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Assessing national park resource condition along an urban–rural gradient in and around Washington, DC, USA

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ABSTRACT

Managing parks within an urban and urbanizing landscape context is the new normal for the U.S. National Park Service (NPS). The NPS Inventory and Monitoring (I&M) program is tasked with collecting data on the natural resource condition of all 270 parks in the NPS system deemed to have significant natural resources. Synthesizing this large amount of diverse data into comprehensive assessments of ecosystem integrity has proven to be a daunting task. We provide an analysis of NPS I&M data for ten national parks located along an urban–rural gradient from Washington, DC to the Blue Ridge Mountains in the Mid-Atlantic, USA. Twelve representative metrics of ecosystem condition were selected and combined into single park scores using four separate approaches for data aggregation. The different analysis methods were compared based on criteria including the ability to differentiate among parks, sensitivity to uncertainty in assessment points, ability to use varied data sources, and information content for management. The results support the use of relatively simple methods such as distance-based aggregation scoring for long-term assessment of lands in this mixed-used landscape. Land use change within 5-km buffers adjacent to the parks was significantly correlated with overall scores and was a strong predictor of water quality measures. Urban parks generally scored slightly lower than parks located in more rural settings. However, the distance-based method penalized the urban parks less than other scoring approaches for several small problems, and urban parks scored fairly well by this recommended method. Trends in regional land use change should be carefully monitored, but at present, most of the parks along this urban–rural gradient are successfully fulfilling their mission of sustaining natural resources at a high level of ecological integrity.

1. Introduction

Protected lands in urban settings safeguard a diverse mix of cultural and natural resources. They are typically small in size relative to many ecological processes and are embedded within complex mosaics of forest, field, residential, and industrial development patches (Forsyth and Musacchio, 2005). Yet, these urban green spaces are considered highly important in maintaining a comprehensive biodiversity conservation strategy (Rudd et al., 2002; Tallamy, 2009).

The theoretical importance of land-use context has been well documented (e.g., Pringle, 2000; Hansen and Defries, 2007), and understanding the larger cultural and natural landscape surrounding parks is an emerging priority in protected areas management (Colwell et al., 2012). Improved quantification of the influence of land-use context relative to other natural resource stressors is needed. Air, water, and highly mobile species are typically unaffected by parcel boundaries and often move at scales much larger than urban parks. Disturbed lands adjacent to forests often have a carry-over effect that may reduce the quality of forested systems despite the forest itself not being altered. For example, non-native, invasive plants (Zuefle et al., 2008) and brood parasites such as the brown headed cowbird (Brittingham and Temple, 1983) may reduce the quality of the native forest plants and animals. Similarly, the amount of disturbed lands in a watershed generally has a negative relationship with measures of aquatic fauna and overall stream condition (Utz et al., 2009, 2010). Thus, the condition of a protected area may be influenced by land uses both within and outside of the unit.

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With the exception of a few flagship parks, relatively little is known about the status of natural resources administered by the U.S. National Park Service (NPS), especially for parks located in an urban context. In recognition of the significant natural resources contained within national parks, the NPS established the Inventory and Monitoring (I&M) program in 2000 to provide a quantitative assessment of the composition, structure, and function of park ecosystems and to determine how well current management practices are sustaining those ecosystems (Kaiser, 2000; Fancy et al., 2009). Given this goal, the I&M program has been measuring dozens of different indicators, known as "vital signs", of ecological integrity across 270 parks. Synthesizing this large amount of diverse data into comprehensive assessments of overall environmental quality has proven to be a daunting task (Dennison et al., 2007; Carruthers et al., 2012).

Although several regional-scale assessments for aquatic resources exist (Roth et al., 1999; EPA, 2000; Stoddard et al., 2005; Hayslip et al., 2006), aggregating and scaling diverse metrics into an integrated, comprehensive assessment across a diverse array of terrestrial and aquatic systems (e.g., Jones et al., 1997) is less common. An overview of data integration methods for regional assessment is provided by Locantore and colleagues (2004). These include basic summary report cards (e.g., Harwell et al., 1999), distance-based weighting methods (e.g., Tran et al., 2006), and ordination and cluster analyses (e.g., Wickham et al., 1999). Selecting from among the analytic menu of integration methods represents a critical step in the monitoring process for large-scale ecosystem assessment programs (Longstaff et al., 2010).

Integrative, multimetric assessment is recognized as a pragmatic and useful method for determining which resource issues are most pressing to a study area (Kerans and Karr, 1994; He et al., 2000; Meyerson et al., 2005). However, the explicit analysis of the impact of contrasting aggregation methods on assessment outcomes is rarely conducted in a manner that is transparent to landscape managers and policy makers (but see Smith et al., 2006; Tran et al., 2007). In comparing among alternative procedures, a desirable method would include many of the following attributes: scores that are relatively simple to generate and interpret for a broad audience; the ability to differentiate among and prioritize sites for management purposes; outcomes that are not overly sensitive to any single parameter or data point; information for management on ways to improve overall condition; the capability to include data of varying spatial and temporal scale; and the flexibility to adapt to potential changes in the monitoring program.

