THE SPATIAL RELATIONSHIP BETWEEN EXURBAN DEVELOPMENT AND DESIGNATED WILDERNESS LANDS IN THE CONTIGUOUS UNITED STATES

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Abstract.—Public lands provide recreational opportunities and preserve historic and ecological values. Increases in low-density residential development in the contiguous United States pose a threat not only along the boundaries of national parks and forests, but also around uniquely valuable Wilderness areas. Development within and around protected lands can affect land management and landscape ecology by fragmenting forest and wildlife habitat, diminishing air and water quality, and limiting recreational opportunities and access. Exurban and rural sprawl particularly affects wilderness areas because land development is inconsistent with the nature of wilderness and its associated values. This research uses U.S. Census and land ownership data to identify National Wilderness Preservation System (NWPS) units with exurban or urban housing densities and large amounts of surrounding private land. Identifying NWPS units within 10 miles of the Wilderness boundary that are most likely to experience housing density increases will assist in the management and protection of these valuable lands.

1.0 INTRODUCTION

Public lands preserve historic and ecological values while also providing unparalleled recreational opportunities. However, increases in low-density residential development in the United States pose a threat along the boundaries of the nation's public lands. This threat affects not only national parks and forests, but also uniquely valuable Wilderness areas[1] that make up the National Wilderness Preservation System (NWPS) (Cordell et al. 2005, Stein et al. 2006). Wilderness areas are in a unique category of federal land protected through the 1964 Wilderness Act, which expressly prohibits human modification of the landscape. Though Wilderness areas are managed by one of four agencies (Bureau of Land Management [BLM], Fish and Wildlife Service [FWS], Forest Service [FS], or National Park Service [NPS]), all Wilderness areas are part of the National Wilderness Preservation System (NWPS). These lands preserve inimitable research and recreational opportunities; provide sources of ecological and biological diversity; and offer oft-perceived aesthetic, existence, bequest, and intrinsic values (Cordell 2005, Noss 1991).

Wilderness areas are particularly affected by exurban and rural sprawl because land development clashes with the nature of wilderness and its associated values (Cordell et al. 2005). Development within and around protected lands can affect both the ecology and management of these ecosystems by increasing forest and wildlife habitat fragmentation and reducing air and water quality. Land ownership patterns may also affect recreational opportunities and access. Thus, housing density increases near Wilderness areas are incompatible with wilderness values and pose challenges to the management of these areas.

[1] Capitalization of "Wilderness" denotes federally designated units of the National Wilderness Preservation System in keeping with the current literature.

1.1 Background

To accommodate an increasing human population, housing density is expected to rise in many areas of the United States, adding to the overall trend of urbanization (Cohen 2003, Theobald 2005). Similarly, America's proclivity for exurban and rural growth results in a "development footprint" that is unequal to population increase. Exurban and rural development disproportionately increases road density per housing unit and contributes to forest fragmentation (Hammer 2003, Theobald 2005). The effects of such low-density development are reflected in both the ecology of the local system and people's enjoyment of the landscape.

Increases in population, housing, and road density together create a marked effect on natural areas (Cordell and Overdevest 2001), often with negative ecological implications. Of primary concern are impacts resulting from development and subsequent fragmentation including critical wildlife habitat loss, a decline in biodiversity, introduction of invasive species, microclimate changes, influences on air and water quality, alteration of nutrient flow, modification of migration patterns, and risks associated with wildfire (Arnold and Gibbons 1996, Debinski and Holt 2000, Radeloff 2005, Riitters 2002, Schueler 1994). Additional effects include a decline in the manufacture of forest products and reduction of recreational opportunities (Stein et al. 2005).

The pressures of human development and private land ownership within the protected landscape add difficult and sensitive aspects to the duties of land managers. Fragmented land ownership patterns create a challenge for managers of public lands as they strive to protect natural and historic values and maintain access for recreation. The term "backcountry sprawl" describes the housing development increase within and near national forests and parks (Russell 2006). A 34-percent increase in the amount of developed land in the United States between 1982 and 1997 is projected to be followed by a 79-percent increase by 2030, almost doubling the total developed land base (Alig 2003). More than 44 million acres of private forests in the contiguous United States are expected to undergo an extensive rise in housing density in the next quarter century, enough to substantially affect the borders of national forests and grasslands in America (Stein et al. 2005). Implications for public lands include direct pressures related to population and economic growth, as well as recreational demands; indirect pressures will result from inconsistent use of neighboring lands (Cordell and Overdevest 2001). However, national forests and grasslands are not the only protected lands at risk from development along the borders; housing density will likely increase in and around Wilderness areas as well (Cordell and Overdevest 2001).

