Global Ecology and Conservation 9 (2017) 142–147

Contents lists available at ScienceDirect

Global Ecology and Conservation

journal homepage: www.elsevier.com/locate/gecco

Short communication

Quantifying the relative contribution of an ecological reserve to conservation objectives

Kevin Aagaard [a,*], James E. Lyons [b], Wayne E. Thogmartin [a]

[a] *U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, WI 54603, USA*
[b] *U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, MD 20708, USA*

ARTICLE INFO

Article history:
Received 27 October 2016
Received in revised form 5 January 2017
Accepted 5 January 2017
Available online 18 January 2017

Keywords:
Conservation valuation
Integrated waterbird management and monitoring
Populations
Waterbirds

ABSTRACT

Evaluating the role public lands play in meeting conservation goals is an essential step in good governance. We present a tool for comparing the regional contribution of each of a suite of wildlife management units to conservation goals. We use weighted summation (*simple additive weighting*) to compute a Unit Contribution Index (*UCI*) based on species richness, population abundance, and a conservation score based on IUCN Red List classified threat levels. We evaluate *UCI* for a subset of the 729 participating wetlands of the Integrated Waterbird Management and Monitoring (IWMM) Program across U.S. Fish and Wildlife Service Regions 3 (Midwest USA), 4 (Southeast USA), and 5 (Northeast USA). We found that the median across-Region *UCI* for Region 5 was greater than Regions 3 and 4, while Region 4 had the greatest within-Region *UCI* median. This index is a powerful tool for wildlife managers to evaluate the performance of units within the conservation estate.

1. Introduction

If one area of ecological conservation or preservation (e.g., a reserve) covers a large expanse and supports a wide variety of unique species, is it inherently more valuable than another reserve of smaller area that supports a fraction of the number of unique species? In terms of abundance of individuals and biodiversity provided, the larger reserve would likely be considered more valuable. Imagine, however, that the species supported at the larger reserve are all of low conservation concern and make use of many different habitats across the landscape. If the few species at the smaller reserve are each endangered and endemic to that reserve, then perhaps this smaller reserve is contributing a greater value than the large reserve in terms of helping to accomplish conservation objectives.

Valuation questions like these pervade ecological investigations (e.g., Pressey and Nicholls, 1989; Margules et al., 2002; Nicol et al., 2016) and are difficult to answer because of inherent subjectivity (Smith and Theberge, 1987). This subjectivity is critical, however (Millsap et al., 1990; Hunter et al., 1993). As long as the specific objectives and metrics of a study are clearly outlined, then other researchers and managers can replicate and change them as they deem necessary. This makes the subjectivity itself testable (Smith and Theberge, 1987; Hunter et al., 1993). Approaches to test subjectivity and quantify the value of landscape units to the networks they comprise have proliferated; for instance, using heterogeneity of habitat types offered by a unit (e.g., Willis et al., 2012), the biodiversity a unit supports (e.g., Humphries et al., 1995; Margules et al., 2002), ecosystem functionality (e.g., nutrient cycling, population dynamics) (e.g., Egoh et al., 2007; Nelson et al., 2009), or a monetary estimate of the services provided by a unit (e.g., ecosystem services, recreation/hunting, materials and

* Correspondence to: 2630 Fanta Reed Road, La Crosse, WI 54603, USA.
E-mail addresses: kaagaard@usgs.gov (K. Aagaard), jelyons@usgs.gov (J.E. Lyons), wthogmartin@usgs.gov (W.E. Thogmartin).

http://dx.doi.org/10.1016/j.gecco.2017.01.002

resources) (Ricketts et al., 2004; Bottrill and Pressey, 2012). The approach selected can vary depending on the focus of the entity conducting the study, data availability, or conservation needs of an area (Nicol et al., 2016).

