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Assessing critical habitat: Evaluating the relative contribution of habitats to population persistence

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ABSTRACT

A principal challenge of species conservation is to identify the specific habitats that are essential for long-term persistence or recovery of imperiled species. However, many commonly used approaches to identify important habitats do not provide direct insight into the contribution of those habitats to population persistence. To assess how habitats contribute to overall population viability and characterize their relative importance, a spatially-explicit population viability model was used to integrate a species occurrence model with habitat quality and demographic information to simulate the population dynamics of the Ord's kangaroo rat (*Dipodomys ordii*) in Alberta, Canada. Long-term productivity (births–deaths) in each patch was simulated and iterative patch removal experiments were conducted to generate estimates of the relative contribution of habitat types to overall population viability. Our results indicated that natural dune habitats are crucial for population viability, while disturbed/human-created habitats make a minor contribution to population persistence. The results also suggest that the habitats currently available to Ord's kangaroo rats in Alberta are unlikely to support long-term persistence. Our approach was useful for identifying habitats that did not contribute to population viability. A large proportion of habitat (39%) represented sinks and their removal increased estimated population viability. The integration of population dynamics with habitat quality and occurrence data can be invaluable when assessing critical habitat, particularly in regions with variable habitat quality. Approaches that do not incorporate population dynamics may undermine conservation efforts by under- or over-estimating the value of habitats, erroneously protecting sink habitats, or failing to prioritize key source habitats.

1. Introduction

A principal challenge of species conservation is to identify the specific habitats that are essential for long-term persistence or recovery of endangered species. Habitat destruction as a result of loss, degradation, and fragmentation often increases the heterogeneity and complexity of landscapes, and complicates decisions as to which habitats should be protected or restored. Several approaches for identifying important habitats have been used, yet they often do not provide clear insight into the population viability consequences of protecting one habitat versus another.

Many studies have assessed habitat use by evaluating occurrence data or associating the presence/abundance of a species with local resources (e.g. Boyce et al., 2003; Carroll et al., 2001; Johnson et al., 2004). However, there are several limitations of using species occurrence data and associated models for identifying essential habitats. Such approaches often assume that short-term data represent the typical state of the population, which may be inappropriate particularly if populations cycle or fluctuate stochastically through time (Armstrong, 2005; Garshelis, 2000). Patterns of occurrence, particularly abundance, may also be misleading indicators of local habitat productivity (Garshelis, 2000) and habitat quality (Battin, 2004; Van Horne, 1983). Aldridge and Boyce (2007) caution of a potential situation where habitat models identify high levels of species occurrence within sink habitats, wherein mortality exceeds survival and/or reproductive rates (Pulliam, 1988). In such cases, high species occurrence is sometimes interpreted to mean 'important' habitat for the species, yet these habitats may not contribute to population persistence or may even jeopardize long-term population viability.

The integration of population data, such as site-specific mortality or reproduction rates with occurrence models, provides a means of assessing relative habitat quality and refining habitat

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conservation priorities (e.g. Aldridge and Boyce, 2007; Falcucci et al., 2009; Nielsen et al., 2006). Yet such approaches cannot directly link local habitat attributes or population performance with regional population viability and therefore do not necessarily identify habitats that have key roles in population persistence.

Local population dynamics, productivity, and persistence may be influenced by patch quality and quantity (e.g. patch size), as well as the spatial effects resulting from patch shape, orientation, and isolation (Bowman et al., 2002; Fleishman et al., 2002; Franken and Hik, 2004). Thus, in heterogeneous landscapes it is likely that individual habitat patches make unequal contributions to regional population persistence. Therefore, the process of assessing which habitats are biologically critical may require the integration of species occurrence mapping, habitat quality studies, population studies, and spatially-explicit population viability analysis.

We present a habitat- and demographic-based approach for identifying and prioritizing habitats that are essential for the persistence of populations. In this approach, habitat characteristics and population dynamics are integrated using population simulation, and the outcomes of the model are used to assess the contribution of individual or aggregate habitat patches to regional population persistence. This approach may be particularly useful when identifying important habitats for dynamic populations in heterogeneous landscapes, especially when habitat quality is variable. The long-term importance of currently unoccupied habitat patches can also be assessed using a population viability modeling approach, allowing a more comprehensive landscape assessment than would be possible using demographic rates alone. Where long-term field data are lacking, simulations also allow the investigation of the effects of environmental stochasticity or directional landscape change on cumulative patch occupancy and productivity. We demonstrate this approach using the Ord's kangaroo rat as a case study.