Without current measures of housing density near NWPS boundaries and landscape-level land cover change to identify areas of primary concern, land managers cannot effectively plan for NWPS areas. Housing density calculations are expected to identify Wilderness areas experiencing the greatest risk of development in the near future. By merging U.S. Census data with known factors affecting development, this study will provide a method for ascertaining which protected areas are most at risk, thus targeting locations where action is most necessary and improving strategies for conservation and protection (Theobald 2003). An understanding of the implications of private land development on the surrounding protected landscape is necessary to preserve the natural resource values currently afforded by America's public lands.

1.2 Study Area

The NWPS comprises 704 federally designated Wilderness areas (Wilderness Institute 2008). The contiguous United States contains 652 individual units of the system (Fig. 1); nearly 107.5 million acres (2 percent of the contiguous U.S. land area) in 44 states are protected as Wilderness (Hendee and Dawson 2002).

2.0 METHODS

Quantification of sprawl near Wilderness areas in the continental United States includes a) determination of current housing density at 0.5-, 3-, and 10-mile distances of NWPS boundaries and b) calculation of

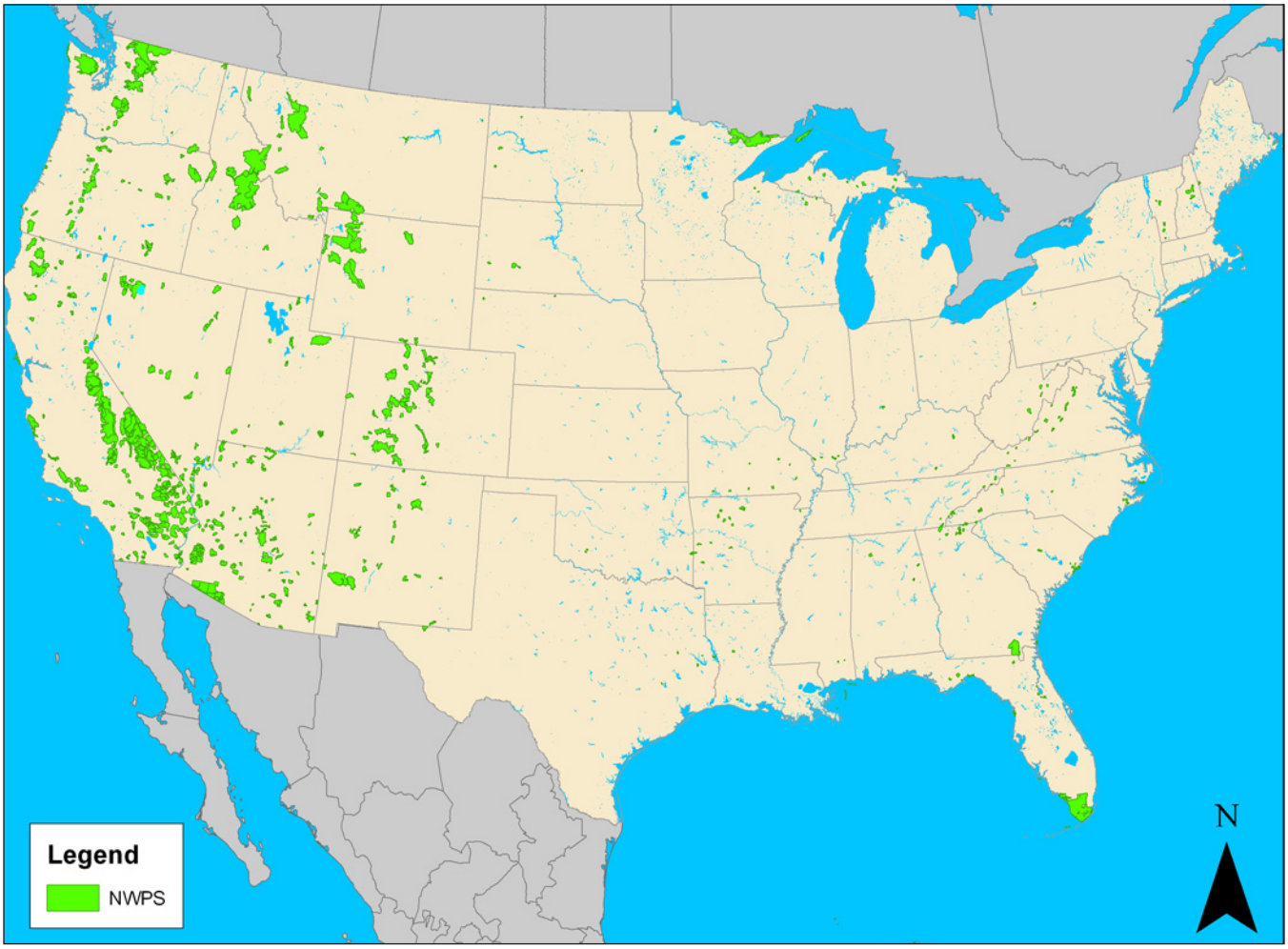

Figure 1.—The National Wilderness Preservation System in the contiguous United States.

the amount and percentage of developable land within 0-, 0.5-, 3-, and 10-mile distances of NWPS lands. Wilderness areas experiencing the greatest likelihood of development are predicted to be positively correlated with exurban or urban housing densities and the presence of nearby private land.

2.1 Analysis

Geographic data known as shapefiles were acquired from National Atlas, U.S. Census Bureau, U.S. Department of Agriculture, U.S. Department of the Interior, and the U.S. Geological Survey and imported to a Geographic Information System (GIS). The accuracy of the shapefiles varies between sources and the finest-scale data for each parameter was used in the final analysis. Geographic data exist for Wilderness areas greater than 640 acres and designated prior to 2004 – a total of 600 NWPS units. For each Wilderness area, buffers were created around the Wilderness area (WA) itself, a 0 to 0.5-mile buffer from the border of the WA, a 0.5- to 3-mile buffer of the border of the WA and a 3- to 10-mile buffer from the border of the WA. These buffers represent straight-line distance from the NWPS border and are analogous to a radius, except that NWPS areas are irregularly shaped (Fig. 2). Additional analysis was conducted on all land within a 10-mile buffer of NWPS area boundaries.

Urban and suburban housing densities are defined as having 64 or more housing units per square mile. Exurban housing densities have 16-64 units per square mile) while rural areas contain less than 16 units per square mile (Stein et al. 2006, Theobald 2005). A

