Forest Ecology and Management 258 (2009) 1025–1037

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Review

# The use of historical range and variability (HRV) in landscape management

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ARTICLE INFO

*Article history:*
Received 26 January 2009
Received in revised form 19 May 2009
Accepted 26 May 2009

*Keywords:*
Ecosystem management
Climate change
Land management
Landscape ecology
Historical ecology

ABSTRACT

This paper examines the past, present, and future use of the concept of historical range and variability (HRV) in land management. The history, central concepts, benefits, and limitations of HRV are presented along with a discussion on the value of HRV in a changing world with rapid climate warming, exotic species invasions, and increased land development. This paper is meant as a reference on the strengths and limitations of applying HRV in land management. Applications of the HRV concept have specific contexts, constraints, and conditions that are relevant to any application and are influential to the extent to which the concept is applied. These conditions notwithstanding, we suggest that the HRV concept offers an objective reference for many applications, and it still offers a comprehensive reference for the short-term and possible long-term management of our nation's landscapes until advances in technology and ecological research provide more suitable and viable approaches in theory and application.

Published by Elsevier B.V.

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0378-1127/$ – see front matter. Published by Elsevier B.V.
doi:10.1016/j.foreco.2009.05.035

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## 1. Introduction

The notion of managing ecosystems in a manner consistent with their native structure and processes was ushered into public land management during the 1990s as an alternative to the resource extraction emphasis that was historically employed by some government agencies (Christensen et al., 1996). This practice of ecosystem management demanded that the land be managed as a whole by considering all organisms, large and small, the pattern, abundance, and connectivity of their habitats, and the ecological processes that influence these organisms on the landscape (Bourgeron and Jensen, 1994; Crow and Gustafson, 1997). Terms like biodiversity, ecosystem integrity, and resiliency were used to describe the ultimate goal of ecosystem management – a healthy, sustainable ecosystem that could maintain its structure and organization through time (Whitford and deSoyza, 1999).

To effectively implement ecosystem management, managers required a reference or benchmark to represent the conditions that fully describe functional ecosystems (Cissel et al., 1994; Laughlin et al., 2004). Contemporary conditions could be evaluated against this reference to determine status and change, and also to design treatments that provide society with its sustainable and valuable resources while also returning declining ecosystems to a more natural or native condition (Hessburg et al., 1999b; Swetnam et al., 1999). It was also critical that these reference conditions had to represent the dynamic character of ecosystems as they vary over time and across landscapes (Swanson et al., 1994). Describing and quantifying ecological health is difficult because ecosystems are highly complex with immense biotic and disturbance variability and diverse processes interacting across multiple space and time scales from genes to species to landscapes, and from seconds to days and centuries. One of the central concerns with implementing ecosystem management was identifying appropriate reference conditions that could be used to describe ecosystem health, prioritize those areas in decline for possible treatment, and design feasible treatments for restoring their health (Aplet et al., 2000).

The relatively new concept of historical range and variability (HRV) was introduced in the 1990s to bring understanding of past spatial and temporal variability into ecosystem management (Cissel et al., 1994; Swanson et al., 1994). HRV provided land use planning and ecosystem management a critical spatial and temporal foundation to plan and implement possible treatments to improve ecosystem health and integrity (Landres et al., 1999). Why not let recent history be a yardstick to compare ecological status and change by assuming recent historical variation represents the broad envelope of conditions that supports landscape resilience and its self-organizing capacity (Harrod et al., 1999; Hessburg et al., 1999b; Swetnam et al., 1999). Managers initially used "target" conditions developed from historical evidence to craft treatment prescriptions and prioritize areas. However, these target conditions tended to be subjective and somewhat arbitrary because they represented only one possible condition from a wide range of conditions that could be created from historical vegetation development and disturbance processes (Keane et al., 2002b). This single objective, target-based approach was then supplanted by a more comprehensive theory of HRV that is based on the full variation and range of conditions occurring across multiple scales of time and space scales, along with a plethora of descriptive ecosystem elements, to protect and conserve wildland landscapes. While easily understood, the concept of HRV can be quite difficult to implement due to scale, data, and analysis limitations (Wong and Iverson, 2004).

This paper examines the past, present, and future use of HRV in land management. We first present the central concepts and history of HRV. We then detail the key benefits and limitations of the use of the HRV concept in land management. Last, we speculate on the value of HRV in a world with rapid climate warming, exotic species invasions, and expanding land development. While the HRV concept can be used to describe any set of ecosystem or landscape characteristics, this paper will focus on the use of HRV to describe *landscape composition* (e.g., vegetation types or structural stages) and *structure* (e.g., patch characteristics, landscape pattern) in land management activities. This paper is meant as a reference or guide for managers on the pitfalls and advantages of using HRV in supporting future planning activities. While HRV has problems, we feel it offers an objective and comprehensive reference for the short- and long-term management of public landscapes, at least until advances in technology and ecological understanding provide suitable alternatives.

### 1.1. Background

The idea of using historical conditions as reference for land management has been around for some time (Egan and Howell, 2001). In the last two decades, planners have been using target stand and landscape conditions that resemble historical analogs to guide landscape management, and research has provided various examples (Christensen et al., 1996; Fule et al., 1997; Harrod et al., 1999; Brown and Cook, 2006). However, the inclusion of temporal variability of ecosystem elements and processes into land management has only recently been proposed. In a special issue of Ecological Applications, Landres et al. (1999) presented some of the theoretical underpinnings behind HRV. Reviews and other background material on HRV and associated terminology can also be found in Kaufmann et al. (1994), Morgan et al. (1994), Swanson et al. (1994), Foster et al. (1996), Millar (1997), Aplet and Keeton (1999), Hessburg et al. (1999a), Hessburg et al. (1999b), Egan and Howell (2001), Veblen (2003) and Perera et al. (2004). The major advancement of HRV over the historical target approach is that the full range of ecological characteristics per se is a critical criterion in the evaluation and management of ecosystems (Swanson et al., 1994). It is this variability that ensures continued health, self-organization, and resilience of ecosystems and landscapes across spatio-temporal scales (Holling, 1992). Understanding the causes and consequences of this variability is key to managing landscapes that sustain ecosystems and the services they offer to society.

The theory behind HRV is that the broad historical envelope of possible ecosystem conditions, such as burned area, vegetation cover type area, or patch size distribution, provides a representative time series of reference conditions to guide land management (Aplet and Keeton, 1999) (see Fig. 1a as an example). This theory assumes the following: (1) ecosystems are dynamic, not static, and their responses to changing processes are represented by past variability (Veblen, 2003); (2) ecosystems are complex and have a range of conditions within which they are self-sustaining, and beyond this range they transition to disequilibrium (Egan and Howell, 2001; Wu et al., 2006); (3) historical conditions can serve as a proxy for ecosystem health (Swetnam et al., 1999); (4) time and space domains of HRV are sufficient to quantify variation (Turner et al., 1993); and (5) the ecological characteristics being assessed for the ecosystem or landscapes match the management objective (Keane et al., 2002b). In this paper, we refer to HRV as the variation of historical ecosystem characteristics and processes over time and space scales that are appropriate for the management application.

Any quantification of HRV requires an explicit specification of the spatial and temporal context. The spatial context is needed to ensure that the variation of the selected ecological attribute is described across the most appropriate area relative to the spatial dynamics of the ecosystem or landscape. The variability of the area occupied by a vegetation type over time, for example, generally decreases as the spatial context increases until it reaches an

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