Landscape and Urban Planning 136 (2015) 13–27

Contents lists available at ScienceDirect

Landscape and Urban Planning

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

Perspective essay

A simple landscape design framework for biodiversity conservation

Sara A. Gagné[a,*], Felix Eigenbrod[b], Daniel G. Bert[c], Glenn M. Cunnington[c], Leif T. Olson[d], Adam C. Smith[e], Lenore Fahrig[c]

[a] Department of Geography and Earth Sciences, University of North Carolina at Charlotte, 9201 University City Blvd., Charlotte, NC 28223, USA
[b] University of Southampton, Southampton, United Kingdom
[c] Carleton University, Ottawa, ON, Canada
[d] O2 Planning + Design, Calgary, AB, Canada
[e] Canadian Wildlife Service, Ottawa, ON, Canada

HIGHLIGHTS

- We propose a simple, flexible framework that uses only readily-available data.
- Our framework is more practical and feasible than existing guidelines.
- Such a framework is needed to keep pace with very rapid global land cover change.

ARTICLE INFO

Article history:
Received 6 October 2013
Received in revised form 4 November 2014
Accepted 11 November 2014
Available online 11 December 2014

Keywords:
Human-dominated landscapes
Land use and land cover change
Landscape ecology
Land use planning
Conservation planning
Integrated landscape management

ABSTRACT

Local government planning agencies play an important role in conserving biodiversity in human-altered landscapes. Such agencies frequently have a limited knowledge of wildlife biology and few resources to carry out research, and therefore require simple, practical guidelines for biodiversity conservation. We propose a landscape design framework for biodiversity conservation that is sequential, prescriptive, and supported by current landscape ecological science. Unlike existing guidelines, our framework can be implemented in any given landscape using only land cover data and it explicitly considers constraints on land use planning. The steps of our framework, in the order in which they should be implemented are: (1) select land cover data and decide which land cover classes constitute unaltered or altered land covers; (2) list the constraints on land use planning (e.g., economic, social) that exist for the landscape; (3) maximize the total amount and diversity of unaltered land cover, especially near water; (4) minimize human disturbance within altered land cover, especially near water; and (5) aggregate altered land covers associated with high-intensity land uses, especially away from water. We illustrate the utility of our approach by applying it to a hypothetical landscape and comparing the outcome to those from the application of traditional ecological guidelines to inform land use planning.

1. Introduction

Land cover change has been the most important direct driver of global terrestrial biodiversity loss in the last 60 years, and is projected to have an increasing impact in most ecosystems (Millennium Ecosystem Assessment, 2005). In addition to an enormous amount of primary research on this subject (e.g., Fahrig, 2003; Fahrig & Rytwinski, 2009; McKinney, 2008; Tscharntke, Klein, Kruess, Steffan-Dewenter, & Thies, 2005), there is a growing literature that attempts to translate our understanding of the effects of land cover change on biodiversity into principles, guidelines, and recommendations to inform land use planning (hereafter, ecological guidelines) (Table 1).

Despite the proliferation of ecological guidelines and the recognition that local planning agencies can make a significant contribution to biodiversity conservation (Ahern, Leduc, & York, 2006; Forman, 2002; Miller et al., 2009), there has been little on-the-ground change in how we plan for use of the land (Ahern, 2013; Berke, 2007; Nassauer & Opdam, 2008; Stein, 2007). Landscape ecological knowledge is not being widely used in landscape decision-making (Ahern, 2013; Nassauer & Opdam, 2008) and

* Corresponding author. Tel.: +1 704 687 5911.
E-mail addresses: sgagne@uncc.edu (S.A. Gagné), F.Eigenbrod@soton.ac.uk (F. Eigenbrod), dan.bert@glel.carleton.ca (D.G. Bert), glenn.cunnington@gmail.com (G.M. Cunnington), leif.olson@gmail.com (L.T. Olson), adam.smith@ec.gc.ca (A.C. Smith), lenore_fahrig@carleton.ca (L. Fahrig).

http://dx.doi.org/10.1016/j.landurbplan.2014.11.006
0169-2046/

Table 1
A selection of ecological principles, guidelines or recommendations for land use planning. Checkmarks indicate that one or more items in each source requires species-specific information, is not prescriptive, does not consider socioeconomic constraints, or the presentation of items is not sequential. N/A = not applicable.

