with permission from the publisher.

ABSTRACT

Landscape scale conservation planning informed by stakeholders is necessary for effective conservation action. We developed a watershed level conservation planning approach by working with two local land trusts that operate in the Upper Oconee subbasin of northeast Georgia. Emphasizing the interdependency of ecological processes and human livelihood to area residents motivates stewardship; hence, we focused on conservation values that draw these linkages. In the United States, private landowner conservation is essential for successful protection of ecological processes and biodiversity. The prevalent route for involving private landowners with conservation is through partnerships with land trusts. A rapid proliferation of land trusts across the U.S. over the past decade indicates the increasing importance of private land conservation efforts. As our primary objective, we developed a GIS model for evaluating nine conservation features in the watershed using a weighted scoring system modified from the Georgia Land Conservation Program evaluation criteria. We extracted the 70 highest-ranking parcels as target recruitment parcels. The land trusts will begin targeting these 70 parcels for easement recruitment immediately. The second objective included quantifying these nine conservation features for current easements and other conservation lands to aid development of strategic conservation plans. Land trust personnel agreed with the relative scoring of their current holdings. We provided the land trusts access to the entire database of values for the features analyzed in all 34,024 parcels, empowering them to visit a potential easement site with *a priori* knowledge; thereby, enhancing the efficiency of their finite funding and personnel resources.

INTRODUCTION

Multitudes of global and continental scale conservation priority-setting schemes exist to date (Brooks et al. 2006). While attracting large sums of funding and donor support (Myers &

Mittermeier 2003), the scales and subsequent coarse resolution data of these models are too general for pragmatic on-the-ground conservation planning and implementation efforts (Margules & Pressey 2000). To begin filling the research-implementation gap (Knight et al. 2008), we developed a stakeholder-informed, watershed level conservation planning approach by working with two local land trusts that operate in the Upper Oconee subbasin of northeast Georgia (Figure E.1). In addition to the traditional conservation values relating to species richness, there are ecosystems and ecological processes highly valued by local watershed residents. Therefore, we selected conservation features for our model that act as proxies for conservation values that were identified as important to land trust personnel and that have value for resident well-being.

BACKGROUND

Biodiversity has been the target of conservation efforts for at least two decades (Wilson et al. 1988). However, emphasizing the interdependency of ecological processes and human livelihood to area residents is important in addition to species richness indicators. Incorporation of an emerging concept that may afford this approach is not a new idea (Ehrlich & Mooney 1983), but a relatively recent popularization of the concept of ecosystem services (Costanza et al. 1997; Daily 1997; Daily & Matson 2008; MEA 2005; Turner et al. 2007). As defined by the United Nations' Millennium Ecosystem Assessment, ecosystems services are those environmental "goods and services provided by nature for the benefit of human welfare" (MEA 2005). The idea of ecosystem services allows for acknowledging more than the "intrinsic" value of biodiversity by expanding the breadth of the conservation argument to include the "utilitarian" values of nature (Daily 1997; Egoh et al. 2007). Hence, we chose to focus on conservation values that capture the concept of ecosystem services.

In the United States, motivating private landowners to engage in conservation is essential for successful protection of ecological processes and biodiversity (Merenlender et al. 2004; Rissman et al. 2007; Scott et al. 2001; Wilcove et al. 1996). The prevalent route for involving private landowners with conservation is through partnerships with land trusts, which are non-profit, non-governmental organizations (NGOs) that operate at scales ranging from the national level to state and local levels. Land trusts and private landowners enter into a contractual deed of conservation easement, defined as, "a voluntary legal agreement between a landowner and another party that restricts the development of a tract of land" in order to protect conservation values (Fowler 1998).[2] Essentially, a private landowner that enters into an easement agreement surrenders certain rights to the property while maintaining legal ownership of the land. The terms of the easement are unique to each property. Thus, each easement agreement includes various restrictions and permissions of land use.

The majority of land trusts are run by volunteers and have limited or no professional staff; hence, often landowners initiate easements rather than land trusts that have identified the most environmentally sensitive lands within their jurisdiction. This is motivating the scientific community to provide practitioners of private land conservation with a stakeholder-informed, scientifically driven model for recruiting easements. Another incentive is the rapid proliferation of land trusts across the U.S. over the past decade. Over the five year period 2000 – 2005, the number of land trusts registered with the Land Trust Alliance (LTA, a national-level umbrella organization for land trusts) increased by 32% to nearly 1700 organizations (LTA 2005). The acreage of land held under conservation easements by these organizations more than doubled in the same five-year period to 37 million acres (LTA 2005), which is nearly 2% of the

[2] Land trusts also purchase property, called fee simple acquisition.

conterminous U.S. land area using Scott et al.'s (2001) estimate of approximately 1.9 billion acres total. Considering that nature reserves constitute only about 6% of the conterminous U.S., this percentage is significant (Scott et al. 2001).

