EVALUATING BEAR MANAGEMENT AREAS

IN YELLOWSTONE NATIONAL PARK

by

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DEDICATION

This work is dedicated to the people who have worked to ensure that future generations can experience wild places and wildlife. And to the animals that share a piece of their lives with us.

ACKNOWLEDGMENTS

One page is not long enough to express gratitude for everyone involved in this project. First, to the bears. Thank you for sharing part of your lives with us. I hope this work makes your world a better place. Andrea Litt, thank you for learning with me and providing a piece of humanity in this thing called academia. Your mentorship means the world to me. Kerry Gunther, I am grateful for your guidance in the field and your commitment to managing bears with the best available science. Thank you for encouraging my curiosity and answering my millions of questions. Frank van Manen, thank you for continually challenging my thinking and providing me with the tools to become a better ecologist. Jay Rotella, your direction in my first steps of grad school was extraordinarily helpful. To my honorary committee member, Mark Haroldson, I am grateful for your willingness to share your invaluable knowledge of bears in this ecosystem to improve this project. This work could not have been completed without the support of the Yellowstone Bear Management Office. Travis Wyman, I am grateful for your constant reminders that all work we do should benefit bears first and foremost, and for your gift of storytelling. Dylan Schneider and Justin Mills, I am grateful for your patience in the early days of field work and teaching me the intricacies of death metal. Field work as part of this project could not have been done without field technicians. Specifically, I would like to thank Isabelle Tiller, Hilary Zaranek, and Oscar Dalling. I would be remis to express my appreciation to Connor, Brenna, Carly, and Becca; the world is brighter because of each of you. To my parents Kathy and Chris, the days of counting plants and banding birds as a child instilled my love for the wild world. I am so grateful for your guidance through life. Kyle, the other half of my heart, maybe we can get in more skiing now. I am grateful for your support. This work was supported by grants from Yellowstone Forever, the Natural Resources Preservation program (U.S. Geological Survey, National Park Service), Yellowstone to Yukon, SITKA Gear, and the Meg and Bert Raynes Wildlife Fund, and scholarships honoring Jim Patton and Daniel Goodman.

VITA, AMERICAN INDIAN HERITAGE

Yellowstone was at times the home of many peoples, including the Nank'haanseine'nan (Northern Arapaho), Hohe Nakota (Assiniboine), Niitsítpiis-stahkoii (Blackfeet), Liksiyu (Cayuse) Tséstho’e (Cheyenne), Ojibwe (Chippewa), Schitsu’umsh (Coeur D'Alene), Nʉmʉnʉʉ (Commanche), Nēhiyaw (Cree), Apsáalooke (Crow), Dakȟóta (Dakota) A'aninin (Gros Ventre), Ka'igwu (Kiowa), Ktunaxa (Kootenai), Nimíipuu (Nez Percé), Séliš-Ql̓ispé (Salish), Boho'inee (Shoshone-Bannock), Tukudeka (Northern Shoshone), and the Očhéthi Šakówiŋ (Sioux). These lands were ceded to the U.S. in the Fort Bridger Treaty, Cession 398, Cession 619, and Cession 517. I acknowledge the genocide that occurred in part to create Yellowstone National Park, and I honor the connections and stewardship to this land that continues to this day.

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ABSTRACT

A growing body of research suggests large predators change their behavior near humans in ways that parallel how prey respond to predators; when outdoor recreation increases, avoiding humans becomes more difficult. Restricting human access to reduce detrimental effects of human-wildlife interactions can be an attractive management tool, however, rarely is the efficacy of such measures assessed. In 1982, Yellowstone National Park began instituting short-term, annual restrictions to areas of the backcountry containing important food resources for grizzly bears (*Ursus arctos*). These areas – Bear Management Areas (BMAs) – were intended to reduce human-caused disturbance of foraging bears and improve visitor safety. We sought to assess whether grizzly bears: 1) preferred BMAs with access restrictions more than other areas in YNP and 2) changed their response to sporadic (trail) and predictable (campsite) recreation sites depending on BMA access restrictions. We modeled resource selection of grizzly bears with step-selection functions, based on GPS locations from male and female bears collected from 2000 to 2020. Our analyses demonstrated that grizzly bears differentially selected BMAs, compared to areas outside BMAs, and that selection changed with sex and season. Bears likely prefer BMAs for the resources they contain more than to avoid people as only males changed their selection of BMAs based on access restrictions. Males avoided hiking trails during the day, but preferred trails at night. Females changed their selection of trails depending on human access restrictions and avoided trails in unrestricted BMAs. Combined with previous work, results suggest bears capitalize on the environment to avoid human presence, often with sex-specific strategies. For sporadic recreation, males temporally avoid the perceived risk of people whereas females spatially avoid the perceived risk of people. Although lower-intensity activities often are thought of as compatible with conservation, such recreation may be cryptic, but important, drivers of behavioral change in wildlife.

CHAPTER ONE

INTRODUCTION TO THESIS

Animals must consider the tradeoff between security and food resources: individuals that spend more time in low-risk areas may have less access to high-quality forage (Frid and Dill 2002). These effects are well documented in prey species and a growing number of studies have illustrated that large predators change their behaviors due to the perceived risk of humans (Lima and Dill 1990, Ordiz et al. 2013, Hertel et al. 2016, Suraci et al. 2019). Disturbance from recreation can force wildlife species into a trade-off between activities that avoid risk and those that increase fitness (Frid and Dill 2002, Smith et al. 2015). Some forms of recreation, such as hiking and horseback riding, are thought of as lower-intensity activities and therefore compatible with wildlife conservation, yet these human activities may be powerful drivers of behavioral change (Naylor et al. 2009, Darimont et al. 2015, Whittington et al. 2019, Naidoo and Burton 2020). When disturbance from recreation is predictable, large predators can alter when and where they are active, as a way to avoid people (Ordiz et al. 2011, Wang et al. 2017, Lamb et al. 2020). However, human activity that is sporadic and unpredictable may not allow animals to anticipate the disturbance, such that predators may instead react with general antipredator responses (Frid and Dill 2002, Ordiz et al. 2011). These shifts in activity patterns can reduce food acquisition by, and survival of, large predators (Hebblewhite et al. 2005, Lamb et al. 2020).

Behavioral changes will be amplified, given that there are 8 billion visits to natural areas annually and both recreation and ecotourism are increasing throughout the world (Cordell 2012, Balmford et al. 2015). As recreation increases, people may venture farther into wildland areas that provide high-quality habitat for animals, making outright avoidance of humans more difficult and energetically costly (Nickel et al. 2020). Restricting human access can be an attractive management tool to mitigate detrimental effects of human-wildlife interactions; such restrictions range from barriers that prohibit access to small areas to seasonal restrictions across landscapes. Despite some evidence that animals exhibit less stressful behaviors in areas with restricted human access, the effectiveness of these restrictions rarely is quantified (Coleman et al. 2013a, Larson et al. 2016).

In 1982, Yellowstone National Park (YNP) instituted short-term, annual restrictions to human access (henceforth, access restrictions) to areas thought to be important to grizzly bears (*Ursus arctos*; National Park Service [NPS] 1982, Gunther 1994). These Bear Management Areas (BMAs) were intended to reduce human-bear interactions in the backcountry (NPS 1982). These areas were established as a response to the listing of the grizzly bear population in the Greater Yellowstone Ecosystem (GYE) as threatened under the Endangered Species Act in 1975 and in concert with new bear management policies aiming to reduce human injuries by bears in the front-country (NPS 1982, Gunther 1994; Federal Register 40 FR:31734–31736). The NPS sought to meet 3 objectives with the implementation of BMAs: 1) to minimize bear-human interactions that could lead to the habituation of bears to people, 2) to prevent human-caused displacement of bears from prime bear food resources, and 3) to reduce bear-caused human injuries in areas with high levels of bear activity (NPS 1982). Bear Management Areas provide a unique opportunity to assess how grizzly bears respond to restrictions to recreation in backcountry areas.

Although BMAs were established, in part, because they contained important bear foods, the distribution and timing of these foods have since shifted. Fires burned about 58% of the park's area (YNP Spatial Analysis Center, unpublished data), the population of cutthroat trout (*Oncorhynchus clarkii*) declined by 90% (Koel et al. 2005, 2017), the elk (*Cervus canadensis*) population fluctuated and ultimately decreased by more than 60% (Barber-Meyer et al. 2008, White et al. 2016), ungulate carcasses are available year-round (following reintroduction of gray wolves [*Canis lupus*] in 1995) (Gunther and Smith 2004), and climate change has and will continue to alter the distribution and abundance of seasonally available foods (Notaro et al. 2019), like whitebark pine cones (Interagency Grizzly Bear Study Team [IGBST] 2013, Bjornlie et al. 2014, Costello et al. 2014). During this same time, the grizzly bear population in the GYE has increased from perhaps fewer than 250 to around 1000 individuals based on recently revised estimates (Eberhardt and Knight 1996; IGBST, unpublished data) and visitation to YNP has doubled, with over 4 million visitors every year since 2016 (NPS 2021). Over 90% of these visits occur between May and September, when bears are active (NPS 2021). Increases in both recreation and human population in the GYE warrant an assessment of the viability of access restrictions as a management tool.

Although many studies have characterized resource selection by grizzly bears, only 2 studies have assessed the effectiveness of BMAs (Gunther 1990; Coleman et al. 2013*a*, *b*).

These studies documented that 1) humans displace grizzly bears from high-quality food resources and 2) restricting recreation likely reduces human-bear interactions (Gunther 1990; Coleman et al. 2013*a*, *b*). Neither study quantified whether grizzly bears spend more time in BMAs relative to other backcountry areas. These findings provide a foundation to answer more nuanced questions regarding BMA restrictions and recreation sites in YNP. By understanding how grizzly bears change their movement and resource selection as a direct result of human presence, we can now assess whether the perceived risk of humans by bears persists in areas with different access restrictions and whether this perceived risk changes depending on predictable and sporadic patterns in recreation.

We sought to better understand whether grizzly bears preferred areas with access restrictions and how access restrictions influenced grizzly bear selection of recreation sites (e.g., trails, backcountry campsites) in YNP. We explored selection by grizzly bears of areas with access restrictions by examining 17 years of GPS telemetry data. Bear Management Areas were created to contain quality food resources, so bears may choose to spend time in BMAs, regardless of closure status, because these areas are intrinsically important. Alternatively, the status of restrictions (whether or not recreation is allowed) may determine whether bears choose to spend time in BMAs. Specifically, we were interested in whether bears preferred BMAs for the food resources or access restrictions and whether drought conditions or whitebark pine cone abundance changed bears' selection of restriction areas. Additionally, we assessed whether bears differed in their responses to sporadic and predictable human recreation and whether bears used space or time to avoid backcountry recreation sites.

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CHAPTER TWO

GRIZZLY BEAR RESPONSES TO RESTRICTIONS OF RECREATION IN YELLOWSTONE NATIONAL PARK

Contribution of Authors and Co-Authors

Manuscript in Chapter 2

Author: Elise A. Loggers

Contributions: Implemented the study, analyzed the data, wrote the manuscript

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Contributions: Guided study design, assisted with data analysis, extensive review of manuscript

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Grizzly bear responses to restrictions of recreation in Yellowstone National Park

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ABSTRACT Avoiding humans will be more difficult and energetically costly for animals as outdoor recreation increases and people venture farther into wildland areas that provide high-quality habitat for animals. Restricting human access to benefit wildlife can be an attractive management tool to mitigate detrimental effects of human-wildlife interactions, however, the efficacy of such measures rarely is assessed. In 1982, Yellowstone National Park (YNP) instituted short-term, annual restrictions of human access to areas thought to be important to grizzly bears (*Ursus arctos*) – Bear Management Areas (BMAs). We explored selection by grizzly bears of BMAs in YNP by examining 17 years of GPS telemetry data. We tested the overall hypothesis that bears spend time in places that allow them to avoid people and select quality food sources. We found support that grizzly bears differentially select BMAs, compared to areas outside BMAs, and that selection changed with sex and season. Only during the summer season and whitebark pine season (when bears seek cached whitebark pine cones) did males change their selection of BMAs based on whether access restrictions were active, and they preferred unrestricted BMAs. Our analyses indicate bears likely choose BMAs based on the resources they contain. Considerable variation of individual selection may help explain some uncertainty in our results. To our knowledge, this is the first study to demonstrate that bears change their resource selection based on short-term, annual restrictions of recreation within a landscape that already restricts human activity (e.g., hiking, horseback riding). Although these lower-intensity activities often are thought of as compatible with wildlife conservation, such recreation may change wildlife behavior in cryptic, but important ways.

KEY WORDS grizzly bear, *Ursus arctos,* resource selection, human restrictions, recreation, Yellowstone

Human activity in wildland areas affects animals directly, through human-caused mortality, and indirectly, by altering movement and behavior (Sinclair and Byrom 2006, Suraci et al. 2019, Nickel et al. 2020). Disturbance from recreation can force wildlife into a trade-off between activities that avoid risk and those that increase fitness (Frid and Dill 2002, Smith et al. 2015). Animals may respond to recreation through increased flight and vigilance (Stankowich 2008, Naylor et al. 2009), altered habitat selection in both space and time (Suraci et al. 2019, Nickel et al. 2020), increased physiological stress (Creel et al. 2002), and reduced reproductive success (Shively et al. 2005). Some forms of recreation, such as hiking and horseback riding, are thought of as lower-intensity activities and therefore compatible with wildlife conservation, yet these activities may change wildlife behavior in cryptic, but important, ways (Naylor et al. 2009, Darimont et al. 2015, Whittington et al. 2019, Naidoo and Burton 2020).

Behavioral changes will be amplified, given that there are 8 billion visits to natural areas annually and both recreation and ecotourism are increasing throughout the world (Balmford et al. 2015). As recreation increases, people venture farther into wildland areas that provide high-quality habitat for animals, making outright avoidance of humans more difficult and energetically costly (Nickel et al. 2020). Restricting human access can be an attractive management tool to mitigate detrimental effects of human-wildlife interactions; such restrictions range from barriers that prohibit access to small areas to seasonal restrictions across large landscapes. When human access has been excluded from areas occupied by species such as fur seals and shorebirds, animals display fewer stress-related behaviors and expand into areas where human activity previously occurred (Cassini 2001, Burger and Niles 2013). Despite some evidence that restricting human access benefits wildlife, the effectiveness of these restrictions rarely is quantified (Coleman et al. 2013a, Larson et al. 2016). Further, the few studies that have evaluated behavioral changes of wildlife in response to recreation restrictions have not focused on protected areas that have preservation mandates (Cassini 2001, Larson et al. 2016, Lamb et al. 2018).

Protected areas around the world allow very different intensities of human activity from high-intensity resource extraction to only low-intensity recreation (e.g., hiking, horseback riding). In the U.S., the National Park Service (NPS) is a land management agency that operates under a directive to provide enjoyment for people while simultaneously preserving species and landscapes for future generations (NPS Organic Act in 1916. 16 U.S.C. §1; Watson et al. 2014). The NPS attempts to balance this conflicting mandate by mainly allowing low-intensity activities across its lands (NPS 2015). Limiting recreation to low-intensity activities may contribute to the agency's outsized effect on the management of species in the United States. The NPS is responsible for stewardship of nearly 25% of the threatened or endangered species in the United States, yet NPS lands account for only 3% of the country's land area (Ament et al. 2008, NPS 2021a, U.S. Census Bureau 2021). Research focused on recreation in protected areas, such as land managed by the NPS, is important to preserve landscapes for large animals that require large areas to roam (Hebblewhite et al. 2021).

In 1982, Yellowstone National Park (YNP) instituted short-term, annual restrictions to human access (henceforth, access restrictions) to areas thought to be important to grizzly bears (*Ursus arctos*; NPS 1982, Gunther 1994). These Bear Management Areas (BMAs) intended to reduce human-bear interactions in the backcountry (Fig. 2.1, Appendix A Table A.1; NPS 1982). Biologists selected these areas because they contained calorie-rich bear foods such as: Yellowstone cutthroat trout (*Oncorhynchus clarkia*), bison (*Bison bison*), elk (*Cervus canadensis*), pocket gophers (*Thomomys talpoides*), whitebark pine (*Pinus albicaulis*, whose cones can be an important late summer-fall food), and other diverse and lush vegetation (Table

2.1; K. A. Gunther personal communication, NPS 1982). Additionally, these areas encompassed locations with high densities of bears and where females consistently produced cubs (Table 2.1; K. A. Gunther personal communication, NPS 1982). Bear Management Areas were established as a response to the listing of the grizzly bear population in the Greater Yellowstone Ecosystem (GYE) as threatened under the Endangered Species Act in 1975 and in concert with new bear management policies intending to reduce human injuries by bears in the front-country (NPS 1982, Gunther 1994, Federal Register 40 FR:31734–31736). The NPS sought to meet 3 objectives with the implementation of BMAs: 1) to minimize bear-human interactions that could lead to the habituation of bears to people, 2) to prevent human-caused displacement of bears from prime bear food resources, and 3) to reduce bear-caused human injuries in areas with high levels of bear activity (NPS 1982). Bear Management Areas provide a unique opportunity to assess how grizzly bears respond to restricting recreation in backcountry areas.

Although BMAs were established, in part, because they contained important bear foods, the distribution and timing of these foods have since shifted. Fires burned about 58% of the park's area (YNP Spatial Analysis Center, unpublished data), the population of cutthroat trout (*Oncorhynchus clarkii*) declined by 90% (Koel et al. 2005, 2017), the elk (*Cervus canadensis*) population fluctuated and ultimately decreased by more than 60% (Barber-Meyer et al. 2008, White et al. 2016) while the bison population increased (NPS 2021c), ungulate carcasses are available year-round following reintroduction of gray wolves (*Canis lupus*) in 1995 (Gunther and Smith 2004), and climate change has and will continue to alter the distribution and abundance of seasonally available foods (Kokaly et al. 2003), like whitebark pine (Interagency Grizzly Bear

Study Team [IGBST] 2013, Bjornlie et al. 2014, Costello et al. 2014). During this same time, the grizzly bear population in the GYE has increased from perhaps fewer than 250 to around 1000 individuals based on recently revised estimates (Eberhardt and Knight 1996; IGBST, unpublished data) and visitation to YNP has doubled, with over 4 million visitors every year since 2016 (NPS 2021b). Over 90% of these visits occur between May and September, when bears are active (NPS 2021b). Increases in both recreation and human population in the GYE warrant an assessment of the viability of closure areas as a management tool.

Although many studies have characterized resource selection by grizzly bears, only 2 studies have assessed the effectiveness of BMAs (Gunther 1990; Coleman et al. 2013*a*, *b*). These studies demonstrated that humans displace grizzly bears from high-quality food resources and restricting recreation likely reduces human-bear interactions (Gunther 1990; Coleman et al. 2013*a*, *b*). However, neither quantified whether grizzly bears spend more time in BMAs relative to other backcountry areas.

We explored selection by grizzly bears of areas with access restrictions in YNP by examining 17 years of GPS telemetry data. We tested the overall hypothesis that bears spend time in places that allow them to avoid people and select quality food sources (Table 2.2). Thus, we predicted that bears would prefer (selection coefficient >0) areas where human access was completely restricted. However, BMAs were delineated primarily based on quality and availability of food resources, so bears may choose to spend time in BMAs, regardless of restriction status, because these areas are intrinsically important. Alternatively, the status of restrictions (whether recreation is allowed) may determine whether bears choose to spend time in BMAs. To better understand this differentiation, we assessed 1) whether bears preferred BMAs due to their intrinsic importance (even if restrictions were not in place), comparing BMAs with areas that are never restricted (non-BMAs) or 2) whether bears chose areas based on the status of access restrictions, comparing BMAs with active restrictions (restricted BMAs), BMAs without active restrictions (unrestricted BMAs), and areas that are never restricted (non-BMAs, Table 2.2). Understanding whether bears change their behavior based on quality foods (regardless of closure status) or due to the status of closures will help discern what trade-offs bears make when spending time in different areas. Finally, we explored whether selection for BMAs changes based on other factors, such as drought and abundance of whitebark pine cones (Table 2.2). Our work seeks to understand how grizzly bears navigate additional access restrictions within an already protected area.

STUDY AREA

We studied grizzly bears in YNP, Wyoming. YNP comprises 8991 km^2 mainly in northwest Wyoming, with some areas in Montana and Idaho (NPS 2019a). YNP includes several large plateaus bordered by rugged mountains in the north, east and south. Spruce-fir (*Picea* spp., *Abies* spp.) and lodgepole pine (*Pinus contorta*) forests cover most of YNP, but extensive sagebrush (*Artemisia* spp.) and grassland vegetation occur on high-elevation plateaus and in low-elevation valleys (Despain 1990).

Unlike other large carnivores, grizzly bears, black bears (*Ursus americanus*) and coyotes (*Canis latrans*) have never been extirpated from YNP. Mountain lions (*Puma concolor*) recolonized on their own and wolves were reintroduced in 1995. Although populations of grizzly bears, black bears, wolves, and mountain lions have increased, the coyote population has decreased since the mid-1990s (Barber-Meyer et al. 2008, White et al. 2016, Ruth et al. 2019, Haroldson et al. 2020). Eight species of ungulates also occur in YNP: elk, bison, moose (*Alces alces*), mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), pronghorn (*Antilocapra americana*), mountain goats (*Oreamnos americanus*), and bighorn sheep (*Ovis canadensis*). Ungulate populations in YNP have fluctuated over time and management efforts limit the bison population to between 2,400 and 5,500 individuals (NPS 2021c).

In 1982, YNP began short-term annual restrictions of human access to BMAs – areas identified as important to grizzly bears (Fig. 2.1, Appendix A Table A.1; NPS 1982). Biologists chose BMA boundaries by identifying areas with high densities of grizzly bears and areas that held important foods for bears, including winter-killed ungulate carcasses, pocket gophers, lush vegetation, summer-fall range for elk, whitebark pine, spawning streams for cutthroat trout, and areas of vegetation that are free from snow early in the year (Table 2.1; NPS 1982). The 16 BMAs currently encompass approximately 21% (188,032 ha) of YNP (Fig. 1; Coleman et al. 2013a).

In BMAs, access restrictions include complete closures, limits to the timing (day-use-only) or type of activities (on-trail-travel only), as well as specifications to the number of nights and type of recreation (stock, people) in backcountry campsites (NPS 1982). Time-of-day restrictions limit travel to daytime (0900 to 1900) hours. In 3 BMAs, people can stay at backcountry campsites along Yellowstone Lake, but may not travel away from these campsites

(NPS 2019b). The timing of BMA restrictions differs among BMAs (Appendix A Table A.1), but when restricted, human activity in BMAs seldom occurs.