There are two principal objectives in conservation valuation. The first is to optimize reserve design, usually with the aim of conserving a given species (Pressey and Nicholls, 1989; Csuti et al., 1997; Thogmartin et al., 2014) or maximizing biodiversity (Humphries et al., 1995; Margules et al., 2002). Optimizing reserve design means valuing an area intrinsically using criteria like regional/global rarity of local habitat types, habitat diversity, size and extent of the area, vulnerability to human modification, and other criteria such as "naturalness" (Margules and Usher, 1981). This objective seeks to measure the properties of the area and extrapolate an expected conservation contribution from these properties, ultimately selecting the best areas to serve as a reserve network. In this case, the condition of an area (in terms of the criteria mentioned above) acts as a baseline against which expectations are measured. The second principal objective takes the inverse perspective; what is the value of a given area *relative to all other areas in the relevant conservation region*. This objective preserves some intrinsic properties (size, extent), but trades others (rarity, vulnerability) for emergent ecological properties (biodiversity supported, total abundance of individuals; Turpie, 1995). In this case, the individual contribution by a given area to the larger region is compared to the contribution to the larger region by all other areas. Rather than creating an optimal reserve design, this perspective seeks to identify how to optimize resource allocation to an already existing reserve network to improve performance of flagging areas while maintaining performance of high-quality areas (Smith and Theberge, 1987). In essence, the first perspective is a forecast and the second perspective offers a snapshot in time.

Our goal matches the second perspective, to take a snapshot in time of an actively surveyed reserve network of wetlands used by migratory waterbirds (waterfowl, shorebirds, wading birds). Migratory waterbird habitat has received significant management focus, largely attributable to the role of waterbirds in recreational harvest (Raftovich and Wilkins, 2013). The scope of waterbird migration across North America highlights the importance of establishing a framework to identify areas that most positively contribute to waterbird conservation to inform management decisions aimed at allocating scarce resources. Of course, waterbird migration is not bounded by political borders, so while we demonstrate the functionality of the valuation framework we describe below by using data from a North American monitoring program, our framework is easily applied to any area included in the global movement of waterbird populations with sufficient data.

We formulate a metric to quantify the contribution of each unit participating in the Integrated Waterbird Management and Monitoring (IWMM) Program to the migratory waterbird conservation efforts of the US Fish and Wildlife Service's (USFWS) Midwest, Southeast, and Northeast Regions (Regions 3, 4, and 5, respectively; see Fig. 1). Because our focus is on conservation, we will adopt a framework in which "value" and "contributions" are in terms of biodiversity and species status (e.g., threatened, endangered, not listed, etc.). Additionally, given the data available, we are interested in formulating a metric that relates unit contributions to waterbird conservation for use by unit managers. This focus is germane to the conservation needs of the IWMM, wetland managers, and the USFWS in general—which has identified waterbirds as a focal guild in part because of their large economic and ecological influence in the area of interest (Eastern USA). The method we employ is known as *weighted summation* or *simple additive weighting* in the multi-criteria evaluation literature and is becoming increasingly used in conservation decision making (Margules and Usher, 1981; Smith and Theberge, 1987; Ananda and Herath, 2009; Nelson et al., 2009).

2. Methods

The IWMM is collaborative, involving multiple government and non-government agencies seeking to identify optimal conservation and management actions across a large spatial scale to provide sufficient habitat for migratory waterbirds during the non-breeding period of their annual cycles. The IWMM provides tools to aid with decision support for management officials. The core of the program is its large-scale monitoring program which includes bird and vegetation surveys with a rigorous protocol aimed at standardizing the observation process across regions. Additionally, there are now well-vetted and robust techniques for IWMM data-handling (Link et al., 2008; Aagaard et al., 2015, submitted for publication). This has provided us with a quality dataset and a rigorous methodology for accounting for variable effort and multiple sources of error that no amount of protocol standardization can eliminate.

The IWMM has established 165 survey sites comprised of 729 wetlands (henceforth, "units") in USFWS Regions 3, 4, and 5, each under a unique management authority participating in frequent and recurring waterbird management actions. The 694 units included in this study (inclusion criteria explained below) have a mean area (±s.d.) of 101.17 ha (±310.72), with a range of 0.26–5015.71 ha. Over 166,000 observations were collected during the pilot phase of the IWMM between 25 January 2010 and 11 July 2014.

We evaluated USFWS focal guilds (waterfowl, shorebirds, wading birds) during the non-breeding period (i.e., excluding June) in USFWS Regions 3, 4, and 5. We removed observations with start times before 05:00 and after 19:00, as these were assumed to be data entry errors. We also excluded units with only one observation or only one species recorded, as these units either precluded bird-use-day calculations (which require multiple samples, see below), or produced superfluous biodiversity metrics. This resulted in a dataset with 131,412 observations. In total, we used data from 21,309 bird surveys and 3747 vegetation surveys.

Because units differ in size, and surveys differ in the date and location in which they occurred, we corrected the data for various sources of potential error. The corrected-counts were converted to a more meaningful management value, bird-use-days. For the error correction we employed the modeling framework proposed by Link et al. (2008) in which variation in