Furthermore, both the U.S. Congress and many state legislatures have recognized the public benefit of private land conservation through easements by increasing the associated income and property tax incentives. Landowners are able to apply for federal tax deductions and in some states, such as Georgia, tax credits. At least 12 states currently offer tax incentives programs (Young 2008). Local governments have joined the bandwagon also by providing property tax reductions that lower fair market value because of the encumbrance, as provided by state law. These economic incentives programs all indicate governmental recognition of the importance of private land conservation. This supports our claim of the need for scientific research to develop models for protecting private lands.

The first objective of our study was to identify and prioritize lands with high conservation value for the land trusts working in the Upper Oconee subbasin. We facilitated this objective by working with the Oconee River Land Trust (ORLT) and Athens Land Trust (ALT), and by gathering input from the land trusts on priority conservation values. Subsequently, we identified parcels of land that, if conserved, would aid maintenance and protection of critical ecological processes and important wildlife habitat. The identified conservation values included: air and water quality, flood and erosion regulation, habitat protection, and food production. Stakeholders identified water quality as one of the most important conservation values. Two-thirds of the conservation features used in the model catered to the protection of water quality, either directly or indirectly. A second goal included quantifying those conservation features that the land trusts are currently protecting to facilitate development of strategic conservation plans for easement recruitment campaigns.

METHODS

For the conservation assessment of the Upper Oconee subbasin, we focused on nine conservation features that the land trust personnel identified as important and that were easily mapped with the ArcGIS Desktop software (ESRI, Redlands, CA). The eleven datasets used for evaluating the conservation features were gathered or created, as necessary (Table E.1). The land cover data accuracy allowed us to analyze parcels greater than or equal to five acres. We analyzed 34,024 parcels. Parcel data ranged from 2005 – 2007 for the entire region except for Hancock County, for which we had no data. Floodplain data were unavailable for Greene, Jasper, and Putnam counties, and prime farmland soils data were unavailable for Greene County. We evaluated parcels in these areas equally.

Nine conservation features representing seven conservation values were evaluated for all parcels (Table E.2). All features were analyzed using ArcGIS and three extensions: Spatial Analyst, Hawth's Analysis Tools (Beyer 2004) and Arc Hydro. We assessed stream order using USGS NHD 1:24K streams burned into the USGS NED 30m data and a sixteenth mile catchment minimum using Arc Hydro. This was done to extend the USGS stream lines, which have been shown to be an underestimate of actual headwater occurrences (Colson et al. 2008). The 2005 natural vegetation layer was calculated by adding 1998 Georgia GAP land cover data (Kramer et al. 2003)

that were recoded for natural vegetation into a binary raster (see GA DNR 2005 for detailed method) with a binary raster of 2005 GLUT forest data (classes deciduous (41), evergreen (42), mixed (43), and forested wetland (91)). The extent of congruency between these two layers was the natural vegetation cover for our model. We used Hawth's Analysis Tools to calculate the percent of each land cover type, as well as the length of first and second order streams in each parcel.

Connectivity of parcels to the protected areas in the GA DNR 2003 dataset, and to 100 ha core area PCOAs from the GA WAP, were evaluated by generating least cost distance rasters. We created these using PCOAs and protected areas as potential species source areas, and recoded 2005 GLUT land cover and impervious surface

data as the cost rasters. The GLUT land cover data were reclassed as follows: rock outcrop (34), deciduous (41), mixed (43), forested wetland (91), and wetland (93) to highly passable (0); beach (7), open water (11), clear-cut and sparse (31), evergreen (42), row crops and pastures (81), to moderately passable (5); and low intensity urban (22) and high intensity urban (24) as low passability (20). We used the impervious surface raster to indicate those areas with relatively high impervious surface cover as greater costs, and to make roads and highways contiguous in the final corridor raster. We used Hawth's Analysis Tools to calculate relative cost values for each parcel. We classified parcel connectivity values into three natural categories using Jenk's Optimization (natural breaks), which seeks to minimize within class and maximize among class standard deviations.

We developed a weighted set of model parameters by assigning each parcel a score from a modified set of criteria drawn from the Georgia Land Conservation Program (GLCP, Table E.2). The first model was our baseline model, totaling a possible 48 points. The second model was an area-weighted multiplicative (AWM) model, which corrected for the size differences of parcels. We multiplied baseline scores of parcels ranging 5 – 99 acres by a factor of 1, parcels ranging

100 – 499 acres by a factor of 3, and parcels over 500 acres by a factor of 5. A high score of 240 was possible.

To select target priority parcels for easement recruitment, we chose an areal target, T, of 2.75% of the subbasin. T was chosen to facilitate increasing the area protected in the Upper Oconee from its current extent of 7.25% to a total of 10%. Finally, we analyzed easements and fee simple holdings of both land trusts as well as other conservation lands to quantify the current protection status of these nine conservation features in the subbasin using the methods above. This step allows the land trusts to identify watershed level features in need of conservation and to develop planning strategies aimed at increasing their protection.

