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A Hierarchical Perspective to Woody Plant Encroachment for Conservation of Prairie-Chickens

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ABSTRACT

Encroachment of Great Plains grasslands by fire-sensitive woody plants is a large-scale, regional process that fragments grassland landscapes. Using prairie grouse (*Tympanuchus* spp.) of conservation concern, we apply hierarchy theory to demonstrate how regional processes constrain lower-level processes and reduce the success of local management. For example, fire and grazing management may be locally important to conservation, but the application of fire and grazing disturbances rarely cause irreversible fragmentation of grasslands in the Great Plains. These disturbance processes cause short-term alterations in vegetation conditions that can be positive or negative, but from a long-term perspective fire maintains large tracts of continuous rangelands by limiting woody plant encroachment. Conservation efforts for prairie grouse should be focused on landscape processes that contribute to landscape fragmentation, such as increased dominance of trees or conversion to other land uses. In fact, reliance on local management (e.g., maintaining vegetation structure) to alter prairie grouse vital rates is less important to grouse population persistence given contemporary landscape level changes. Changing grass height, litter depth, or increasing the cover of forbs may impact a few remaining prairie-chickens, but it will not create useable space at a scale relevant to the historic conditions that existed before land conversion and fire suppression.

Introduction

Many factors contribute to the fragmentation of rangelands, which is a primary cause of population declines in species endemic to these landscapes (Herkert 1994; Helzer and Jelinski 1999). Fragmentation describes the active conversion or separation of large tracts of a vegetation type or state into small isolated fragments that may have limited value for certain species (Pietz et al. 2009). Separation of habitat into smaller, more isolated units can lead to local extinction or regional declines because of limited dispersal among habitat patches (Herkert 1994). For populations of species such as grouse that rely on expansive landscapes, fragmentation can have dire consequences. Population declines of Lesser Prairie-Chicken *(Tympanuchus pallidicinctus)* and Greater Prairie-Chicken *(Tympanuchus cupido)* have been attributed to fragmentation from alteration of disturbance regimes (primarily fire) and the associated woody plant encroachment (Merrill et al. 1999; Wu et al. 2001; Fuhlendorf et al. 2002a; McNew et al. 2012).

One of the major challenges for conservation efforts of a myriad of species occurring on public and private lands is that the conditions that are critical for the support and restoration of a population often occur at many spatial scales that may or may not correspond to management scales (Wiens 1989; Fuhlendorf and Smeins 1996). For example, many grouse species have specific life history requirements that are proximally required and variable for different activities such as nesting, brood rearing, lekking, or roosting (Fig. 1). This local heterogeneity may be critical to maintain populations, but from a broader spatial and temporal perspective, large suitable landscapes that are connected to other populations may be more important for species persistence (Fuhlendorf et al. 2002a; Johnson et al. 2003). In fact, the size of the landscapes necessary for even a given population to persist often can exceed parcel size, making local management largely irrelevant if the landscape matrix is not suitable for the species of concern. Further, conservation practices at the more local scale (e.g., for a given parcel or landholding) can be quite different from those focused on broader scales and either population or species persistence. For example, local conservation practices may focus on conditions related to successful nesting or brood rearing while broader scale perspectives may focus on landscape composition and pattern that prioritize connectivity between local populations. While reproduction and survival at the local scale are obviously necessary for population persistence, they are inherently constrained by higher-order processes and are therefore a secondary concern to landscape-scale conservation efforts. As resources for conservation are always limited, it is critical that we prioritize conservation actions that

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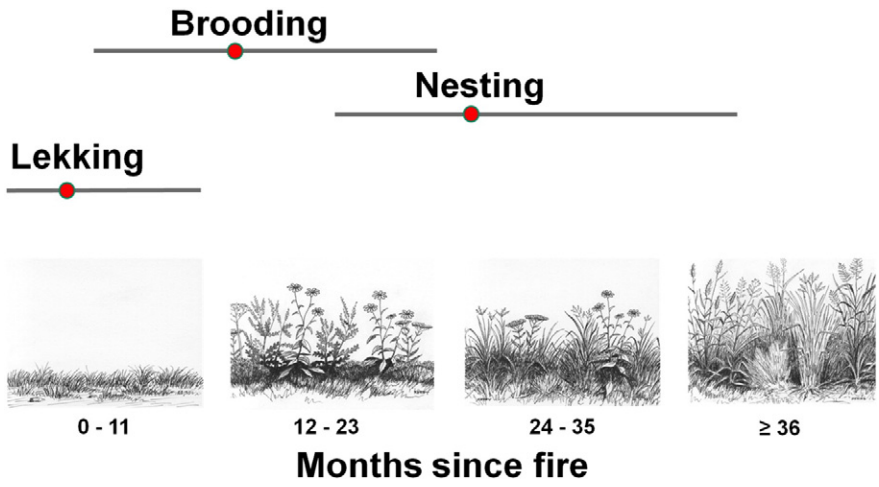

Figure 1. Median (red dot) and first and third quartile (lines) of sites selected by Greater Prairie-Chickens *(Tympanuchus cupido)* for lekking, nesting, and brood rearing, illustrating how different life history needs are met by various vegetation conditions. Data were collected at The Nature Conservancy's Tallgrass Prairie Preserve, OK, USA, 2010-2013. (Artwork courtesy of Gary Kirby.)

are most likely to be successful. It is the goal of this paper to provide a generalized framework to prioritize conservation from a landscape perspective for prairie grouse in the Great Plains.