METHODS

Capture and Collaring

The Interagency Grizzly Bear Study Team (IGBST) captured grizzly bears annually from 2000 to 2020 using culvert traps and Aldrich leg-hold snares (Blanchard 1985). Capture activities followed approved protocols to conform with the Animal Welfare Act (U.S. Geological Survey Animal Care and Use Committee protocol #201201) and were conducted under a U.S. Fish and Wildlife Service Endangered Species Permit [Section (i) C and D of the grizzly bear 4(d) rule, 50 CFR17.40(b)], with additional NPS research permits in Yellowstone and Grand Teton national parks and state research permits in Montana, Idaho and Wyoming. We used locational data collected from GPS-enabled radio collars (Telonics, Mesa, Arizona, USA). Collars recorded programed fixes at different time intervals ranging from 13 to 208 minutes. We performed all analyses on GPS data from on-board memory downloaded after collar retrieval. We excluded 2- and 3-dimensional GPS fixes with PDOP >10 and horizontal error >125 m (D'Eon and Delparte 2005).

Defining Seasons

Grizzly bears select for different resources throughout the non-denning period (April – October; Nielsen et al. 2004, 2010, Zeller et al. 2019, McClelland et al. 2020), so we created ecologically-based seasons using methods of Basille et al. (2013) (Appendix B). This approach incorporates both environmental and movement variables to account for changes in bear behavior based on food availability and life history (Basille et al. 2013). Seasons were defined using both male and female bears to enable comparisons between sexes, based on data from bears with a 105-minute fix interval to standardize speed and turn angles. We calculated the speed and turn angle between consecutive locations using the speed and ta_ functions in the amt package (Signer et al. 2019). For each location, we determined the vegetation landcover type and elevation using the extract function in the Raster package (Hijmans 2020). Then we calculated the Euclidean distance to the nearest forest edge with the st_distance function in the sf package (Pebesma 2018). We centered and scaled all continuous variables (speed, turn angle, elevation, and distance to edge). We smoothed environmental and movement data based on an 11-day moving window. We used k-means clustering to identify similar observations in multivariate space and used the weighted gap statistic to select the number of clusters (Basille et al. 2013). The weighted gap statistic weights within cluster homogeneity by averaging the sum of pairwise distances between all points in a cluster to reduce the potential of overestimating the number of clusters (Basille et al. 2013). These clusters encompassed a series of days which were combined to create a season. We delineated six ecologically-based seasons when bears had similar activity patterns in space: post denning (March 15 - April 6); spring (April 7 – April 30); mating (May 1 to June 29); summer (June 30 – August 10); whitebark pine (August 11 – October 3); and fall (October 4 until denning). We developed season-specific, step-selection functions for 3 of these seasons (mating, summer, whitebark pine) as these are the seasons with highest park visitation (NPS 2021b). We conducted all analyses in R version 4.0.4 (R Core Team 2021).

Two Stages of Analysis

Overview. – We used a 2-stage analysis to quantify grizzly bear responses to short-term, annual access restrictions. In stage I, we used ecological variables to create step-selection functions for grizzly bears, with different models for each sex (male and female) and season combination. In stage II, we used these ecological models as the foundation to test our hypotheses about BMAs. To do this, we added categorical variables representing potential intrinsic importance of BMAs and restriction status of BMAs to evaluate whether these factors could further explain the patterns of resource selection by grizzly bears. We also explored hypotheses about whether drought or whitebark pine cone abundance influence selection of BMAs by grizzly bears. This multi-stage approach allowed us to characterize and account for overall resource selection by grizzly bears and then make inferences about our specific variables of interest.

For both stages of analysis, we focused on fine-scale resource selection using step-selection functions (Thurfjell et al. 2014). The matched-point design inherent to step-selection functions pairs each used location with at least 1 available location (Thurfjell et al. 2014). We accounted for the movement of bears in availability by simulating available locations from distributions of an individual's turn angles and step lengths (Signer et al. 2019). We classified an individual as a unique bear-year. We generated 10 available locations for each used location using the random_steps function in the amt package (Signer et al. 2019), which randomly selects locations based on a gamma distribution of an individual's step lengths and a von Mises distribution of an individual's turn angles (Signer et al. 2019). Creating available locations from an individual's movements minimizes autocorrelation issues common with spatial and temporal data and allows variable values to change as the animal moves (Avgar et al. 2016, Signer et al. 2019). Due to the variety in the frequency of GPS locations recorded and the requirement of consistent fixes in step-selection functions, we subsampled the data to include only consecutive fixes that were within 90 to 120 minutes and only included individuals with at least 100 fixes (equaling one week of monitoring) in each season.

We followed the modeling approach outlined by Muff et al. (2020) and Duchesne et al. (2010). We used conditional Poisson mixed models with stratum-specific intercepts, which compare temporally correlated matched pairs. The variance of stratum-specific intercepts was fixed to 10,000 to avoid shrinkage (Muff et al. 2020). The parameter estimates and standard errors resulting from these models are likelihood-equivalent (Duchesne et al. 2010, Muff et al. 2020). We included a random intercept for each individual (Muff et al. 2020). We included random slopes for covariates of resource selection to account for variation in individual selection. This also reduces bias in availability and allow for more robust population-level estimates of fixed effects when modeling step-selection functions (Gillies et al. 2006, Hebblewhite and Merrill 2008, Duchesne et al. 2010, Muff et al. 2020). During the first stage of analysis, we evaluated the inclusion of random slopes on covariates of step-selection using likelihood-ratio tests (Zuur et al. 2009). We compared the iterative random coefficient structures estimated with restricted maximum likelihood (Zuur et al. 2009). During the second stage of analysis, we included random slopes on BMA variables for each sex-season combination. We used the package glmmTMB to fit all models (Brooks et al. 2017).

Stage I: Ecological Models. – To create our initial ecological models, we included variables known or hypothesized to influence resource selection by grizzly bears such as landcover, terrain, and anthropogenic attributes. We measured all distances using st_distance in the sf package (Pebesma 2018). Distributions of plant species can affect where grizzly bears occur, so we included categories of vegetation cover to account for important food resources (Table 2.1; McClelland et al. 2020). Grizzly bears often forage and seek refuge (i.e., daybed) near the interface between forest and open areas, so we created a distance to nearest forest edge raster; we assigned negative distance values to locations in the forest and positive values to non-forested areas (Peck et al. 2017). We quantified distance to nearest water given that water sources are important for bears to thermoregulate (Rogers et al. 2021), find foods such as spawning trout (Haroldson et al. 2005), consume succulent vegetation (Tiesberg et al. 2014), and travel along (Wilson et al. 2005). Terrain features and topography affect the movement of bears (Carnahan et al. 2021); we included Terrain Roughness Index (TRI), aspect, elevation, and slope rasterized from a Digital Elevation Model with a 30-m resolution to account for variation in landscape permeability. To account for changes in resource selection due to roadways and developments, we included the nearest Euclidean distance to anthropogenic areas, with negative distance values associated with locations inside developments.

Bears often direct their movements towards a carcass using olfactory cues (White et al. 2017). Due to human and carnivore safety considerations, YNP biologists move wildlife carcasses resulting from vehicle strikes, natural deaths, or management actions in developments and road corridors to 9 carcass-redistribution sites. We created a GIS layer for carcass-redistribution sites in YNP to account for the influence of this concentrated, high-quality food. First, we added a 400-m radius buffer around the center of a carcass-redistribution site to account for subordinate bears who may visit a carcass opportunistically throughout a feeding event (Ebinger et al. 2016). We classified a feeding event as beginning at the location just before the bear entered the buffer of the carcass-redistribution site and ending with the location just after the bear left the buffered area; a feeding event included at least 2 GPS locations within the buffered area within 24 hours. This approach allowed bears to revisit a carcass-distribution site multiple times within a feeding event. We defined the spatial extent of a carcass-redistribution site based on the area where 90% of all feeding-event locations occurred; we then assigned a Boolean value depending on whether the location fell within (1) or outside (0) the defined carcass-redistribution site. We examined correlations between pairs of continuous covariates and removed elevation due to relationships with distance to anthropogenic, distance to water and TRI (R >0.6). All continuous covariates (distance to anthropogenic, distance to water, TRI, distance to edge) were centered and scaled.

To select the ecological model that best explained the variation in grizzly bear step-selection, we developed separate model suites for each combination of sex and season. We considered models with all possible additive combinations of vegetation cover, distance to forest edge, distance to water, TRI, aspect, distance to anthropogenic, and carcass redistribution site. We compared models for each sex and season based on Akaike's Information Criterion corrected for small sample size (AICc), calculated using the MuMIn package (Burnham and Anderson 2002, Barton 2020). We used the top model from this first stage of analysis as the foundation to test our BMA hypotheses (Appendix C Tables C.1 – C.6)

Stage II: BMA Models. – In the second stage of analysis, we tested our hypotheses related to BMAs by adding combinations of 4 covariates (intrinsic BMA, BMA status, whitebark pine cone abundance, drought) to the ecological model from stage I (Table 2.3). As we were interested in testing the nuanced selection of BMAs, we added an intrinsic BMA variable (categorical: BMA at any time or non-BMA) or a BMA status variable (categorical: non-BMA [areas outside of BMAs], unrestricted BMA [BMA open to human access], or restricted BMA [BMA closed to human access]). For BMAs with recreation restricted to only on-trail travel, we categorized areas with 200 m of trails as unrestricted BMA and areas father than 200 m from trails as restricted BMA (Appendix C Tables C.7 – C.8). We used 200 m to delineate a zone of influence around backcountry trails in YNP as bears change their movements at 80 m to 1000 m from roads, which allow motorized access unlike trails (Proctor et al. 2019, Parsons et al. 2020).

We also were interested in examining whether grizzly bears change their selection of BMAs based on other factors, namely whitebark pine cone abundance or drought severity (Table 2.2, 2.3). To explore these ideas, we included interaction terms for each of these 2 factors with each of the 2 BMA variables (intrinsic BMA and BMA status). Whitebark pine are a masting species and grizzly bears consume the seeds from their cones during the fall (August 15 to September 30; Costello et al. 2014). However, abundance of whitebark pine has declined due to white pine blister rust and mountain pine beetle which cause tree mortality (Jewett et al. 2011). We categorized abundance of whitebark pine cones by year based on cone count surveys conducted by the NPS in YNP (Haroldson et al. 2004, Haroldson 2020). Years classified as “abundant” whitebark pine were above the cumulative median value, whereas “scarce” years were below the cumulative median value of cones per tree (Haroldson and Gunther 2013). We included interaction terms with whitebark pine cone abundance in models for the whitebark pine season which overlaps with when grizzly bears consume these foods (Appendix C Tables C.9 – C.10; August 15 – September 30; Costello et al. 2014). Given that whitebark pine stands occurs within some BMAs, we predicted that grizzly bears would increase their selection of BMAs during years with abundant whitebark pine cones, compared to scarce years (Haroldson et al. 2004).

Since BMA establishment, climate change has altered the distribution and phenology of plants in YNP (Notaro et al. 2019), so we tested whether selection of BMAs changed depending on relative drought severity. We classified drought severity based on monthly values for the Palmer Drought Severity Index (PDSI) (Palmer 1965; provided by A. Enriquez, University of Wyoming). We predicted that selection of BMAs would be greater during periods of drought, given that BMA boundaries were created to encompass important vegetative foods for grizzly bears.

We compared 7 models for each season and sex combination to determine the model that best explained resource selection by grizzly bears (Table 2.3). We only included PDSI and whitebark pine cone abundance as an interaction with BMA variables, given that values for these variables do not differ between used and available locations (Street et al. 2016). Our model suite included the ecological model without additional covariates, as a benchmark model, so we could test whether the addition of BMA-related variables better explained variation in resource selection. We compared models using AICc, calculated using the MuMIn package (Burnham and Anderson 2002, Barton 2020)

RESULTS

Grizzly Bear Spatial Data

We obtained 280,353 useable GPS locations from 116 bears collared from 2004 to 2020. After standardizing fix-interval among bears and reducing fixes to only those occurring in the mating, summer, and whitebark pine seasons, these GPS locations provided data for 39,148 used steps from 56 bear-years (35 male bear-years, 21 female bear-years). For males, each season included 3,939 to 8,567 usable GPS locations from 15 to 24 bear-years. We obtained 5,441 to 9,312 points from 14 to 18 female bear-years per season. We matched these used locations with 391,480 available locations (1 used:10 available). The importance of different resources changed across seasons and sexes, resulting in different ecological models (Table 2.4, Appendix C Table C.1 – C.6).

BMA Models

For females during the mating and summer seasons and for males during all seasons, we found support that grizzly bears differentially selected BMAs, compared to areas outside BMAs; the benchmark ecological model was never among competing models (Table 2.5). Additionally, male grizzly bears differentially selected areas based on the status of BMA restrictions; a model including the BMA status variable held the most support in 2 of the 3 seasons (Table 2.5). We found less evidence that bears changed their selection of BMAs based on other factors;

competing models included interactions with drought and whitebark pine cone abundance, but these variables were never in the model with the most support (Table 2.5). Below we present estimates and detailed findings from the top models for each sex-season combination (Table 2.5, Appendix C Table C.11).

Females. – Females preferred BMAs to non-BMAs in the mating and summer seasons (Appendix C Table C.11). Female grizzly bears were 1.3 times (95% CI = 1.0 to 1.8) as likely to be in a BMA during the mating season and 1.2 times (0.8 to 2.0) during the summer season, compared to non-BMAs (Appendix C Table C.11). During the whitebark pine season, patterns of selection were less clear, given that as the ecological model was among competing models. However, based on the most supported model, female bears were 1.2 times (0.8 to 1.9) as likely to be in BMAs compared to non-BMAs (Appendix C Table C.11). We also found some evidence that females' patterns of selection of BMAs also may depend on drought; an interaction between intrinsic BMA and drought was included in competing models in all seasons (Table 2.5).

Males. – Males preferred BMAs to areas outside of BMAs in all seasons (Appendix C Table C.11). We also found support that male grizzly bears changed their selection based on the restriction status of BMAs in the summer and whitebark pine seasons (Table 2.5). Patterns of selection of BMAs may also depend on other factors, namely drought during the mating, summer, and whitebark pine seasons, as well as abundance of whitebark pine cones during the whitebark pine season (Table 2.5). We present estimates and detailed findings from the most supported models.

During the mating season, males were 1.2 times (0.9 to 1.6) as likely to be in BMAs as non-BMAs (Appendix C Table C.11). We found some evidence that drought conditions increased these selection patterns; during hot, dry periods (PDSI=-3.5) males were 1.6 times (0.9 to 2.9) as likely to be in BMAs, whereas during cool, wet periods (PDSI=3.5), males were 0.8 times (0.5 to 1.5) as likely to be in BMAs, compared to non-BMAs (Appendix C Table C.11). During the summer season, males were 1.8 times (1.3 to 2.4) as likely to be in unrestricted BMAs and 1.2 times (0.9 to 1.6) as likely to be in restricted BMAs, compared to non-BMAs (Appendix C Table C.11). During the whitebark pine season, males were 1.9 times (1.1 to 3.0) as likely to be in unrestricted BMAs and 1.2 times (0.9 to 1.6) as likely to be in restricted BMAs, compared to non-BMAs (Appendix C Table C.11).

Individual Variation

Although we estimated and describe population-level patterns of selection, we also detected pronounced variation among individuals (Fig. 2.2). For example, during the mating season, some males were 0.8 times as likely to be in BMAs, whereas others were 2.7 times as likely, compared to similar areas in non-BMAs (Fig. 2.2). Although we did not see clear patterns in this variation based on age, whether females had cubs, or known habituation, we did observe spatial patterns across YNP (Fig. 2.2). Specifically, bears who showed greater selection for BMAs typically resided in the central and southern areas of YNP (Fig. 2.2).

DISCUSSION

Our study builds on previous research focused on the direct responses of grizzly bears to human presence (Gunther 1990; Coleman et al. 2013*a*, *b*) and suggests grizzly bears change their behavior in areas with low-intensity recreation, even in the absence of people. Grizzly bears preferred to spend time in BMAs with or without access restrictions in place, as compared to similar areas without BMA designation, suggesting that BMAs are important areas for male and female grizzly bears in YNP. Additionally, males changed their selection based on the status of access restrictions, suggesting male bears alter their behavior to spend time in areas without people. We also found evidence that bears may change their selection of BMAs depending on drought conditions, although the coarse nature of this variable hindered precise estimates. Finally, we found substantial variation among individuals in their selection of BMAs which indicates nuance in behavior. To our knowledge, this is the first study to demonstrate that grizzly bears change their habitat selection based on short-term, annual restrictions of recreation in areas with low-intensity human activity.

Bear Management Areas originally were selected to encompass areas with high-quality food resources, and, even 40 years later, we found evidence that grizzly bears prefer these areas over non-BMAs. This finding provides support that biologists placed BMAs in the correct locations, yet exactly why bears select these locations remains somewhat uncertain. Grizzly bears may spend time these areas because of differences in perceived risk relative to other areas of YNP or because of the food resources within BMAs. For most sex-season combinations, bears did not select BMAs based on access restrictions or they preferred unrestricted BMAs to restricted BMAs, supporting the idea that the timing of available resources within BMAs (Table 2.1) may have changed. Changes in food resources in YNP have not substantially altered *where* bears prefer to spend time, but instead perhaps altered *when* bears prefer to be in BMAs.

Although our results show some uncertainty around the population-level estimates of bear selection for BMAs and access restrictions (Appendix C Table C.11), some of this can be attributed to individual variation (Fig. 2.2). Grizzly bears likely learn about the environment and change their behavior based on spatial memory and current conditions (Thompson et al. 2021). Furthermore, bears, particularly females, learn some selection of resources from their mothers and display similar selection patterns (Nielsen et al. 2013). Some individual variation may be due to differences in learned selection, with lineages of bears learning a “tradition” of spending time in BMAs. Individual bears display highly repeatable patterns of movement, activity, and habitat selection (Hertel et al. 2019), which could also help explain the consistent pattern of stronger selection of BMAs for bears in central and southern areas of YNP (Fig. 2.2). There are more BMAs in this part of the park, such that bears have more opportunities to learn about BMAs (Fig. 2.1, 2.2). Additionally, male grizzly bears generally have large home-ranges, which increases the probability that they encounter BMAs, and thus learn when people are absent (Blanchard and Knight 1991). In contrast, females have smaller home ranges that often overlap with their mother’s, which may restrict whether some females experience BMAs (Støen et al. 2005, Bjornlie et al. 2014). Investigating relationships among bears and individual selection over time could provide insights into how related bears select BMAs, and thus whether BMA selection is a learned tradition. Although estimating population-level selection helps us understand overall trends, further exploring individual variation can provide more insights about this highly intelligent species and the various influences on their selection patterns.

Most male bears preferred BMAs with restrictions in place, compared to non-BMAs, consistent with previous research indicating that grizzly bears, particularly males, avoid humans, and do so even in areas with low-intensity recreation (Ordiz et al. 2011, Penteriani et al. 2020). In contrast, females generally selected areas designated as BMAs, regardless of whether restrictions were in place (Table 2.5). This difference between sexes could reflect intraspecific competition or demographic differences in space use. Selection may be density-dependent, with dominant (male) bears outcompeting subordinate (female) bears. We did not include bear density in our analysis, but bears may compete for quality resources within BMAs. Furthermore, females often avoid areas where males spend time, particularly if females have cubs (Steyaert et al. 2013). Distinguishing the roles that sex and reproductive status play in the tradeoffs between risk avoidance and resource selection can clarify what factors influence bears' selection of BMAs and whether intraspecific competition limits some bears' access to BMAs and associated resources.

Although BMAs were established for specific food resources, changes in the distribution and abundance of these foods may explain why we observed less selection of restricted BMAs (Kokaly et al. 2003, Barber-Meyer et al. 2008, White et al. 2016, Koel et al. 2017, NPS 2021b). We generally found smaller selection coefficients for BMAs by individuals in the northern area of the park, where few BMAs exist and where wolf and cougar densities are highest (Fig. 2.2; Smith and Bangs 2009, Ruth et al. 2019). In this area, bears may prefer areas outside of BMAs as they may capitalize on wolf- and cougar-killed ungulate carcasses (Gunther and Smith 2004, Smith and Bangs 2009, Ruth et al. 2019), a consistent, high-quality food resource that did not exist when BMAs were established. The individual-based, spatial variation in selection also may reflect changes in ungulate distributions (Rickbeil et al. 2020); 12 BMAs were partially established to encompass areas with spring ungulate mortality or summer-fall ungulate range (Table 2.1). Fluctuations in environmental cues like snow melt and spring green-up have led ungulates to extensively shift their space use throughout YNP (Rickbeil et al. 2020). Although bears may track these changes to consume ungulates, shifts in the abundance and distribution of vegetation also alters food resources for bears.

The changes in the climate of YNP will alter the occurrence and phenology of plant resources that grizzly bears consume continually throughout the non-denning period (Gunther et al. 2014). Bears did not change their selection of BMAs based on relative abundance of whitebark pine cones (Table 2.5), one of the calorie-rich food resources considered when BMAs were established (Table 2.1). However, bears do not change their movements to access whitebark pine stands during years with abundant whitebark pine cones (Costello et al. 2014), and may neither do so to access BMAs depending on whitebark pine cone abundance. Drought conditions do change the caloric content and timing of available plant foods (Mattson 2004, Baruch-Mordo et al. 2014). Drought severity may influence bears to change their selection of BMAs (Table 2.5); but, PDSI may be too spatially and temporally coarse for precise insights. If climate change alters the availability of calorie-rich food resources, bears may compensate by consuming more herbaceous material. However, bears that consume higher concentrations of chlorophyll produce higher concentrations of cortisol, suggesting these bears may be consuming lower-quality foods (Christianson et al. 2021). As climate change increases the number of snow-free days in YNP, assessing BMA selection with a more fine-scale metric of drought merits further attention (Notaro et al. 2019).

MANAGEMENT IMPLICATIONS

Bears likely spend time in BMAs for the food resources they contain, rather than strict avoidance of people, as bears preferred BMAs to non-BMAs in all sex-season combinations. Thus, BMAs contain high levels of bear activity, regardless of the restriction status. Access restrictions likely reduce human-bear interactions and allow bears to forage on prime food resources without human disturbance. Additionally, males in the summer and whitebark pine seasons preferred unrestricted BMAs to restricted or non-BMAs, suggesting greatest bear activity in unrestricted BMAs. Human-bear encounters have a higher probability of occurring in unrestricted BMAs. People recreating in unrestricted BMAs should be particularly wary of human-bear encounters. Before considering any changes to the BMA system, further work is warranted. First, bear behavior regarding BMAs is nuanced and understanding *why* individuals vary in their selection could reveal important insights for management. Second, as climate change increases the number of snow-free days in YNP, assessing BMA selection with a more fine-scale metric of drought merits further attention.

