Fire and beaver in the boreal forest-grassland transition of western Canada – A case study from Elk Island National Park, Canada

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Abstract: Prescribed fire is used as a management tool in many areas throughout the world to restore vegetation communities, reduce fuel loading, and enhance wildlife habitats. However, the effect of prescribed fire on many wildlife species has not been well studied, especially on beavers (*Castor canadensis*). The purpose of our study was to examine whether prescribed fire influences beaver lodge occupancy in the aspen and mixed-wood habitats of Elk Island National Park, Alberta, Canada. In particular, we examined whether lodges in burned habitats experience lower occupancy levels than lodges in unburned habitats, whether the frequency of burns influences lodge abandonment, and whether the distance to suitable habitat potentially accessible from those lodges abandoned following a burn, influence beaver lodge occupancy. Since 1979, over 51% of Elk Island National Park (196 km^2) has been burned with the goal of restoring prairie plant communities. We found that fire negatively affected beaver lodge occupancy, an effect compounded with frequent burns. Though prescribed fire is considered an important landscape restoration process, the frequency of prescribed burning should be mitigated to ensure that flooding by beavers can continue as a key process that maintains wetlands on the landscape.

Keywords: Castor canadensis, beaver, fire, drought, ungulates, Elk Island National Park, Alberta, Canada.

Introduction

In Canada, there are several pressing issues in ecology, but one of the most controversial is the use of prescribed fire. Despite the major ecological role that beavers (*Castor canadensis*) play on the landscape (Naiman et al. 1988, Johnston & Naiman 1990), studies that specifically examine how fire affects beaver populations are lacking. Elk Island National Park (EINP) (figure 1) provides an ideal setting for such a study. Beaver numbers have been documented there since the early 1960s, there has been an active prescribed fire programme in the park since 1979, and being completely fenced, it has some of the highest year-round ungulate densities in the world. Over 340 lodges in the park are in areas exposed to prescribed fire, while approximately 800 lodges are in unburned areas. Six species of large ungulates roam freely in both burned and unburned habitats where they feed on riparian vegetation adjacent to beaver ponds.

Since 1979 over 51% of the park has been burned; in some areas as many as eight times. The most recent burn was in 2002. Beaver populations are regularly surveyed and the park has been divided into 20 beaver units to facilitate these surveys. The park is located in the Aspen Parkland Natural Subregion (Achuff 1994) and is dominated by trembling aspen (*Populus tremuloides*). These stands typically have a diverse understory in which beaked hazel (*Corylus cornuta*) is prevalent. The topography is morainal and consists of numerous small lakes and ponds within a hummocky landscape. Major rivers and streams are uncommon. The Aspen Parkland is the transition zone between the boreal forests to the north and the prairie grasslands to the south. EINP, located in the Beaver Hills of east-central Alberta, provides one of the few remaining protected areas between these two dramatically different ecosystems.

