Universität Münster

Alberta Parks

The effects of human facilities, roads, and trails on Grizzly Bear movement behavior

Source: wildlife camera of Alberta Parks, Kananaskis Country, 2019

wissen.leben

1. Abstract

Understanding the effects of anthropogenic structures on Grizzly Bear (*Ursus arctos horribilis*) movement behavior is essential for wildlife management and conservation. This project studies the habitat preferences of Grizzlies in response to distances to anthropogenic structures, such as facilities, roads, and trails, across seasons and greenness levels in Kananaskis Country, Alberta. Using a Bayesian Mixed Multinomial Logit model, we analyzed GPS data from 23 Grizzlies to study their habitat preference patterns.

Our results show a consistent preference for aspen forests across all conditions, while shrubland habitats were least favored unless greenness levels were high. Notably, distance to facilities had a notable negative effect on conifer forest preferences, which decreased by 5-7% with increasing distance, contrasting with grassland habitats, such as meadows, which showed a 5-6% increase in preference.

Greenness influenced preferences for conifer forests, grass-, and shrublands positively, whereas mountainous barren habitat preferences were negatively affected by increasing greenness levels. Seasonal differences were most notable in Fall, where the preferences shifted from conifer forests to grass habitats was observed. Additionally, male Grizzlies generally preferred conifer forests over barren and grassland habitats, while females showed variable preferences based on greenness levels. These findings emphasize the context-dependent habitat preferences of Grizzlies in anthropogenically influenced environments, highlighting the importance of considering both ecological variables and human activity in Grizzly Bear conservation and wildlife management strategies.

2. Introduction

Progressing anthropologic influences are inevitable nowadays due to the continuous growth of the human world population. Influences such as tourism, recreational activities, or urbanization often come along with human-wildlife conflicts (Messmer 2009, Soulsbury and White 2015). The detrimental effects of anthropologic influences on wildlife are well documented and in order to stop ongoing ecosystem degradation (Giam 2017), and human-wildlife conflicts (Taylor and Knight 2003, Cui et al. 2021), it is essential to ensure and maintain the coexistence between humans and wildlife (Tallis and Kareiva 2005, Fu et al. 2013).

Being subject to extensive tourism, Alberta (Canada) shows how anthropogenic influences may lead to human-wildlife conflicts. Alberta is a popular destination for tourists due to the wide range of recreational activities offered by its wilderness. Tourism often comes along with corresponding infrastructure and poses a challenge for wildlife conversational matters due to many potential human-wildlife conflicts caused by these anthropologic structures (Draper 2000, Ford et al. 2010). Alberta’s wilderness is prominent for inhabiting imposing large mammals such as the American black bear (*Ursus americanus*) or the Grizzly bear (*Ursus arctos horibilis*) (Tough and Butt 1993). Though Alberta’s Black bear population is stable and counts around 40.000 individuals, its Grizzly bear population is considered to be provincially threatened. In the year 2008, the Grizzly bear population counted around 700 individuals (Alberta Wilderness Association 2021).

The Grizzly bear (hereafter Grizzly/Grizzlies) is a subspecies of the Brown bear (*Ursus arctos*) that inhabits a variety of habitats at higher elevations (~2100 m). The Grizzly is North America’s largest predator in the mountains and preferably forages in open areas such as meadows and forest edges, or fish spawning grounds. Though their diet is mainly herbivorous, Grizzlies also prey on weakened or young animals if opportunity is given (Tough and Butt 1993). Attacks on humans are rare and poorly documented, but mostly, Grizzlies rather avoid humans unless habituated by human feeding or attracted by human food sources, often found at camping grounds or as leftovers in general (Craighead and Craighead 1971, Jope 1985, Tough and Butt 1993).

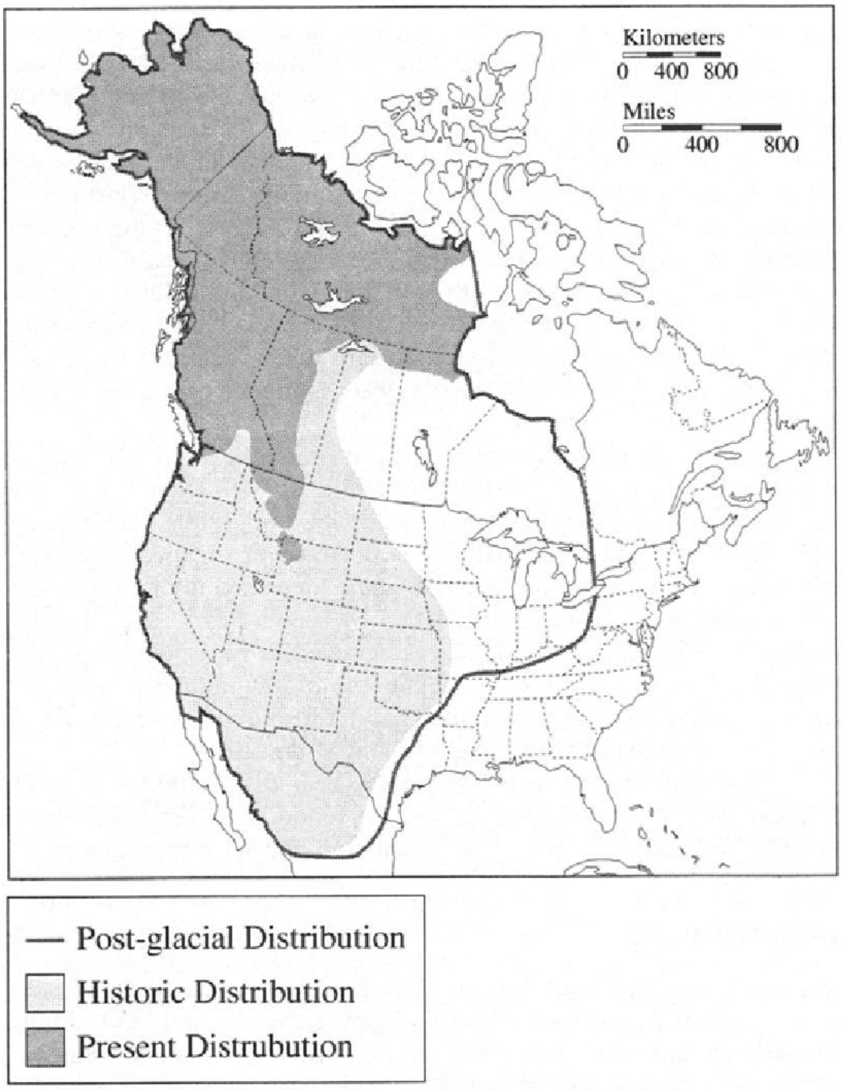


Figure 1: Comparison between the historical and present distribution of the Grizzly bear. (Schwartz et al. 2003)

Historically, Grizzlies have faced drastic range losses due to human-caused habitat degradation (Figure 1), and systematical eliminations (Schwartz et al. 2003). Even nowadays, Grizzlies are heavily affected by anthropologic influences. From the years 2008 – 2018, 208 human-caused Grizzly bear deaths were documented in Alberta, which makes up 91.63% of all Grizzly bear deaths within this period (Alberta Wilderness Association 2021). This alarming number of human-caused Grizzly deaths instigated several recovery plans, aiming to recover several distinct Grizzly populations such as the population in Alberta (Boulanger and Stenhouse 2014, Proctor et al. 2020, Alberta Wilderness Association 2021).

Alberta has a network of protected landscapes and wild areas (Supplements S1). Though protected areas are designated to offer wildlife grounds for recovery (Alberta Wilderness Association 2021), they are not untouched by anthropologic influences. For instance, prominent national parks such as Banff National Park, or Jasper National Park are located within protected areas of Alberta, but are subject to extensive tourism that comes along with many anthropologic structures within these protected areas (Locke 1997, Ford et al. 2010, Mirzaalian 2021). Consequently, human-wildlife encounters are not fully avoidable and may lead to conflicts (Jope 1985, Elmeligi et al. 2021). Additionally, Grizzlies have ranges that can vary between 26 km^2 and 400 km^2 (Tough and Butt 1993) and therefore may not always remain within these protected areas (S1). For conversational matters, it is therefore essential to understand the bear movement behavior in order to prevent further human-Grizzly conflicts.

This project aims to study the Grizzly movement behavior in response to environmental cues. For instance, we aim to study how the Grizzly movement is affected by anthropologic structures such as facilities (including camping grounds), roads, and hiking trails, or water sources such as streams, and rivers. We will study the responses of the Grizzlies to these cues in contrasting habitats, taking the habitat quality into account. OHV trails will be disregarded due to the decommissioning of most of them (Alberta Wilderness Association 2021). To do so, we will study Grizzlies that were monitored for years via GPS radio collars in the Kananaskis Country region in Alberta (Supplements S2).

We hypothesize that human facilities affect the foraging behavior of observed Grizzlies. We predict that potential food sources from human facilities may attract the observed Grizzlies. We also hypothesize that Grizzlies will be attracted by roads due to the effect of road placement on floral diversity (Roever et al. 2008). We predict that Grizzlies will be attracted by the diverse food sources in proximity to roads, even though the likelihood of encounters with humans is increased.