Table 2.1. Reasons Bear Management Areas were established in Yellowstone National Park WY, USA (NPS 1982; K. A. Gunther, personal communication).

		Bear Management Area															
	Reason for Establishment	Antelope	Blacktail	Clear Creek (J1/J2)	Firehole	Gallatin	Gneiss Creek	Grant Campground	Heart Lake	Lake Spawn	Mary Mountain	Mirror Plateau	Pelican Valley	Richard's Pond	Riddle Lake	Two Ocean Plateau	Washburn
Area Resources	Meadow & Forest Diversity	x	x			x	x					x	x			x	x
	Diversity of Vegetation	x	x			x	x					x	x	x		x	x
	Lush Vegetation					x	x			x		x	x	x	x		
	Bison: Spring Mortality				x						x	x	x				
	Elk: Spring Mortality		x	x	x		x				x			x			x
	Elk: Calves	x		x									x				
	Spawning Streams			x				x	x	x			x		x		
	Pocket Gophers					x							x				
	Whitebark Pine	x	x			x						x				x	x
	Bison: Summer & Fall Range											x	x				
	Elk Summer Fall		x	x		x						x	x	x		x	x
Demographics	Major Cub Producing Area					x							x			x	
	High Density of Bears	x	x			x	x		x			x	x			x	x
	Moderate Density of Bears													x			
	High Density of Bears During Spawn			x				x		x					x		
	High Density of Bears During Spring				x						x		x				

Table 2.2. Hypotheses and predictions we tested in the analysis of grizzly bear selection of Bear Management Areas (BMAs) in Yellowstone National Park, WY, USA, 2004–2020. We included the ecological principle on which we based our hypotheses and which sex-season analyses indicated support of predictions.

ECOLOGICAL PRINCIPLE		HYPOTHESIS	PREDICTION	SUPPORTED (sex-season)
WILDLIFE MAKE TRADE-OFFS BETWEEN ACTIVITIES THAT AVOID RISK AND THOSE THAT INCREASE FITNESS	**H1**	Bears spend time in places that contain quality food resources and restrict human access	(i) Bears prefer BMAs when human access is completely restricted	**Males** (Summer, Whitebark pine) **Females** (None)
WILDLIFE SPEND TIME IN AREAS WITH QUALTIY FOOD RESOURCES	**H2**	Bears spend time in areas that contain quality food resources	(ii) Bears select for BMAs regardless of restriction status	**Females** (All) **Males** (Mating)
	H3	Bears change their behavior to select areas with quality food resources	(ii) Bears select greater for BMAs during times of drought, compared to non-BMAs	**Some evidence for males in the mating season**
			(ii) Bears select greater for BMAs during years with good whitebark pine cone abundance, compared to non-BMAs	**No**

Table 2.3. Candidate models to test hypotheses (Table 2.2) about Bear Management Areas (BMA) in Yellowstone National Park, WY, USA, 2004–2020. The ecological models characterized resource selection by grizzly bears (Table 2.5). BMA Intrinsic = whether an area was a BMA at any point during the year or not; BMA Status = non-BMAs, unrestricted BMAs, restricted BMAs; PDSI = Palmer Drought Severity Index (-4,4; continuous); WBP = abundant/scarce whitebark pine cone crops per year (abundant years occur when the mean cones per tree is greater than the cumulative median and scarce years occur when the mean cones per tree is less than the cumulative median).

Model	Model Structure
Ecological	ecological model
BMA Intrinsic	ecological + BMA Intrinsic
BMA Status	ecological + BMA Status
Drought – BMA Intrinsic	ecological + BMA Intrinsic × PDSI
Drought – BMA Status	ecological + BMA Status × PDSI
WBP – BMA Intrinsic	ecological + BMA Intrinsic × Yearly WBP
WBP – BMA Status	ecological + BMA Status × Yearly WBP

Table 2.4. The best supported model describing ecological resource selection by grizzly bears for each sex-season combination, Yellowstone National Park, WY, USA, 2004–2020. We added BMA variables to these base ecological models to test our hypotheses (Table 2.2) about grizzly bear responses to short-term, annual closures (Table 2.3). All models included a random intercept on individual bear-year (id); below, we also specify additional random slopes that we included based on likelihood-ratio tests. Landcover = categorical landcover (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water); TRI = Terrain Roughness Index; Aspect = categorical for N, S, E, W; Distance to Anthropogenic = Euclidean distance to the nearest road or development (negative values within developments); Distance to Forest Edge = Euclidean distance to the nearest forest edge (negative values within a forest); Distance to Water = Euclidean distance to nearest stream or lake (negative values within lakes); CRS = Carcass Redistribution Site (inside or outside).

Sex	Season	Model Structure
Females	Mating	Landcover +TRI + Aspect + Distance to Anthropogenic + CRS + (0+Distance to Anthropogenic|id)
	Summer	Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS
	Whitebark Pine	Landcover + TRI + Aspect + Distance to Anthropogenic + Distance to Forest Edge + Distance to Water + CRS
Males	Mating	Landcover + TRI + Aspect + Distance to Anthropogenic + Distance to Forest Edge + Distance to Water + CRS + (0+Distance to Anthropogenic|id)
	Summer	Landcover + TRI + Aspect + Distance to Anthropogenic + Distance to Water + CRS + (0+Distance to Anthropogenic|id) + (0+CRS|id)
	Whitebark Pine	Landcover + TRI + Aspect + CRS

Table 2.5. Competing models (ΔAICc ≤ 4) describing selection of short-term, annual closures (BMAs) by grizzly bears for each sex-season combination, Yellowstone National Park, WY, USA, 2004–2020. We compared 7 candidate models (Table 2.3) to test our hypotheses about grizzly bear responses to BMAs. We also show the ecological model (Table 2.4), for comparison, as this represents resource selection without accounting for BMAs. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is *k*, weight is the AICc model weight, *n* is the number of individual bear-years in each sex-season combination, and ecological is the best supported ecological model structure for the sex-season combination (Table 2.4).

Sex	*Season*	*Model Structure*	*k*	*ΔAICc*	*Weight*	*n*
Female	Mating	BMA Intrinsic	19	0.00	0.69	18
		BMA Intrinsic × PDSI	20	1.86	0.27	
		BMA Status	21	6.65	0.02	
		BMA Status × PDSI	23	7.94	0.01	
		ecological	17	20.89	0.00	
	Summer	BMA Intrinsic	18	0.00	0.64	14
		BMA Intrinsic × PDSI	19	1.44	0.31	
		BMA Status	20	6.18	0.03	
		BMA Status × PDSI	22	9.00	0.01	
		ecological	16	9.91	0.00	
	Whitebark Pine	BMA Intrinsic	20	0.00	0.33	14
		BMA Status × WBP	21	0.58	0.24	
		BMA Intrinsic × PDSI	21	1.08	0.19	
		BMA Status	22	2.15	0.11	
		ecological	18	3.46	0.06	
		BMA Status × PDSI	24	3.89	0.05	
		BMA Status × WBP	24	5.37	0.02	
Male	Mating	BMA Intrinsic	21	0.00	0.47	24
		BMA Intrinsic × PDSI	22	0.14	0.44	
		BMA Status	23	4.28	0.06	
		BMA Status × PDSI	25	5.49	0.03	
		ecological	19	35.36	0.00	
	Summer	BMA Status	23	0.00	0.85	19
		BMA Status × PDSI	25	3.48	0.15	
		BMA Intrinsic	21	12.18	0.00	
		BMA Intrinsic × PDSI	22	13.61	0.00	
		ecological	19	37.68	0.00	
	Whitebark Pine	BMA Status	19	0.00	0.59	15
		BMA Status × PDSI	21	1.58	0.27	
		BMA Status × WBP	21	3.98	0.08	
		BMA Intrinsic	17	5.76	0.03	

Table 2.5 Continued

Sex	***Season***	***Model Structure***	***k***	***ΔAICc***	***Weight***	***n***
		BMA Intrinsic × PDSI	18	7.69	0.01	
		BMA Intrinsic × WBP	18	7.73	0.01	
		ecological	15	34.35	0.00	

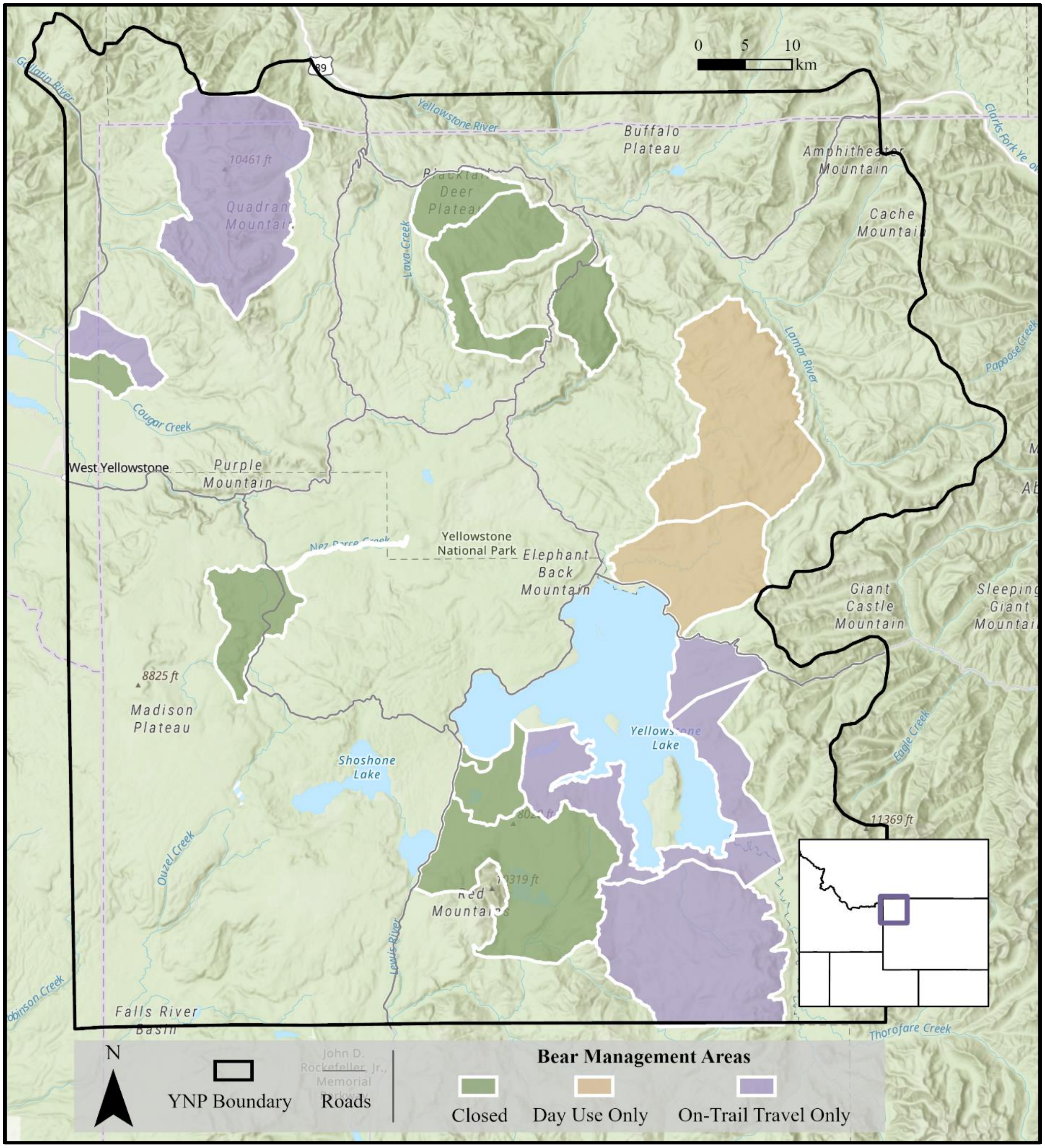

Figure 2.1. Study area, including Bear Management Areas, access restrictions to BMAs (Closed, Day Use Only, On-Trail Travel Only), and major roads in Yellowstone National Park, WY, USA.

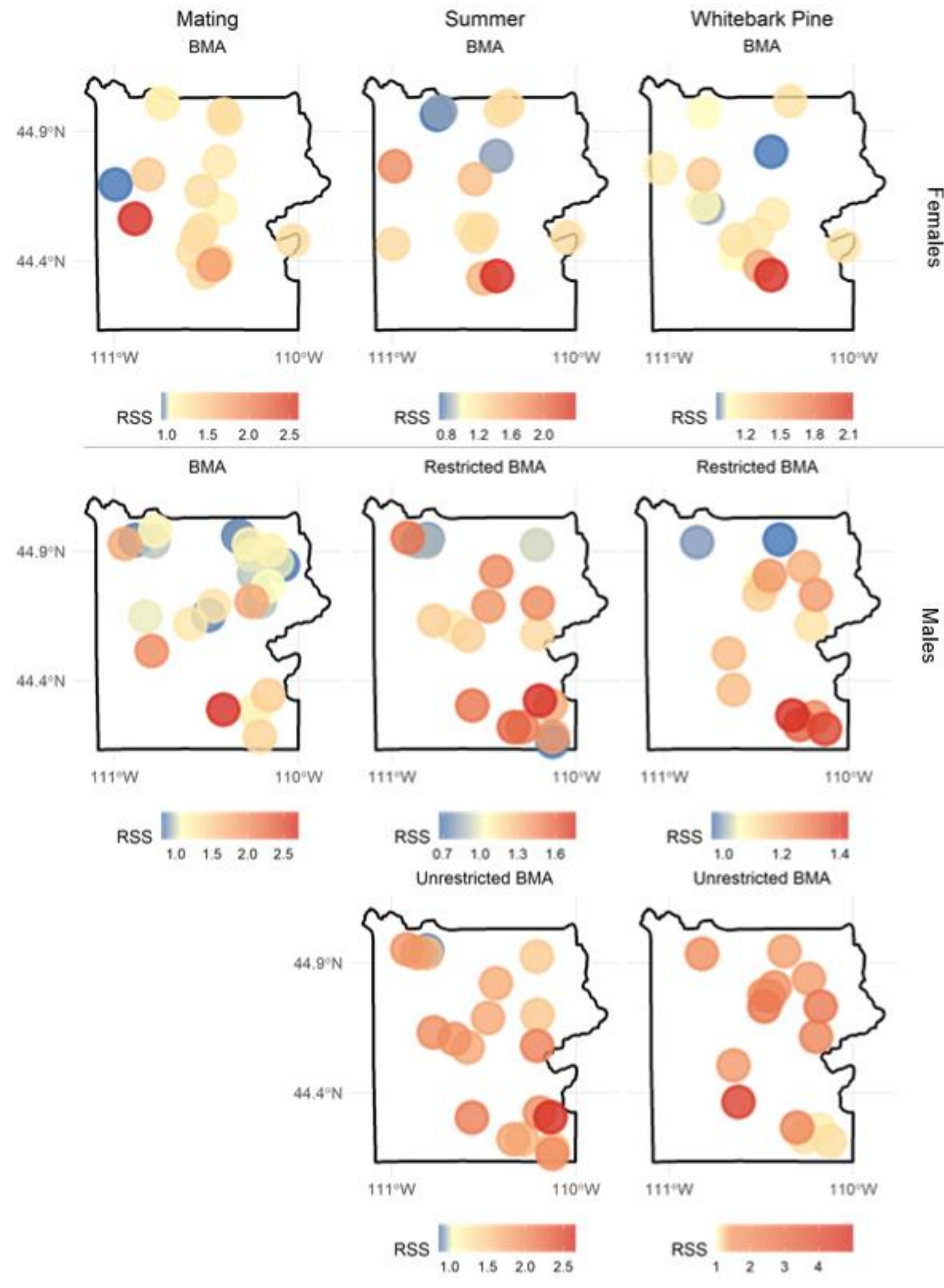

Figure 2.2. Selection patterns (Relative Selection Strength [RSS]) by individual male and female grizzly bears of Bear Management Areas, based on the top model for each sex-season combination (Table 2.5), Yellowstone National Park, WY, USA, 2004–2020. The spatial location represents the centroid of an individual's movements for the season. Cooler colors represent selection coefficients <1 while warmer colors represent selection coefficients >1.

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CHAPTER THREE

MALE AND FEMALE GRIZZLY BEARS DIFFER IN RESPONSE TO LOW-INTENSITY RECREATION IN A PROTECTED AREA

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Male and female grizzly bears differ in response to low-intensity recreation in a protected area

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ABSTRACT Predictable patterns of human activity provide an opportunity for large predators to adjust their behavior to avoid people, whereas sporadic activity may not allow animals to anticipate disturbance. We used step-selection functions to study grizzly bears' selection of predictable (backcountry campsites) and sporadic (hiking trails) recreation in areas where human access is restricted during short-term, annual closures. Male grizzly bears avoided hiking trails during times when humans typically recreate but were closer to hiking trails at night. Females changed their selection of trails depending on restrictions to human access. We found less evidence that grizzly bears change where they spend time based on proximity to

backcountry campsites. Combined with previous work in this region, our results suggest grizzly bears use the environment to avoid human presence, as males temporally avoided the perceived risk of people in areas with sporadic recreation and females spatially avoided areas with sporadic recreation. We were unable to determine whether females' selection patterns were driven by avoiding male bears or recreating humans. Importantly, bears are finding ways to co-occur with backcountry recreation, but these behaviors come with consequences: bears likely experience a functional loss of habitat, even in areas where human access is restricted.

KEY WORDS Grizzly bear, backcountry recreation, resource selection, Yellowstone, risk-disturbance hypothesis, *Ursus arctos*

Animals must make tradeoffs between minimizing risk and finding food: individuals that spend more time in low-risk areas may have less access to high-quality forage (Frid and Dill 2002). The balance between risk and reward differs among individuals and changes with age, body condition, and reproductive status, but these tradeoffs have lasting effects on the distribution and abundance of populations (Frid and Dill 2002). These effects are well documented in prey species and a growing number of studies have illustrated that large predators change their behaviors due to perceived risk of humans (e.g., Lima and Dill 1990, Ordiz et al. 2013, Hertel et al. 2016, Suraci et al. 2019). For much of human existence, large predators posed a threat to human survival (Lamb et al. 2020), but now, large predators may perceive humans as a "super predator" (Darimont et al. 2015). Predators change their behavior in response to the perceived risk of human presence (Frid and Dill 2002, Ordiz et al. 2011, Suraci et al. 2019).

Large predators can alter when and where they are active as a way to avoid people (Ordiz et al. 2011, Wang et al. 2017, Lamb et al. 2020). In urban areas, predators become more nocturnal and spend time in denser cover to balance the perceived risk of humans while maximizing fitness (Ordiz et al. 2011, Suraci et al. 2019, Lamb et al. 2020). Predators can become more nocturnal to avoid periods of human activity in non-urban areas (Coltrane and Sinnott 2015, Anton et al. 2020); during crepuscular and nocturnal hours, brown bears (*Ursus arctos*) increase their activity on popular hiking trails and gray wolves (*Canis lupus*) occur closer to roads (Gibeau et al. 2002, Coltrane and Sinnott 2015, Anton et al. 2020). These shifts in activity patterns can lead to reduced food acquisition and lower survival of large predators (Hebblewhite et al. 2005, Lamb et al. 2020). Yet in some instances, predators may benefit from human activity. Female brown bears (*Ursus* arctos) will spend time closer to developments, regardless of whether humans are present, possibly to avoid competition with males and reduce infanticide (Rode et al. 2006, Steyaert et al. 2016, but see Mattson et al. 1987). When patterns of human activity are relatively predictable, animals have the opportunity to reshape their behavior to co-occur with people (Lamb et al. 2020).

Alternatively, sporadic and unpredictable human activity may not allow animals to anticipate the disturbance, such that animals may instead react with general antipredator responses (Frid and Dill 2002, Ordiz et al. 2011). These evolutionary responses may cause animals to move farther distances after an unpredictable encounter and subsequently associate places with sporadic human activity with higher risk (Miller et al. 2001, Seip et al. 2007, Lesmerises et al. 2018). Mule deer (*Odocoileus hemionus*) respond to people hiking off-trail by traveling farther distances, compared to their response to hikers remaining on trails (Miller et al. 2001), and caribou (*Rangifer tarandus*) abandon high-quality habitat after encounters with snowmobiles were inconsistent in timing and frequency (Seip et al. 2007). Little is understood about whether large predators change their behavior and movement patterns in space and time as a response to sporadic recreation. Additionally, animals may use previous encounters with people to inform the degree of risk they associate with an area or human presence (Dill 1974, Ditmer et al. 2019). If large predators associate sporadic human disturbance with increased risk and avoid these areas, regardless of whether people are present, then large predators could functionally lose habitat.

Anthropogenic activities have reduced grizzly bears to a small percentage of their original distribution in North America (Mattson and Merrill 2002), with populations in the continuous United States mainly constrained to protected areas (i.e., national parks, wilderness areas; Fish and Wildlife Service 2022). Yet, as bear populations increase, the proportion of grizzly bear range occurring on private and public land managed for multiple purposes increases (Hebblewhite et al. 2021). Concurrently, the growth of outdoor recreation means more people venture into areas that previously saw little human activity (Nickel et al. 2020). The effects of outdoor recreation on bears are relatively well studied in areas with high human use (e.g., McLellan et al. 1999, Gibeau et al. 2002, Ordiz et al. 2011, Ladle et al. 2019). For example, in areas with both motorized and non-motorized recreation, bears generally avoid trails with high motorized activity, yet males and solitary females also avoid sections of non-motorized trails when few people use them (Coltrane and Sinnott 2015, Ladle et al. 2019). This may be due to the predictable patterns of humans on trails with high activity and the sporadic nature of recreation on trails with little human activity. Bears typically do not avoid trails altogether because these paths provide easy movement corridors (Carnahan et al. 2021). Management plans rarely completely exclude people from large areas of land, but we can use backcountry settings to explore how bears respond to human presence and perceived risk of humans.

Yellowstone National Park (YNP) offers the ideal study system to determine how predictable and sporadic recreation affect grizzly bear behavior. Terrestrial recreation in YNP is limited to low-intensity activities (e.g., hiking, horseback riding; National Park Service [NPS] 2015). Additionally, each year managers in YNP restrict recreation in some backcountry areas for short periods – from 1 to 7 months (Appendix A; NPS 1982). Human access is limited in several different ways: completely closing an area to people, limiting access to on-trail-travel, or only allowing recreation during daytime hours (henceforth access restrictions; NPS 1982). These areas – Bear Management Areas (BMAs) – were demarcated as important for grizzly bears and encompass ~21% of YNP (NPS 2019a). Two objectives of BMAs are to reduce human-bear encounters that lead to the habituation of bears to people and to reduce bear-caused human injuries in areas with high levels of bear activity (NPS 1982).