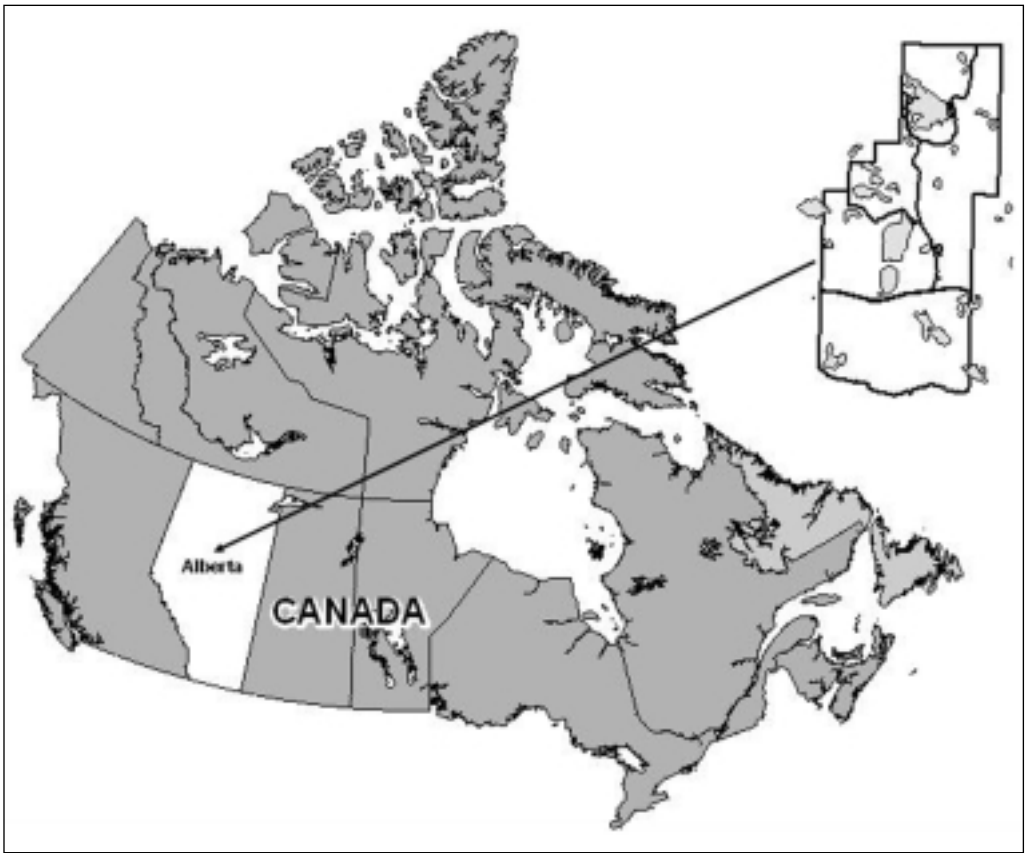

Figure 1. Location of Elk Island National Park in east-central Alberta, Canada.

Prescribed fire has been used in North America since pre-colonial times. Aboriginal people used fire as a game management tool and early settlers used it for land clearing (Lewis 1982, Murphy 1985). However, with increased settlement and dependence on forest resources, fire suppression became the primary focus throughout much of the 20th century (Woodley 1993). And now, after decades of fire suppression activities, fire is often used by land managers inside and outside of protected areas to regenerate early seral stages of vegetation, enhance wildlife habitat, and reduce fuel loads (Woodley 1993). But the question is: does it accomplish these goals given all the variables in today's ecosystems? Specifically, we addressed whether fire enhances wildlife habitat for beavers. We investigated whether fires decrease beaver lodge occupancy and if the distance between active and abandoned lodges increases under a burning regime. We also addressed whether the cumulative impacts of drought (plus fire) and high levels of ungulate herbivory cause an additive loss of active beaver lodges. Some studies have found that the use of prescribed fire does not always achieve expected results (White et al. 1998). In areas with high densities of ungulates, woody plant species, such as those preferred by beavers, fail to regenerate following a burn (Campbell et al. 1994, Bailey & Whitham 2002). The combination of repeated burning and climatic conditions (e.g. drought) are known to reduce the ability of woody plants to recover from fire (Elliot et al. 1999, Roques et al. 2001). Given the presence of all these conditions (prescribed fire, high densities of ungulates,

repeated burning, and a recent drought) in EINP, we predicted that (1) beaver lodge occupancy would be lower in burned areas, (2) repeated burning would result in the long-term abandonment of previously active beaver lodges, and (3) burning during drought conditions would intensify the effects of prescribed fire on beaver lodge occupancy. Further, we predicted that if there was an increase in the abandonment of beaver lodges in burned areas, the distances separating active and abandoned lodges would be greater than in areas that had never been burned. Fires in EINP often consume or damage most woody vegetation that would otherwise be available as forage. Consequently, burned areas would experience a delay in the re-colonization of abandoned lodge sites.

Lodge occupancy in burned and unburned areas

EINP currently has 1,172 beaver lodges, of which 152 were active during the aerial survey in the fall of 2002 (Hood et al., in review). To facilitate our analysis only the occupancy data from 1989-2003 were used and all lodges that were never active during this time period were removed from the dataset. Of the total number of lodges analyzed for this study, 346 were in burned areas and 799 were in unburned areas. As expected, the proportion of active lodges in burned areas was significantly lower than the proportion of active lodges in unburned areas. In addition, when we compared the year immediately prior to a burn to the year immediately following a burn we had almost identical results (Hood et al., in review). When we examined the entire ten-year period following a burn, there was no predictable reoccupation of lodges despite the fact that various authors indicate that beavers should benefit from the regeneration of woody species after a burn (Bird 1961, Kellyhouse 1979, Lewis 1982, Naiman et al. 1988, Fryxell 2001). Although there was an increase in occupancy two years after a burn, it was not sustained. This finding indicates that food resources were still available to beavers two years after a burn, however, it was evident that the subsequent declines in the occupancy rate were likely driven by something else than just fire.