3. Methods

3.1. Grizzly monitoring

Between the years 1993 – 2019, the wildlife management staff of Alberta Parks ("AlbertaParks.ca | Alberta Parks" 2024) captured, marked, and radio-collared 118 Grizzlies in total. Out of these, we study ten adult male and 13 adult female Grizzlies. Most of the Grizzlies were captured and collared during the Spring. All Grizzlies were captured following an established protocol by Jonkel and Thier 1993. After capturing a Grizzly, it was tranquilized with a dart containing Telazol® (7-9 mg/kg) (Taylor et al. 1989), and collared with radio-collars from Lotek ("Lotek.com | Lotek Wireless Inc" 2017) afterwards. Due to the limited lifespan of the collars (up to three years), the Grizzlies had to be recaptured and recollared in intervals of one to three years. The occasional poor reception did not always allow the collars to send the GPS location of the Grizzlies at regular intervals. The age of the Grizzlies was determined by sending the first premolar to Matson's Laboratory ("The Cementum Aging Wildlife Lab" 2024) for further analyses. All Grizzlies were also marked with a pulse sensor, so the wildlife management staff was able to record all circumstances of bear deaths immediately.

This project studies the Grizzly movement behavior within the Kananaskis Country region of Alberta (hereafter Kananaskis) (Supplements S2). We received topography data of Kananaskis from Alberta Parks ("AlbertaParks.ca | Alberta Parks" 2024) that describes the habitat type, water sources, and the locations of anthropogenic structures. Regarding the habitat types, we distinguished between aspen forests, conifer forests, (alpine) rocky barren landscapes, shrublands, and grassy areas (including alpine meadows). All habitat types also received a greenness index. As covariates, we distinguished between streams and rivers as water sources, and anthropogenic structures, including facilities (e.g. camping grounds), roads, and hiking trails. For the analysis, we excluded data that was collected during the Winter, because of the hibernation period of the Grizzlies. GPS entries with a dilution of precision (DOP) higher than three, or entries with an estimated movement speed exceeding 60 kph were also excluded.

3.2. Statistical analysis

The data was analyzed with a Bayesian Mixed Multinomial Logit model (Burda et al. 2008, Bansal et al. 2020), using the following packages in R: “brms” (Bürkner et al. 2023), “adehabitatHR” (Calenge and Fortmann-Roe 2023), “HDInterval” (Juat et al. 2022). The model used the following parameters: iterations = 2000, warmup = 1000, chains = 4.

The distances to human facilities, roads, trails, and habitat greenness served as predictors. Greenness served as a quality index for our habitats. The predictors were normalized by dividing the mean distance to each predictor (or respectively the mean greenness value) by its standard deviation. The water sources were taken into account for further analyses but will not be further elaborated in the results, since this project aims to study how anthropogenic structures influence Grizzly occurrence patterns across different habitat types. Additionally, we also separated between sexes and seasons (Winter excluded). All Grizzlies were individually analyzed and the data was bootstrapped afterwards. The individual Grizzly ID served as a random factor. Finally, we examined the variations between seasons and sexes by comparing the corresponding posterior distributions pairwise with each other (Wade 2000).

For the visualization (Results), we compared both sexes across all seasons and distances to human facilities, roads, and trails at three different greenness levels. We compared between the overall mean greenness, and two standard deviations subtracted/added to the mean (low and high greenness).

All observed differences in habitat preferences between male and female Grizzlies are meaningful within the Bayesian statistics applied in this project, even though, even though these differences only seem to appear on a small percentual scale. The applied Bayesian statistics emphasize the probability of an actual observation. Consequently, these small percentage changes are being interpreted with a focus on their consistency and credibility. The applied model shows that these differences are unlikely to be random, reflecting true variations in Grizzly habitat preferences that are applicable across different seasons and greenness levels.

4. Results

4.1. Distance to facilities

The occurrence probabilities (hereafter habitat preferences) for Aspen and Conifer habitats show a negative relationship to the distance to facilities, with preferences for Conifer decreasing by approximately 5-7% as distance increases. Contrastingly, Grass habitats show an increased preference by around 5-6% with increasing distance from facilities, while Barren habitats show a slightly negative relationship of about 3%. Shrub habitats remain mostly neutral at any distance to facilities, with only minor variations of 1-2%.

The greenness levels show a positive relationship to preferences for Conifer and Grass habitats, particularly at high greenness levels where preferences can increase by up to 3-4%, while Shrub habitats exhibit only a subtle positive effect of around 2% (Figures 2-4). At lower greenness levels, both sexes show an increased preference for Barren habitats by approximately 4%, while showing decreased preferences for Grass and Conifer habitats by 3-5% at higher greenness levels. Notably, males generally favor Conifer habitats by about 5% more than females, who instead prefer Barren and Grass habitats (Figures 2-4).

Between Spring and Summer, the differences in habitat preferences are subtle, generally within a range of approx. 1% (Figures 2-3). However, in Fall, both sexes show a more notable shift, with a reduced preference for Conifer habitats by about 2-3% and an increased preference for Grass habitats by 2-3% at higher distances to facilities (Figure 4). Both sexes generally show the highest preference for Aspen habitats, with percentages consistently over 25% across all seasons and greenness levels.

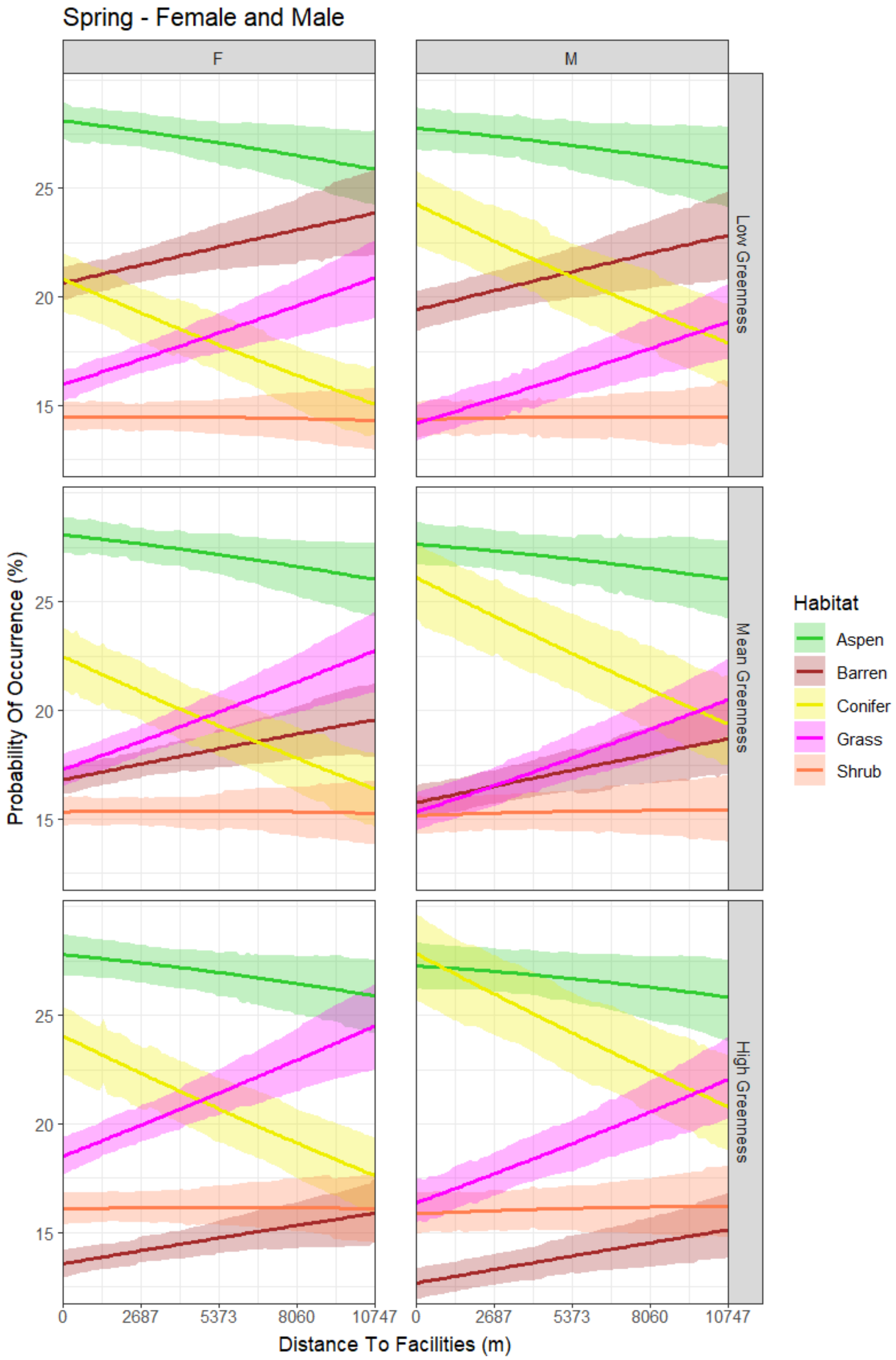


Figure 2: Occurrence probability of Grizzlies in relation to the distance to facilities in Spring. Each step on the x-axis represents two standard deviations (1343.307 m) of the mean distance to facilities (1796.69 m). Low/high greenness is equivalent to two standard deviations subtracted or added to the mean greenness.

