Forest Ecology and Management 389 (2017) 220–227

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Summer-fall home-range fidelity of female elk in northwestern Colorado: Implications for aspen management

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ARTICLE INFO

Article history:
Received 16 September 2016
Received in revised form 21 November 2016
Accepted 22 November 2016

Keywords:
Aspen recruitment
Aspen reproduction
Browsing
Coppice silviculture
Elk (*Cervus elaphus*)
Home-range fidelity
Philopatry

ABSTRACT

Understanding the degree of spatial fidelity exhibited by individuals within a species increases our ability to manage for desired future outcomes. Elk (*Cervus elaphus*) is a closely managed species in the Western US, but there is little research evaluating their summer home-range fidelity. Elk summer-fall home-ranges overlap considerably with aspen (*Populus tremuloides*)-dominated forest types, and elk can impact aspen regeneration because it is a preferred browse species. We evaluated the fidelity of 72 adult female elk to individual summer-fall home ranges in northwestern Colorado, USA, during two consecutive summers (1996 and 1997). To compare elk summer-fall home-range overlap and distribution based on individual kernel-estimated utilization distributions, we calculated the volume-of-intersection statistic and the inter-annual distances between centers-of-mass. We found adult female elk in the White River Study area exhibited strong fidelity to individual home ranges. Volume-of-intersection results indicated that 93% of the elk showed explicit home-range overlap between 1996 and 1997, but that all the elk returned to the same vicinity as the previous year (median = 0.42, SE = 0.02, n = 72). Between-year center-of-mass distances ranged from 183 m to 34,170 m (mean = 3819, SE = 619, n = 72), while within-year maximum distances between location points ranged from 4320 m to 31,680 m (mean = 13,958, SE = 628, n = 72). Hunting increased the distance traveled by individual elk, but did not change the center of their home-range. Understanding female elk home-range fidelity could influence forest management focused on aspen regeneration. Specifically, targeted removal of female elk from their summer-fall home ranges could create a 'window of opportunity' in which browsing pressure was reduced, and the likelihood of aspen recruitment increased.

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1. Introduction

The fidelity of an individual animal to a specific area, or philopatry, is often characterized in terms of home-range fidelity, or site fidelity. Philopatric behavior is thought to enhance individual fitness because adaptation to an area through evolution or learned behavior increases the likelihood of survival and/or reproductive success (Part, 1991). This is in direct contrast to nomadic ungulates such as the North America bison (*Bison bison*) whose space-use patterns are much less predictable (Knapp et al., 1999). Philopatric behavior is a common home-range procurement strategy across taxa (e.g., birds, bats, skinks, and squirrels; Brown et al., 2004; Haughland and Larsen, 2004; Stow and Sunnucks, 2004; Veilleux and Veilleux, 2004). One example among ungulates is white-tailed deer (*Odocoileus virginianus*) in the eastern United States; female offspring return to the same vicinity as their mother's summer home range and establish an individual home range to which they are extremely faithful (Ozoga et al., 1982; Sage et al., 2003). This intergenerational, matriarchal mosaic of home ranges is referred to as the Rose Petal effect (Matthews, 1989), and suggests that animal density can vary locally as a function of spatially variable survival rates. Understanding philopatric behavior is important; as we improve our understanding of the spatial fidelity of individuals, we may more effectively manage critical habitats to sustain desirable species.

Elk (*Cervus elaphus*) are an economically important ungulate in the Intermountain West and are managed for high densities to support maximum hunting opportunity, but also aesthetics, species diversity, and associated habitat. Short-term and long-term studies have demonstrated herd fidelity to summer-fall ranges, as elk are

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http://dx.doi.org/10.1016/j.foreco.2016.11.034
0378-1127/Published by Elsevier B.V.

much less faithful to their winter range (Benkobi et al., 2005; Craighead et al., 1973; Edge et al., 1987; Hershey and Leege, 1982; Irwin and Peek, 1983; Knight, 1970), specific patterns of habitat use (Anderson et al., 2005; McCorquodale, 2003; Millspaugh et al., 2004), and have typically been conducted using locations from radio-collared elk. Although these studies described elk space use, to our knowledge only one has specifically addressed individual home-range fidelity (Webb et al., 2011).

Elk in the Interior West have large annual home-ranges, spending time in lower elevation sagebrush steppe communities during the winter, and higher elevation mid- to upper-montane forested communities during the summer and fall (Conner et al., 2001). Elk migrate to summer ranges predicated on energetic demands associated with calving (Beck et al., 2006). During the postpartum period, elk must acquire sufficient nutrients to support lactation and build fat reserves for the oncoming winter (Green and Bear, 1990). Elk exhibit a divers feeding spectrum and are considered generalists, as they readily browse as availability dictates (Hofmann, 1989). For example, shifting between grass an woody plants depending on nutrient content, including young aspen (Canon et al., 1987), and in particular when competition for other forage is strong. Consequently, female elk on summer-fall ranges are consuming large quantities of high quality forage, of which aspen is both widely available and highly palatable. Moreover, they occur in dense herds which leads to substantial local impacts on aspen regeneration.