Fire and ungulate herbivory

At 196 km^2, EINP has extremely high year-round ungulate densities with 13 ungulates/km^2 (Hood & Bayley, unpublished data). There are five ungulate species in the park: Manitoba elk (*Cervus elaphus manitobensis*), moose (*Alces alces*), plains bison (*Bison bison bison*), wood bison (*Bison bison athabascae*), white-tailed deer (*Odocoileus virginianus*), and mule deer (*Odocoileus hemionus*). Apart from coyote (*Canis latrans*), the park lacks any large resident species of predators. Park officials periodically cull elk and bison from the park to reduce ungulate densities.

Studies that have examined ungulate use of burned areas indicate that many ungulate species are drawn to these areas (Vinton et al. 1993, Bailey & Whitham 2002). Use can increase to the point where overgrazing by ungulates in burned areas inhibits the regeneration of woody plants (Bork et al. 1997, Campbell et al. 1994, White et al. 1998, Bailey & Whitham 2002, Hessl & Graumlich 2002). In their study on the effects of fire and herbivory on vegetation in EINP, Bork et al. (1997) found that fire-tolerant species such as beaked hazel and wild raspberry (*Rubes ideaus*) were significantly shorter and more hedged than those same species outside the park. They also found that the use of fire in the park failed to increase smaller size classes of woody species. We too found that shrubby vegetation inside the park, such as beaked hazel, was significantly shorter than the same species immediately outside the park (Hood et al., in review). Although one of the beaver's preferred forage species, serviceberry (*Amelancier alnifolia*), is considered a fire-tolerant species (Noste & Bushey 1987), mature forms of this plant were rarely present inside the park (Bork et al. 1997, Hood & Bayley, unpublished data). The interac-

tion of fire and herbivory is a commonly cited mechanism of the historic maintenance of the grassland ecosystems of the Great Plains of North America (Bird 1961, Vinton et al. 1993, Campbell et al. 1994). Even now, fire, in combination with cattle grazing, is often used as a means to remove woody species for the creation of agricultural pasturelands (Anderson & Bailey 1979, Bailey et al. 1990). The combined effect of fire and intense ungulate herbivory is likely having similar effects on woody vegetation in EINP.

Fire frequency

When we examined the effects of fire frequency on beaver lodge occupancy in the park, we found a clear trend in lodge abandonment. Lodge occupancy increased slightly after one burn (from 25% to 26%), which could be a reflection of the increase in lodge occupancy during the second year post-burn, but is just as likely due to natural variation. After two burns, however, occupancy decreased dramatically (from 26% to 16%) and after three or more burns, occupancy dropped to zero (Hood et al., in review). Beavers are a cyclic animal, abandoning areas when food supplies are exhausted and moving on to new areas (Ives 1942). They also exhibit density-dependent reproduction and beaver colonies regulate themselves once reaching carrying capacity (Paine 1984, Schulte 1998). It could be that the occupancy patterns we observed in response to fire were part of a normal cycle for the area. An examination of the trend in beaver populations since 1963 revealed that the population does have natural fluctuations. However, when the lodges in burned areas were analyzed separately from the lodges in unburned areas, only the lodges in burned areas showed a dramatic decrease in occupancy.

Suitable habitat in burned areas

Of the 121 fires in the park since 1979, 95% of prescribed fires in EINP were lit in the spring, which can result in fires that burn right up to wetland edges. Some lodges in the park have been completely consumed by prescribed fires. Beavers are then forced to either disperse to more suitable habitat or rebuild. To capture some indication of the typical distance to the nearest potential (previously occupied) habitats for dispersing juveniles from active lodges, we measured the distance from all abandoned lodges to the nearest active lodge in both burned and unburned habitats for each year since 1989.

The average distance to the nearest active lodge in burned areas was significantly higher than that in unburned areas (Hood et al., in review), indicating that suitable habitat was less accessible in burned areas. The higher risk of predation associated with these long distances that beavers would have to travel to find new lodge locations or reconstruction materials may have translated to a higher mortality of beavers in these areas, contributing to the lower occupancy we observed immediately after fires. In addition, re-colonization of abandoned areas might take a long time due to the larger distances between active lodges and abandoned lodges in burned areas.

Cumulative disturbances

In our analysis, we also found a particularly large increase in distances between abandoned and active lodges during the years 1999-2003 (Hood et al., in review). Two events that might have influenced this trend are a record-breaking drought from 1999-2002 (most severe in 2002), and extensive burning in three of the beaver units in the year 2000.