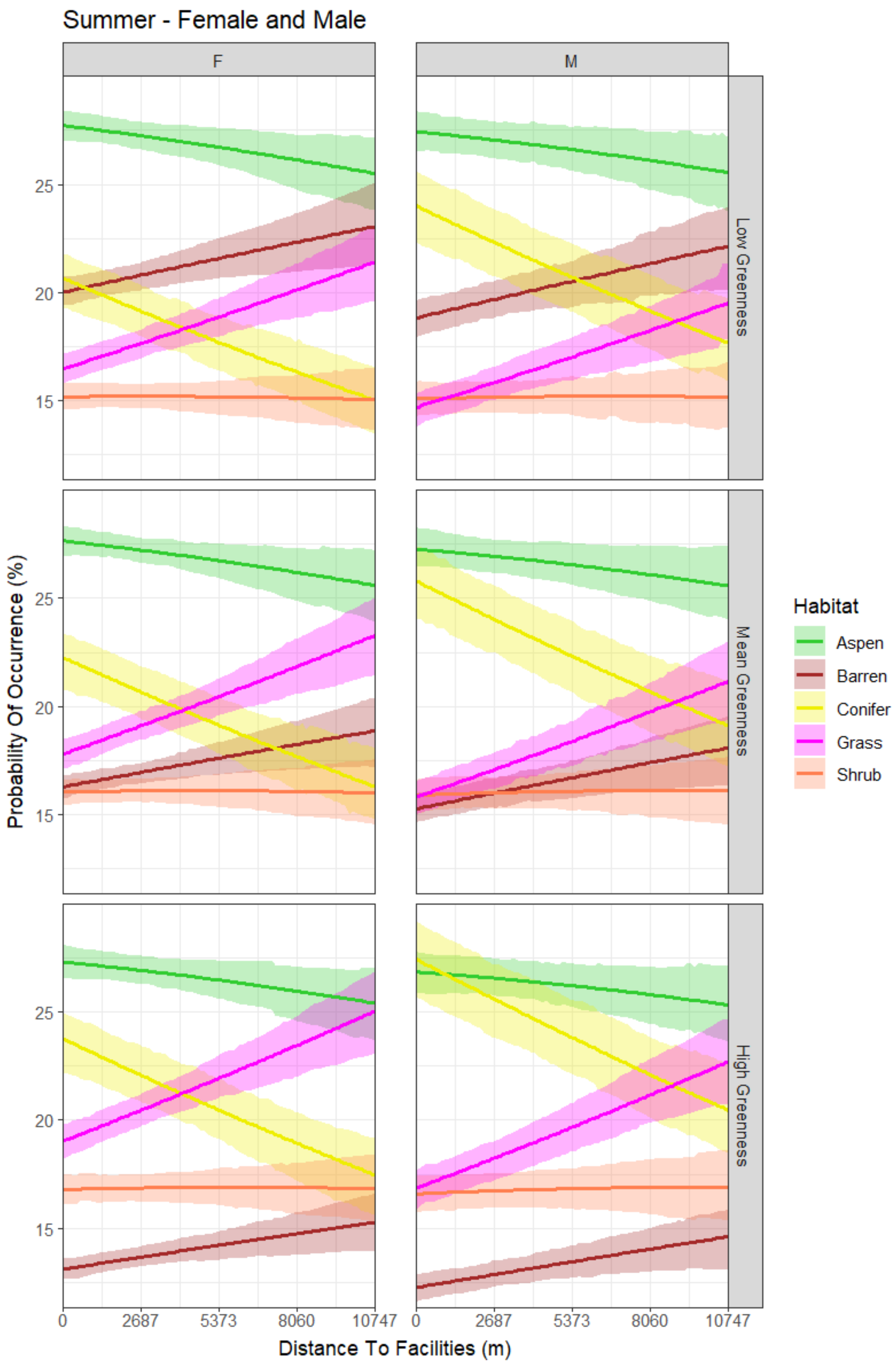


Figure 3: Occurrence probability of Grizzlies in relation to the distance to facilities in Summer. Each step on the x-axis represents two standard deviations (1343.307 m) of the mean distance to facilities (1796.69 m). Low/high greenness is equivalent to two standard deviations subtracted or added to the mean greenness.

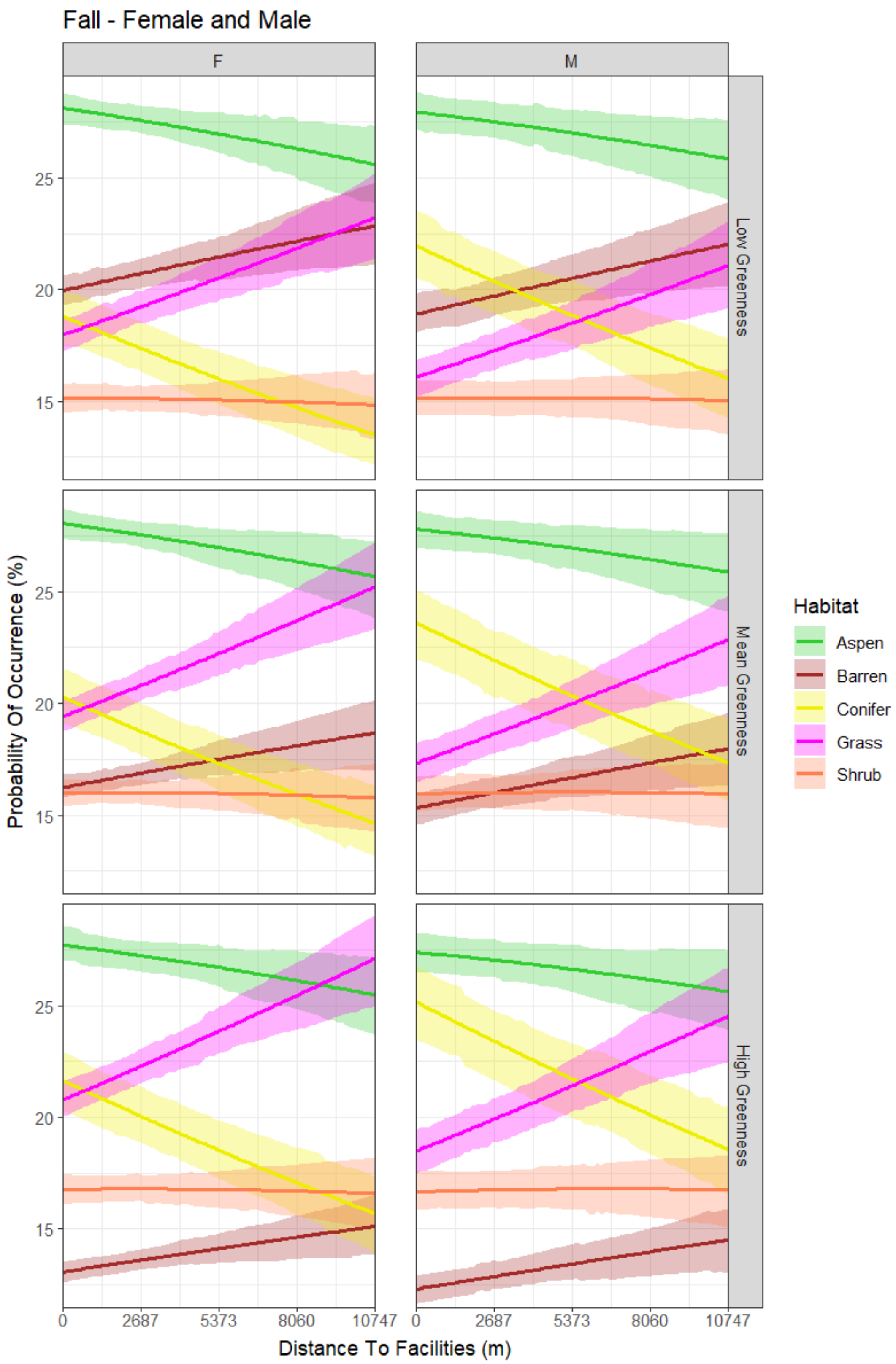


Figure 4: Occurrence probability of Grizzlies in relation to the distance to facilities in Fall. Each step on the x-axis represents two standard deviations (1343.307 m) of the mean distance to facilities (1796.69 m). Low/high greenness is equivalent to two standard deviations subtracted or added to the mean greenness.

4.2. Distance to roads

Preferences for Aspen and Conifer habitats both show a slightly positive relationship to the distance to roads, with increases of about 2-3% over the range. For Grass habitats, this relationship is negative, showing a decrease of 4-5%, while Barren and Shrub habitats remain neutral with changes below 1%. The greenness levels show a positive relationship to preferences for Conifer, Grass, and Shrub habitats, particularly with Grass increasing by approx. 2.5% at higher greenness levels (Figures 5-7).

Between Spring and Summer, there are marginal changes in habitat preference, generally within approx. 1%. However, in Fall, both sexes show a lowered preference for Conifer habitats by approx. 2.5%, while showing an increased preference for Grass habitats by the same percentage instead (Figure 7). Overall, both sexes show the highest preference for Aspen habitats across seasons, with percentages around 25-27.5%.

At lower greenness levels, both sexes favor Barren habitats, with increases of up to 7-8%, while showing a decreased preference for Conifer habitats by about 3-4%. Despite this, male Grizzlies still prefer Conifer habitats over Barren by approximately 1-3%, whereas at higher greenness levels, the preferences reverse. Females also prefer Grass habitats at mean and high greenness levels near roads with differences of around 2.5% (Figures 5-7).