A few previous studies did explore how human activity in BMAs changes grizzly bear behavior (Gunther 1990, Coleman et al. 2013a). When human access was restricted, bears were closer to recreation sites, but when BMAs were unrestricted, people displaced bears from important food resources and bears spent time closer to cover refugia (Gunther 1990, Coleman et al. 2013a). These findings provide a framework to answer more nuanced questions regarding access restrictions and recreation sites in YNP. By understanding how grizzly bears change their movement and resource selection as a result of recreation, we can assess whether the perceived risk of people by bears persists in areas with different levels of access restrictions and whether this perceived risk changes between predictable and sporadic recreation sites.

Although bears usually avoid humans, the majority of bear-inflicted injuries to people occurs in the backcountry (Gunther and Hoekstra 1998). Terrestrial backcountry recreation in YNP consists of backcountry camping and non-motorized backcountry trail travel (i.e., hiking, horseback riding). Bears may perceive camping as more predictable, as people generally stay in the vicinity of the campsite, and typically move around in the late afternoon and early morning, whereas people occur sporadically along hiking trails throughout the day, given that few trails have constant human foot-traffic. We sought to build on previous work in YNP to understand the potential for bear displacement resulting from human recreation.

We compared how grizzly bear selection of sporadic (trails where human activity is temporally unpredictable) and predictable (backcountry campsites where human use is temporally predictable) recreation sites changed with different levels of access restrictions (restricted BMA, unrestricted BMA, non-BMA) and whether these restrictions reduce displacement of bears by people. These distinctions allowed us to compare the influences of actual and perceived risk of human recreation and assess whether selection patterns differed between sexes, among seasons, and based on time of day. We hypothesized that bears associate trails with humans during the day and associate backcountry campsites with humans during crepuscular and nighttime hours (Table 3.1). As such, we predicted bears would show the greatest avoidance of trails (be farthest away) during daytime hours in non-BMAs but would choose areas closer to trails in BMAs with complete restrictions to human access. We also predicted that bears would avoid backcountry campsites during crepuscular hours in non-BMAs but show little selection based on distances from backcountry campsites in BMAs with complete restrictions to human access (Table 3.1). Given that males generally avoid areas with people and females occasionally prefer areas with people, we predicted males would be farther from, and females closer to, backcountry recreation sites. Backcountry recreation is increasing worldwide and better understanding how bears respond to different recreation sites and access restrictions will help improve the safety of people and bears.

METHODS

Study Area

Yellowstone National Park encompasses 8991 km^2, mainly in northwest Wyoming, with some areas in Montana and Idaho (NPS 2019b). Geography in YNP consists of a large plateau bordered by rugged mountains in the north, east and south. Forests dominated by spruce-fir (*Picea* and *Abies* spp.) and lodgepole pine (*Pinus contorta*) cover much of YNP, but extensive areas of sagebrush (*Artemisia* spp.) and grassland also occur at higher and lower elevations (Despain 1990).

Yellowstone National Park contains about 1704 km of maintained backcountry trails, occurring from 1630 m to 3150 m in elevation and from stream bottoms to thermal areas to alpine ridges (Yellowstone Spatial Analysis Center; Fig. 3.1). Trail recreation is limited to bipedal modes of transport (e.g., hiking, skiing) and hooved stock; biking is prohibited on trails (NPS

2021). Backcountry campsites are denoted by a trail-marker and contain either a food pole or a bear box for food storage, however, specific tent locations are not indicated (Coleman et al. 2013b). Backcountry campsites are reserved for one group and have limitations on the number of stock users allowed throughout the year (NPS 2019c).

Bear Management Areas in YNP encompass approximately 21% (188,032 ha) of YNP (Fig. 3.1; Coleman et al. 2013a). There are 61 backcountry campsites in BMAs and 232 campsites outside of BMAs (Fig. 3.1). Within BMAs, restrictions limit when and where people can recreate (Appendix A Table A.1). These restrictions include complete closures to human access, only allowing recreation on trails and not away from campsites, and only allowing recreation between 9 am and 7 pm (NPS 1982). Some campgrounds and backcountry campsites within BMAs have additional closures when human access is allowed (NPS 2019a). Of the 16 BMAs, 7 have access restrictions from March 1 through November 1, whereas other BMAs mainly restrict access between March 1 and July 1 (Appendix A; NPS 1982). Access for research or management purposes must be approved by the Bear Management Office (NPS 2019a). When restrictions are in place, people rarely occur in BMAs.

Capture and Collaring

The Interagency Grizzly Bear Study Team (IGBST) captured grizzly bears annually from 2000 to 2020 using culvert traps and Aldrich leg-hold snares (Blanchard 1985). Capture activities followed approved protocols to conform with the Animal Welfare Act (U.S. Geological Survey Animal Care and Use Committee protocol #201201) and were conducted under a U.S. Fish and Wildlife Service Endangered Species Permit [Section (i) C and D of the grizzly bear 4(d) rule, 50

CFR17.40(b)], with additional National Park Service research permits in Yellowstone and Grand Teton national parks and state research permits in Montana, Idaho and Wyoming. We used data collected from GPS-enabled radio collars (Telonics, Mesa, Arizona, USA). Collars recorded programed fixes at different time intervals ranging from 13 to 208 minutes. We performed all analyses on GPS data from on-board memory downloaded after collar retrieval. We excluded three-dimensional and two-dimensional GPS fixes with PDOP >10 and horizontal error >125 m (D'Eon and Delparte 2005). Given that our interest focused on understanding bear behavior as a function of recreation sites in YNP, we limited our dataset to all bear locations within YNP, as well as those within a 5% buffer outside the park boundary.

Seasons

We delineated six ecologically-based seasons when bears had similar activity patterns in space: post denning (March 15 - April 6); spring (April 7 – May 4); mating (May 5 to June 29); summer (June 30 – August 10); whitebark pine (August 11 – October 3); and fall (October 4 until denning) (Chapter 2, Appendix B). We focused on the mating, summer, and whitebark pine seasons, given that most recreation occurs during this time.

Two Stages of Analysis

Overview – We used two stages of analysis for each recreation site (trails, campsites) to first characterize and account for resource selection by grizzly bears, and then determine how recreation sites and access restrictions might influence selection by grizzly bears. In stage I, we used ecological variables to model resource selection for grizzly bears, with different models for each sex (male and female) and season (mating, summer, whitebark pine) combination. In stage

II, we used these ecological models as a foundation to test our hypotheses about bears' selection of trails and campsites in relation to access restrictions (Table 3.2). We conducted all analyses in R version 4.0.4 (R Core Team 2021).

For both stages of analysis, we focused on fine-scale selection through step-selection functions (Thurfjell et al. 2014). The matched-point design inherent to step-selection functions pairs each used location with available locations (Thurfjell et al. 2014). We classified an individual as a unique bear-year. We helped to account for the movement of bears by simulating available locations from distributions of an individual's turn angles and step lengths (Avgar et al. 2016, Signer et al. 2019). Specifically, we generated available locations using the random_steps function in the amt package (Signer et al. 2019), which randomly selects locations based on a gamma distribution of an individual's step lengths and a von Mises distribution of an individual's turn angles (Signer et al. 2019). Creating available locations from an individual's movements minimizes autocorrelation issues common with spatial and temporal data (Avgar et al. 2016). This approach also allows availability to change as the animal moves (Signer et al. 2019). Due to the variety in the frequency of GPS locations and the requirement of consistent fixes in step-selection functions, we subsampled the data to include consecutive fixes within 90 to 120 minutes and only included individuals with at least 100 fixes (equaling one week of monitoring) in each season. We matched 10 available locations to each used location.

We followed the modeling approach outlined by Muff et al. (2020) and Duchesne et al. (2010). We used conditional Poisson mixed models with stratum-specific intercepts, which compare temporally correlated matched pairs. The variance of stratum-specific intercepts were fixed to 10,000 to avoid shrinkage (Muff et al. 2020). Parameter estimates and standard errors resulting from these models are likelihood-equivalent (Duchesne et al. 2010, Muff et al. 2020). We also included a random intercept for each individual (Muff et al. 2020). We accounted for variation in individual selection by including random coefficients for covariates of resource selection (Table 3.3). This also reduces bias and allows for more robust population-level estimates of fixed effects when modeling step-selection functions (Gillies et al. 2006, Hebblewhite and Merrill 2008, Duchesne et al. 2010, Muff et al. 2020). To evaluate whether to include random coefficients, we compared iterative random coefficient structures with likelihood-ratio tests and p-values corrected for testing random coefficients (Zuur et al. 2009). We used the package glmmTMB to fit all models (Brooks et al. 2017).

Stage I: Ecological Models. – To create our initial ecological models, we included variables known or hypothesized to influence resource selection by grizzly bears such as landcover, terrain, and anthropogenic attributes. Distributions of plant species can affect grizzly bear occurrence, so we included vegetation cover (categorical with 10 levels, Table 3.2) to account for important food resources (McClelland et al. 2020). Grizzly bears often forage and seek refuge (i.e., daybed) near the interface between forest and open areas, so we created a distance to forest edge raster; we assigned negative distance values to locations in the forest and positive values to non-forested areas (Peck et al. 2017). We measured distance to water using st_distance in the sf package (Pebesma 2018) given that water sources are important for bears to thermoregulate (Rogers et al. 2021), find foods such as spawning trout (Haroldson et al. 2005), consume succulent vegetation (Teisberg et al. 2014), and travel along (Wilson et al. 2005). Terrain features and topography affect the movement of bears (Carnahan et al. 2021); we included Terrain Roughness Index (TRI), aspect, elevation, and slope rasterized from a Digital Elevation Model with a 30-m resolution to account for variation in landscape permeability. To account for changes in resource selection due to roadways and developments, we included the Euclidean distance to anthropogenic areas, with negative distance values associated with locations inside developments (Mattson et al. 1987, Proctor et al. 2019). Biologists move wildlife carcasses resulting from vehicle strikes or euthanized individuals to 9 carcass redistribution sites in YNP. To account for the influence of this concentrated, high-quality food, we created a GIS layer for carcass redistribution sites (Chapter 2). We assigned a Boolean value depending on whether the location fell within (1) or outside (0) the defined carcass-redistribution site. We examined correlations between pairs of continuous covariates and removed elevation due to relationships with distance to anthropogenic areas, distance to water and TRI (R >0.6). All continuous covariates (distance to anthropogenic areas, distance to water, TRI, distance to edge) were centered and scaled.

To select the ecological model that best explained variation in resource selection by grizzly bears, we evaluated candidate model suites separately for each combination of sex and season. We considered models with all possible additive combinations of vegetation cover, distance to forest edge, distance to water, TRI, aspect, distance to anthropogenic areas, and carcass redistribution site. To determine the best supported ecological model for each sex and season, we compared all fixed-effects models with appropriate random coefficients from the log-likelihood ratio tests with Akaike's Information Criterion corrected for small sample size (AICc). We calculated AICc with the MuMIn package (Burnham and Anderson 2002, Barton 2020). We used the top model from this first stage of analysis as the foundation to test our recreation sites and BMA hypotheses. Our analyses focused on trails and backcountry campsites and required slightly different data sets, therefore, we excluded days when no campsites were occupied in YNP, such that we evaluated ecological models separately for these two types of recreation sites (Appendix D Table D.1 – D.12).

Stage II: Recreation Models. – In the second stage of analysis, we tested our hypotheses related to recreation sites and access restrictions. To distinguish between the variation in predictability of recreation, we created two separate suites of candidate models – one for trails (sporadic human use) and another for backcountry campsites (predictable human use). Models for trails included combinations of BMA restrictions, time of day, and distance to trail (Table 3.2). Models for campsites included BMA restrictions, time of day, and distance to the nearest backcountry campsite or distance to the nearest *occupied* backcountry campsite, to determine whether bears changed their selection based the current or perceived risk of people (Table 3.2). In each model, we included a random coefficient for the BMA variable and distance to recreation site variable to account for differences in availability among individuals (Muff et al. 2020).

The BMA variable accounted for different access restrictions: non-BMA (areas outside of BMAs), unrestricted BMA (BMA open to human access), and restricted BMA (BMA closed to human access). Bears change their movements in response to roads at 80 m to 1000 m from a road as topography and vegetation influence bears' perception of roads (Proctor et al. 2019, Parsons et al. 2020). Trails in YNP are non-motorized and less traveled than roads so we categorized areas within 200 m of trails as an unrestricted BMA and areas farther than 200 m from trails as restricted BMA, for BMAs with access restricted to on-trail travel (Appendix D Table D.13, D.16). We included time of day to account for variation in bear activity and to test whether bears temporally varied their responses to recreation sites and access restrictions. We categorized time of day as: crepuscular (1 hour before dawn to 1 hour after dawn and 1 hour before dusk to 1 hour after dusk), day (1 hour after dawn to 1 hour before dusk), and night (1 hour after dusk to 1 hour before dawn; Appendix D Table D.14 – D.15, D.17 – D.18).

We calculated the nearest distance to trails and backcountry campsites using the st_distance function in the sf package (Pebesma 2018). We obtained reservation information for backcountry campsites from the Central Backcountry Office in YNP. People arrive at and depart from campsites at different times, but most people arrive between 1530 and 1815 and depart between 0830 and 1100 (Coleman et al. 2013b); for consistency, we defined a campsite as occupied from 12 pm on the day of the reservation to 12 pm the following day. We log-transformed all distances (distance to trail, distance to backcountry campsite, and distance to occupied backcountry campsite) as wildlife often exponentially diminish their response to human presence (Avgar et al. 2017).

We aimed to determine whether grizzly bears changed their selection among recreation sites with different restrictions to human access and based on the time of day by including several interaction terms (BMA × time of day, BMA × distance to recreation site, BMA × time of day × distance to recreation site; Table 3.2). We only included the time-of-day variable as an interaction with the distance covariates, given that time of day did not differ between used and available locations (Street et al. 2016). We compared models using AICc, calculated with MuMIn (Burnham and Anderson 2002, Barton 2020); we compared models separately for each recreation site and sex-season combination.

RESULTS

Distance to Trails

After standardizing fix-interval among bears and removing locations outside of the study area, GPS locations provided data for 55,742 used steps from 85 bears-years (57 males, 28 females). For males, each season included 6,313 to 13,012 usable GPS locations from 26 to 37 bear-years. We obtained 7,715 to 11,421 points from 19 to 24 female bear-years per season. The importance of different resources changed by seasons and sexes, resulting in different ecological models (Table 3.3, Appendix D Table D.1 – D.6).

Female grizzly bears differentially selected for distance to trails depending on access restrictions during all seasons, but we found little evidence that male bears changed their proximity to trails depending on access restrictions (Table 3.4, Appendix D Table D.19 – D.24). Male bears, however, changed their preferences regarding proximity to trails based on the time of day (distance to trail × time of day), and we found some evidence of this pattern for female bears in the summer season (BMA x time of day x distance to trail; Table 3.4). Below we present estimates and detailed findings from the top models by sex for each season (Appendix D Table D.31).

Females. – During the mating and whitebark pine seasons, females showed little differentiation of selection of distance to trail in restricted and non-BMAs, however, in unrestricted BMAs, females preferred areas farther from trails (Fig. 3.2). During the summer season, females changed their selection patterns for distance to trail depending on time of day and access restrictions (Fig. 3.3, Table 3.4). During the day, female bears preferred areas farther from trails in unrestricted BMAs and showed little differentiation in selection of distance to trail in restricted and non-BMAs (Fig. 3.3, Appendix Table D.31). During crepuscular hours, females preferred areas near trails in restricted BMAs, but farther from trails in unrestricted BMAs (Fig. 3.3). At night, females preferred areas near trails in unrestricted BMAs, but showed little differentiation in selection of proximity of trail in non-BMAs and restricted BMAs (Fig. 3.3).

Males. – Male grizzly bears exhibited similar selection patterns for proximity to trail depending on time of day across all seasons (mating, summer, whitebark pine), however, the strength of the pattern differed among seasons (Fig. 3.4, Table 3.4). During the mating season, males were similarly likely to be near trails during crepuscular and night hours, compared to during the day (Fig. 3.4). During the summer and whitebark pine seasons, males were most likely to be near trails at night, followed by crepuscular hours, as compared to during the day (Fig. 3.4).

Distance to Backcountry Campsites

After standardizing fix-interval among bears and removing days when no backcountry campsite in YNP was occupied, these GPS locations provided data for 54,685 used steps from 85 bear-years (57 male bear-years, 28 female bear-years). For males, each season included 6,313 to

12,897 useable GPS locations from 26 to 37 bear-years. We obtained 7,715 to 10,479 points from 19 to 24 female bear-years per season. The importance of different resources changed by seasons and sexes, resulting in different ecological models (Table 3.3, Appendix D Table D.7 – D.12).

We found little evidence that bears changed their selection of distance to backcountry campsites depending on access restrictions during most sex-season combinations, with the exception of males during the mating and summer seasons (Table 3.5). In some cases, we also found that bears changed their proximity to backcountry campsites at different times of day (females in the mating season, males in the summer season; Table 3.5). We found little evidence that selection depended on whether campsites were occupied, except during the summer season (Table 3.5, Appendix D Table D.25 – D.30). We present estimates and detailed findings from the top models by sex for each season below (Table 3.5, Appendix D Table D.32).

Females. – During the mating season, females were 3.6 times (1.3 to 9.4) as likely to be 50 m from a campsite at night and 2.5 times (0.8 to 8.1) as likely during crepuscular hours, compared to the same locations during the day (Fig. 3.5, Appendix D Table D.32). During the summer season, patterns of selection were less clear (Table 3.5), but based on the top model, female bears did not change their selection based on distance to backcountry campsite (Table 3.5). During the whitebark pine season, the top model included distance to backcountry campsite, yet this parameter was uninformative; females were equally (β=1; 0.5 to 2.0) likely to be far (1000 m) from a backcountry campsite as they were to be near (50 m) these locations (Appendix D Table D.32).

Males. – During the mating season, males were 1.4 times (1.1 to 1.9) as likely to be 50 m from a backcountry campsite than 1000 m from a backcountry campsite (Appendix D Table D.32). During the summer season, males were 2.2 times (1.12 to 4.2) as likely to be 50 m from a backcountry campsite at night and 1.3 times (0.6 to 2.9) as likely during crepuscular hours, compared to during the day (Fig. 3.5, Appendix D Table D.32). We found similar support that access restrictions also influenced bear selection of proximity to backcountry campsites, but only at night (Appendix D Table D.32). We found limited evidence that males changed where they spent time, based proximity to backcountry campsites, during the whitebark pine season (Table 3.5).

DISCUSSION

Our findings suggest that grizzly bears may temporally and spatially alter their movement to avoid people, which is consistent with previous studies (e.g., Rode et al. 2006, Ordiz et al. 2011, Ladle et al. 2019, Proctor et al. 2019). However, to our knowledge, the discovery that this pattern occurs even in areas with low-intensity recreation, without hunting, and where recreation is completely restricted is novel (Ordiz et al. 2011, 2013, 2021). Coupled with previous work in YNP (Gunther 1990; Coleman et al. 2013*a*, *b*), our study expanded the limited understanding of how grizzly bears respond to predictable (campsites) and sporadic (hiking trails) recreation in the backcountry. Specifically, sexes differ in their selection of sporadic recreation sites, regardless of whether people are present: females alter their selection based on access restrictions whereas male bears temporally alter their selection. Recreation is complex to quantify and predict, and our findings provide a nuanced understanding of how grizzly bears navigate sporadic and predictable recreation in areas with different levels of human access.

Grizzly bears likely experience a functional loss of habitat based on perceived human risk as bears use current resources and memory cues to decide where to spend time (Thompson et al. 2021). Regardless of the access restrictions, grizzly bears avoided recreation sites during some seasons and times of day and often similarly selected recreation sites in restricted and non-BMAs, counter to our predictions (Table 3.1). Avoidance of recreation sites, even if people are not present (e.g., restricted BMAs), may be an artifact of memory – bears know humans occur in those areas at some point during the year. Alternatively, avoidance of recreation sites may illustrate a lag in perceived risk as bears travel from an area with people to an area with access restrictions. For example, male bears changed their selection of proximity to trails based on time of day which may represent a carry-over effect from an area with people. Like other apex predators that change their movements to avoid areas with humans (even merely voice playbacks), grizzly bears may associate all recreation sites with people (Suraci et al. 2019).

Our study focused on the proximity of grizzly bears to recreation sites, whereas previous work on BMAs focused on the proximity of bears to people, finding that bears are more likely to be in recreation sites when humans are absent and spend time in cover to directly avoid human presence (Gunther 1990, Coleman et al. 2013a). Our analysis, which adds a temporal component, supports these findings while expanding that bears' preference of both sporadic and predictable recreation sites is greatest at night. Day-use only BMA restrictions thus likely reduce human-bear interactions that may occur near recreation sites at night in areas with high bear activity. Additionally, if vegetation cover is available near recreation sites, grizzly bears may spend time closer to recreation sites knowing they can avoid people by escaping to cover (Ordiz et al. 2011). By combining our results with previous work in YNP, we developed a more detailed understanding of how bears avoid people: bears change their behavior in time to avoid the perceived risk of encountering humans but change their immediate behaviors in space to avoid “actual” people. Grizzly bears are not passive actors shaping their co-occurrence with people in the backcountry (Lamb et al. 2020).

Our findings that males and females differ in their selection of areas with sporadic and predictable recreation were counter to our predictions but focusing on the tradeoffs between security and foraging could provide useful insights. Females may prioritize security, selecting places that help them avoid male bears and people (Rode et al. 2006, Steyaert et al. 2013, 2016). Females may facilitate male bear avoidance in space by avoiding areas near trails in unrestricted BMAS (Fig. 3.2, 3.3), given that male bears prefer unrestricted BMAs more than other access restrictions and temporally prefer trails (Appendix D Tables D.31 - D.32). This may differ with reproductive status as females with cubs often select different resources and exhibit different movement strategies than non-reproductive females (Steyaert et al. 2013, Ladle et al. 2019). Alternatively, males and females may combine changes in selection with changes in movement, as a way to balance security and food acquisition (Ordiz et al. 2011). Instead of completely avoiding areas associated with human activity, bears may move faster through these areas (Ladle et al. 2019). Differences in movement speeds may be especially pronounced in areas with quality food resources, as bears are more likely to spend time closer to trails in high-quality habitat (Gibeau et al. 2002). Bears can modify where they spend time if recreation is predictable, but they likely expend greater energy and have fewer foraging opportunities when responding to sporadic human activity (Cristescu et al. 2016, Ladle et al. 2019).