How to Prioritize Conservation Practices on Rangelands

The range management discipline has focused traditionally on managing vegetation to sustain production of forage for the livestock industry (Holechek et al. 2004). Recently, an alternative approach that is based on conservation of pattern and processes on rangelands has been proposed (Fuhlendorf et al. 2012). This approach suggested the following principles: 1) maintain large continuous tracts of rangeland, 2) understand the importance of stocking rate while recognizing that no single rate is appropriate, 3) promote uneven distribution and understand heterogeneity, 4) promote shifting mosaics where disturbance patterns are variable in space and time, 5) recognize that all species are important to conservation, and 6) emphasize the importance of restoring disturbance regimes on large landscapes. In addition to the need for a new approach focused on conservation of rangelands, many other practices and actions on rangelands influence the ability of a landscape or region to support species of conservation concern.

A primary approach for prioritizing conservation is to use hierarchy theory, viewing habitat as a hierarchically nested organization of conditions and resources required by an organism, where all units are composed of subunits within larger subunits (Kolasa and Waltho 1998; Fuhlendorf et al. 2002a). This pattern results in a situation where broad-scale patterns constrain fine-scale processes and suggests that broad-scale conditions must be suitable before success (e.g., increased nest survival) can occur from finer-scale management actions. Through this framework, there is no justification for conducting local management if populations are constrained by higher-level fragmentation as the objectives will not be achievable until higher-order patterns and conditions are addressed relevant to the species of interest. Therefore, in fragmented landscapes, the major conservation focus should be on limiting additional fragmentation and attempting to identify the best places to reverse previous fragmentation. A first step in this process is to determine what constitutes fragmentation for the species of conservation concern.

When prioritizing factors that contribute to fragmentation, it would be most effective to first focus on factors that are at risk of crossing a threshold where reversal is unlikely (Fahrig 2001). This aims to limit additional and irreversible damage to landscapes and the species that require broad-scale continuity. For example, land cover/land use changes contribute to fragmentation, but if change is due to development from suburban conversion or cultivation, reversal of those changes is unlikely. Avoiding these kinds of nonreversible changes should be the initial goal of conservation, particularly when they occur at large spatial scales (Fig. 2). Once the landscape is largely converted, then the priority should be addressing the most at-risk and easily restored landscape elements that will provide the greatest connectivity. When landscape connectivity is maintained and large rangeland landscapes are intact, finer-scaled and reversible management focused on factors that influence proximal vegetation structure suitable for certain life history activities have a reasonable expectation of success (Fitzgerald and Tanner, 1992).

A hierarchical approach requires recognition of factors that alter conservation by constraining the success of local management. Broadly, we can categorize these into constraining and fine-scaled (proximal) management factors. The argument through hierarchy theory is that conservation should first focus on limiting constraining factors and then focus on the fine-scaled management. This process of classification

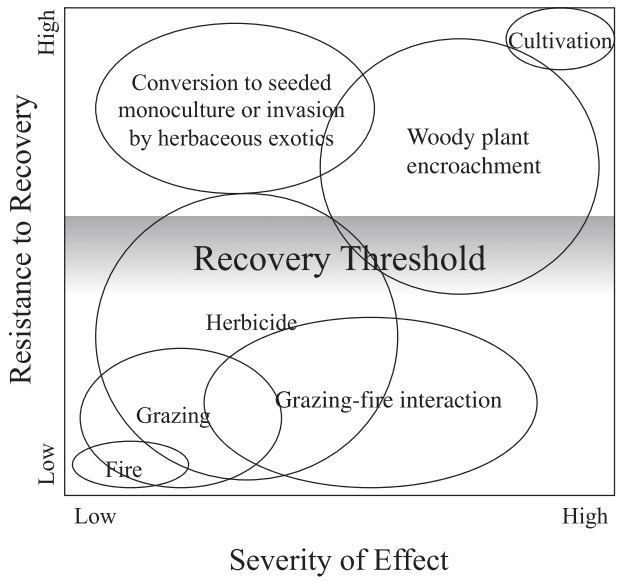

Figure 2. Descriptive matrix of categories of practices grouped by resistance to recovery and by severity of change. Size and shape of a sphere denote the relative severity of the change and influence of the disturbance practice on the resulting patch's resistance to recovery. The horizontal line marks a recovery threshold beyond which rangeland will not likely recover from the change. Rangelands subjected to change above the recovery threshold constrain the influence of local management practices.