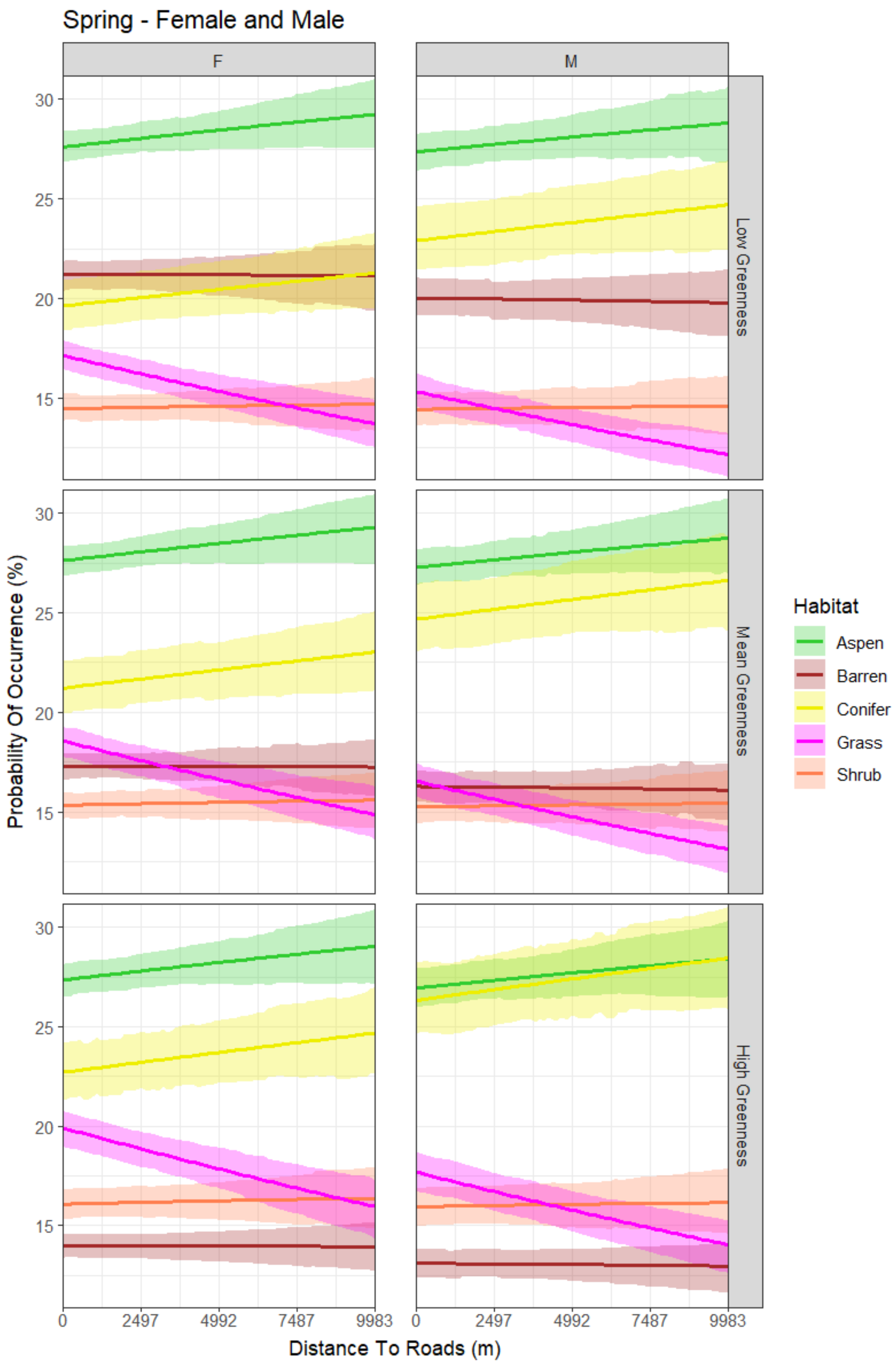


Figure 5: Occurrence probability of Grizzlies in relation to the distance to roads in Spring. Each step on the x-axis represents two standard deviations (1343.307 m) of the mean distance to facilities (1796.69 m). Low/high greenness is equivalent to two standard deviations subtracted or added to the mean greenness.

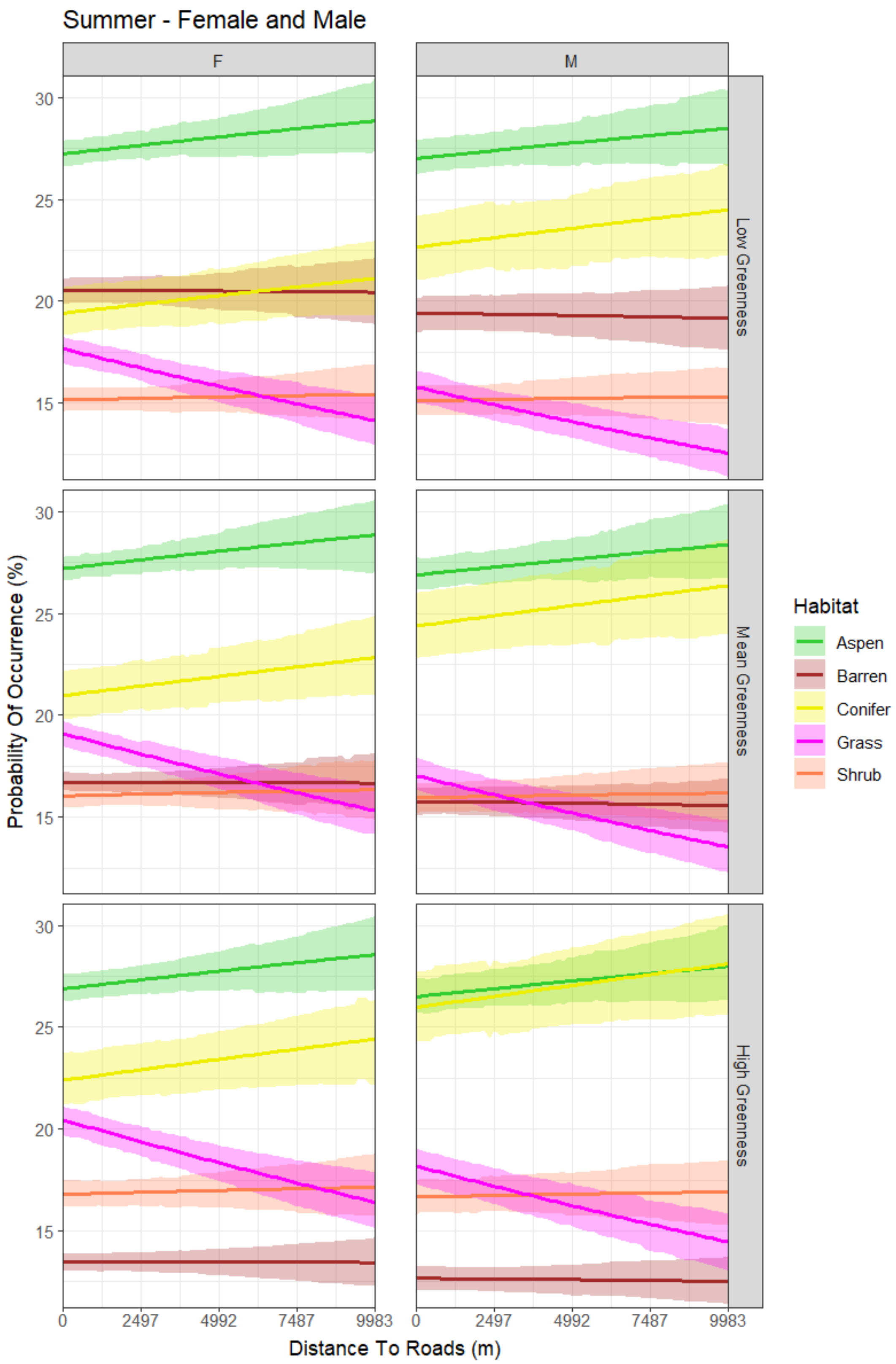


Figure 6: Occurrence probability of Grizzlies in relation to the distance to roads in Summer. Each step on the x-axis represents two standard deviations (1343.307 m) of the mean distance to facilities (1796.69 m). Low/high greenness is equivalent to two standard deviations subtracted or added to the mean greenness.

