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Valuation of ecosystem services to inform management of multiple-use landscapes

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ABSTRACT

Public agencies worldwide are increasingly adopting an ecosystem service framework to manage lands serving multiple uses. Yet, reliable, practical, and well-tailored methods remain a major limitation in moving from conceptual to actionable approaches. Together with one of the largest federal land managing agencies, we co-develop and co-demonstrate an ecosystem services approach tailored to specific decisions, through a process with potentially widespread relevance. With the U.S. Department of Defense (DoD), we focus on balancing military training with biodiversity and resource conservation under both budgetary and land-use pressures at a representative installation. In an iterative process of co-design and application, we define, map, and quantify multiple ecosystem services under realistic management options. Resource management budget emerges as a major determinant of the degree to which managers can sustain both necessary training environments – a DoD-specific ecosystem service – and a prairie ecosystem with species of conservation concern. We also found clear tradeoffs between training intensity and forest-related services. Our co-developed approach brings otherwise hidden values and tradeoffs to the fore in a balanced way that can help public agencies safeguard priority services under potentially conflicting uses and budget limitations.

1. Introduction

Ecosystems provide a variety of benefits that sustain and fulfill human life (MA, 2005), most commonly through lands serving multiple uses. Public agencies, many with mandates to support diverse objectives, are increasingly adopting an ecosystem service framework to provide a consistent basis for assessing and sustaining the multiple values of lands (USEPA, 2009, Bateman et al. 2013, Ruckelshaus et al. 2013, Scarlett and Boyd. 2013, Palomo et al. 2014). The Chinese government, for example, is implementing a national ecosystem assessment, coupled with national land zoning and financial compensation, to achieve protection of priority ecosystem services (Liu et al. 2008, Daily et al. 2013, Zheng et al. 2013). Across Latin America, public-private watershed agreements are proliferating to channel investments into hydrologic and other desired services (Pagiola 2008, Goldman-Benner et al. 2012). In the United States, the Forest Service now requires incorporating ecosystem services in national forest management plans (USDA, Forest Service 2012), and the Bureau of Land Management has initiated ecosystem-service pilot studies (Bagstad et al. 2013); together these agencies manage ~177 million ha of U.S. land.

Despite growing application of ecosystem service tools (Polasky et al. 2011, Goldstein et al. 2012, Nemec and Raudsepp-Hearne 2013, Bhagabati et al. 2014, Villa et al. 2014), demonstrations of practical ecosystem services approaches – jointly developed with public agencies to address their resource management challenges and at appropriate scales – are still lacking. According to a recent review, approximately 40% ecosystem services studies involved stakeholders to some degree to help identify ecosystem services,

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evaluate management options, and assess impacts (Seppelt et al. 2011). The stakeholder process is predominantly viewed positively among researchers (Koschke et al. 2014) as it is useful to gather information and knowledge (Koschke et al. 2014), build understanding and consensus (McNie 2007, Reed et al. 2009), increase legitimacy of analysis (Cowling et al. 2008), and promote acceptance of implementation (Menzel and Teng 2010, Cowling et al. 2008). Because of the time and financial cost, as well as institutional constraints in public land management (Menzel and Teng 2010, Koschke et al. 2014), ecosystem services approaches developed with public agencies in an interactive and iterative process are not common in practice.

To fill this gap, we illustrate an ecosystem services approach for managing multi-use landscapes through a case co-developed closely with one of the largest public land managing agencies–the U.S. Department of Defense (DoD) (Daily et al. 2015), which manages 12.1 million ha (over 1%) of U.S. lands. While dedicated to military training and testing, these lands also host well-preserved ecosystems and species of conservation importance. Sustaining these natural assets is a key objective for the DoD, as its natural resource policy embraces maintenance of biodiversity and ecosystem services (DoD, 2011). Pertinent examples of ecosystem services include provision of realistic training environments; support for rare ecosystems with species of conservation concern; smoke and noise mitigation by natural buffers; provision of timber, clean water, and renewable energy; nature-based recreation opportunities for soldiers and civilians; and carbon sequestration.

Here, we examine how alternative management options for the intensity and siting of activities on DoD installations may balance potentially competing land uses for maintaining military mission and sustaining biodiversity and ecosystem services. To define, map, and value focal ecosystem benefits under each alternative, we demonstrate a practical, spatially explicit, and scenario-based approach using the Integrated Valuation of Environmental Services and Tradeoffs (InVEST) software. Working with DoD collaborators, we addressed three policy-related questions of broad relevance across agencies and regions globally:

1. How could future land-use intensity and budget variations affect ecosystem service provision?
2. How might spatial assessment of ecosystem services improve natural resources management in different areas?
3. Is it possible to enhance multiple ecosystem services efficiently, considering their tradeoffs and synergies?