We assessed ecological condition of ten national parks relative to their land-use context along an urban–rural gradient. The region of study has experienced some of the highest growth rates in the U.S. in recent years, with some counties increasing in population by 40% in the past decade (US Census Bureau, 2010). Forecasts of residential development and population structure suggest these trends will continue (Suarez-Rubio et al., 2012; Sexton et al., 2013). Given the rapidly changing landscapes around these parks, we set out to better understand the current conditions of the parks and how those conditions are influenced by land use at multiple scales. To accomplish these objectives, we first develop, compare, and evaluate four methods for standardized reporting of park ecosystem integrity.

2. Methods

2.1. Study area

Of the 270 parks included in the NPS Inventory and Monitoring Program, we identified 50 as being within 20 km of a population center of greater than 50,000 people. The highest density of these parks is found with the National Capital Region Network (NCRN) located in and around Washington, DC. The NCRN covers 11 parks in the District of Columbia, Maryland, Virginia and West Virginia (the full names of parks along with the four-letter abbreviations used throughout the rest of this paper are provided in Fig. 1). Parks in this network have been established to preserve a variety of cultural and natural resource values including civil war battlegrounds, mountain landscapes surrounding a U.S. Presidential retreat, and one of the first federally managed urban forests. In all cases, the dominant natural vegetation type is eastern mixed/deciduous forest. Surrounding land uses range from predominantly developed to forests and agricultural fields and row crops.

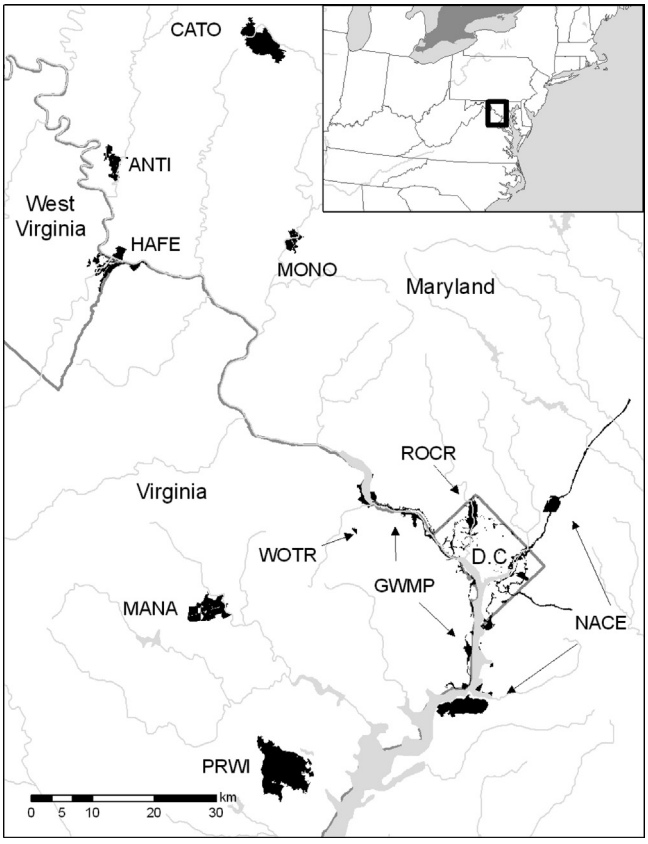

Fig. 1. Map of the National Capital Region Parks in and around Washington DC, USA. Park abbreviations are as follows: ANTI—Antietam National Battlefield, CATO—Catoctin Mountain Park, GWMP—George Washington Memorial Parkway, HAFE—Harpers Ferry National Historical Park, MANA—Manassas National Battlefield Park, MONO—Monocacy National Battlefield, NACE—National Capital Parks East, PRWI—Prince William Forest Park, ROCR—Rock Creek Park, WOTR—Wolf Trap Park for the Performing Arts.

All National Parks are subject to the Organic Act of 1916 requiring conservation of natural resources, unimpaired, for the enjoyment of future generations. In their recent report on the future of natural resource stewardship in the parks, the Scientific Committee of the NPS Advisory Board emphasized the change in character of the National Park System as it has acquired significant numbers of new cultural and urban resources (Colwell et al., 2012). Preserving ecological integrity on these new landscapes will be a primary goal of the next century. The parks of the NCRN have all been explicitly recognized for their high-value natural resources through their incorporation into the Inventory and Monitoring Program.

Monitoring of NCRN vital signs began in 2006 and is ongoing. The analyses in this paper use available data for each of three key aspects of the parks' natural resources: forest vegetation, stream quality, and landscape pattern. These aspects represent a subset of all NCRN monitoring, and not all monitoring relating to these