Grizzly bears changed their selection of recreation sites contingent on the predictable or sporadic nature of recreational activities; while bears change their behavior in response to the perceived risk of human presence (Ordiz et al. 2011, Lamb et al. 2020), they likely make different tradeoffs between potential risk and security depending on the predictability of recreation. Although we addressed the variation in predictability of several kinds of recreation, BMAs themselves also may create an unpredictable environment for bears, given that access restrictions are not in place year-round (Appendix A Table A.1; Gunther 1990). Female bears avoided sporadic recreation sites more in unrestricted BMAs than non-BMAs, such that they may associate non-BMAs with continuous, and therefore, more predictable human activity. It is worth noting that bears prefer unrestricted and restricted BMAs to non-BMA, though bears often did not change their selection of recreation sites based on access restrictions (Appendix D Table D.31 – D.32). Greater selection of BMAs indicates more bear activity in these areas which increases the potential for human-bear interactions, even while bears temporally avoid human activity throughout a day.

We focused our work on characterizing selection of recreation sites as a function of different levels of access restrictions, however, additional information would further enhance our inferences. Trails and backcountry campsites in YNP often occur where bears find herbaceous plant foods (Gunther et al. 2014), and distinguishing whether bears are moving along or foraging near trails, by assessing selection patterns for different movement states (encamped, foraging, and traveling), could help us better understand the physiological consequences of human disturbance in the backcountry. We assumed that human activity in the backcountry was constant because YNP only tracks backcountry campsite occupancy and stock day-use (since 2017, Yellowstone Backcountry Office, personal communication). Although bears seem to spatially avoid recreation sites when people are typically present, a bear's response to human activity in the backcountry may depend on how many people are in the group or a bear's previous experience with people (Coleman et al. 2013a, Lesmerises et al. 2018). Monitoring bear movements in association with fine-scale recreation activities across years could provide insights as to how bears may learn about recreation and change their behavior in response (Nielsen et al. 2013). Finally, bears differ in their tolerance of humans, based on sex, reproductive status, time of year, and other factors, emphasizing the need for sufficient data to characterize this variation (Steyaert et al. 2013, Hertel et al. 2019, Lamb et al. 2020). Distinguishing the influences of male bears compared to the perceived risk of humans on where females (with and without cubs) spend time could strengthen our understanding of an important population cohort.

MANAGEMENT IMPLICATIONS

Bears temporally vary how they interact with recreation sites and considering temporal differences in management plans could improve safety of both people and bears. Additionally, it is important to consider the type (trail, campsite) of recreation activity when creating management plans as bears respond differently to backcountry campsites and hiking trails. Male and female bears have different strategies to mitigate perceived risks associated with human activities; these differences are important to consider when evaluating potential changes to types of recreation or access restrictions. Restricting recreation to diurnal periods likely reduces potential nocturnal human-bear interactions and allows people and bears to use the same landscapes with temporal separation. This could be especially important in areas highly used by grizzly bears.

Table 3.1. Hypotheses and predictions we tested to understand influences on grizzly bear selection of recreation sites in Yellowstone National Park, WY, USA, 2004–2020. We included the ecological principle on which we based our hypotheses and which sex-season analyses indicated support of predictions.

ECOLOGICAL PRINCIPLE		HYPOTHESIS	PREDICTION	SUPPORTED
WILDLIFE TEMPORALLY CHANGE THEIR BEHAVIOR BASED ON THE PERCEIVED RISK OF PEOPLE, THIS DIFFERS BETWEEN SPORADIC AND PREDICTABLE RECREATION	**H1**	Bears associate trails with sporadic human activity during the day	(i) Bears avoid areas near trails during the day and prefer areas near trails at night	**Yes**
	H2	Bears associate campsites with predictable human activity during crepuscular and night hours	(ii) Bears avoid backcountry campsites during crepuscular hours	**No**
WILDLIFE SPATIALLY CHANGE THEIR BEHAVIOR BASED ON THE PERCEIVED RISK OF PEOPLE	**H3**	Bears change their selection of recreation sites based on access restrictions	(iii) Bears prefer areas farther from recreation sites in non-BMAs and unrestricted BMAs but spend time closer to recreation sites in restricted BMAs	**No**
DIRECT HUMAN ACTIVITY CHANGES WILDLIFE BEHAVIOR	**H4**	Bears avoid recreation sites when people are at the site	(iv) Bears change their selection of campsites based on whether the site is occupied	**Some evidence** Females (summer) Males (whitebark pine)

Table 3.2. Candidate models to test hypotheses about recreation sites, time of day, and Bear Management Areas (BMA) restrictions, Yellowstone National Park, Montana and Wyoming, 2004–2020. The ecological models characterized resource selection by grizzly bears (Table 3.3). BMA = BMA restriction type (non-BMAs, unrestricted BMAs, restricted BMAs); HRS = human recreation site (trail, backcountry campsite or occupied backcountry campsite); we created separate model suites for trails and campsites; TOD = time of day (day, crepuscular, night).

Model	**Model Structure**
Ecological	Ecological Model
BMA	Ecological + BMA
Distance	Ecological + Distance to HRS
BMA + HRS	Ecological + BMA + Distance to HRS
BMA × HRS	Ecological + BMA × Distance to HRS
TOD HRS	Ecological + TOD × Distance to HRS
BMA + TOD × HRS	Ecological + BMA + TOD × Distance to HRS
BMA × TOD × HRS	Ecological + BMA × TOD × Distance to HRS

Table 3.3. The best-supported model describing ecological resource selection by grizzly bears for each sex-season combination, Yellowstone National Park, WY, USA 2004–2020. We used these as our base models to test hypotheses about grizzly bear responses to human recreation sites (trails, backcountry campsites) in BMAs by adding BMA variables, distance to human recreation site, and time of day (Table 3.2). All models included a random intercept on individual bear-year (id) and we note additional random slopes included based on likelihood-ratio tests. Landcover = categorical landcover (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water); TRI = Terrain Roughness Index; Aspect = categorical slope (N, S, E, W); Distance to Anthropogenic = Euclidean distance to the nearest road or development (negative values within developments); Distance to Forest Edge = Euclidean distance to the nearest forest edge (negative values within a forest); Distance to Water = Euclidean distance to nearest stream or lake (negative values within lakes); CRS = Carcass Redistribution Site.

Analysis	**Sex**	**Season**	**Model Structure**
Trails	Female	Mating	Landcover +TRI + Aspect + Distance to Anthropogenic + Distance to Water + CRS + (0+Distance to Anthropogenic | id)
		Summer	Landcover + TRI + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS + (0+Distance to Anthropogenic | id)
		Whitebark Pine	Landcover + TRI + Aspect + Distance to Forest Edge + CRS
	Male	Mating	Landcover + TRI + Aspect + Distance to Water + Distance to Anthropogenic + CRS + (0+CRS | id) + (0+Distance to Anthropogenic | id)
		Summer	Landcover + TRI + Aspect + Distance to Water + Distance to Anthropogenic + CRS + (0+CRS | id) + (0+Distance to Anthropogenic | id)
		Whitebark Pine	Landcover + TRI + Aspect + Distance to Forest Edge + CRS
Campsites	Female	Mating	Landcover + TRI + Aspect + Distance to Water + Distance to Anthropogenic + CRS + (0 + Distance to Anthropogenic | id)
		Summer	Landcover + TRI + Aspect + Distance to Forest Edge + Distance to Anthropogenic + CRS + (0 + Distance to Anthropogenic | id)
		Whitebark Pine	Landcover + TRI + Aspect + Distance to Forest Edge + CRS
	Male	Mating	Landcover + TRI + Aspect + Distance to Water + Distance to Anthropogenic + CRS + (0 + Distance to Anthropogenic | id) + (0 + CRS | id)
		Summer	Landcover + TRI + Aspect + Distance to Water + Distance to Anthropogenic + CRS + (0 + Distance to Anthropogenic | id) + (0 + CRS | id)
		Whitebark Pine	Landcover + TRI + Aspect + Distance to Forest Edge + CRS

Table 3.4. Competing models (ΔAICc ≤ 4) describing selection of trails and BMA restrictions by grizzly bears for each sex-season combination, Yellowstone National Park, WY, USA, 2004–2020. We compared 8 candidate models (Table 3.2) based on characteristics of paired used and available locations using conditional Poisson mixed models. Weight is the AICc model weight, *k* is the number of parameters in the model, *n* is the number of individual bear-years in each sex-season combination, ecological is the best supported ecological model structure for this sex-season combination (Table 3.3), and Trail is the distance to nearest trail.

Sex	Season	Model Structure	*k*	ΔAICc	Weight	*n*
Female	Mating	BMA × Trail	26	0.00	1.00	24
	Summer	BMA × Trail × TOD	35	0.00	0.88	19
	Whitebark Pine	BMA × Trail	23	0.00	0.99	19
Male	Mating	BMA + Trail × TOD	27	0.00	0.94	37
	Summer	BMA + Trail × TOD	27	0.00	0.96	29
	Whitebark Pine	BMA + Trail × TOD	24	0.00	0.74	26
		BMA × Trail × TOD	34	2.06	0.26	

Table 3.5. Competing models (ΔAICc ≤ 4) describing the selection of backcountry campsites and BMAs by grizzly bears for each sex-season combination, Yellowstone National Park, WY, USA, 2004–2020. We compared 8 candidate models (Table 3.2) based on characteristics of paired used and available locations using conditional Poisson mixed models. *K* is the number of parameters in the model, weight is the AICc model weight, *n* is the number of individual bear-years in each sex-season combination, ecological is the best supported ecological model structure for this sex-season combination (Table 3.3), Camp is the distance to nearest backcountry campsite, and Camp Occupied is the distance to nearest occupied backcountry campsite.

Sex	**Season**	**Model Structure**	***k***	**ΔAICc**	**Weight**	***n***
Female	Mating	BMA + TOD × Camp	26	0.00	0.76	24
		BMA + Camp	24	2.70	0.20	
	Summer	BMA	22	0.00	0.33	19
		BMA × Camp Occupied	26	0.89	0.21	
		BMA × TOD × Camp Occupied	36	1.62	0.15	
		BMA × TOD × Camp	36	2.31	0.10	
		BMA + Camp Occupied	24	3.36	0.06	
		BMA + Camp	24	3.50	0.06	
	Whitebark Pine	BMA + Camp	23	0.00	0.53	19
		Camp	19	1.50	0.25	
		BMA × Camp	25	3.49	0.09	
		BMA + TOD × Camp	25	3.53	0.09	
Male	Mating	BMA + Camp	25	0.00	0.46	37
		BMA × Camp	27	0.46	0.36	
		BMA + TOD × Camp	27	2.30	0.15	
	Summer	BMA + TOD × Camp	27	0.00	0.38	29
		BMA × TOD × Camp	37	0.27	0.33	
		BMA + Camp	25	1.53	0.18	
		BMA × Camp	27	2.47	0.11	
	Whitebark Pine	BMA	20	0.00	0.64	26
		BMA + Camp Occupied	22	3.59	0.11	
		BMA × Camp Occupied	24	3.78	0.10	

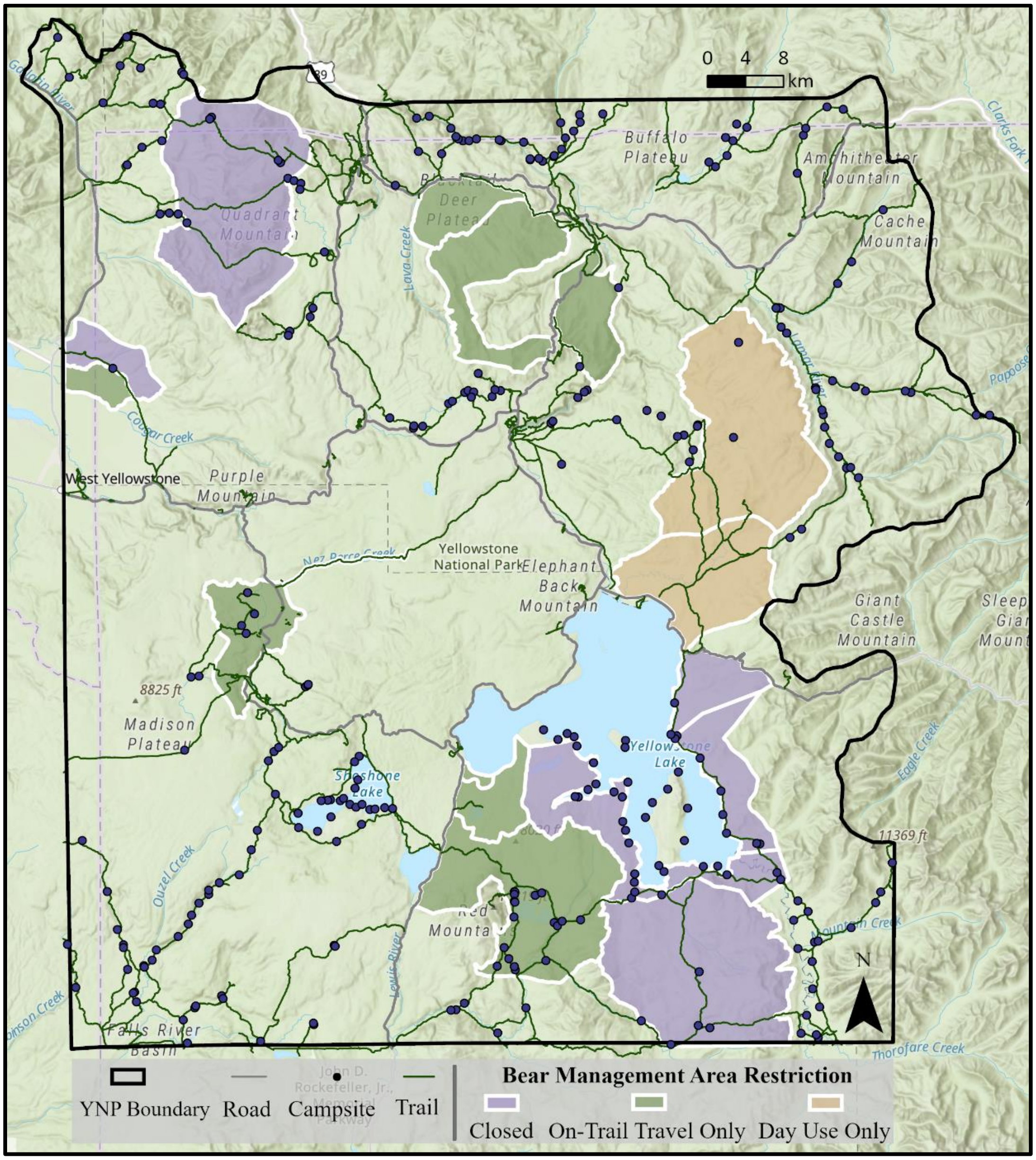

Figure 3.1. Study area, including Bear Management Areas, access restrictions to BMAs (Closed, Day Use Only, On-Trail Travel Only), major roads, backcountry trails, and backcountry campsites in Yellowstone National Park, WY, USA.

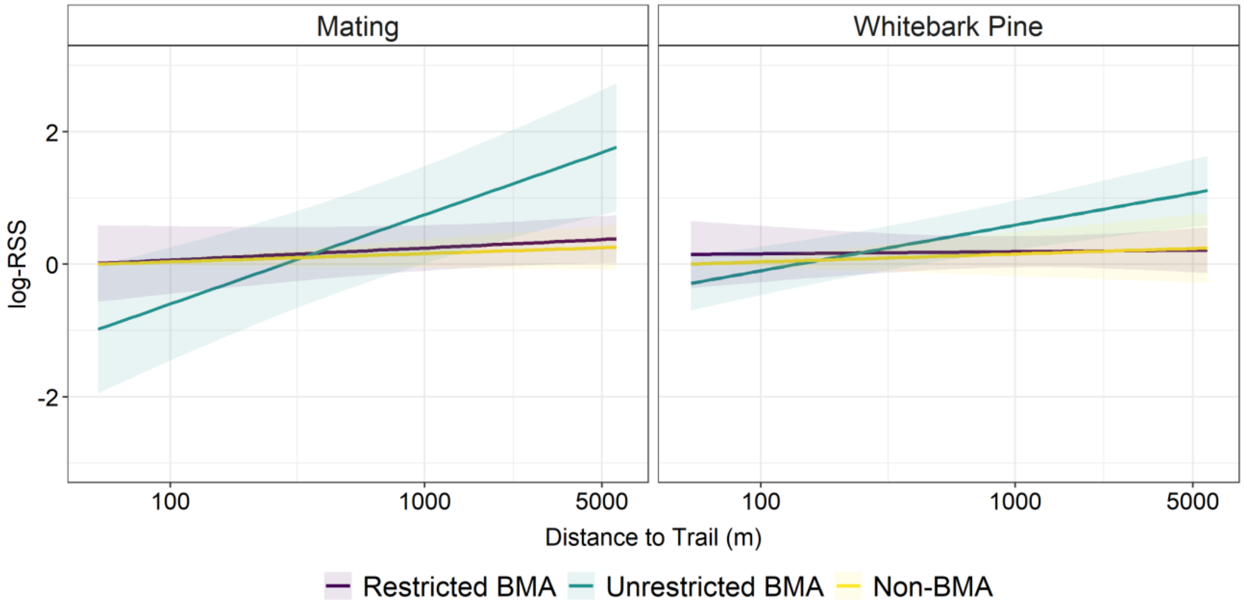

Figure 3.2. Selection patterns (log-Relative Selection Strength [RSS] and 95% confidence intervals) by female grizzly bears as a function of human access restriction (restricted BMA, unrestricted BMA, non-BMA) and distance to trail, based on the top models in the mating and whitebark pine seasons (Table 3.4), Yellowstone National Park, WY, USA, 2004–2020. Values >0 indicate preference and values <0 indicate avoidance.

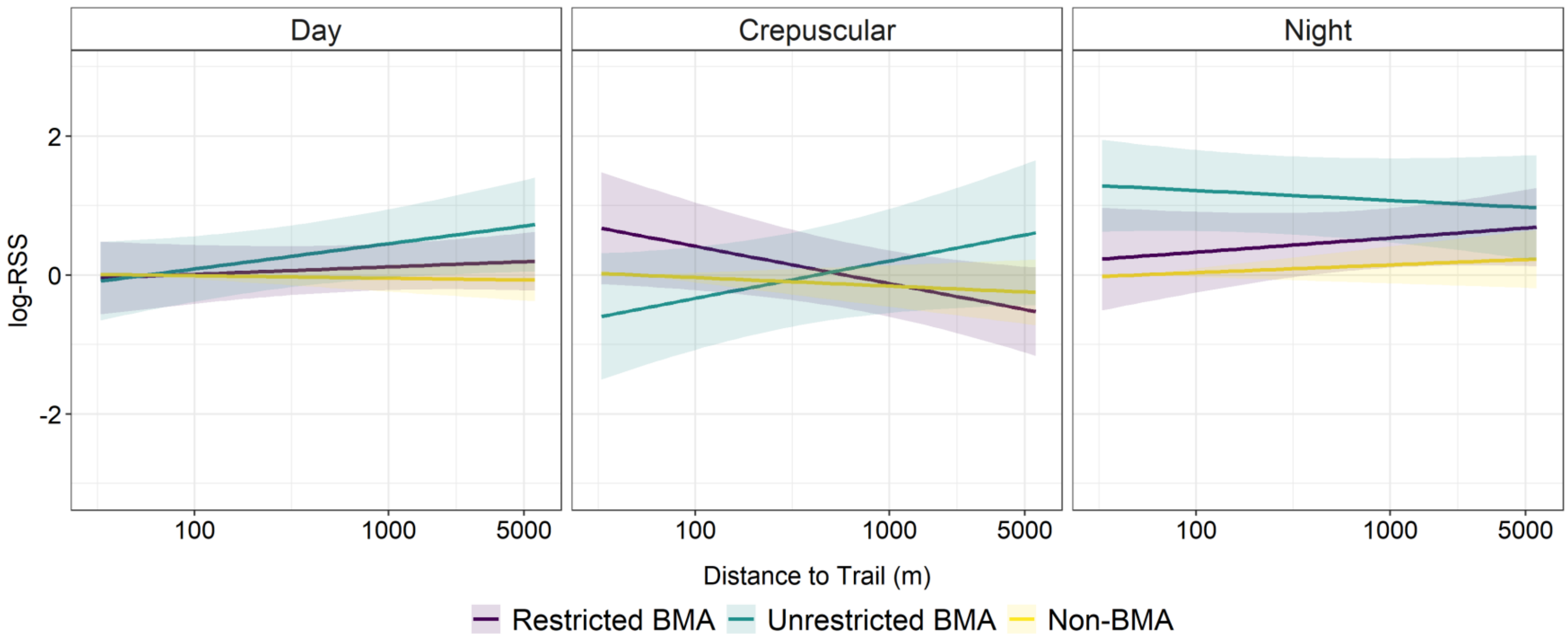

Figure 3.3. Selection patterns (log-Relative Selection Strength [RSS] and 95% confidence intervals) by female grizzly bears as a function of human access restriction (restricted BMA, unrestricted BMA, non-BMA), time of day (Day, Crepuscular, Night), and distance to trail, based on the top models in the summer season (Table 3.4), Yellowstone National Park, WY, USA, 2004–2020. Values >0 indicate preference and values <0 indicate avoidance.

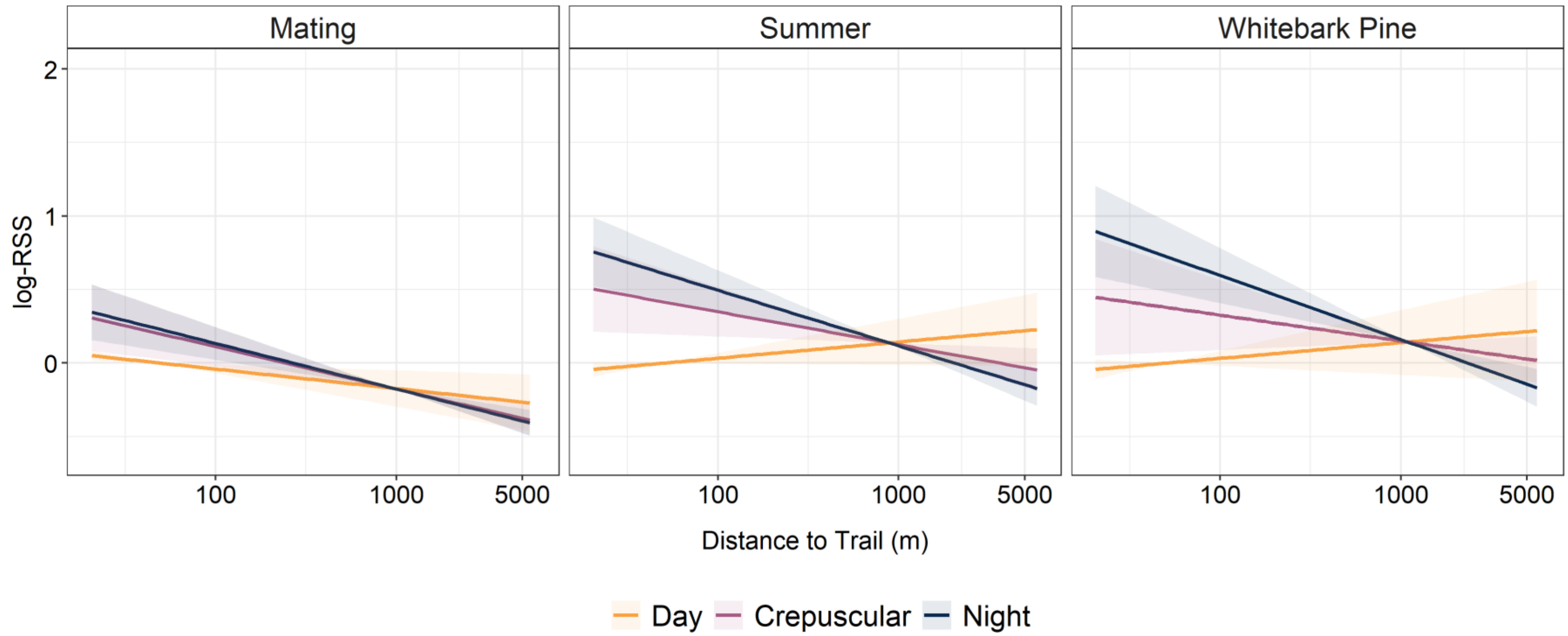

Figure 3.4. Selection patterns (log-Relative Selection Strength [RSS] and 95% confidence intervals) by male grizzly bears as a function of time of day (day, crepuscular, night) and distance to trail, based on the top model in the mating, summer, and whitebark pine seasons (Table 3.3), Yellowstone National Park, WY, USA, 2004–2020. Values >0 indicate preference and values <0 indicate avoidance.