RESULTS

Of the Upper Oconee subbasin's 2,917 mi^2, natural vegetation covers 30% of the watershed. The total impervious surface cover is 2.3%, with the northwest region containing the highest coverage and the southwest region having the lowest coverage. 100-year flood zones cover 9.7% of the 1,802 mi^2 for which digitized data were available. Of the approximately 9,770 miles of GIS-calculated streams, 4,929 miles are first order streams and 2,271 miles are second order streams. This means that headwater streams, as estimated here, comprise 74% of all the streams in the subbasin. Wetlands cover 4.8%, and steep slopes extend over 0.2% of the subbasin. From the Georgia WAP, PCOAs cover 8.4%, and HPWs represent 29% of the subbasin's extent. Prime farmland soils cover 19% of the 2,400 mi^2 for which data were available.

Figure E.2 shows the subbasin percentage of each feature protected in the 211.5 mi^2 of conservation lands for eight of the conservation features. Subwatershed impervious surface cover is not included because it was used as a negative indicator and is not desirable in protected areas.

Landscape connectivity was categorical and was not included either. GA WAP priority areas are subdivided into their constituent parts of PCOAs and HPWs for Figure E.2.

Area-weighted multiplicative model scores ranged from 1 – 160, with a mean of 17.7 (Figure E.3). The areal target, T, for priority area identification was defined as 2.75%; thus, the 70 highest scoring parcels were identified as the target priority parcels because they facilitated capturing T (Figure E.4). These 70 parcels comprise 3.09% of the Upper Oconee subbasin. Scores ranged from 115 – 160.

Taken together, these 70 parcels encompass 35.6 mi^2 of natural vegetation; 9.4 mi^2 of 100-year flood zones; 222 miles of headwater streams; 9.4 mi^2 of wetlands; 180 acres of steep slopes; from the GA WAP, 26.7 mi^2 of PCOAs and 47.2 mi^2 of HPWs; and 30.2 mi^2 of prime farmland soils. All parcels are greater than 500 acres and located in an area identified as having a high landscape connectivity value. Figure E.2 shows the potential percentage increase in these eight features' protection for the Upper Oconee Subbasin if the 70 target priority parcels were under easement.

At the time of analysis, ORLT and ALT had 20 and 14 easements and fee simple holdings in the Upper Oconee subbasin covering 1,314 and 638 GIS-calculated acres, respectively. Figure E.4 shows the total acreage of eight conservation features, organized by land trust. ORLT and ALT are protecting eight and three miles, respectively, of headwater streams.

DISCUSSION

We met our objectives of 1) identifying and prioritizing parcels of land that contribute to conservation value and 2) quantifying current conservation features protected by existing land trust easements and fee simple holdings (Figures E.2 and E.4).

As Figure E.4 shows, the results for objective two answers the call of Rissman et al. (2007) for land trusts in the Upper Oconee subbasin. This will facilitate development of watershed level, easement recruitment strategies by the land trusts for protection of these conservation features. We chose to focus our efforts on the Upper Oconee subbasin for two reasons. First, Oconee River Land Trust and Athens Land Trust operate in the subbasin. Second, our interests were to identify specific landscape features that enhance water quality, such as wetlands and headwater streams. Watershed level planning is critical when targeting factors affecting water quality.

Upon completion of our study, UGA law students began working with the land trusts to develop a draft letter for contacting the owners of the target priority parcels. Further, the land trusts will use the database to contact landowners beyond the initial target. A significant side-benefit of this study is providing the land trusts access to the entire database of values for the features analyzed in all 34,024 parcels, which empowers them to visit potential easement sites with *a priori* knowledge.

Our study extends the assessment made by GA DNR (2005), to identify areas with conservation values in addition to habitat and species of concern. Our model does not attempt to quantify the processes or ecosystem services provided by the conservation features, rather we view them as proxies for ecosystem services such as: air and water quality, flood and erosion regulation, and potential food production. Further, we recognize that only portions of the target parcels are of the greatest significance to stakeholder conservation goals. Further analyses using higher resolution analysis are required to identify which areas in the target parcels should be under easement.

A true accuracy assessment would benefit our results; however, due to time and financial constraints we assume the accuracy from the coarsest datasets in our model, the land cover and elevation datasets. However, we made visual assessments with 2007 National Agriculture Imagery Program (NAIP) photography to evaluate the target priority parcels. Moreover, ORLT board members agree with the relative scoring of ORLT's easements, which helps to strengthen the model's predictions, as they are experienced field staff and expert biologists with onsite knowledge of their easement holdings.