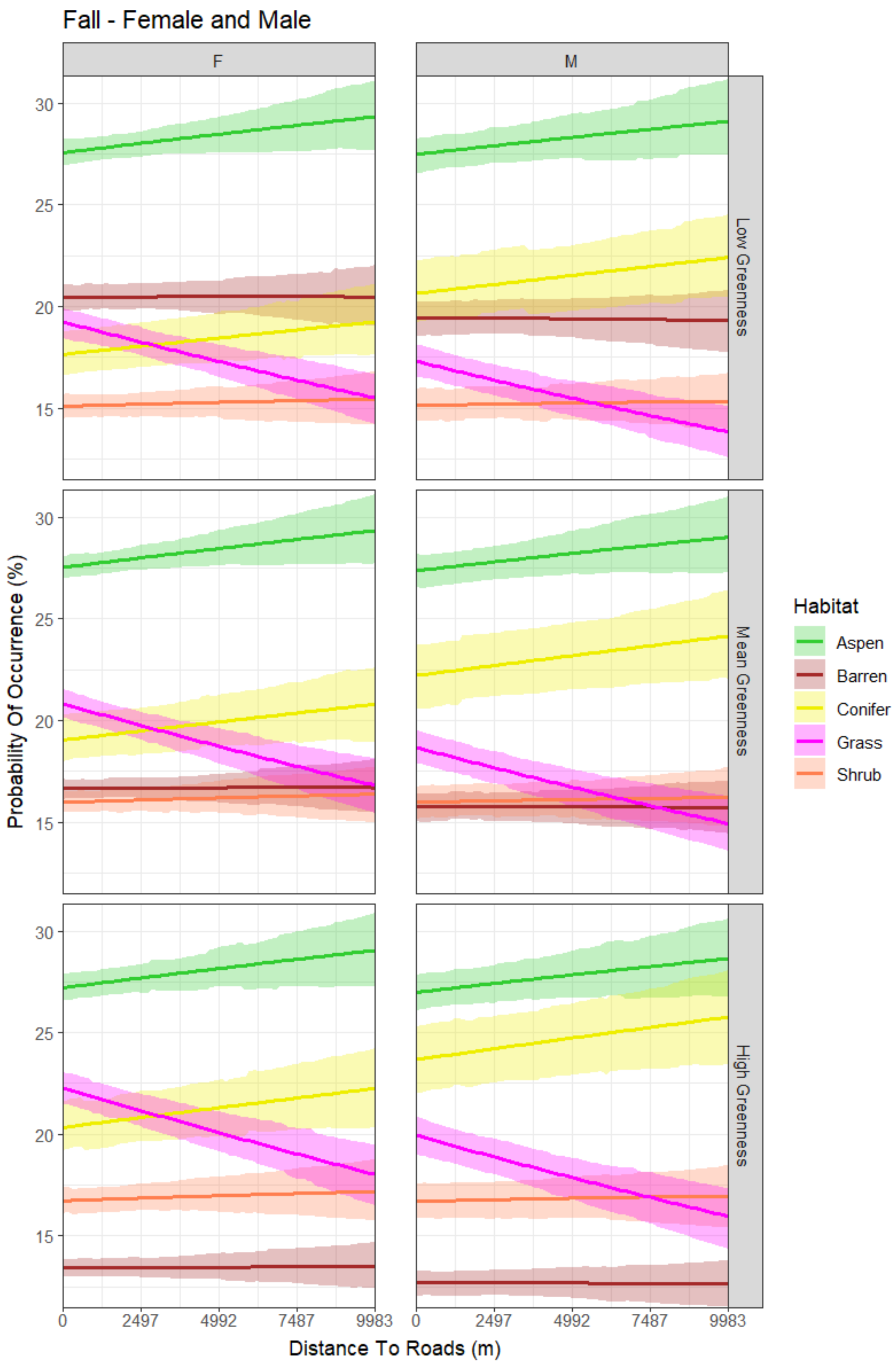


Figure 7: Occurrence probability of Grizzlies in relation to the distance to roads in Fall. Each step on the x-axis represents two standard deviations (1343.307 m) of the mean distance to facilities (1796.69 m). Low/high greenness is equivalent to two standard deviations subtracted or added to the mean greenness.

4.3. Distance to trails

Aspen, Conifer, and Grass habitats show a neutral relationship to the distance to trails, with changes below 1%. Shrub habitats, however, show a positive relationship with an increase in preference of about 4%, while Barren habitats show a decrease of approx. 3-4%. The greenness levels similarly show a positive effect on Conifer and Grass habitats, with increases up to 2.5%, whereas Barren habitats show a decrease of about 6-7% with increasing greenness (Figures 8-10).

Seasonal differences are subtle between Spring and Summer, generally around 1%. During Fall, preferences for Conifer habitats drop notably by around 2.5%, while preferences for Grass habitats increase by the same magnitude. Aspen, Barren, and Shrub habitats remain relatively stable across seasons, with changes below 1% (Figures 8-10).

Similarly to the distance to facilities and roads (Figures 2-7), male Grizzlies show a higher preference for Aspen and Conifer habitats overall. The preference is reduced in Fall, and male Grizzlies show an increased preference for Grass habitats instead (Figures 8-10). Furthermore, the greenness levels affect the preference between Barren, and Grass habitats, since lower greenness levels increase the preference for Barren habitats, while higher greenness levels increase the preference for Grass habitats (Figures 8-10). Female Grizzlies show a similar interaction between Conifer, Barren, and Grass habitats. But in contrast to male Grizzlies, females show an overall reduced preference for Conifer habitats (Figures 8-10).

As similarly observed with distance to facilities and roads (Figures 2-7), male Grizzlies tend to prefer Aspen and Conifer habitats, with a decrease in preference for Conifer during Fall by 2.5%, showing an increased preference for Grass instead by the same magnitude (Figures 8-10). Females show a similar pattern but have an overall reduced preference for Conifer habitats, favoring Grass and Barren habitats instead at lower greenness levels by approx. 2-3% compared to males (Figures 8-10).

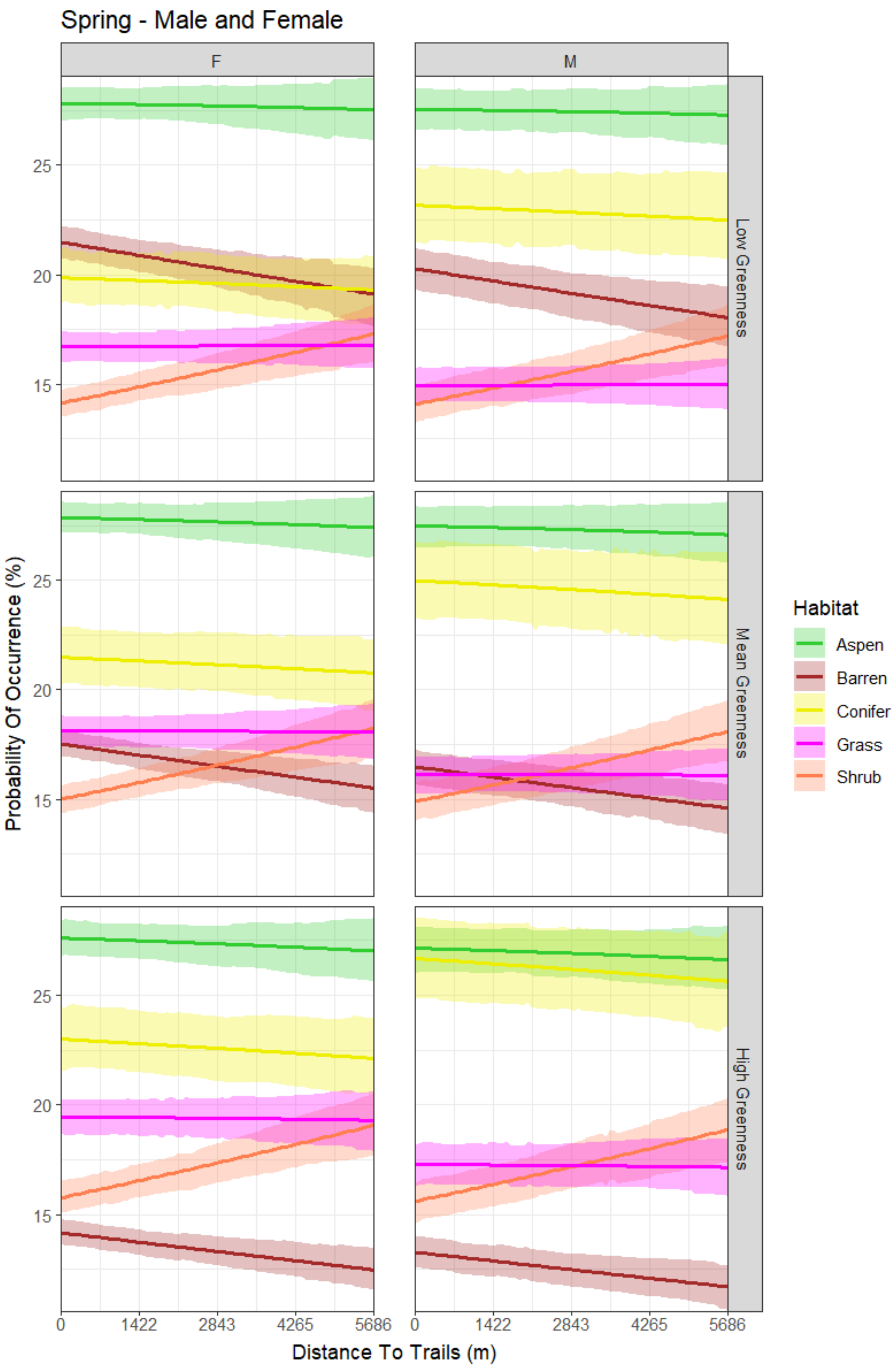


Figure 8: Occurrence probability of Grizzlies in relation to the distance to trails in Spring. Each step on the x-axis represents two standard deviations (1343.307 m) of the mean distance to facilities (1796.69 m). Low/high greenness is equivalent to two standard deviations subtracted or added to the mean greenness.