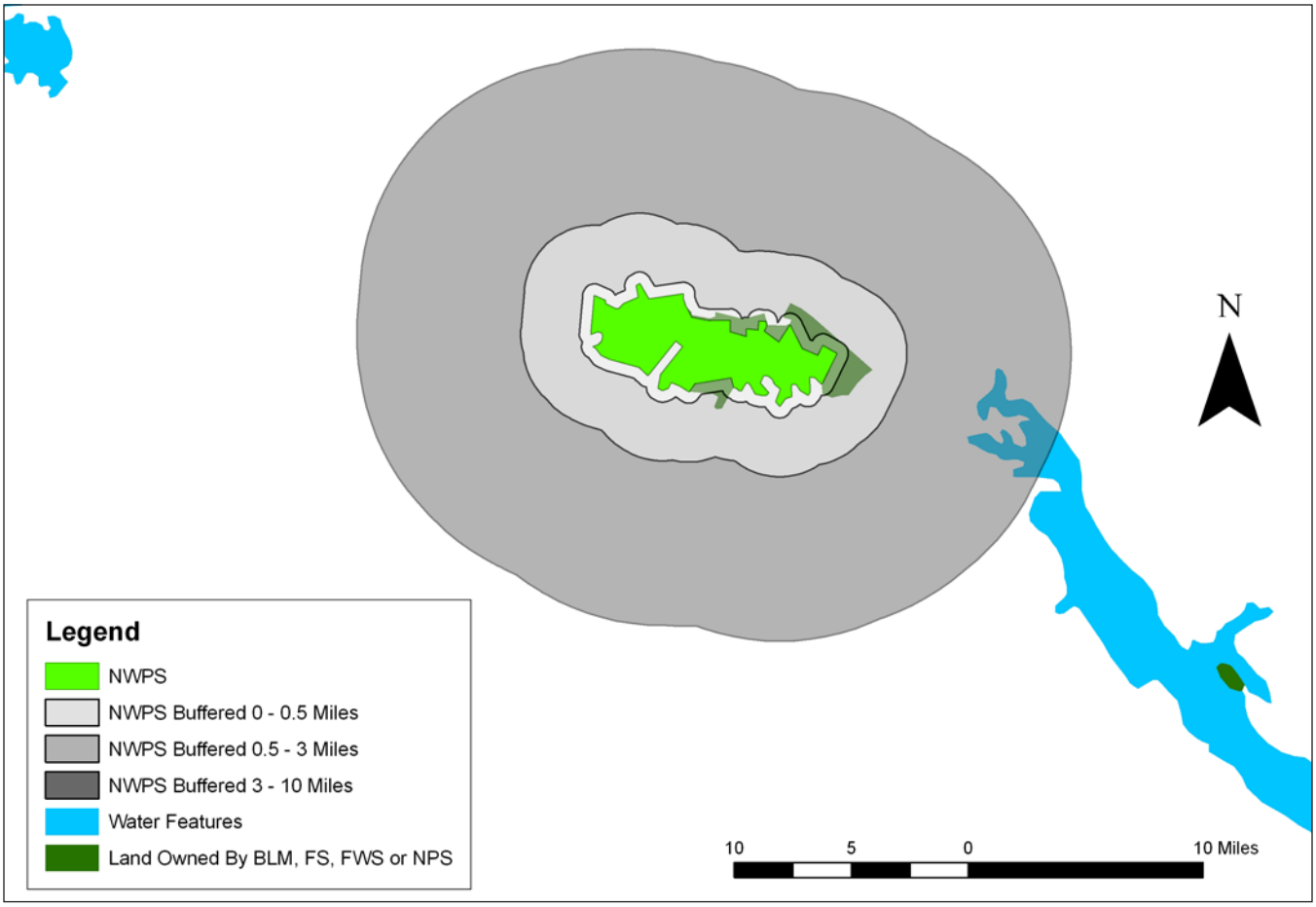

Figure 2.—Example of buffer construction for Congaree National Park Wilderness Area, South Carolina.

database of NWPS units that intersect Census block groups at urban and exurban housing densities was created in ArcGIS by assigning urban, exurban, and rural housing density categories to all Census block groups in the contiguous United States. Those NWPS lands that intersect Census block groups for each housing density category were selected by location. Additionally, all Census block groups that intersect with Wilderness boundaries or within a 10-mile buffer of NWPS lands were exported for further analysis.

Land ownership has a substantial role in the likelihood of development of a particular parcel. Areas excluded from potential development in this study include all water features and land owned by BLM, FWS, FS, or NPS. Surface ownership files including information regarding inholdings were utilized for BLM and FS, but the remaining agencies have geographic data for the administrative boundaries only. Thus, the actual amount of developable land may be underestimated. State lands and conservation easements were not included because the data are not available nationwide. For each buffer distance, the amount and percent of nonfederal land for each protection category within each buffer was calculated.

3.0 RESULTS

The results were organized according to each parameter: Census data and land ownership.

3.1 Wilderness and Census Data

Of the 600 NWPS units in the contiguous United States for which geographic data were obtained, 489 were completely surrounded by land in the rural housing density category. Forty Wilderness areas contain part of a Census block group at urban housing densities while 99 NWPS units intersect with Census block groups at exurban housing densities. Note that 28 Wilderness areas intersect with both urban and exurban Census block groups.