Other limitations in our analyses include the missing floodplain and prime farmland soils data, which may have skewed the results. However, many of the highest ranked parcels were in areas where the data were absent; thus, many of the highest-ranking parcels would likely be even more strongly implicated for conservation action. Additionally, although we explicitly chose to increase the number of headwater streams in our analysis beyond the USGS 1:24K streams based on the findings of Colson et al. (2008), our analysis may have spatially misidentified and/or wrongly quantified headwater streams as a result of the low accuracy of the 30m NED, leading to a misrepresentation of features contained within parcels.

CONCLUSION

In conclusion, conservation practitioners need services that link existing scientific data to their missions of preserving ecological processes and wildlife habitats. Developing processes and tools to facilitate the transfer of scientific knowledge into the conservation community is paramount to a successful conservation paradigm and to closing the research-implementation gap (Knight et al. 2008). Finally, It is important to recognize that any prioritization process necessarily chooses to value one set of parameters at the expense of others. There is no model that can capture the breadth of values and features we need to protect and conserve. Conservation modelers and practitioners are wise to keep these thoughts in mind throughout all phases of development and implementation of conservation strategies.

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REFERENCES

Beyer, H. L. 2004. Hawth's Analysis Tools for ArcGIS, Available at http://www.spatialecology.com/htools.

Brooks, T. M., R. A. Mittermeier, G. A. B. da Fonseca, J. Gerlach, M. Hoffmann, J. F. Lamoreux, C. G. Mittermeier, J. D. Pilgrim, and A. S. L. Rodrigues. 2006. Global biodiversity conservation priorities. Science **313**:58-61.

Colson, T., J. Gregory, J. Dorney, and P. Russell. 2008. Topographic and Soil Maps Do Not Accurately Depict Headwater Stream Networks. National Wetlands Newsletter. Environmental Law Institute, Washington D.C.

Costanza, R., R. dArge, R. deGroot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. Oneill, J. Paruelo, R. G. Raskin, P. Sutton, and M. vandenBelt. 1997. The value of the world's ecosystem services and natural capital. Nature **387**:253-260.

Daily, G. C. 1997. Nature's services : societal dependence on natural ecosystems. Island Press, Washington, DC.

Daily, G. C., and P. A. Matson. 2008. Ecosystem services: From theory to implementation. Proceedings of the National Academy of Sciences **105**:9455-9456.

Egoh, B., M. Rouget, B. Reyers, A. T. Knight, R. M. Cowling, A. S. van Jaarsveld, and A. Welz. 2007. Integrating ecosystem services into conservation assessments: A review. Ecological Economics **63**:714-721.

Ehrlich, P. R., and H. A. Mooney. 1983. Extinction, Substitution, and Ecosystem Services. BioScience **33**:248-254.

Fowler, L. 1998. A Landowner's Guide: Conservation easements for natural resource protection. Georgia Land Trust Service Center.

GA DNR. 2005. A Comprehensive Wildlife Conservation Strategy for Georgia. Wildlife Resources Division.

Knight, A. T., R. M. Cowling, M. Rouget, A. Balmford, A. T. Lombard, and B. M. Campbell. 2008. Knowing but not doing: Selecting priority conservation areas and the research-implementation gap. Conservation Biology **22**:610-617.

Kramer, E., M. J. Conroy, M. J. Elliot, E. A. Anderson, W. R. Burnback, and J. Epstein. 2003. The Georgia Gap Analysis Project. University of Georgia and USGS, Athens, GA.

LTA. 2005. National Land Trust Census Report. Land Trust Alliance, Washington D.C.

Margules, C. R., and R. L. Pressey. 2000. Systematic conservation planning. Nature **405**:243-253.

MEA 2005. Ecosystems and human well-being : synthesis. Island Press, Washington, DC.

Merenlender, A. M., L. Huntsinger, G. Guthey, and S. K. Fairfax. 2004. Land trusts and conservation easements: Who is conserving what for whom? Conservation Biology **18**:65-75.

Myers, N., and R. A. Mittermeier. 2003. Impact and acceptance of the hotspots strategy: Response to Ovadia and to Brummitt and Lughadha. Conservation Biology **17**:1449-1450.

Rissman, A. R., L. Lozier, T. Comendant, P. Kareiva, J. M. Kiesecker, M. R. Shaw, and A. M. Merenlender. 2007. Conservation easements: Biodiversity protection and private use. Conservation Biology **21**:709-718.

Scott, J. M., F. W. Davis, R. G. McGhie, R. G. Wright, C. Groves, and J. Estes. 2001. Nature reserves: Do they capture the full range of America's biological diversity? Ecological Applications **11**:999-1007.

Turner, W. R., K. Brandon, T. M. Brooks, R. Costanza, G. A. B. da Fonseca, and R. Portela. 2007. Global conservation of biodiversity and ecosystem services. Bioscience **57**:868-873.