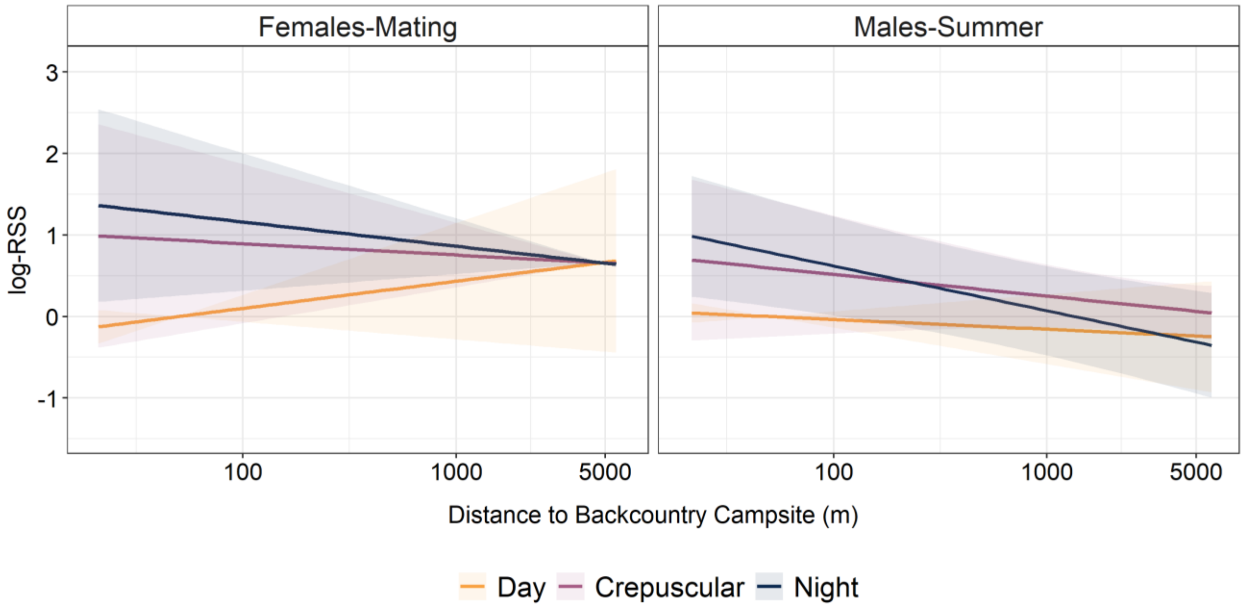

Figure 3.5. Selection patterns (log-Relative Selection Strength [RSS] and 95% confidence intervals) by female and male grizzly bears as a function of time of day (day, crepuscular, night) and distance to backcountry campsite, based on the top models in the mating (female) and whitebark pine (male) seasons (Table 3.4), Yellowstone National Park, WY, USA, 2004–2020. Values >0 indicate preference and values <0 indicate avoidance.

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CHAPTER FOUR

CONCLUSIONS

Bear Management Areas (BMAs) were created based on qualitative data and yet, forty years later and after extensive changes of resources available to bears in YNP, our analyses demonstrate that these areas are still important for male and female grizzly bears (Chapter 2). However, *when* bears prefer these areas may have shifted, given that male bears preferred unrestricted BMAs, particularly later in their active period, and females did not change their selection based on access restrictions (Chapter 2). The lack of selection for BMA restrictions in some seasons may be due to bears changing their movements in response to recreation sites, regardless of access restrictions (Chapter 3).

Grizzly bears tend to avoid areas where people recreate, even in areas where human access was restricted, suggesting bears perceive recreation sites as unpredictable, particularly when recreation activity is sporadic (Chapter 3). This finding is a novel addition in support of the risk-disturbance hypothesis (Frid and Dill 2002). Additionally, males and females exhibited different behaviors in response to sporadic recreation sites; males made temporal changes in their behavior and selected for areas near trails more at night, whereas females made spatial changes (Chapter 3). Notably, males showed the greatest selection for unrestricted BMAs in the summer and whitebark pine seasons (Chapter 2), and females made the greatest changes in their movement in response to trails in unrestricted BMAs (Chapter 3). These combined findings suggest females may alter their movements to avoid people and male bears, particularly in areas with higher male bear activity. Alternatively, in unrestricted BMAs, the changes in female selection may be attributed to the compounding unpredictability of sporadic recreation (hiking trails) and access restrictions. The marked variation in selection of recreation sites among individual bears supports our interpretation that bears are not passive actors in their co-occurrence with people in the backcountry. However, as recreation activity increases, bears' avoidance strategies could lead to a functional loss of habitat (Chapter 3).

Exactly why bears prefer BMAs remains somewhat uncertain, but food resources likely drive preferences more than the lack of human activity (Chapter 2). Although drought conditions were not included in top models in any sex-season combination, parsimonious (i.e., ΔAICc <4) models usually included this variable so changes in temperature and precipitation may play a role in where bears spend time (Chapter 2). Dominant bears outcompete subordinate bears for resources and changes in the abundance and distribution of calorie-rich foods may lead to subordinate individuals consuming lower-quality diets. Exploring the nutritional content of foods in BMAs as a function of spatiotemporal variation in climate will be important, given that YNP is expected to become increasingly warmer and drier (Notaro et al. 2019).

Females, particularly females with offspring, must consider tradeoffs between quality food resources and human activity in addition to risks associated with male bears (Rode et al. 2006; Steyaert et al. 2013, 2016). We found substantial sex-based differences in whether bears changed their proximity to recreation sites based on time of day or access restrictions (Chapter 3). However, our analysis could not differentiate whether females were choosing to spend time in areas because of resources present or to avoid male bears. Females with offspring may make different choices than solitary females, but we could not account for reproductive status in analyses (Rode et al. 2006; Steyaert et al. 2013, 2016). Due to male competition, females may be limited to areas with lower-quality foods. Alternatively, males may avoid the perceived risk of people, creating a realized niche for females to exploit.

Our work expanded the breadth of information regarding grizzly bear responses to restrictions in recreation and specifically helped clarify how bears in YNP navigate access restrictions following widespread changes to the ecosystem (Kokaly et al. 2003, Gunther and Smith 2004, Costello et al. 2014, White et al. 2016, Koel et al. 2017). Rarely do opportunities arise to assess management actions, especially multiple layers of management plans. Our work, when combined with Coleman et al. (2013) and Gunther (1990), suggests that BMAs with restrictions in place likely reduce human-bear conflict. In these restricted areas, bears likely do not pay the energetic costs associated with human encounters (e.g., quickly moving to cover), even if there is some functional loss of habitat (temporally avoiding recreation sites due to the perceived risk of humans, Chapter 3). Quantifying changes in speed and distances bears move in areas with different recreation restrictions will help clarify potential physiological effects of BMAs (Ladle et al. 2019).

Bear Management Areas were implemented to reduce human-bear interactions that would lead to the displacement of bears from prime food resources, the habituation of bears in the backcountry, and bear-inflicted human injury (NPS 1982). Our work demonstrates bears still choose to spend more time in BMAs over non-BMAs with the same environmental characteristics, supporting our interpretation that BMAs contain prime food resources for bears

(Chapter 2). Additionally, access restrictions do provide times and places where people cannot displace bears, reducing human-bear interactions and allowing bears to capitalize on quality foods without direct, human-caused displacement (Chapter 3). Regardless of whether restrictions are in place, bear activity is higher in BMAs compared with non-BMA areas, thus increasing the probability of human-bear interactions in BMAs (Chapter 2). Access restrictions in BMAs reduces human-bear interactions, yet backcountry recreators have heightened potential of human-bear interactions once restrictions are lifted (Chapter 2), particularly during crepuscular and nighttime hours when male bears are more likely to be near recreation sites (Chapter 3). Although further work could strengthen our understanding of the varied and nuanced responses by grizzly bear to BMAs and access restrictions, our analyses support the conclusion that BMAs are fulfilling their original objectives, especially from a bears' perspective.

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APPENDICES

APPENDIX A

BEAR MANAGEMENT AREA INFORMATION

Table A.1. Types and dates of access restrictions in Bear Management Areas in Yellowstone National Park, WY, USA.

Type of Access Restriction	BMA	Start Date	End Date
Complete Closure	Firehole	March 10	Friday before Memorial Day
	Richard's Pond	March 10	Friday before Memorial Day
	Blacktail	March 10	June 30
	Gneiss Creek	March 10	June 30
	Antelope	March 10	November 10
	Heart Lake	April 1	June 30
	Pelican Valley	April 1	July 3
	Grant Campground	Road Opening	June 20
	Riddle/Solution	April 30	July 14
	Lake Spawn	May 15	July 14
	Washburn	August 1	November 10
On-Trail-Travel Only	Two Ocean	March 14	July 14
	J2	April 1	July 14
	Clear Creek	April 1	August 10
	Gallatin	May 1	November 10
	Gneiss Creek	July 1	November 10
	Two Ocean	August 22	November 10
Day Use Only	Mirror Plateau	May 15	November 10
	Pelican Valley	July 4	November 10
Off-Trail with Special Permit	Two Ocean	July 15	August 21
By Special Permit	Washburn	March 10	July 31
Trail Closure	Mary Mountain Trail	March 10	June 15

APPENDIX B

DELINEATING ECOLOGICALLY MEANINGFUL SEASONS

Delineating Ecologically Meaningful Seasons

We followed the approach of Basille et al. (2013) to delineate ecologically meaningful seasons for grizzly bears in Yellowstone National Park, WY, USA. We used a moving window (5 days before and after) to summarize variables for a given individual, smoothing temporal trends. We included both movement and landcover characteristics. For movement, we calculated the mean speed and mean tortuosity (average departure from 0 to 180) using the speed and ta_ functions in the amt package (Signer et al. 2019). For landcover, we used vegetation characteristics as a way to capture the influence of bear foods (Nielsen et al. 2010). This included: Douglas fir forest, subalpine/whitebark pine forest, lodgepole pine forest, wet forests/streams, shrubs, herbaceous meadows, talus slopes, and distance to forest edge. We created a raster to calculate distance to forest edge and assigned negative distance values to locations in the forest and positive locations to non-forested areas (Peck et al. 2017). These were averaged for each individual per year and then across all individuals. All covariates were scaled.

We used k-means clustering to identify similar observations (Basille et al. 2013). The distance in multivariate space between each observation and a random point was calculated; this was iterated until the structure stabilized, resulting in clusters of points. We calculated within cluster homogeneity and contrasted this with cluster homogeneity, assuming a uniform multivariate distribution. The difference in these values was used to calculate the gap statistic, which is sometimes used to estimate the number of clusters in a dataset (Basille et al. 2013). Given that the gap statistic often overestimates the number of clusters, we used a weighted gap statistic which weights within cluster homogeneity by averaging the sum of pairwise distances (in multivariate space) between all points in a cluster (Basille et al. 2013).

To characterize each day of the year into its appropriate cluster, the original dataset was bootstrapped by individual-year. We then used k-means clustering on each bootstrapped dataset with the estimated number of clusters given by the weighed gap statistic (Basille et al. 2013). These computations delineated six ecological seasons (Table B.1). We computed the likelihood that a given day is associated with a season; dates within the top 20% were retained to identify cutoff dates for each season. We changed the end date of the spring season (2) and the start date of mating season (3) to reflect that some BMA restrictions change on May 1. We used these seasons to assess resource selection by male and female grizzly bears in Yellowstone National Park.

Table B.1. Ecological seasons, along with start and end dates, for grizzly bears in Yellowstone National Park, WY, USA, 2004 – 2020. We followed methods by Basille et al. (2013) to define seasons based on movement and environmental characteristics.

Season	Cluster	Start and End Dates
Post-Denning	1	Post denning to4/6
Spring	2	4/7 to 5/4
Mating	3	5/5 to 6/29
Summer	4	6/30 to 8/10
Whitebark Pine	5	8/11 to 10/3
Fall	6	10/4 to den

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APPENDIX C

MODEL SELECTION RESULTS, PARAMETER ESTIMATES, AND SUMMARY TABLES FOR

ECOLOGICAL AND BMA MODELS

Table C.1. Results of model selection for ecological resource selection by female grizzly bears during the mating season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to varying levels of human access (Chapter 2). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-95656.7	191347.4	0.00	17
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95656.2	191348.4	1.00	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-95656.2	191348.4	1.00	18
Landcover + Aspect + TRI + Distance to Anthropogenic	-95658.6	191349.3	1.88	16
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95655.8	191349.6	2.24	19
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-95658.2	191350.3	2.93	17
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-95658.2	191350.3	2.95	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-95657.8	191351.6	4.23	18
Landcover + Aspect + TRI + CRS	-95665.7	191361.5	14.07	15
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-95665.5	191363.0	15.62	16
Landcover + Aspect + TRI + Distance to Water + CRS	-95665.6	191363.3	15.88	16
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-95665.4	191364.9	17.51	17
Landcover + Aspect + TRI	-95668.7	191365.5	18.06	14
Landcover + Aspect + TRI + Distance to Forest Edge	-95668.6	191367.1	19.75	15
Landcover + Aspect + TRI + Distance to Water	-95668.6	191367.3	19.91	15
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-95668.5	191369.0	21.65	16
Landcover + TRI + Distance to Anthropogenic + CRS	-95679.3	191386.6	39.22	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-95678.8	191387.6	40.23	15
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95679.0	191388.0	40.61	15
Landcover + TRI + Distance to Anthropogenic	-95681.3	191388.5	41.13	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95678.6	191389.2	41.81	16

Table C.1 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-95680.8	191389.6	42.18	14
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-95681.0	191390.0	42.57	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-95680.6	191391.2	43.80	15
Landcover + TRI + CRS	-95688.3	191400.6	53.20	12
Landcover + TRI + Distance to Forest Edge + CRS	-95688.2	191402.4	54.98	13
Landcover + TRI + Distance to Water + CRS	-95688.2	191402.4	55.03	13
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-95688.1	191404.2	56.86	14
Landcover + TRI	-95691.3	191404.6	57.23	11
Landcover + TRI + Distance to Water	-95691.2	191406.5	59.09	12
Landcover + TRI + Distance to Forest Edge	-95691.2	191406.5	59.09	12
Landcover + TRI + Distance to Water + Distance to Forest Edge	-95691.2	191408.4	60.99	13
Landcover + Aspect + Distance to Anthropogenic + CRS	-95738.9	191509.7	162.36	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-95738.0	191510.0	162.65	17
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95738.1	191510.2	162.81	17
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95737.4	191510.9	163.51	18
Landcover + Aspect + Distance to Anthropogenic	-95741.0	191512.0	164.59	15
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-95740.3	191512.5	165.16	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-95739.6	191513.3	165.89	17
Landcover + Aspect + CRS	-95745.9	191519.8	172.45	14
Landcover + Aspect + Distance to Forest Edge + CRS	-95745.4	191520.9	173.48	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-95745.2	191522.5	175.09	16
Landcover + Aspect	-95748.9	191523.8	176.45	13
Landcover + Aspect + Distance to Forest Edge	-95748.5	191525.1	177.71	14
Landcover + Aspect + Distance to Water	-95748.7	191525.3	177.93	14
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-95748.4	191526.7	179.34	15
Landcover + Distance to Anthropogenic + CRS	-95762.0	191550.0	202.62	13
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-95761.1	191550.3	202.87	14

Table C.1 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95761.5	191551.0	203.60	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95761.5	191551.0	203.60	14
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95760.8	191551.6	204.18	15
Landcover + Distance to Anthropogenic	-95764.1	191552.3	204.90	12
Landcover + Distance to Water + Distance to Anthropogenic	-95763.3	191552.6	205.21	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-95763.7	191553.4	205.96	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-95763.0	191554.0	206.59	14
Landcover + CRS	-95769.0	191559.9	212.55	11
Landcover + Distance to Forest Edge + CRS	-95768.7	191561.3	213.95	12
Landcover + Distance to Water + CRS	-95768.7	191561.4	213.97	12
Landcover + Distance to Water + Distance to Forest Edge + CRS	-95768.5	191562.9	215.52	13
Landcover	-95772.0	191564.0	216.58	10
Landcover + Distance to Water	-95771.7	191565.4	218.05	11
Landcover + Distance to Forest Edge	-95771.8	191565.5	218.15	11
Landcover + Distance to Water + Distance to Forest Edge	-95771.6	191567.1	219.74	12
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-95781.9	191581.8	234.42	9
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-95782.2	191582.4	235.02	9
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-95784.8	191585.5	238.15	8
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95784.8	191587.7	240.27	9
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-95787.8	191591.6	244.23	8
Aspect + TRI + Distance to Anthropogenic + CRS	-95790.5	191597.0	249.65	8
Aspect + TRI + Distance to Anthropogenic	-95793.3	191600.7	253.31	7
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-95792.5	191601.0	253.61	8
Aspect + TRI + Distance to Water + CRS	-95794.7	191603.5	256.10	7
Aspect + TRI + Distance to Forest Edge + CRS	-95796.5	191607.0	259.61	7
Aspect + TRI + Distance to Water + Distance to Forest Edge	-95797.2	191608.5	261.07	7
Aspect + TRI + Distance to Water	-95799.2	191610.4	262.98	6
Aspect + TRI + CRS	-95801.1	191614.2	266.85	6
Aspect + TRI + Distance to Forest Edge	-95801.3	191614.5	267.16	6

Table C.1 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + TRI	-95805.5	191621.0	273.57	5
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95805.5	191625.0	277.58	7
TRI + Distance to Water + Distance to Anthropogenic + CRS	-95807.4	191626.9	279.47	6
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-95808.6	191629.2	281.78	6
TRI + Distance to Water + Distance to Anthropogenic	-95810.5	191630.9	283.51	5
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95811.7	191635.4	288.00	6
TRI + Distance to Anthropogenic + Distance to Forest Edge	-95814.8	191639.6	292.26	5
TRI + Distance to Anthropogenic + CRS	-95816.6	191643.1	295.72	5
TRI + Distance to Anthropogenic	-95819.6	191647.1	299.74	4
TRI + Distance to Water + Distance to Forest Edge + CRS	-95818.9	191647.9	300.49	5
TRI + Distance to Water + CRS	-95820.6	191649.1	301.72	4
TRI + Distance to Forest Edge + CRS	-95823.4	191654.8	307.40	4
TRI + Distance to Water + Distance to Forest Edge	-95823.9	191655.7	308.33	4
TRI + Distance to Water	-95825.2	191656.5	309.08	3
TRI + CRS	-95827.3	191660.6	313.20	3
TRI + Distance to Forest Edge	-95828.4	191662.8	315.38	3
TRI	-95831.9	191667.8	320.45	2
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95862.5	191743.1	395.70	9
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-95865.5	191747.1	399.70	8
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-95865.5	191747.1	399.70	8
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-95865.8	191747.6	400.22	8
Aspect + Distance to Water + Distance to Anthropogenic	-95868.7	191751.3	403.96	7
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95869.2	191754.4	406.98	8
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-95872.5	191758.9	411.54	7
Aspect + Distance to Water + Distance to Forest Edge + CRS	-95872.9	191759.9	412.49	7
Aspect + Distance to Water + CRS	-95875.7	191763.4	415.97	6
Aspect + Distance to Anthropogenic + CRS	-95875.7	191765.3	417.94	7
Aspect + Distance to Water + Distance to Forest Edge	-95877.7	191767.4	420.03	6
Aspect + Distance to Forest Edge + CRS	-95877.8	191767.7	420.31	6
Aspect + Distance to Anthropogenic	-95878.8	191769.5	422.12	6
Aspect + Distance to Water	-95880.1	191770.2	422.82	5
Aspect + Distance to Forest Edge	-95882.7	191775.4	427.96	5

Table C.1 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + CRS	-95883.5	191776.9	429.55	5
Aspect	-95887.8	191783.6	436.23	4
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-95889.2	191790.4	443.04	6
Distance to Water + Distance to Anthropogenic + CRS	-95891.4	191792.9	445.47	5
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-95892.6	191795.3	447.86	5
Distance to Water + Distance to Anthropogenic	-95894.7	191797.5	450.09	4
Distance to Water + Distance to Forest Edge + CRS	-95899.8	191807.5	460.13	4
Distance to Anthropogenic + Distance to Forest Edge	-95900.1	191808.2	460.77	4
Distance to Water + CRS	-95901.8	191809.6	462.21	3
Distance to Anthropogenic + CRS	-95902.2	191812.4	465.05	4
Distance to Water + Distance to Forest Edge	-95904.7	191815.4	468.05	3
Distance to Forest Edge + CRS	-95905.3	191816.5	469.14	3
Distance to Water	-95906.5	191816.9	469.55	2
Distance to Anthropogenic	-95905.5	191817.1	469.68	3
CRS	-95910.1	191824.2	476.85	2
Distance to Forest Edge	-95910.3	191824.6	477.23	2