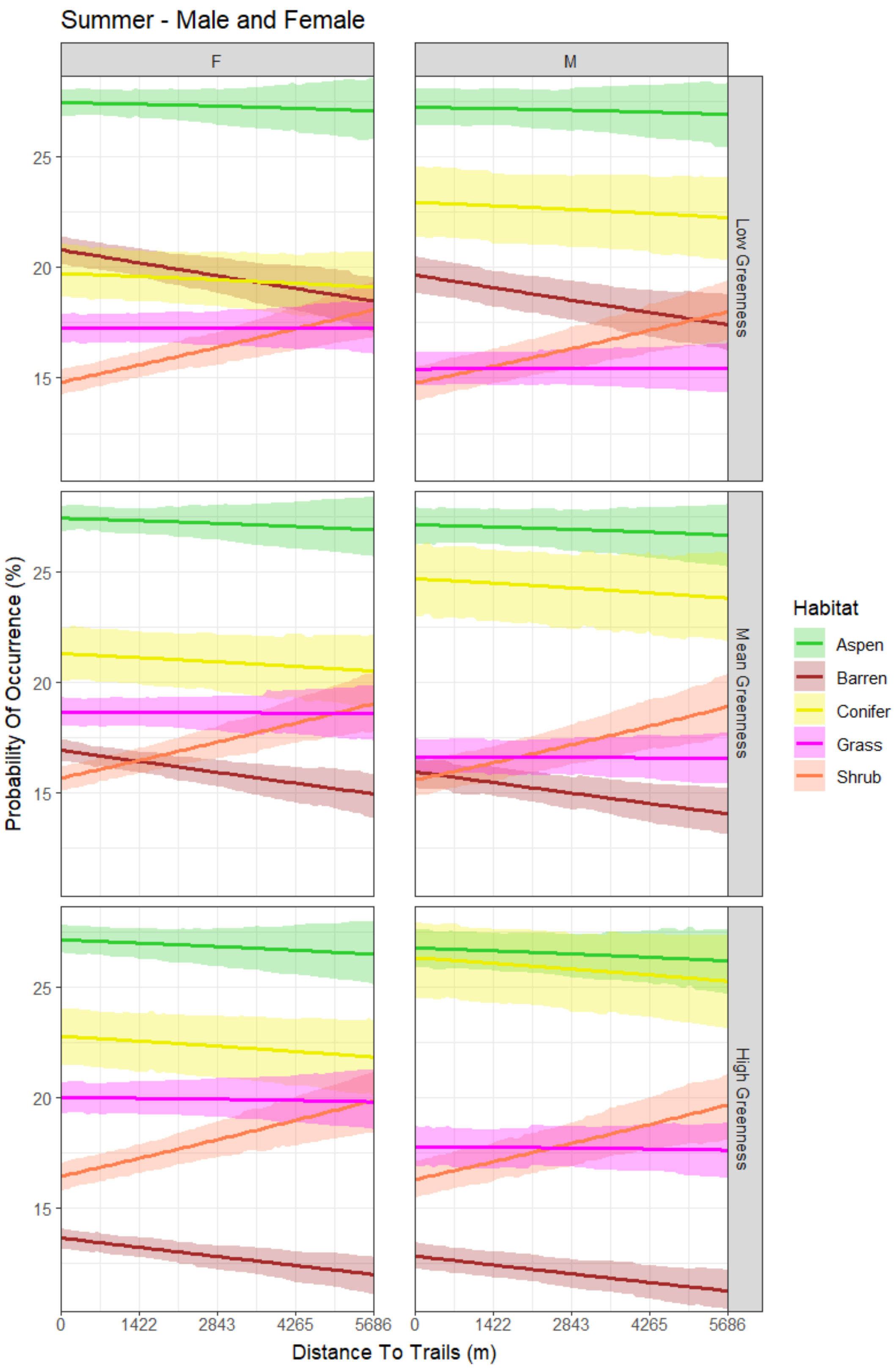


Figure 9: Occurrence probability of Grizzlies in relation to the distance to trails in Summer. Each step on the x-axis represents two standard deviations (1343.307 m) of the mean distance to facilities (1796.69 m). Low/high greenness is equivalent to two standard deviations subtracted or added to the mean greenness.

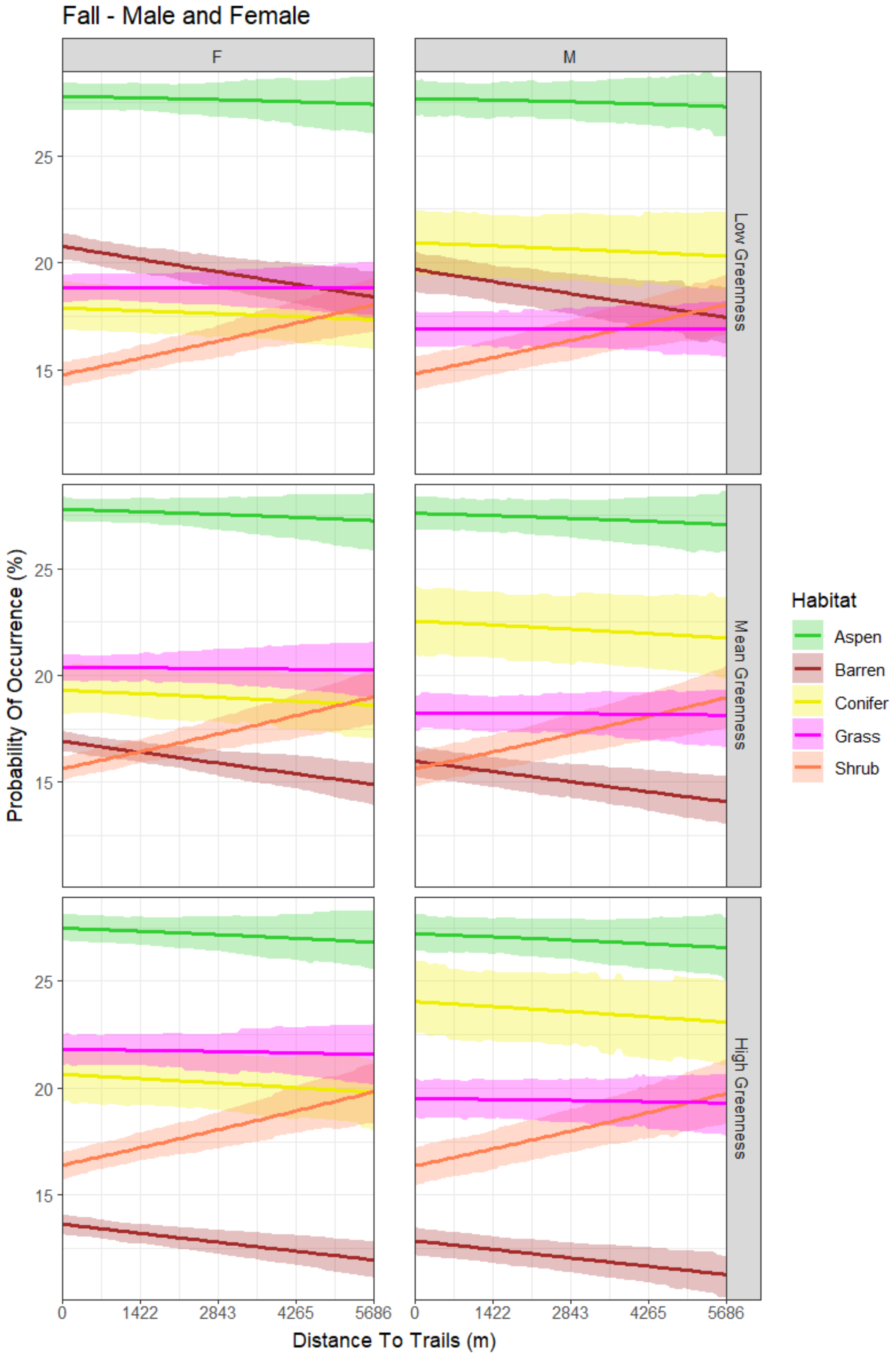


Figure 10: Occurrence probability of Grizzlies in relation to the distance to trails in Fall. Each step on the x-axis represents two standard deviations (1343.307 m) of the mean distance to facilities (1796.69 m). Low/high greenness is equivalent to two standard deviations subtracted or added to the mean greenness.

4.4. Summary

The habitat preferences of the studied Grizzlies vary with distance to facilities, roads, and trails, as well as across seasons and greenness levels. Overall, Aspen habitats are consistently favored by both sexes across all seasons, greenness levels, and anthropogenic structures, with preferences remaining above 25% across most conditions (Figures 2-10). Shrub habitats, on the other hand, turned out to be the least favored habitats, with preferences generally around 15%, unless greenness levels are high, where preferences increase by about 2-3%. Greenness also shows a notable negative relationship with the preference for Barren habitats, with preferences dropping by approx. 6-7% as greenness levels increase (Figures 2-10).

Preferences for Conifer habitats are particularly affected by the distance to facilities, showing a notable negative relationship with a decrease of 5-7%, whereas Grass habitats show a positive relationship, increasing by about 5-6% as distance to facilities increased (Figures 2-4). Grass habitats also show a negative relationship with the distance to roads, decreasing by around 4-5%. The distance to trails shows a positive relationship with preferences for Shrub habitats, increasing by about 4%, and a negative relationship for Barren habitats, with a decrease of approx. 3-4% (Figures 8-10).

Different levels of greenness affect the habitat preferences of both sexes. Both sexes show increased preferences for Conifer, Grass, and Shrub habitats with higher greenness levels, with increases up to 2-4%, while simultaneously showing a decreased preference for Barren habitats by 6-7% (Figures 2-10). Seasonal variations are subtle between Spring and Summer, but in Fall, both sexes show a decreased preference for Conifer habitats by 2.5%, while showing an increased preference for Grass habitats by the same magnitude (Figures 2-10). Finally, sexes differ in their habitat preferences. Male Grizzlies generally prefer Conifer habitats over Barren and Grass habitats by approximately 5%, while females favored Barren habitats at lower greenness levels and Grass habitats at higher greenness levels with differences of around 2.5-3% (Figures 2-10).