Wilcove, D. S., M. J. Bean, R. Bonnie, and M. McMillan. 1996. Rebuilding the Ark: Toward a More Effective Endangered Species Act for Private Land. Environmental Defense Fund, Washington, D.C.

Wilson, E. O., F. M. Peter, National Academy of Sciences (U.S.), and Smithsonian Institution. 1988. Biodiversity. National Academy Press, Washington, D.C.

Table E.1: GIS data layers used for prioritizing parcels; their sources, scales, and years. UGA NARSAL = University of Georgia Natural Resources Spatial Analysis Lab. GLUT = Georgia Land Use Trends. FEMA Q3 DFIRM = Federal Emergency Management Agency Q3 Digital Flood Insurance Maps. USGS NED = United States Geological Survey National Elevation Dataset. DNR WAP = Dept. Natural Resources Wildlife Action Plan. NRCS SSURGO = Natural Resources Conservation Science Soil Survey Geographic Database.

GIS Data Layer	*Data Source*	*Scale*	*Year*
Stream Order	Created in a GIS	1:100K	1999
Natural Vegetation	UGA NARSAL GAP & GLUT	1:100K	2005
Impervious Surface Cover	UGA NARSAL GLUT	1:100K	2005
Floodplains	FEMA Q3 DFIRM	1:24K	2001
Wetlands	UGA NARSAL GLUT	1:100K	2005
Terrain Slope	USGS NED	1:100K	1999
Potential Conservation Opportunity Areas	GA DNR WAP	1:100K	2005
High Priority Waters	GA DNR WAP	1:100K	2005
Prime Farmlands	NRCS SSURGO	1:24K	2001
Connectivity	Created in a GIS	1:100K	2005
Parcels	Counties & RDC	1:24K	2005 - 07

Table E.2: Seven GLCP conservation values and their respective conservation features' scoring categories for prioritizing parcels of the Upper Oconee subbasin. PCOAs (Potential Conservation Opportunity Areas) and HPWs (High Priority Watersheds) are from the GA WAP (Georgia Wildlife Action Plan).

Conservation Value	*Conservation Feature*	*Score*			
		5	3	1	0
Water Quality Protection	Natural Vegetation Cover (%)	75 – 100	50 – 74	25 – 49	0 – 24
	Impervious Surface Cover of HUC 12 Subwatershed (%)	< 5	5 – 10	-	≥ 1
Flood Protection	100-Year Flood Zone Cover (%)	≥ 50	25 – 49	1 – 24	< 1
	Headwater Streams (mi.)	≥ 1	0.5 – 0.9	0.1 – 0.4	< 0.1
Wetland Protection	Wetland Cover (%)	≥ 50	25 – 49	1 – 24	< 1
Erosion Reduction	Steep Slopes (%)	≥ 50	25 – 49	1 – 24	< 1
Habitat Protection	GA WAP Priority Area	PCOA	HPW	-	-
Agricultural Land Protection	Prime Agricultural Soils (%)	≥ 66	33 – 65	5 – 32	< 5
Landscape Connectivity	Connectivity to Conservation Lands & PCOAs	High	Moderate	Low	-