Census block groups from the year 2000 intersecting NPWS buffer were analyzed. Of 1139 Census block groups intersecting a Wilderness area boundary, 70 block groups were at urban housing densities and 142 block groups were at exurban housing density. The remaining 927 block groups were below the rural housing density threshold. Average housing density for all Census block groups was 15.77 units per square mile. Median housing density was 3.63 units per square mile with maximum housing density reaching 1743.59 units per square mile. Minimum housing density was 0.00. The 2000 Census block group population data yielded an average population density of 44.49 persons per square mile. The median population density was 5.73 persons per square mile with a maximum density of 4203.70 persons per square mile and a minimum of 0.00 persons per square mile.

Analysis was repeated for the 11,165 Census block groups intersecting the 10-mile buffer around NWPS lands. Of these block groups, 7,424 were at urban housing density, 1,409 were exurban density, and 2,332 were rural. The average housing density for block groups within 10 miles of NWPS lands was 1161.18 units per square mile. The minimum housing density was 0.00 units per square mile, the median housing density was 458.84 units per square mile, and the maximum housing density was 30,520.83 units per square mile. Population of Census block groups within a 10-mile buffer of NWPS lands yielded an average population density of 2,949.03 persons per square mile. Population density peaked at 76,180.36 persons per square mile for this area. The minimum population density was 0.00 persons per square mile and the median was 1,048.90 persons per square mile.