5. Discussion

This project aimed to study how anthropogenic structures affect Grizzly movement behavior by comparing the habitat preferences of male and female Grizzlies across the seasons (excluding Winter), five different habitat types, and three greenness levels. We analyzed the GPS data of 23 Grizzlies by utilizing a Bayesian Mixed Multinomial Logit model (Burda et al. 2008, Bansal et al. 2020).

In terms of habitat choice, our results provide insight into the general preferences of Grizzlies in Kananaskis Country (S2), Alberta. Our results show that our 23 studied Grizzlies preferred both forest habitats, Aspen and Conifer (Figures 2-10). Our methods did not allow us to visualize the exact location of the Grizzlies within the forest habitats, but according to (Tough and Butt 1993), Grizzlies generally prefer open areas such as forest edges. Since Grizzlies are known to be rather cautious towards humans (Craighead and Craighead 1971, Jope 1985, Tough and Butt 1993), forest habitats with high vegetation serving as potential cover in the case of encounters with humans might be favored for Grizzlies. The negative relationship between distance to facilities and habitat preference in forest habitats implies that both sexes prefer to be in high proximity to facilities when opportunities to hide from humans are given.

However, Grizzlies in Kananaskis (S2) are usually aware of humans, so it might also be reasonable to approach the habitat preferences from a foraging perspective. For instance, Grizzlies are known to be attracted by berries from *Vaccinium myrtilloides,* or *Shepherdia canadensis*, two exemplary plants growing throughout the majority of the range of Grizzlies (Figure 1), also being most abundant in forests (Noble 1985, Roever et al. 2008). We hypothesized that facilities may affect the foraging behavior of Grizzlies, and the preference of high proximity to facilities within forest habitats (Figures 2-4) may imply, that leftovers of human food contribute to attracting Grizzlies in that area. In terms of wildlife management, it might therefore be reasonable to remove Grizzly-attracting vegetation, and dispose human leftovers in an inaccessible way for Grizzlies at locations with a higher probability of frequently encountering humans.

Even though Grizzlies are known to exhibit a high preference for open Grass habitats, such as meadows (Tough and Butt 1993), our results only show a high preference by both sexes in these types of habitats at high distances to facilities (Figure 2-4), while showing at high proximity to roads instead (Figure 4-5). Road-sided Grizzlies are usually attracted by the typical vegetation of road-sided grass patches such as *Equisetum arvense* (MacHutchon and Wellwood 2003, Roever et al. 2008). Visitors that cause traffic jams in order to view and photograph Grizzlies are a well-known problem (Gunther 2015), and it might be reasonable to build up visual obstacles on roadsides in order to prevent these visitors from spotting road-sided animals in general.

In the case of Barren habitats, the increased preference of both sexes at high distances to facilities (Figures 2-4) might be related to the generally lower amount of infrastructure in alpine areas. The higher preference for Barren habitats in close proximity to trails (Figures 5-7) might be related to the lower amount of resistance present on trails (Knight 2021) in comparison to the rest of the rocky alpine terrain. These areas are less frequently visited by humans than facilities and roads, but this does not mean that encounters with wildlife are less likely. It is already a practical measure of wildlife conservational officers in Alberta to block certain trails during periods of high bear activity.

6. Conclusion

In terms of conservational matters, our results may come in helpful as recreational activities in Kananaskis Country, and Alberta in general, become increasingly popular for locals and tourists. For instance, our data provides information about potential measures before extending infrastructure without creating further conflicts with wildlife such as Grizzly Bears. Since our observed Grizzly Bears seemed to show a resource-driven selection for habitats, it might be reasonable to remove Grizzly Bear attracting vegetation at high proximity to facilities, where it is typically more likely to encounter humans.

Grizzly Bears in Kananaskis are usually aware of humans and habituated to their presence. Due to the high rate of traffic jams caused by visitors stopping mid-road to view and photograph animals, it might be reasonable to block the vision offside the road in order to prevent sighting of Grizzly bears for visitors driving by. Besides active matters, the only reasonable measure left to prevent wildlife-human conflicts is educating visitors on how to behave in Grizzly Bear territory properly. Encounters might be avoided that way or at least be prevented from escalating into aggressive encounters.

7. References

Alberta Wilderness Association, A. W. A. 2010. At the intersection of the grasslands and forests, the Parkland Natural Region is exceptionally diverse and also the least protected Natural Region within Alberta.

Alberta Wilderness Association, A. W. A. 2018. Kananaskis Country, a well-known wilderness destination along the southern Eastern Slopes, and home to the headwaters of the mighty South Saskatchewan River Basin.

Alberta Wilderness Association, A. W. A. 2021. Alberta Wilderness Association Annual Report 2020-2021.

AlbertaParks.ca | Alberta Parks. 2024. . https://www.albertaparks.ca/.

Bansal, P., R. Krueger, M. Bierlaire, R. A. Daziano, and T. H. Rashidi. 2020. Bayesian estimation of mixed multinomial logit models: Advances and simulation-based evaluations. Transportation Research Part B: Methodological 131:124–142.

Boulanger, J., and G. B. Stenhouse. 2014. The Impact of Roads on the Demography of Grizzly Bears in Alberta. PLOS ONE 9:e115535.

Burda, M., M. Harding, and J. Hausman. 2008. A Bayesian mixed logit–probit model for multinomial choice. Journal of Econometrics 147:232–246.

Bürkner, P.-C., J. Gabry, S. Weber, A. Johnson, M. Modrak, H. S. Badr, F. Weber, M. S. Ben-Shachar, H. Rabel, S. C. Mills, and S. Wild. 2023, September 25. brms: Bayesian Regression Models using "Stan."

Calenge, C., and contributions from S. Fortmann-Roe. 2023, April 6. adehabitatHR: Home Range Estimation.

Craighead, J. J., and F. C. Craighead Jr. 1971. Grizzly Bear - Man Relationships in Yellowstone National Park. BioScience 21:845–857.

Cui, Q., Y. Ren, and H. Xu. 2021. The Escalating Effects of Wildlife Tourism on Human–Wildlife Conflict. Animals 11:1378.

Draper, D. 2000. Toward Sustainable Mountain Communities: Balancing Tourism Development and Environmental Protection in Banff and Banff National Park, Canada. AMBIO: A Journal of the Human Environment 29:408–415.

Elmeligi, S., O. T. Nevin, J. Taylor, and I. Convery. 2021. Visitor attitudes and expectations of grizzly bear management in the Canadian Rocky Mountain National Parks. Journal of Outdoor Recreation and Tourism 36:100444.

Ford, A., K. Rettie, and A. Clevenger. 2010. Fostering ecosystem function through an international public-private partnership: A case study of wildlife mitigation measures along the Trans-Canada Highway in Banff National Park, Alberta, Canada. International Journal of Biodiversity Science & Management 5:181–189.

Fu, B.-J., S. Wang, C. Su, and M. Forsius. 2013. Linking ecosystem processes and ecosystem services. Current Opinion in Environmental Sustainability 5:4–10.

Giam, X. 2017. Global biodiversity loss from tropical deforestation. Proceedings of the National Academy of Sciences of the United States of America 114.

Gunther, K. 2015. Habituated Grizzly Bears: A Natural Response to Increasing Visitation in Yellowstone & Grand Teton National Parks. Yellowstone Science 23:33–39.

Jonkel, J. L., and T. J. Thier. 1993. A manual for handling bears for managers and researchers. U.S. Fish and Wildlife Service, Office of Grizzly Bear Recovery, Missoula, Mont.

Jope, K. L. 1985. Implications of Grizzly Bear Habituation to Hikers. Wildlife Society Bulletin (1973-2006) 13:32–37.

Juat, N., M. Meredith, and J. Kruschke. 2022, November 17. HDInterval: Highest (Posterior) Density Intervals.

Knight, K. 2021. Hiking trails ideal for sauntering grizzlies. Journal of Experimental Biology 224:jeb242520.

Locke, H. 1997. The Role of Banff National Park as a Protected Area in the Yellowstone to Yukon Mountain Corridor of Western North America. Pages 117–124 *in* J. G. Nelson and R. Serafin, editors. National Parks and Protected Areas. Springer, Berlin, Heidelberg.

Lotek.com | Lotek Wireless Inc. 2017, September 20. . https://www.lotek.com/.

MacHutchon, A. G., and D. W. Wellwood. 2003. Grizzly Bear Food Habits in the Northern Yukon, Canada. Ursus 14:225–235.

Messmer, T. 2009. Human-wildlife conflicts: Emerging challenges and opportunities. Human-Wildlife Conflicts 3.

Mirzaalian, F. 2021. Exploring Competitiveness of Nature-based Tourism Destinations Using Social Media Analytics: A Case Study of Jasper National Park.

Noble, W. 1985. Shepherdia canadensis: its Ecology, Distribution, and Utilization by the Grizzly Bear.

Proctor, M. F., B. N. McLellan, G. B. Stenhouse, G. Mowat, C. T. Lamb, and M. S. Boyce. 2020. Effects of roads and motorized human access on grizzly bear populations in British Columbia and Alberta, Canada. Ursus 2019:16–39.

Roever, C. L., M. S. Boyce, and G. B. Stenhouse. 2008. Grizzly bears and forestry: I: Road vegetation and placement as an attractant to grizzly bears. Forest Ecology and Management 256:1253–1261.