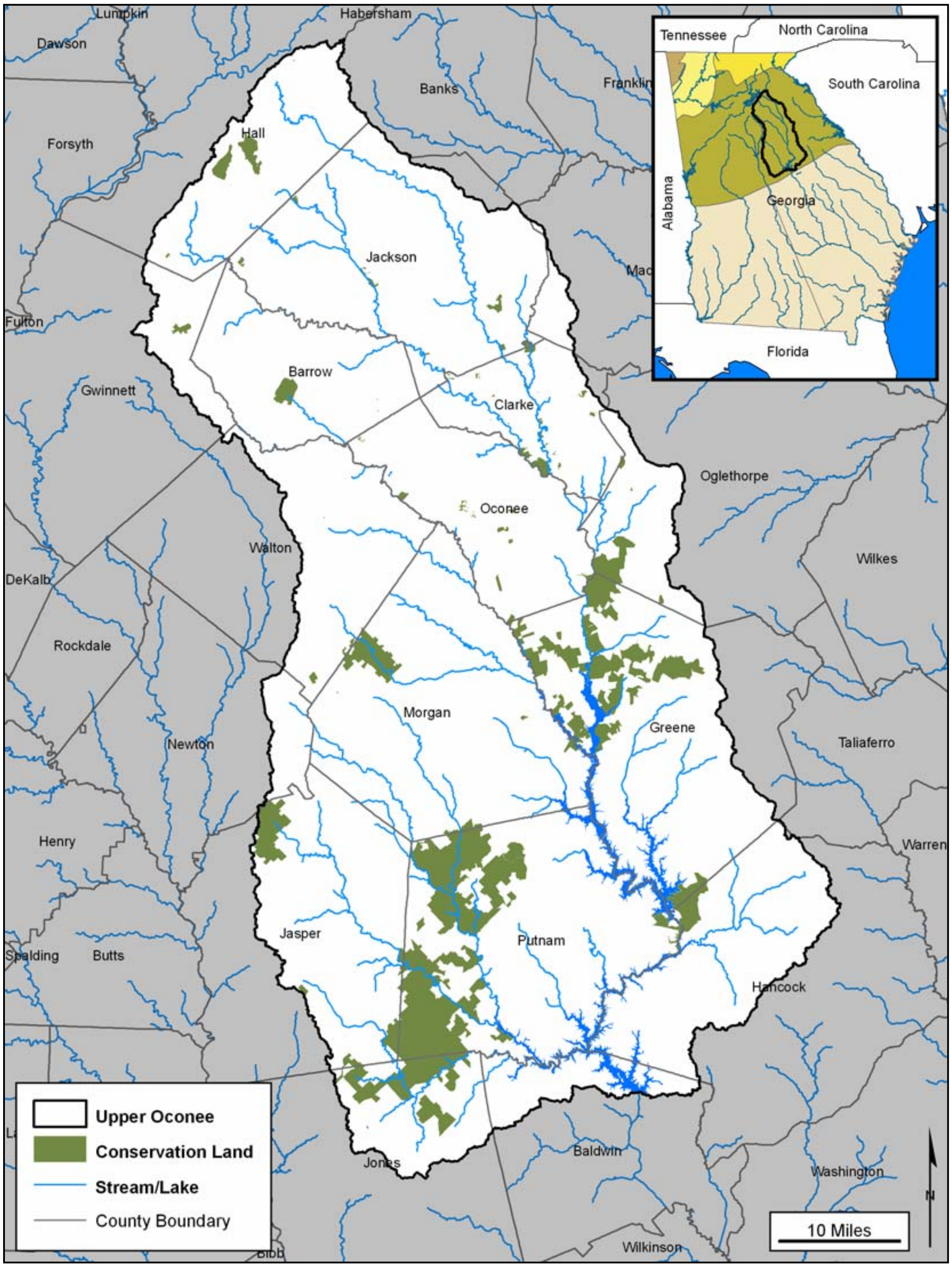

Figure E.1: Map of the study site, the Upper Oconee subbasin, which is located in the Piedmont Physiographic Province in Northeast Georgia.