Table C.2. Results of model selection for ecological resource selection by female grizzly bears during the summer season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to varying levels of human access (Chapter 2). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64416.2	128864.4	0.00	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64416.1	128866.2	1.74	17
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64416.1	128866.3	1.86	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64416.0	128868.0	3.57	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64416.0	128868.0	3.57	18
Landcover + Aspect + Distance to Forest Edge + CRS	-64419.4	128868.9	4.44	15
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-64419.5	128869.0	4.56	15
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64422.2	128870.4	5.99	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64422.2	128870.4	5.99	13
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-64419.3	128870.6	6.11	16
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-64419.3	128870.7	6.27	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64419.4	128870.8	6.33	16
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-64419.4	128870.9	6.42	16
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64422.1	128872.1	7.71	14
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64422.1	128872.3	7.82	14
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-64419.2	128872.3	7.90	17
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64422.0	128874.0	9.51	15
Landcover + Aspect + Distance to Forest Edge	-64423.5	128875.0	10.57	14

Table C.2 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-64425.5	128875.1	10.66	12
Landcover + Distance to Forest Edge + CRS	-64425.6	128875.3	10.82	12
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-64423.4	128876.7	12.27	15
Landcover + Aspect + Distance to Anthropogenic + CRS	-64423.4	128876.8	12.37	15
Landcover + Aspect + TRI + Distance to Forest Edge	-64423.4	128876.8	12.38	15
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64425.4	128876.9	12.42	13
Landcover + Distance to Water + Distance to Forest Edge + CRS	-64425.5	128876.9	12.47	13
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-64425.5	128876.9	12.49	13
Landcover + TRI + Distance to Forest Edge + CRS	-64425.5	128877.0	12.61	13
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-64423.2	128878.5	14.06	16
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-64423.3	128878.6	14.17	16
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-64425.3	128878.7	14.22	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64425.3	128878.7	14.22	14
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-64423.3	128878.7	14.27	16
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-64423.2	128880.5	16.04	17
Landcover + Distance to Anthropogenic + CRS	-64428.5	128881.0	16.56	12
Landcover + Distance to Forest Edge	-64429.8	128881.6	17.11	11
Landcover + Aspect + CRS	-64427.0	128882.1	17.64	14
Landcover + Aspect + Distance to Anthropogenic	-64427.4	128882.7	18.29	14
Landcover + TRI + Distance to Anthropogenic + CRS	-64428.4	128882.8	18.34	13
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-64428.4	128882.9	18.44	13
Landcover + Distance to Water + Distance to Forest Edge	-64429.6	128883.2	18.80	12
Landcover + TRI + Distance to Forest Edge	-64429.7	128883.3	18.90	12
Landcover + Aspect + TRI + CRS	-64426.9	128883.8	19.39	15
Landcover + Aspect + TRI + Distance to Anthropogenic	-64427.3	128884.5	20.08	15
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-64428.3	128884.6	20.19	14
Landcover + TRI + Distance to Water + Distance to Forest Edge	-64429.5	128885.0	20.55	13

Table C.2 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Water + CRS	-64426.8	128885.7	21.22	16
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-64427.2	128886.4	21.98	16
Landcover + CRS	-64432.3	128886.6	22.16	11
Landcover + Distance to Anthropogenic	-64432.5	128887.0	22.54	11
Landcover + TRI + CRS	-64432.2	128888.3	23.89	12
Landcover + Distance to Water + CRS	-64432.2	128888.4	23.99	12
Landcover + TRI + Distance to Anthropogenic	-64432.4	128888.7	24.31	12
Landcover + Distance to Water + Distance to Anthropogenic	-64432.4	128888.9	24.45	12
Landcover + Aspect	-64431.9	128889.9	25.44	13
Landcover + TRI + Distance to Water + CRS	-64432.1	128890.1	25.69	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-64432.3	128890.6	26.20	13
Landcover + Aspect + TRI	-64431.8	128891.6	27.18	14
Landcover + Aspect + Distance to Water	-64431.9	128891.8	27.33	14
Landcover + Aspect + TRI + Distance to Water	-64431.7	128893.5	29.04	15
Landcover	-64437.2	128894.5	30.06	10
Landcover + TRI	-64437.1	128896.2	31.77	11
Landcover + Distance to Water	-64437.2	128896.4	31.93	11
Landcover + TRI + Distance to Water	-64437.0	128898.0	33.61	12
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64530.7	129075.4	210.92	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64530.3	129076.6	212.17	8
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64530.4	129076.7	212.28	8
Aspect + Distance to Forest Edge + CRS	-64533.7	129079.3	214.91	6
Aspect + Distance to Water + Distance to Forest Edge + CRS	-64533.2	129080.5	216.02	7
Aspect + TRI + Distance to Forest Edge + CRS	-64533.3	129080.6	216.19	7
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64535.5	129081.0	216.51	5
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64535.5	129081.0	216.54	5
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-64532.8	129081.6	217.17	8
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64535.1	129082.2	217.72	6
+ Distance to Forest Edge + CRS	-64539.0	129083.9	219.49	3
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-64536.2	129084.4	220.00	6
Distance to Water + Distance to Forest Edge + CRS	-64538.5	129085.1	220.64	4

Table C.2 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
TRI + Distance to Forest Edge + CRS	-64538.6	129085.2	220.74	4
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64535.9	129085.7	221.27	7
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-64535.9	129085.8	221.35	7
TRI + Distance to Water + Distance to Forest Edge + CRS	-64538.1	129086.2	221.75	5
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64535.5	129087.0	222.52	8
Distance to Anthropogenic + Distance to Forest Edge	-64541.4	129088.8	224.40	3
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64541.1	129090.2	225.71	4
TRI + Distance to Anthropogenic + Distance to Forest Edge	-64541.1	129090.2	225.73	4
Aspect + Distance to Forest Edge	-64540.2	129090.4	226.00	5
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64540.7	129091.4	226.93	5
Aspect + Distance to Water + Distance to Forest Edge	-64539.8	129091.6	227.12	6
Aspect + TRI + Distance to Forest Edge	-64539.9	129091.7	227.27	6
Aspect + TRI + Distance to Water + Distance to Forest Edge	-64539.3	129092.7	228.26	7
Distance to Forest Edge	-64545.6	129095.2	230.73	2
Distance to Water + Distance to Forest Edge	-64545.2	129096.3	231.89	3
TRI + Distance to Forest Edge	-64545.2	129096.4	231.97	3
TRI + Distance to Water + Distance to Forest Edge	-64544.7	129097.4	233.00	4
Distance to Anthropogenic + CRS	-64552.9	129111.7	247.28	3
Aspect + Distance to Anthropogenic + CRS	-64550.1	129112.3	247.82	6
TRI + Distance to Anthropogenic + CRS	-64552.3	129112.6	248.20	4
Aspect + TRI + Distance to Anthropogenic + CRS	-64549.6	129113.2	248.73	7
Distance to Water + Distance to Anthropogenic + CRS	-64552.8	129113.7	249.26	4
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-64550.1	129114.2	249.81	7
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-64550.1	129114.2	249.81	7
TRI + Distance to Water + Distance to Anthropogenic + CRS	-64552.3	129114.6	250.16	5
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-64549.6	129115.1	250.70	8
CRS	-64556.4	129116.9	252.45	2
Aspect + CRS	-64553.6	129117.3	252.83	5
TRI + CRS	-64555.9	129117.7	253.28	3
Aspect + TRI + CRS	-64553.0	129118.1	253.65	6
Distance to Water + CRS	-64556.4	129118.9	254.41	3
Aspect + Distance to Water + CRS	-64553.6	129119.2	254.80	6
TRI + Distance to Water + CRS	-64555.8	129119.6	255.20	4

Table C.2 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + TRI + Distance to Water + CRS	-64553.0	129120.0	255.59	7
Distance to Anthropogenic	-64560.0	129124.1	259.66	2
Aspect + Distance to Anthropogenic	-64557.3	129124.7	260.25	5
TRI + Distance to Anthropogenic	-64559.5	129125.0	260.56	3
Aspect + TRI + Distance to Anthropogenic	-64556.8	129125.6	261.14	6
Distance to Water + Distance to Anthropogenic	-64560.0	129126.1	261.66	3
Aspect + Distance to Water + Distance to Anthropogenic	-64557.3	129126.7	262.25	6
TRI + Distance to Water + Distance to Anthropogenic	-64559.5	129127.0	262.54	4
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-64556.8	129127.6	263.13	7
Aspect	-64562.1	129132.3	267.84	4
TRI	-64564.3	129132.6	268.21	2
Aspect + TRI	-64561.5	129133.0	268.61	5
Distance to Water	-64564.9	129133.8	269.40	2
Aspect + Distance to Water	-64562.1	129134.3	269.83	5
TRI + Distance to Water	-64564.3	129134.6	270.16	3
Aspect + TRI + Distance to Water	-64561.5	129135.0	270.57	6

Table C.3. Results of model selection for ecological resource selection by female grizzly bears during the whitebark pine season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to varying levels of human access (Chapter 2). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55804.4	111644.9	0.00	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55804.4	111644.9	0.00	18
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-55805.7	111645.5	0.60	17
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55806.5	111647.1	2.17	17
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-55807.7	111647.4	2.55	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55806.8	111647.6	2.73	17
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-55808.1	111648.3	3.43	16
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55809.1	111650.2	5.30	16
Landcover + Aspect + Distance to Forest Edge + CRS	-55810.3	111650.7	5.77	15
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-55809.6	111653.3	8.38	17
Landcover + Aspect + TRI + Distance to Water + CRS	-55810.9	111653.7	8.85	16
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-55810.9	111653.9	8.98	16
Landcover + Aspect + TRI + CRS	-55812.1	111654.2	9.29	15
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-55812.2	111656.4	11.54	16
Landcover + Aspect + Distance to Anthropogenic + CRS	-55813.7	111657.3	12.44	15
Landcover + Aspect + CRS	-55814.9	111657.7	12.84	14
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-55813.3	111658.6	13.70	16
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-55813.6	111659.1	14.24	16
Landcover + Aspect + TRI + Distance to Forest Edge	-55814.9	111659.9	14.98	15
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-55814.1	111660.3	15.38	16

Table C.3 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55815.3	111660.5	15.65	15
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-55816.5	111661.0	16.11	14
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-55815.8	111661.6	16.72	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-55816.0	111661.9	17.04	15
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55817.0	111662.1	17.18	14
Landcover + TRI + Distance to Forest Edge + CRS	-55818.2	111662.3	17.44	13
Landcover + Aspect + Distance to Forest Edge	-55817.5	111663.0	18.10	14
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55817.5	111663.1	18.22	14
Landcover + Distance to Water + Distance to Forest Edge + CRS	-55818.8	111663.7	18.77	13
Landcover + Aspect + TRI + Distance to Anthropogenic	-55817.2	111664.5	19.58	15
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-55816.3	111664.7	19.79	16
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55819.5	111665.0	20.13	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55819.5	111665.0	20.13	13
Landcover + Distance to Forest Edge + CRS	-55820.7	111665.4	20.48	12
Landcover + Aspect + TRI	-55818.8	111665.6	20.75	14
Landcover + Aspect + TRI + Distance to Water	-55818.0	111666.0	21.15	15
Landcover + Aspect + Distance to Anthropogenic	-55819.9	111667.8	22.91	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-55820.2	111668.4	23.56	14
Landcover + TRI + Distance to Anthropogenic + CRS	-55821.3	111668.5	23.67	13
Landcover + TRI + CRS	-55822.4	111668.7	23.86	12
Landcover + TRI + Distance to Water + CRS	-55821.4	111668.8	23.89	13
Landcover + Aspect	-55821.5	111669.1	24.19	13
Landcover + Aspect + Distance to Water	-55820.6	111669.2	24.35	14
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-55822.7	111671.4	26.53	13
Landcover + Distance to Anthropogenic + CRS	-55823.9	111671.8	26.92	12
Landcover + Distance to Water + CRS	-55823.9	111671.8	26.96	12
Landcover + CRS	-55825.0	111672.1	27.20	11
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-55822.9	111673.9	28.99	14

Table C.3 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-55824.1	111674.3	29.42	13
Landcover + TRI + Distance to Water + Distance to Forest Edge	-55824.6	111675.3	30.39	13
Landcover + TRI + Distance to Forest Edge	-55825.7	111675.5	30.59	12
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-55825.2	111676.4	31.53	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-55826.6	111677.1	32.27	12
Landcover + Distance to Water + Distance to Forest Edge	-55827.0	111677.9	33.03	12
Landcover + Distance to Forest Edge	-55828.2	111678.4	33.53	11
Landcover + TRI + Distance to Anthropogenic	-55827.9	111679.9	34.98	12
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-55827.2	111680.5	35.61	13
Landcover + TRI	-55829.5	111680.9	36.05	11
Landcover + TRI + Distance to Water	-55828.9	111681.7	36.83	12
Landcover + Distance to Anthropogenic	-55830.5	111683.0	38.12	11
Landcover + Distance to Water + Distance to Anthropogenic	-55829.7	111683.4	38.53	12
Landcover	-55832.1	111684.2	39.28	10
Landcover + Distance to Water	-55831.4	111684.7	39.86	11
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-55872.5	111761.1	116.20	8
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55872.6	111761.2	116.36	8
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55872.9	111761.8	116.91	8
Aspect + Distance to Water + Distance to Forest Edge + CRS	-55874.1	111762.2	117.31	7
Aspect + TRI + Distance to Forest Edge + CRS	-55874.2	111762.4	117.57	7
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55874.6	111763.2	118.28	7
Aspect + Distance to Forest Edge + CRS	-55875.9	111763.9	119.02	6
Aspect + TRI + Distance to Anthropogenic + CRS	-55875.6	111765.3	120.42	7
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-55874.7	111765.4	120.52	8
Aspect + TRI + CRS	-55876.9	111765.8	120.93	6
Aspect + TRI + Distance to Water + CRS	-55876.0	111766.0	121.15	7
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-55876.3	111766.6	121.75	7
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-55876.3	111766.6	121.75	7
Aspect + Distance to Anthropogenic + CRS	-55877.4	111766.8	121.89	6

Table C.3 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + Distance to Water + CRS	-55877.7	111767.3	122.45	6
Aspect + CRS	-55878.7	111767.4	122.47	5
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-55878.2	111772.4	127.49	8
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-55879.5	111772.9	128.06	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-55879.7	111773.3	128.45	7
Aspect + TRI + Distance to Water + Distance to Forest Edge	-55880.1	111774.2	129.28	7
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-55881.1	111774.2	129.31	6
Aspect + TRI + Distance to Forest Edge	-55881.2	111774.5	129.61	6
Aspect + Distance to Water + Distance to Forest Edge	-55881.6	111775.2	130.33	6
Aspect + TRI + Distance to Anthropogenic	-55881.9	111775.8	130.87	6
Aspect + Distance to Forest Edge	-55882.9	111775.8	130.95	5
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-55881.2	111776.5	131.58	7
Aspect + Distance to Anthropogenic	-55883.6	111777.1	132.23	5
Aspect + TRI	-55883.6	111777.1	132.24	5
Aspect + Distance to Water + Distance to Anthropogenic	-55882.8	111777.6	132.75	6
Aspect + TRI + Distance to Water	-55883.0	111778.0	133.09	6
Aspect	-55885.3	111778.6	133.68	4
Aspect + Distance to Water	-55884.6	111779.2	134.34	5
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55884.0	111779.9	135.07	6
TRI + Distance to Water + Distance to Forest Edge + CRS	-55885.3	111780.7	135.80	5
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55885.4	111780.8	135.94	5
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-55885.5	111781.0	136.13	5
TRI + Distance to Forest Edge + CRS	-55886.7	111781.4	136.50	4
Distance to Water + Distance to Forest Edge + CRS	-55886.9	111781.8	136.94	4
Distance to Forest Edge + CRS	-55888.4	111782.8	137.97	3
TRI + Distance to Anthropogenic + CRS	-55887.9	111783.7	138.86	4
TRI + CRS	-55889.1	111784.1	139.27	3
TRI + Distance to Water + Distance to Anthropogenic + CRS	-55887.1	111784.3	139.40	5
TRI + Distance to Water + CRS	-55888.4	111784.8	139.90	4
Distance to Anthropogenic + CRS	-55889.6	111785.2	140.32	3
Distance to Water + Distance to Anthropogenic + CRS	-55888.8	111785.5	140.63	4
CRS	-55890.8	111785.7	140.80	2
Distance to Water + CRS	-55890.0	111786.1	141.21	3

Table C.3 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
TRI + Distance to Anthropogenic + Distance to Forest Edge	-55892.4	111792.8	147.90	4
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-55891.4	111792.8	147.95	5
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-55892.9	111793.8	148.96	4
Distance to Anthropogenic + Distance to Forest Edge	-55894.0	111794.1	149.19	3
TRI + Distance to Forest Edge	-55894.1	111794.3	149.37	3
TRI + Distance to Water + Distance to Forest Edge	-55893.2	111794.5	149.61	4
TRI + Distance to Anthropogenic	-55894.5	111795.0	150.15	3
Distance to Water + Distance to Forest Edge	-55894.8	111795.6	150.72	3
Distance to Forest Edge	-55895.8	111795.6	150.74	2
TRI + Distance to Water + Distance to Anthropogenic	-55894.1	111796.1	151.23	4
TRI	-55896.2	111796.3	151.43	2
Distance to Anthropogenic	-55896.2	111796.4	151.51	2
Distance to Water + Distance to Anthropogenic	-55895.6	111797.3	152.41	3
TRI + Distance to Water	-55895.8	111797.5	152.63	3
Distance to Water	-55897.4	111798.8	153.89	2

Table C.4. Results of model selection for ecological resource selection by male grizzly bears during the mating season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to varying levels of human access (Chapter 2). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88161.4	176360.8	0.00	19
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88163.7	176363.5	2.67	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88163.9	176363.7	2.93	18
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-88165.1	176364.2	3.40	17
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-88165.7	176365.5	4.67	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88165.5	176367.0	6.24	18
Landcover + Aspect + TRI + Distance to Water + CRS	-88167.6	176367.1	6.32	16
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-88167.9	176367.8	6.98	16
Landcover + Aspect + TRI + CRS	-88169.8	176369.6	8.82	15
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88168.1	176370.1	9.33	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-88168.1	176370.2	9.37	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-88169.7	176371.4	10.58	16
Landcover + Aspect + TRI + Distance to Anthropogenic	-88170.1	176372.3	11.48	16
Landcover + Aspect + TRI + Distance to Water	-88172.2	176374.4	13.65	15
Landcover + Aspect + TRI + Distance to Forest Edge	-88172.8	176375.6	14.77	15
Landcover + Aspect + TRI	-88174.7	176377.5	16.70	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88179.9	176391.9	31.07	16
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88181.8	176393.6	32.84	15
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88182.4	176394.8	34.02	15
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-88183.5	176394.9	34.13	14
Landcover + TRI + Distance to Anthropogenic + CRS	-88183.9	176395.8	34.97	14

Table C.4 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Water + CRS	-88185.4	176396.7	35.94	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88183.8	176397.7	36.90	15
Landcover + TRI + Distance to Forest Edge + CRS	-88186.4	176398.8	37.98	13
Landcover + TRI + CRS	-88187.8	176399.6	38.82	12
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-88185.8	176399.7	38.87	14
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88186.5	176401.1	40.29	14
Landcover + TRI + Distance to Water + Distance to Forest Edge	-88187.8	176401.6	40.84	13
Landcover + TRI + Distance to Anthropogenic	-88188.1	176402.2	41.37	13
Landcover + TRI + Distance to Water	-88189.8	176403.6	42.80	12
Landcover + TRI + Distance to Forest Edge	-88191.1	176406.1	45.32	12
Landcover + TRI	-88192.5	176407.0	46.24	11
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88190.1	176416.2	55.36	18
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-88192.6	176419.3	58.50	17
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-88194.0	176420.0	59.19	16
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88193.9	176421.7	60.94	17
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88194.3	176422.7	61.90	17
Landcover + Aspect + Distance to Anthropogenic + CRS	-88195.8	176423.7	62.89	16
Landcover + Aspect + Distance to Forest Edge + CRS	-88198.4	176426.8	65.97	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-88198.7	176427.5	66.71	15
Landcover + Aspect + CRS	-88200.2	176428.5	67.70	14
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-88198.4	176428.8	68.04	16
Landcover + Aspect + Distance to Water	-88201.4	176430.7	69.93	14
Landcover + Aspect + Distance to Anthropogenic	-88200.5	176430.9	70.13	15
Landcover + Aspect + Distance to Forest Edge	-88203.5	176435.1	74.30	14
Landcover + Aspect	-88205.4	176436.9	76.09	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88208.1	176446.3	85.49	15
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-88210.1	176448.3	87.49	14

Table C.4 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Water + Distance to Forest Edge + CRS	-88211.8	176449.7	88.91	13
Landcover + Distance to Water + CRS	-88213.8	176451.7	90.91	12
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88212.1	176452.2	91.41	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88212.1	176452.2	91.41	14
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88212.2	176452.4	91.62	14
Landcover + Distance to Anthropogenic + CRS	-88213.6	176453.1	92.35	13
Landcover + Distance to Water + Distance to Anthropogenic	-88214.3	176454.6	93.82	13
Landcover + Distance to Water + Distance to Forest Edge	-88216.4	176456.7	95.95	12
Landcover + Distance to Forest Edge + CRS	-88216.4	176456.8	96.00	12
Landcover + CRS	-88217.8	176457.6	96.78	11
Landcover + Distance to Water	-88218.4	176458.9	98.09	11
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-88216.4	176458.9	98.11	13
Landcover + Distance to Anthropogenic	-88218.0	176460.0	99.19	12
Landcover + Distance to Forest Edge	-88221.3	176464.6	103.85	11
Landcover	-88222.7	176465.5	104.71	10
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88226.1	176470.2	109.41	9
Aspect + TRI + Distance to Water + CRS	-88229.4	176472.9	112.06	7
Aspect + TRI + Distance to Anthropogenic + CRS	-88228.8	176473.6	112.82	8
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-88229.4	176474.9	114.07	8
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88228.8	176475.5	114.75	9
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-88230.2	176476.4	115.63	8
Aspect + TRI + CRS	-88232.7	176477.4	116.65	6
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88230.2	176478.4	117.63	9
Aspect + TRI + Distance to Forest Edge + CRS	-88232.6	176479.3	118.51	7
Aspect + TRI + Distance to Water	-88234.0	176480.0	119.22	6
Aspect + TRI + Distance to Anthropogenic	-88233.1	176480.2	119.43	7
Aspect + TRI + Distance to Water + Distance to Forest Edge	-88234.0	176482.0	121.22	7
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88233.1	176482.2	121.37	8
Aspect + TRI	-88237.6	176485.2	124.42	5
Aspect + TRI + Distance to Forest Edge	-88237.5	176487.1	126.29	6