Schwartz, C., S. Miller, and M. Haroldson. 2003. Grizzly bear (Ursus arctos). Pages 556–586 Wild Mammals of North America: Biology, Management, and Conservation.

Soulsbury, C., and P. White. 2015. Human-wildlife interactions in urban areas: A review of conflicts, benefits and opportunities. Wildlife Research 42:541–553.

Tallis, H., and P. Kareiva. 2005. Ecosystem services. Current Biology 15:R746–R748.

Taylor, A., and R. Knight. 2003. Wildlife responses to recreation and associated visitor perceptions. Ecological Applications 13:951–963.

Taylor, W. P., H. V. Reynolds, and W. B. Ballard. 1989. Immobilization of Grizzly Bears with Tiletamine Hydrochloride and Zolazepam Hydrochloride. The Journal of Wildlife Management 53:978–981.

The Cementum Aging Wildlife Lab. 2024. . https://matsonslab.com/about-us/.

Tough, S. C., and J. C. Butt. 1993. A review of fatal bear maulings in Alberta, Canada. The American journal of forensic medicine and pathology 14:22–27.

Wade, P. R. 2000. Bayesian Methods in Conservation Biology. Conservation Biology 14:1308–1316.

8. Acknowledgements

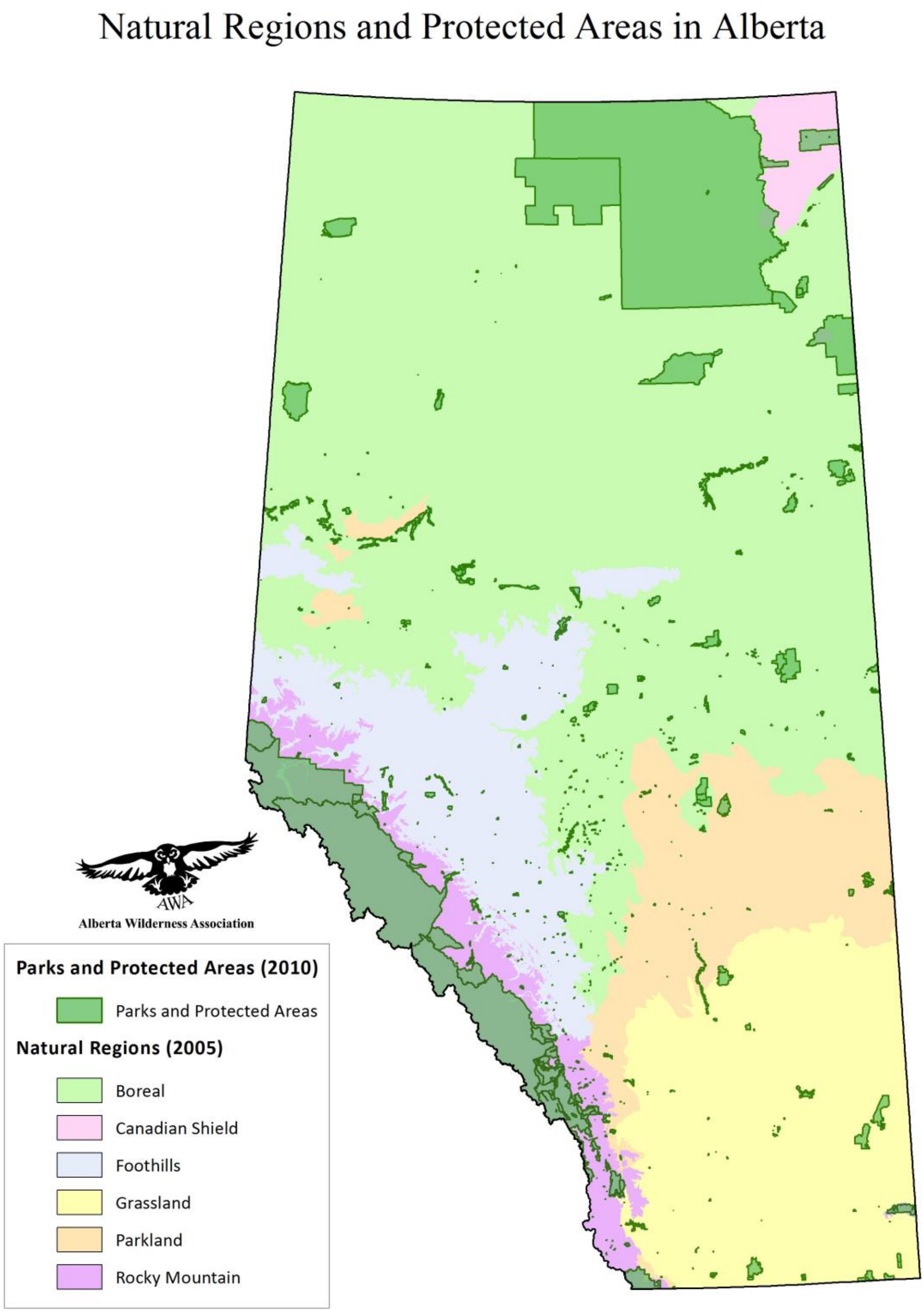
Dr. Jaime M. Anaya-Rojas – AG Kurtz, IEB Münster

M. Sc. Sean M. Konkolics – Government of Alberta

M. Sc. John Paczkowski – Government of Alberta

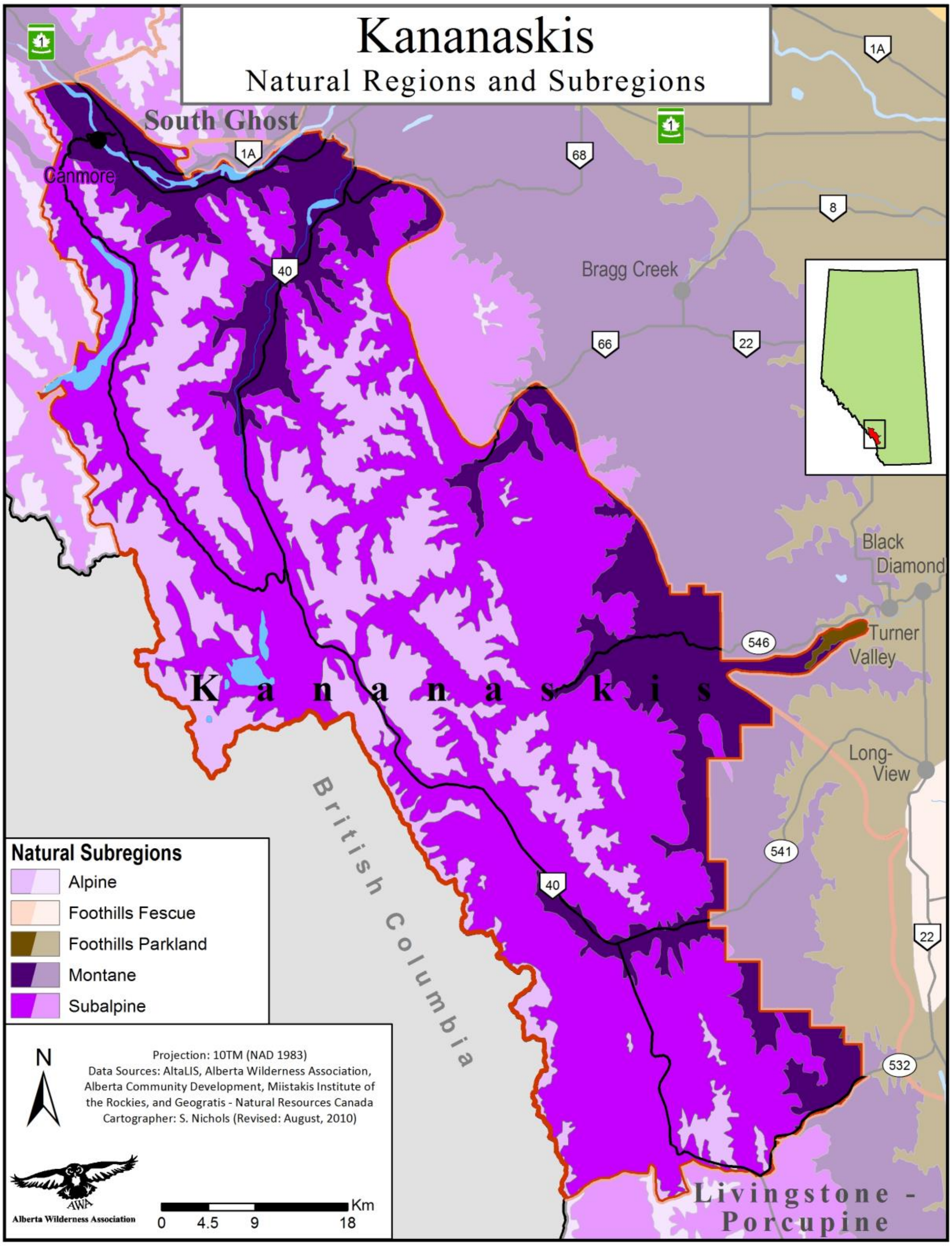
9. Supplements

S1 – Map of Alberta



S1: Map of Alberta, highlighting several designated areas. From (Alberta Wilderness Association 2010).

S2 – Map of Kananaskis Country



S2: Map of Kananaskis Country, highlighting the natural subregions and the location of Kananaskis Country within Alberta (S1). From (Alberta Wilderness Association 2018).