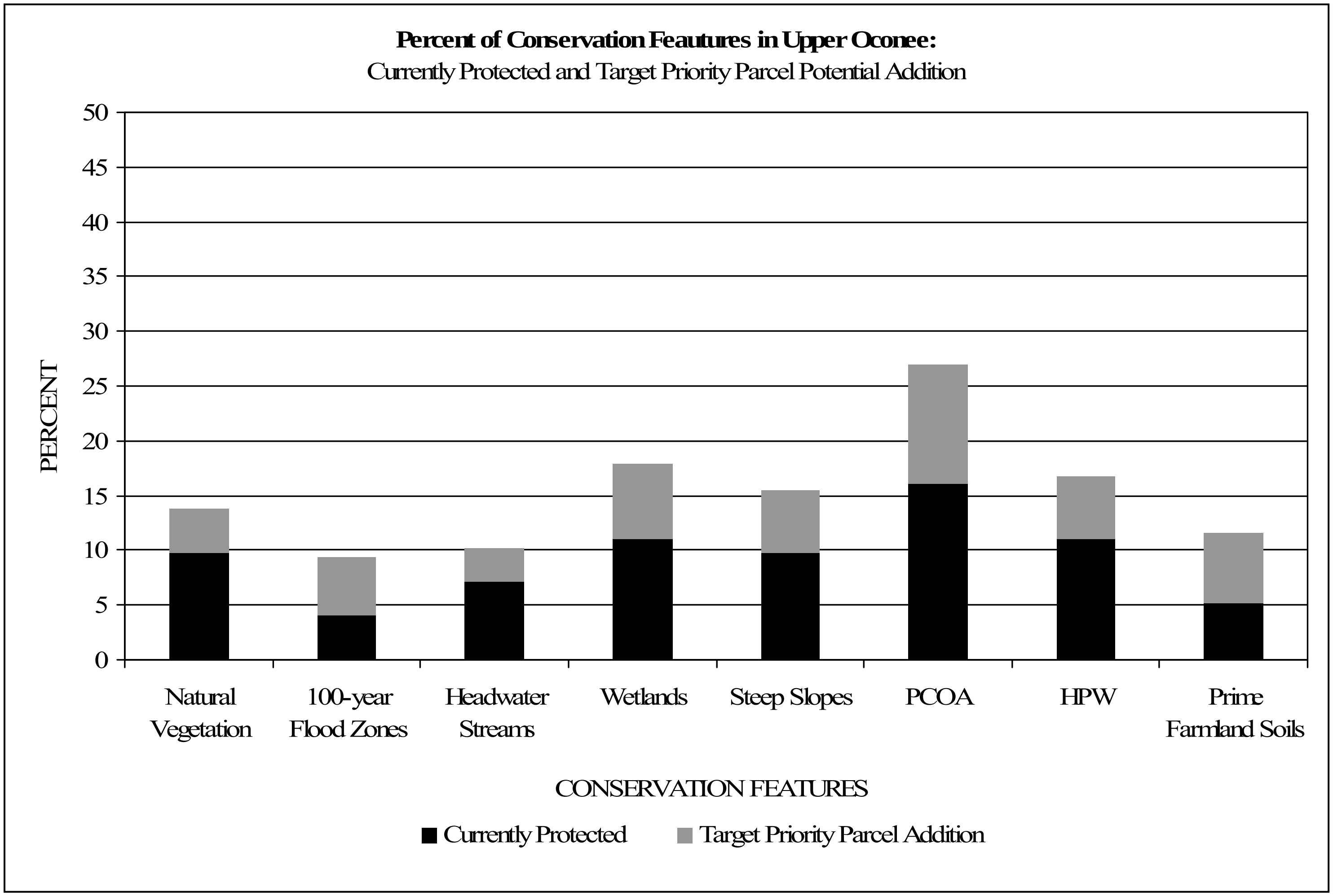

Figure E.2: Percent of Upper Oconee conservation features currently protected and potential addition to that percentage from Target Priority Parcels.

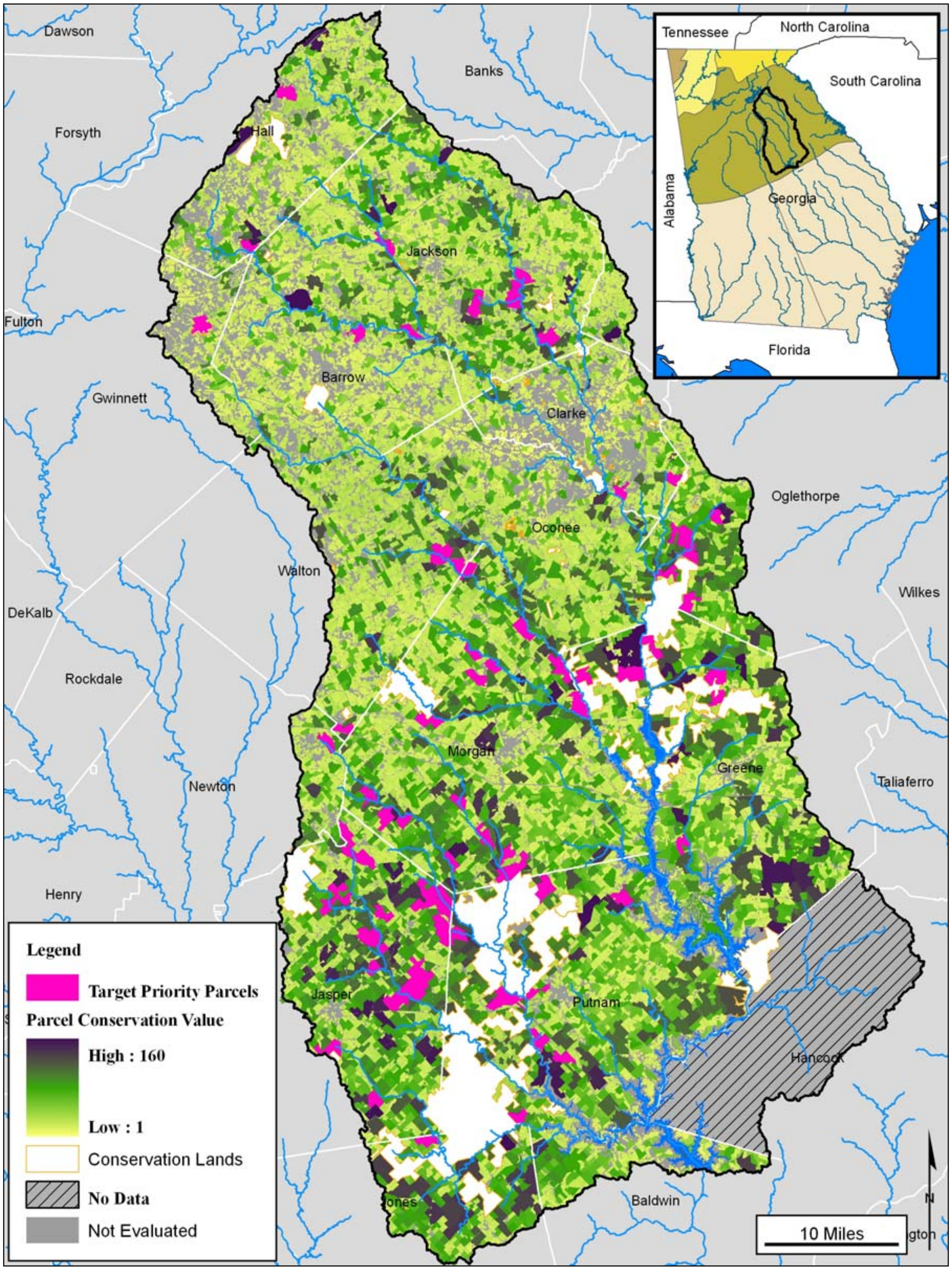

Figure E.3: Seventy Target Priority Parcels with area-weighted scores for all parcels, excluding conservation lands. Higher scores equal higher conservation value.