3.2 Wilderness and Land Ownership

The amount and percent of land within 0-, 0.5-, 3-, and 10-mile buffers of NWPS lands owned by BLM, FS, FWS, or NPS was calculated. For the purposes of this publication, water features and lands owned by the four Wilderness managing agencies are referred to as "protected." Because the amount of land is primarily a function of NWPS unit size, only percentages will be discussed. Within NWPS boundaries, the percentage of land that was not owned by the four Wilderness-managing federal agencies ranged from 0.00 percent to 51.37 percent. The median percentage of nonfederal land within NWPS boundaries was 0.34 percent and the average was 2.02 percent.

For a 0- to 0.5-mile buffer of NWPS lands, the average percentage of land per NWPS unit not protected by these four agencies was 20.02 percent. Percentage of nonprotected land varied from 0.00 percent to 98.88 percent with a median value of 12.33 percent. The average percentage of nonprotected land increased to 30.96 percent for the 0.5- to 3-mile buffer. Values for this buffer ranged from 0.00 percent to 100.00 percent nonprotected with a median value of 26.61 percent. In the 3- to 10-mile buffer of NWPS lands, the minimum percentage of nonprotected land is still 0.00 percent with a maximum of 100 percent. Average percentage of protected land in this buffer was 46.79 percent and the median was 47.90 percent.

A 10-mile buffer of individual NWPS boundaries allowed a picture of federal protection at the landscape level. Ranging from 0.00 percent to 96.44 percent unprotected, the percent of nonprotected land within a 10-mile buffer of NWPS lands averaged 35.97 percent and the median was 32.69 percent (Fig. 3). Only three Wilderness areas experience 100-percent protection of the land within 10 miles of their borders: Farallon Wilderness in California, Isle Royale Wilderness in Michigan, and Jumbo Springs Wilderness in Nevada. Of these, Farallon and Isle Royale are completely surrounded by water so the protection is a function of removal from the mainland, not federal land ownership.

Preliminary calculations for each parameter identified 10 NWPS Wilderness areas where less than 10 percent of the land is protected by any of the four Wilderness managing agencies at a distance of 10 miles from the border (Table 1). In these cases, the Wilderness areas are essentially islands of BLM, FS, FWS, or NPS land within a nonfederally owned landscape. Hypothetically, development can occur right up to the edges of these NWPS units.