Both the drought and high levels of ungulate herbivory allowed us to address cumulative disturbances to beaver habitats in burned areas. We compared the beaver units that were extensively burned in 2000 to units that had never been exposed to prescribed fire. In the four units that had never been burned, the distance between abandoned and active lodges actually decreased (except in one unit where there was a slight increase). In the three units that had been exten-

sively burned during the drought, the distances between abandoned and active lodges did the opposite and actually increased significantly. It is possible that unburned areas provide habitats that endure drought, while habitats in burned areas were less likely to maintain adequate water and forage. Morgan (1991) noted in her beaver habitat assessments that beavers in EINP did not browse on charred or singed wood. To find appropriate forage, beavers would be forced to either disperse or increase their foraging distances in burned areas.

Although we know that factors like topography, predation, disease, and population densities will always affect how beavers move across the landscape (Johnston & Naiman 1990), the combined effects of fire and drought appear to be possible factors influencing the dispersal of beavers to alternate habitat in this case. Our results suggest that fire alone can have some effect on access for beavers to suitable habitats, but when occurring during drought, the combination appears to be too much for wetland habitats (and beavers) to accommodate.

Conclusions

Through our study, we found that fire does not always enhance beaver habitat as has been assumed in the scant literature available. Single burns without drought did not appear to affect lodge occupancy. Repeated burning in beaver habitats caused the most dramatic effects on beaver persistence in established ponds and resulted in the long-term abandonment of lodges after three or more burns. It is also possible that in areas of multiple burns, the inter-fire period is too short for adequate recovery of woody plant species and results in grassland habitats being dominant. As a result, multiple burns in beaver habitat had the most negative effect on long-term lodge occupancy. We also found that the mean distance between abandoned lodges and active lodges increased significantly in burned areas. The cumulative impacts of fire and drought appear to intensify the effect: mean distances increased dramatically in burned areas even though they decreased in unburned beaver units. Combining multiple perturbations such as drought and extensive burning appears to cause more disruption to wetland habitat than beavers can tolerate. The combined effects of ungulate herbivory and fire also appears to result in less suitable beaver habitat, largely by depressing shrub growth.

In many areas, beavers play a pivotal role in the dominant ecological processes. The appropriate use of fire in both natural areas and agricultural environments can help ensure that beaver habitats remain viable, so their populations can continue to contribute to the creation and maintenance of wetland ecosystems.

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Samenvatting

Branden en bevers in de boreale overganszone bos-grasland van west Canada – Een case-studie in Elk Island National Park, Canada

Gecontroleerd branden wordt wereldwijd gebruikt in het natuurbeheer met het doel bepaalde vegetatietypen terug te brengen, de kans op oncontroleerbare branden te verkleinen en habitats te verbeteren. Het exacte effect van branden op veel diersoorten, waaronder de bever (*Castor canadensis*), is echter weinig bestudeerd. Het doel van onze studie is te onderzoeken of branden de bezetting van beverburchten beïnvloedt in de populierenbossen en gemengde bossen van Elk Island National Park, Alberta, Canada. We onderzochten met name of de bezettingsgraad van de burchten in gebrande delen lager is dan die in ongebrande delen, of de frequentie van branden het verlaten van burchten beïnvloedt en of de afstand tot het dichstbijzijnde geschikte habitat de bezettingsgraad van burchten beïn-

vloedt. Sinds 1979 is meer dan 51% van Elk Island National Park (196 km^2) gebrand om de prairie-plantengemeenschappen terug te brengen. We ontdekten dat vuur de bezetting van beverburchten negatief kan beïnvloeden: hoewel één keer branden geen effect op de burchtbezetting heeft, brengt drie of meer jaren achtereen branden de proportie bewoonde burchten omlaag. Afstanden tussen bezette burchten waren hoger in gebrande dan in ongebrande gebieden. Dit duidt erop dat in de gebrande gebieden minder geschikt habitat aanwezig is. Deze afstanden tussen burchten en geschikte gebieden wijst er tevens op dat in gebrande gebieden de burchten minder snel geherkoloniseerd worden, en zou kunnen resulteren in een hogere mortaliteit onder de bevers na een brand. Bij brand tijdens een droogte nam deze afstand nog sterker toe: gecombineerde verstoringen lijken dus een ongewenst effect te geven. Alhoewel het gecontroleerd branden beschouwd wordt als een belangrijk landschapsherstellend proces, dient de frequentie van branden aangepast te worden om te verzekeren dat overstromingen door bevers kunnen blijven plaatsvinden als een sleutelproces voor het behoud van wetlands in het landschap.

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