2. Co-development and application process

2.1. Study area

We selected Joint Base Lewis-McChord (JBLM), a 37,000-ha joint Army/Air Force installation located in Washington, USA, as our demonstration site because of its active roles in both military training and natural resource conservation. JBLM is located within the South Puget Sound Landscape, historically a mosaic of grasslands, oak and conifer savannas, and wetlands. The landscape has transformed dramatically since European settlement, due to fire suppression, species invasions, and land conversion (Chappell and Crawford 1997).

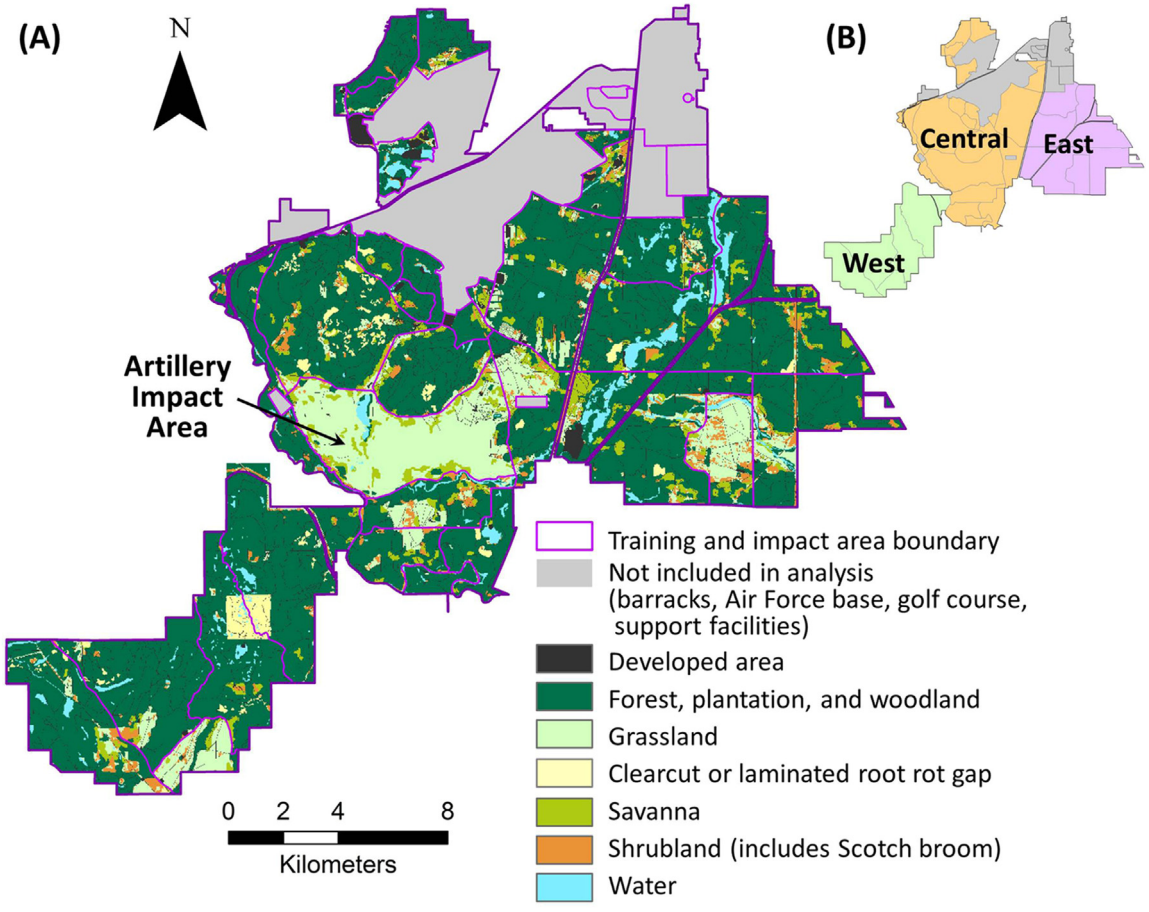

Fig. 1. (A) Land Use / Land Cover map for Joint Base Lewis-McChord (JBLM), western Washington State, USA, derived from 2007 to 2010 vegetation mapping and remotely sensed imagery; (B) Three ecological management regions for JBLM.