1.1. Case study

The Ord's kangaroo rat (*Dipodomys ordii*) is the only species of kangaroo rat to occur within Canada and its distribution is limited to one small region (a cluster of active sand dune complexes) in south-eastern Alberta and south-western Saskatchewan (COSEWIC, 2006). This is a disjunct population at the northernmost periphery of the species' range (Gummer, 1997; Kenny, 1989), isolated from the nearest conspecifics in Montana by a distance of approximately 270 km (COSEWIC, 2006). Small population size, geographic isolation, extreme fluctuations in population size, and rapid loss and degradation of natural habitat have led to the identification of this species as *endangered* in Canada (COSEWIC, 2006). The majority (76%) of kangaroo rat habitats in Alberta are

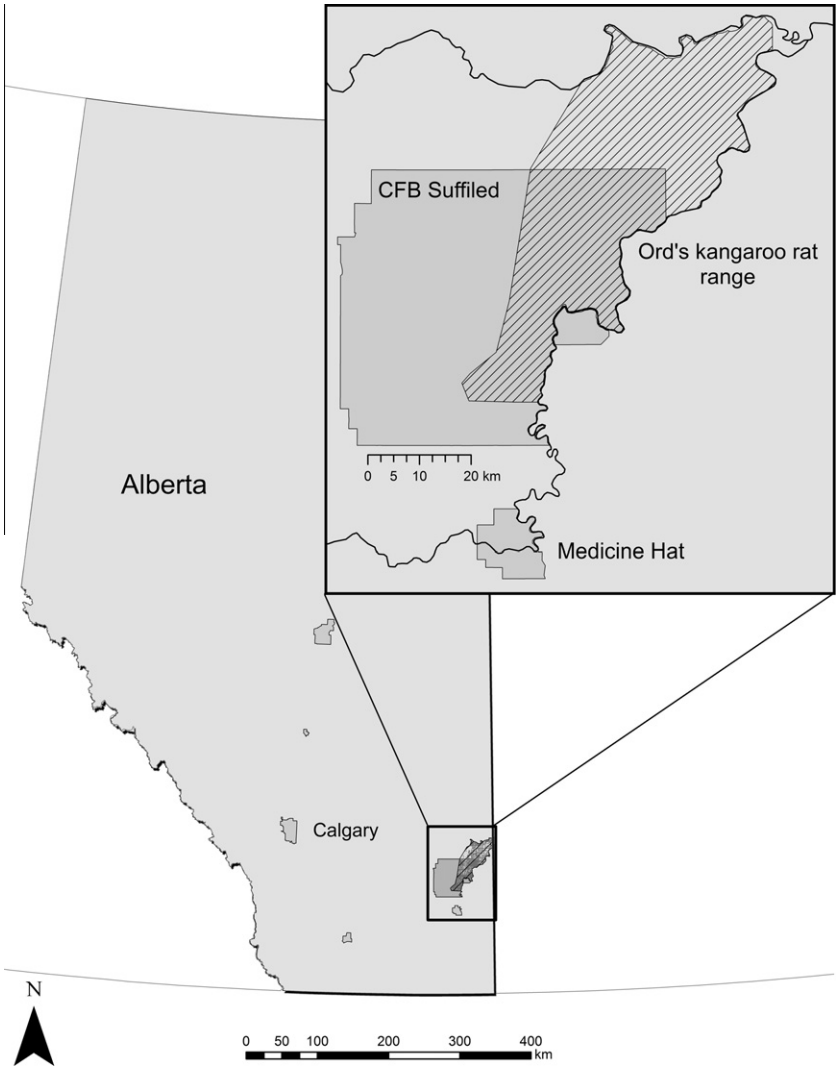

Fig. 1. Known range of Ord's kangaroo rats in Alberta, Canada (adapted from Alberta Ord's Kangaroo Rat Recovery Team, 2005).