Ungulate herbivory has long been known to exert impacts in managed forests (e.g., Lyon and Jensen, 1980), but more recently has been hypothesized to have strong negative impacts on the regeneration, composition, and associated ecological services of aspen communities, whether after fire, regeneration harvests, or in unmanaged settings (Baker et al., 1997; Britton et al., 2016; Fairweather et al., 2014; Rogers and Mittanck, 2014). In the Western US, the distribution of quaking aspen occurs in vegetation communities across the range of elk distribution, e.g., from sagebrush to spruce-fir forests. Moreover, aspen is the only canopy dominant deciduous hardwood tree in much of the Interior West. Because aspen is an important, keystone species—providing a disproportionate amount of biodiversity, ecosystem functioning (e.g., water holding capacity), forage for wildlife and livestock, and aesthetics, and is the subject of concern regarding its spatial distribution and abundance (Rogers and Clair, 2016), – possible management tools focused on the maintenance and/or reproduction of aspen are highly desirable.

As has been observed for white-tailed deer (*Odocoileus virginianus*) in the eastern U.S. (Campbell et al., 2004; Oyer and Porter, 2004), the degree to which individual elk exhibit fidelity to summer-fall range could aid management decisions regarding where and when to conduct regeneration treatments, and whether and how elk should be locally controlled to ensure timely regeneration. If summer-fall home-ranges of female elk occurred in aspen-dominated communities where regeneration harvests were planned, managers could take advantage of the fidelity concept to create 'windows of opportunity' for regenerating aspen (*sensu* Sage et al., 2003) by selectively removing a limited number of elk. Because elk in the Western U.S. typically spend a substantial amount of time in aspen-dominated communities, a demonstration of home-range fidelity would open a new tool box of management potential based on sub-population-level targeted removal.

We evaluated the fidelity of individual elk to their summer-fall home-range, specifically focusing on adult female elk in the migratory White River herd of northwestern Colorado, USA. To evaluate spatial fidelity, we assessed overlap of summer-fall home ranges for 72 elk across two consecutive summers using data that were originally collected to study the impacts of hunting on elk movement to private land in the late summer. We asked the question, to what degree do individual female elk return to the same home range in subsequent years? We hypothesized that female elk would return to the same place each year. Furthermore, because individual home-range fidelity could be influenced by changes in hunting seasons, we also addressed potential changes in home-range fidelity due to the timing of hunting. We hypothesized that hunting would act as a disturbance and alter home-range fidelity of individual elk.

2. Methods

2.1. Study area

The White River study area was located in northwestern Colorado and covered approximately 4540 km^2 (Fig. 1). Ownership was 34% private land and 66% public land managed by the Bureau of Land Management or the United States Forest Service. The study area represented a major portion of the Colorado Division of Wildlife (CDOW) elk population Data Analysis Unit E-6 but was limited to the western portion of E-6 as demarcated by Game Management Units (GMU) 12, 23, 24, and 33 (CDOW, 2005). A diversity of public land uses in this area included hiking and camping recreation, timber sales, domestic livestock grazing, hunting, and limited surface coal mining. Elevation in the study area ranged from 1600 to 3700 m. The central and eastern portions of the study area contained high elevation sub-alpine and alpine areas commonly used by elk during the summer. Generally, terrain was moderately steep north of the White River (GMU 12) while large and gorge-like canyons were more common south of the White River (GMU 33) (Fig. 1). Elevation declined from east to west, with elk winter ranges located in the western portions of the study area in the lower White River.

Climate at higher elevations of the study area was characterized by long-term mean temperatures for July and January of 14 °C and −8 °C; mean annual precipitation of 70 cm, and average total snowfall of 527 cm (Marvine Ranch Station, 2379 m elevation, WRCC, 2006). At lower elevations within the study area, mean temperatures for July and January were 19 °C and −6 °C; mean annual precipitation was 42 cm, and average total snowfall was 177 cm (Meeker COOP Station, 1903 m elevation, WRCC, 2006). Precipitation during the first study year (1996) did not vary greatly from the 100-year average. However, the precipitation in the second study year (1997) increased substantially during the July – October period with 14 cm received in September compared to the long-term average of 4 cm in that month. Temperatures during both study years were close to the 100-year averages. As result range conditions for herbivores were likely average or slightly above average during the study time period.

Vegetation composition in the higher montane/subalpine zones (>2600 m) consisted of Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), and aspen (*Populus tremuloides*) interspersed with meadows of grasses and sagebrush (*Artemisia* spp.), common for spruce-fir forest types of the Interior West (Peet, 2000). Vegetation at mid-elevations of 2000– 2600 m included aspen woodlands, Gambel oak (*Quercus gambelii*) shrubland, and woodlands of pinion (*Pinus edulis*) - juniper (*Juniperus scopulorum*). Sagebrush steppe, grasslands, and agriculture were prevalent at elevations lower than 2000 m. Aspen-dominated forest types covered 23% of the study area and were primarily located between 2000 m and 3400 m (CDOW, 2005; United States Geological Survey, 2004).

Elk in the White River population were considered migratory. Spring migration from winter to summer range commenced in April, calving occurred during late May and into June, usually at mid-elevations. Elk occupied summer ranges from June into