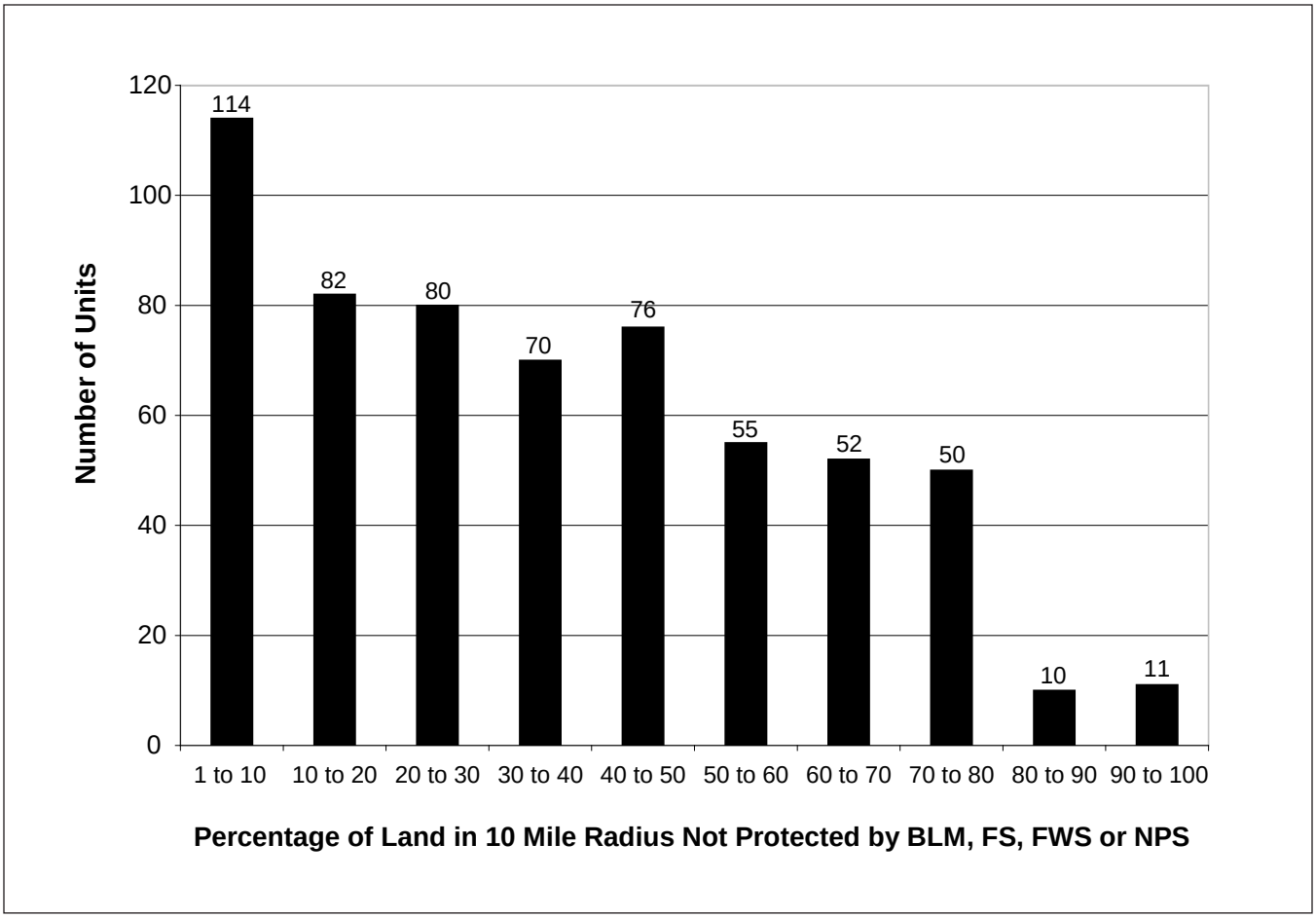

Figure 3.—Number of National Wilderness Preservation System units by percent of land within 10-mile buffer not protected by the four Wilderness managing agencies.

Table 1.—National Wilderness Preservation System lands experiencing the greatest percentage of lands not owned by the four wilderness managing agencies within 10 miles of their border

NWPS Unit	Management Agency	State	Percent of Nonfederal Land
Great Swamp National Wildlife Refuge Wilderness	FWS	NJ	96.44
Coyote Mountains Wilderness	BLM	AZ	96.16
Chase Lake Wilderness	FWS	ND	95.39
Big Lake Wilderness	FWS	AR	95.28
Fort Niobra Wilderness	FWS	NE	93.85
Birkhead Mountains Wilderness	FS	NC	93.80
McCormick Wilderness	FS	MI	93.32
Congaree National Park Wilderness	NPS	SC	93.25
Pinnacles Wilderness	NPS	CA	92.17
Lostwood Wilderness	FWS	ND	90.43

4.0 DISCUSSION AND CONCLUSIONS

Although the majority of NWPS units experience less than 50-percent nonprotected land within 10 miles of their border, those with large reserves of private land may experience housing density increases as Americans search for natural areas to build second, vacation, and retirement homes. Identification of NWPS units with such stores of unprotected land is the first step in protecting areas where additional easements and acquisition may be necessary.

Future research will include creating an overall description of development pressures for each Wilderness area based on an ordinal system ranking each pixel in the landscape on the likelihood of development based on land ownership, distance to nearest road, distance to the nearest urban area, distance to a major city, and land cover change of neighboring pixels. A second tier of protection where housing density increase is unlikely includes land owned by the Tennessee Valley Authority or by the Department of Energy, tribal lands, and Protected Areas of Canada. Though residential development is prohibited on these lands, preservation of Wilderness characteristics is not expressly considered by these agencies and was not included in this report, but future research should include these data. Ideally, future research will include information on state parks and conservation easements as geographic data become readily available. An updated shapefile containing Wilderness areas designated since 2004 is also necessary to complete an up-to-date analysis. Additionally, current GIS data for Alaska, Hawaii, and United States territories is at too coarse a resolution for this particular research goal; thus this study focuses only on the continental United States.

5.0 ACKNOWLEGMENTS

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