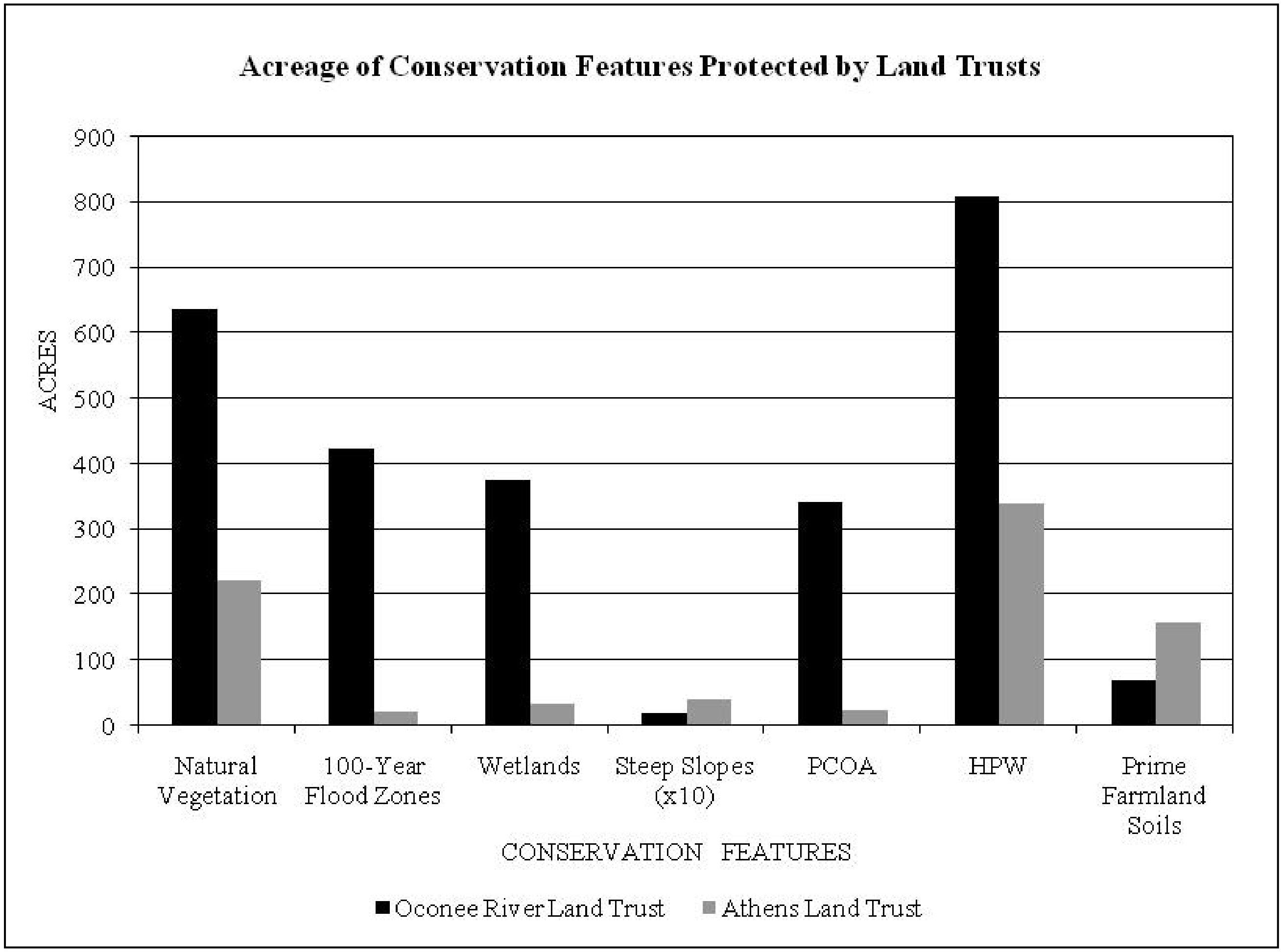

Figure E.4: Acreage of eight conservation features protected by the land trusts. PCOA (Potential Conservation Opportunity Area) and HPW (High Priority Watershed) come from the GA WAP Priority Area feature in Table E.2.