Source	Species-specific information required	Not prescriptive	Number of items	Not sequential	Does not consider socioeconomic constraints
Soulé (1991)	√	√	5	√	√
Dramstad, Olson, and Forman (1996)	√	√	55	√	√
Duerksen et al. (1997)	√	√	19	√	√
Bennett (1999)	√	√	5	√	√
Dale et al. (2000)	√	√	8	√	√
Zipperer, Wu, Pouyat, and Pickett (2000)		√	6	√	√
Forman (2002)	√	√	7	√	√
Pulliam and Johnson (2002)		√	4	√	√
Environmental Law Institute (2003)	√	√	16	√	√
Environment Canada (2004)	√	√	18	√	√
Li, Wang, Paulussen, and Liu (2005)	√	√	21	√	√
Fischer, Lindenmayer, and Manning (2006)	√		10	√	√
Lindenmayer et al. (2006)	√	√	31	√	√
Colding (2007)			1	N/A	√
Noss (2007)	√	√	7	√	√
Forman (2008)	√	√	121	√	√
Lindenmayer et al. (2008)	√	√	13	√	
Opdam and Steingröver (2008)	√	√	10	√	√
Lovell and Johnston (2009)	√	√	6		√
Stagoll, Manning, Knight, Fischer, and Lindenmayer (2010)	√	√	16	√	√
Sayer et al. (2013)	√	√	10	√	
The present framework			5		

more broadly, land use planners generally do not incorporate science-based information into plans (Berke, 2007; Stein, 2007). For example, less than five percent of staff time is devoted to biodiversity conservation in the municipalities of three large metropolitan regions in the US (Miller et al., 2009).

Based on a review of ecological guidelines (Table 1), we argue that they are not considered in land use planning because they exhibit one or more characteristics that limit their practicality and feasibility. First, most guidelines require species-specific information, which limits their utility since such information at the spatial scales required for planning is scarce for the majority of species and costly and time-consuming to collect (Ahern et al., 2006; Pullin, Knight, Stone, & Charman, 2004). To exacerbate this, insufficient resources are allocated to the collection of biodiversity data in most planning offices (Ahern et al., 2006; Miller et al., 2009). Second, most ecological guidelines are not prescriptive, in the sense that they do not provide specific, actionable instruction. The majority of planning offices in the US lack the ecological expertise to interpret broad guidelines for their particular context (Beatley, 2000; Stein, 2007), making it difficult for planners to translate general principles into specific planning actions (Theobald et al., 2000). Third, guidelines may include dozens of items, belying planners' need for simple, succinct, and integrative rules (Azzerad & Nilon, 2006). Fourth, with one exception, none of the guidelines we reviewed present their suggestions in a sequential manner (Table 1). This is an impediment to use by planners because of the possibility of mutually-conflicting guidelines in a non-sequential list (which occurred in one-third of the guidelines that we reviewed). Finally, very few ecological guidelines incorporate socioeconomic constraints on biodiversity conservation. This is incompatible with the compromises required of planners to satisfy multiple, often competing objectives and reduces the likelihood of successful implementation of conservation initiatives (Ahern et al., 2006; McShane et al., 2011; Stein, 2007).

Here, we propose a simple landscape design framework intended to maximize native biodiversity, i.e., the "genes, individuals, demes, populations, metapopulations, species, communities, ecosystems, and the interactions between these entities" (Lindenmayer, Franklin, & Fischer, 2006), in a given planning area. Our framework, which is based on current landscape ecological science, is sequential and prescriptive, can be implemented in any given landscape using only GIS-based land cover data, and explicitly considers socioeconomic constraints on land use planning. In the following, we demonstrate that these characteristics make our framework more practical and feasible than existing approaches and consequently more likely to be used by planners.

2. The framework

Our framework is organized into five steps, ordered by the sequence in which they should be implemented:

1. Select land cover data and decide which land cover classes constitute unaltered or altered land covers.
2. List the constraints on land use planning (e.g., economic, social) that exist for the landscape; and, within the constraints identified in Step 2.
3. Maximize the total amount and diversity of unaltered land cover, especially near water.
4. Minimize human disturbance within altered land cover, especially near water; and
5. Aggregate altered land covers associated with high-intensity land uses, especially away from water.

2.1. Step 1: Select land cover data and decide which land cover classes constitute unaltered or altered land covers

The distinction between unaltered and altered land cover classes is central to our approach but we acknowledge that this binary classification is an extreme simplification of a diverse multidimensional reality. Since the goal of our framework is to maximize native biodiversity in a broad sense (see above), it is necessary to use a very broad categorization of cover types. The intent of the categorization is to distinguish between cover types that are associated with lower (unaltered) or higher (altered) intensities of human use and thus generally support or do not support native biodiversity, respectively. This binary definition will be subject to differences in interpretation among users of our framework. Indeed, the subjectivity of our categorization of cover types is necessary to allow our framework to be applied to a wide variety of