Table C.4 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
TRI + Distance to Water + Distance to Anthropogenic + CRS	-88250.6	176513.2	152.39	6
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88250.2	176514.5	153.70	7
TRI + Distance to Water + CRS	-88253.7	176515.5	154.70	4
TRI + Distance to Water + Distance to Forest Edge + CRS	-88253.4	176516.7	155.96	5
TRI + Distance to Anthropogenic + CRS	-88253.5	176516.9	156.13	5
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-88250.7	176517.3	156.56	8
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-88250.7	176517.3	156.56	8
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88252.8	176517.6	156.85	6
TRI + Distance to Water + Distance to Anthropogenic	-88254.4	176518.7	157.96	5
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88250.7	176519.3	158.56	9
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88254.1	176520.2	159.37	6
TRI + CRS	-88257.2	176520.4	159.63	3
Aspect + Distance to Water + CRS	-88254.3	176520.5	159.73	6
TRI + Distance to Forest Edge + CRS	-88256.5	176520.9	160.13	4
TRI + Distance to Water	-88258.0	176521.9	161.15	3
Aspect + Distance to Water + Distance to Forest Edge + CRS	-88254.3	176522.5	161.73	7
TRI + Distance to Anthropogenic	-88257.4	176522.9	162.09	4
TRI + Distance to Water + Distance to Forest Edge	-88257.6	176523.3	162.49	4
TRI + Distance to Anthropogenic + Distance to Forest Edge	-88256.9	176523.7	162.92	5
Aspect + Distance to Water + Distance to Anthropogenic	-88255.0	176523.9	163.15	7
Aspect + Distance to Anthropogenic + CRS	-88255.2	176524.4	163.62	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88255.0	176525.9	165.15	8
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88255.1	176526.3	165.50	8
TRI	-88261.7	176527.5	166.70	2
TRI + Distance to Forest Edge	-88261.0	176528.1	167.28	3
Aspect + Distance to Water	-88259.1	176528.1	167.31	5
Aspect + CRS	-88259.6	176529.2	168.36	5
Aspect + Distance to Water + Distance to Forest Edge	-88259.1	176530.1	169.31	6
Aspect + Distance to Forest Edge + CRS	-88259.5	176530.9	170.16	6
Aspect + Distance to Anthropogenic	-88259.8	176531.5	170.75	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-88259.7	176533.4	172.66	7
Aspect	-88264.8	176537.6	176.78	4

Table C.4 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + Distance to Forest Edge	-88264.7	176539.4	178.58	5
Distance to Water + Distance to Anthropogenic + CRS	-88274.8	176559.7	198.89	5
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88274.5	176561.0	200.25	6
Distance to Water + CRS	-88278.2	176562.4	201.65	3
Distance to Water + Distance to Forest Edge + CRS	-88277.9	176563.7	202.94	4
Distance to Water + Distance to Anthropogenic	-88278.8	176565.6	204.80	4
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88278.5	176567.0	206.26	5
Distance to Anthropogenic + CRS	-88279.5	176567.1	206.30	4
Distance to Water	-88282.6	176569.3	208.49	2
Distance to Water + Distance to Forest Edge	-88282.3	176570.6	209.86	3
CRS	-88283.7	176571.4	210.63	2
Distance to Forest Edge + CRS	-88282.9	176571.7	210.96	3
Distance to Anthropogenic	-88283.8	176573.5	212.76	3
Distance to Anthropogenic + Distance to Forest Edge	-88283.1	176574.2	213.45	4
Distance to Forest Edge	-88287.7	176579.5	218.70	2

Table C.5. Results of model selection for ecological resource selection by male grizzly bears during the summer season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to varying levels of human access (Chapter 2). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-57701.9	115441.8	0.00	19
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57701.8	115443.7	1.91	20
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-57709.3	115450.6	8.85	16
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57709.3	115452.6	10.85	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-57710.7	115455.4	13.64	17
Landcover + Aspect + TRI + Distance to Water + CRS	-57711.0	115455.9	14.16	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-57710.6	115457.3	15.47	18
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-57710.9	115457.7	15.96	18
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-57714.0	115464.0	22.26	18
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-57718.1	115464.1	22.34	14
Landcover + TRI + Distance to Water + CRS	-57718.3	115464.6	22.81	14
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57713.6	115465.2	23.37	19
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-57718.0	115466.1	24.31	15
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-57718.3	115466.6	24.77	15
Landcover + Aspect + TRI + Distance to Water	-57721.1	115472.2	30.38	15
Landcover + TRI + Distance to Anthropogenic + CRS	-57721.8	115473.6	31.79	15
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-57720.9	115473.8	31.99	16
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57721.5	115475.1	33.29	16
Landcover + Aspect + TRI + Distance to Anthropogenic	-57721.7	115475.3	33.53	16

Table C.5 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-57721.1	115476.3	34.50	17
Landcover + Aspect + TRI + CRS	-57722.8	115477.7	35.89	16
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-57722.3	115478.5	36.74	17
Landcover + TRI + Distance to Water	-57728.3	115480.7	38.87	12
Landcover + TRI + Distance to Water + Distance to Forest Edge	-57728.3	115482.5	40.72	13
Landcover + TRI + Distance to Anthropogenic	-57729.3	115484.6	42.86	13
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-57729.0	115486.0	44.25	14
Landcover + TRI + CRS	-57730.5	115487.0	45.19	13
Landcover + TRI + Distance to Forest Edge + CRS	-57730.1	115488.3	46.50	14
Landcover + Aspect + TRI	-57731.6	115491.2	49.42	14
Landcover + Aspect + TRI + Distance to Forest Edge	-57730.9	115491.8	49.97	15
Landcover + TRI	-57739.1	115500.3	58.51	11
Landcover + TRI + Distance to Forest Edge	-57738.7	115501.4	59.57	12
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-57762.4	115560.8	119.06	18
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57762.4	115562.8	121.05	19
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-57770.9	115571.7	129.95	15
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57770.9	115573.7	131.92	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-57771.7	115577.4	135.60	17
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-57772.0	115578.1	136.27	17
Landcover + Distance to Water + Distance to Anthropogenic	-57780.1	115586.2	144.38	13
Landcover + Distance to Water + CRS	-57780.4	115586.9	145.07	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-57780.1	115588.2	146.38	14
Landcover + Distance to Water + Distance to Forest Edge + CRS	-57780.4	115588.9	147.07	14
Landcover + Aspect + Distance to Water	-57782.7	115593.4	151.64	14
Landcover + Aspect + Distance to Anthropogenic + CRS	-57780.4	115594.8	152.97	17
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-57782.6	115595.2	153.45	15
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57780.0	115596.0	154.26	18
Landcover + Distance to Water	-57791.0	115604.0	162.22	11

Table C.5 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Water + Distance to Forest Edge	-57791.0	115606.0	164.19	12
Landcover + Aspect + Distance to Anthropogenic	-57788.2	115606.4	164.65	15
Landcover + Distance to Anthropogenic + CRS	-57789.3	115606.7	164.87	14
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-57787.8	115607.6	165.82	16
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57789.2	115608.3	166.54	15
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57789.2	115608.3	166.54	15
Landcover + Aspect + CRS	-57789.7	115609.4	167.57	15
Landcover + Aspect + Distance to Forest Edge + CRS	-57789.2	115610.4	168.61	16
Landcover + Distance to Anthropogenic	-57797.1	115618.1	176.35	12
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-57796.9	115619.7	177.92	13
Landcover + CRS	-57798.5	115621.1	179.29	12
Landcover + Distance to Forest Edge + CRS	-57798.3	115622.6	180.79	13
Landcover + Aspect	-57798.7	115623.4	181.57	13
Landcover + Aspect + Distance to Forest Edge	-57798.1	115624.1	182.32	14
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-57805.1	115630.2	188.38	10
Landcover	-57807.4	115634.9	193.08	10
Landcover + Distance to Forest Edge	-57807.1	115636.1	194.35	11
TRI + Distance to Water + Distance to Anthropogenic + CRS	-57812.1	115638.2	196.46	7
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57811.8	115639.7	197.90	8
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-57814.7	115645.4	203.60	8
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-57813.8	115645.6	203.86	9
Aspect + TRI + Distance to Water + CRS	-57815.0	115646.1	204.31	8
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-57814.1	115646.1	204.35	9
TRI + Distance to Water + Distance to Anthropogenic	-57821.7	115653.3	211.55	5
TRI + Distance to Water + CRS	-57822.0	115654.0	212.17	5
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-57821.3	115654.6	212.83	6
TRI + Distance to Water + Distance to Forest Edge + CRS	-57821.6	115655.1	213.33	6
Aspect + TRI + Distance to Water + Distance to Forest Edge	-57825.0	115664.0	222.20	7
Aspect + TRI + Distance to Water	-57826.2	115664.4	222.63	6
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57822.2	115664.4	222.64	10

Table C.5 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + TRI + Distance to Anthropogenic + CRS	-57824.9	115667.7	225.92	9
TRI + Distance to Water	-57833.1	115672.1	230.34	3
TRI + Distance to Water + Distance to Forest Edge	-57832.5	115673.0	231.17	4
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57830.6	115675.2	233.39	7
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-57830.1	115676.2	234.45	8
TRI + Distance to Anthropogenic + CRS	-57832.2	115676.5	234.70	6
Aspect + TRI + Distance to Forest Edge + CRS	-57831.6	115679.1	237.34	8
Aspect + TRI + Distance to Anthropogenic	-57832.8	115679.7	237.90	7
Aspect + TRI + CRS	-57834.6	115683.2	241.44	7
TRI + Distance to Anthropogenic + Distance to Forest Edge	-57838.4	115686.8	245.03	5
TRI + Distance to Anthropogenic	-57840.1	115688.3	246.50	4
TRI + Distance to Forest Edge + CRS	-57839.9	115689.8	247.99	5
TRI + CRS	-57841.9	115691.7	249.92	4
Aspect + TRI + Distance to Forest Edge	-57840.6	115693.2	251.45	6
Aspect + TRI	-57843.9	115697.8	256.02	5
TRI + Distance to Forest Edge	-57848.9	115703.7	261.96	3
TRI	-57851.0	115706.1	264.29	2
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-57898.0	115814.0	372.19	9
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-57898.0	115814.0	372.19	9
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57897.2	115814.5	372.71	10
Distance to Water + Distance to Anthropogenic + CRS	-57905.8	115823.5	381.73	6
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57905.5	115825.0	383.26	7
Aspect + Distance to Water + Distance to Anthropogenic	-57908.3	115830.5	388.76	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-57907.4	115830.8	389.05	8
Aspect + Distance to Water + Distance to Forest Edge + CRS	-57908.2	115832.3	390.54	8
Aspect + Distance to Water + CRS	-57909.2	115832.4	390.59	7
Distance to Water + Distance to Anthropogenic	-57916.0	115839.9	398.15	4
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-57915.7	115841.3	399.54	5
Distance to Water + CRS	-57916.9	115841.7	399.92	4
Distance to Water + Distance to Forest Edge + CRS	-57916.5	115842.9	401.14	5
Aspect + Distance to Water + Distance to Forest Edge	-57919.9	115851.9	410.10	6
Aspect + Distance to Water	-57921.2	115852.4	410.61	5
Distance to Water	-57928.8	115861.6	419.78	2

Table C.5 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Distance to Water + Distance to Forest Edge	-57928.2	115862.5	420.68	3
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-57927.1	115872.2	430.42	9
Aspect + Distance to Anthropogenic + CRS	-57930.3	115876.6	434.78	8
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-57935.2	115884.5	442.68	7
Distance to Anthropogenic + CRS	-57938.7	115887.3	445.53	5
Aspect + Distance to Anthropogenic	-57938.5	115889.0	447.23	6
Aspect + Distance to Forest Edge + CRS	-57937.5	115889.1	447.30	7
Aspect + CRS	-57941.3	115894.6	452.77	6
Distance to Anthropogenic + Distance to Forest Edge	-57944.7	115897.5	455.69	4
Distance to Anthropogenic	-57946.8	115899.6	457.77	3
Distance to Forest Edge + CRS	-57947.2	115902.3	460.52	4
Aspect + Distance to Forest Edge	-57946.9	115903.8	462.00	5
CRS	-57949.5	115905.0	463.24	3
Aspect	-57950.9	115909.8	467.99	4
Distance to Forest Edge	-57956.4	115916.8	475.05	2

Table C.6. Results of model selection for ecological resource selection by male grizzly bears during the whitebark pine season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to varying levels of human access (Chapter 2). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + CRS	-40444.6	80919.2	0.00	15
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-40443.6	80919.2	0.02	16
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40442.8	80919.7	0.52	17
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-40443.9	80919.9	0.72	16
Landcover + Aspect + TRI + Distance to Water + CRS	-40444.5	80921.0	1.88	16
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-40443.6	80921.2	2.00	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40442.8	80921.7	2.50	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40442.8	80921.7	2.50	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-40443.9	80921.8	2.60	17
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-40446.1	80924.1	4.96	16
Landcover + Aspect + TRI	-40448.1	80924.1	4.97	14
Landcover + Aspect + TRI + Distance to Forest Edge	-40447.1	80924.2	5.02	15
Landcover + Aspect + TRI + Distance to Anthropogenic	-40447.2	80924.3	5.18	15
Landcover + Aspect + TRI + Distance to Water	-40448.0	80926.0	6.79	15
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-40447.1	80926.1	6.96	16
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-40447.1	80926.2	7.00	16
Landcover + TRI + CRS	-40459.2	80942.4	23.29	12
Landcover + TRI + Distance to Forest Edge + CRS	-40458.5	80943.0	23.84	13
Landcover + TRI + Distance to Anthropogenic + CRS	-40458.5	80943.0	23.87	13
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40457.7	80943.4	24.23	14
Landcover + TRI + Distance to Water + CRS	-40459.1	80944.3	25.13	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-40458.4	80944.9	25.71	14

Table C.6 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-40458.5	80944.9	25.78	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40457.7	80945.3	26.17	15
Landcover + TRI	-40462.4	80946.9	27.71	11
Landcover + TRI + Distance to Anthropogenic	-40461.5	80946.9	27.78	12
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-40460.6	80947.3	28.12	13
Landcover + TRI + Distance to Forest Edge	-40461.7	80947.4	28.27	12
Landcover + TRI + Distance to Water	-40462.3	80948.6	29.48	12
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-40461.4	80948.7	29.55	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-40460.6	80949.2	30.02	14
Landcover + TRI + Distance to Water + Distance to Forest Edge	-40461.7	80949.3	30.17	13
Landcover + Aspect + Distance to Forest Edge + CRS	-40480.6	80991.3	72.12	15
Landcover + Aspect + CRS	-40481.7	80991.4	72.19	14
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40479.8	80991.6	72.43	16
Landcover + Aspect + Distance to Anthropogenic + CRS	-40480.9	80991.9	72.75	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-40480.5	80993.1	73.92	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40479.7	80993.4	74.23	17
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-40480.9	80993.8	74.68	16
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-40483.5	80997.0	77.83	15
Landcover + Aspect + Distance to Forest Edge	-40484.7	80997.3	78.15	14
Landcover + Aspect + Distance to Anthropogenic	-40484.7	80997.3	78.15	14
Landcover + Aspect	-40485.7	80997.4	78.19	13
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-40483.4	80998.9	79.69	16
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-40484.6	80999.2	80.02	15
Landcover + Aspect + Distance to Water	-40485.7	80999.3	80.16	14
Landcover + CRS	-40496.1	81014.2	95.00	11
Landcover + Distance to Anthropogenic + CRS	-40495.3	81014.6	95.39	12
Landcover + Distance to Forest Edge + CRS	-40495.3	81014.7	95.49	12

Table C.6 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40494.4	81014.8	95.68	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40494.4	81014.8	95.68	13
Landcover + Distance to Water + CRS	-40496.1	81016.1	96.96	12
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-40495.3	81016.5	97.35	13
Landcover + Distance to Water + Distance to Forest Edge + CRS	-40495.3	81016.5	97.36	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40494.3	81016.7	97.54	14
Landcover + Distance to Anthropogenic	-40498.7	81019.4	100.24	11
Landcover	-40499.8	81019.6	100.45	10
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-40497.8	81019.7	100.50	12
Landcover + Distance to Forest Edge	-40499.1	81020.1	100.95	11
Landcover + Distance to Water + Distance to Anthropogenic	-40498.7	81021.4	102.22	12
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-40497.8	81021.6	102.41	13
Landcover + Distance to Water	-40499.8	81021.6	102.43	11
Landcover + Distance to Water + Distance to Forest Edge	-40499.0	81022.0	102.87	12
Aspect + TRI + Distance to Forest Edge + CRS	-40514.7	81043.4	124.21	7
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40514.2	81044.4	125.26	8
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-40514.3	81044.6	125.43	8
Aspect + TRI + Distance to Forest Edge	-40518.2	81048.5	129.31	6
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-40517.5	81049.1	129.91	7
Aspect + TRI + Distance to Water + Distance to Forest Edge	-40517.9	81049.8	130.67	7
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-40517.2	81050.4	131.26	8
Aspect + TRI + CRS	-40523.9	81059.9	140.74	6
Aspect + TRI + Distance to Anthropogenic + CRS	-40523.7	81061.5	142.31	7
Aspect + TRI + Distance to Water + CRS	-40523.9	81061.9	142.69	7
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-40523.7	81063.4	144.27	8
Aspect + TRI	-40527.6	81065.2	146.03	5
TRI + Distance to Forest Edge + CRS	-40529.1	81066.2	146.99	4
Aspect + TRI + Distance to Anthropogenic	-40527.2	81066.4	147.29	6

Table C.6 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40528.6	81067.1	147.95	5
Aspect + TRI + Distance to Water	-40527.6	81067.2	148.02	6
TRI + Distance to Water + Distance to Forest Edge + CRS	-40528.7	81067.5	148.32	5
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-40527.2	81068.4	149.27	7
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40528.2	81068.4	149.29	6
TRI + Distance to Forest Edge	-40532.4	81070.8	151.61	3
TRI + Distance to Anthropogenic + Distance to Forest Edge	-40531.6	81071.3	152.11	4
TRI + Distance to Water + Distance to Forest Edge	-40532.1	81072.2	153.07	4
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-40531.4	81072.7	153.57	5
TRI + CRS	-40537.4	81080.9	161.70	3
TRI + Distance to Anthropogenic + CRS	-40537.2	81082.3	163.18	4
TRI + Distance to Water + CRS	-40537.4	81082.8	163.67	4
TRI + Distance to Water + Distance to Anthropogenic + CRS	-40537.2	81084.3	165.15	5
TRI	-40540.9	81085.8	166.60	2
TRI + Distance to Anthropogenic	-40540.4	81086.9	167.73	3
TRI + Distance to Water	-40540.9	81087.7	168.59	3
TRI + Distance to Water + Distance to Anthropogenic	-40540.4	81088.9	169.72	4
Aspect + Distance to Water + Distance to Forest Edge + CRS	-40566.2	81146.4	227.27	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40565.7	81147.4	228.22	8
Aspect + Distance to Forest Edge + CRS	-40567.8	81147.6	228.39	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40567.3	81148.5	229.35	7
Aspect + Distance to Water + Distance to Forest Edge	-40570.6	81153.2	234.06	6
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-40569.8	81153.6	234.48	7
Aspect + Distance to Forest Edge	-40572.0	81154.0	234.87	5
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-40571.2	81154.5	235.30	6
Aspect + CRS	-40576.7	81163.4	244.22	5
Aspect + Distance to Water + CRS	-40576.1	81164.1	244.98	6
Aspect + Distance to Anthropogenic + CRS	-40576.4	81164.9	245.72	6
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-40575.8	81165.7	246.49	7
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-40575.8	81165.7	246.49	7
Distance to Water + Distance to Forest Edge + CRS	-40580.5	81168.9	249.75	4

Table C.6 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-40579.9	81169.8	250.60	5
Distance to Forest Edge + CRS	-40581.9	81169.8	250.66	3
Aspect	-40581.0	81170.1	250.90	4
Aspect + Distance to Water	-40580.5	81171.0	251.86	5
Aspect + Distance to Anthropogenic	-40580.6	81171.2	252.02	5
Aspect + Distance to Water + Distance to Anthropogenic	-40580.1	81172.1	252.98	6
Distance to Water + Distance to Forest Edge	-40584.6	81175.2	256.02	3
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-40583.7	81175.5	256.31	4
Distance to Forest Edge	-40585.9	81175.8	256.64	2
Distance to Anthropogenic + Distance to Forest Edge	-40585.1	81176.1	256.94	3
CRS	-40589.8	81183.7	264.52	2
Distance to Water + CRS	-40589.2	81184.5	265.33	3
Distance to Anthropogenic + CRS	-40589.5	81185.1	265.90	3
Distance to Water + Distance to Anthropogenic + CRS	-40588.9	81185.9	266.72	4
Distance to Anthropogenic	-40593.5	81190.9	271.75	2
Distance to Water	-40593.5	81191.0	271.79	2
Distance to Water + Distance to Anthropogenic	-40593.0	81191.9	272.77	3

Table C.7. Summary of the number of grizzly bears with at least one used location per Bear Management Area (BMA) status (Restricted BMA, Unrestricted BMA, Non-BMA) for all sex-season combinations in Yellowstone National Park, WY, USA, 2004–2020. We used these variables to test our hypotheses (Table 2.3) about grizzly bear selection of access restrictions (Table 2.5).

		Restricted BMA	Unrestricted BMA	Non-BMA
Females	Mating	11	2	18
	Summer	8	8	14
	Whitebark Pine	4	6	14
Males	Mating	16	16	24
	Summer	17	17	19
	Whitebark Pine	13	12	15

Table C.8. Summary of the number of grizzly bears with at least one used location in a Bear Management Area (BMA), regardless of whether restrictions were in place (BMA, Non-BMA), for all sex-season combinations in Yellowstone National Park, WY, USA, 2004–2020. We used these variables to test our hypotheses (Table 2.3) about grizzly bear selection of BMAs (Table 2.5).

		BMA	**Non-BMA**
Females	**Mating**	11	18
	Summer	9	14
	Whitebark Pine	8	14
Males	**Mating**	18	24
	Summer	19	19
	Whitebark Pine	14	15

Table C.9. Summary of the number of grizzly bears with at least one used location per Bear Management Area (BMA) status (Restricted BMA, Unrestricted BMA, Non-BMA) between years with abundant and scarce whitebark pine cone production, for the whitebark pine season for both sexes in Yellowstone National Park, WY, USA, 2004–2020.

		Restricted BMA	Unrestricted BMA	Non-BMA
Females	**Abundant**	3	4	12
	Scarce	1	2	2
Males	**Abundant**	10	9	12
	Scarce	3	3	3

Table C.10. Summary of the number of grizzly bears with at least one used location in a Bear Management Area (BMA), regardless of whether restrictions were in place (BMA, Non-BMA), between years with abundant and scarce whitebark pine cone production, for the whitebark pine season for both sexes in Yellowstone National Park, WY, USA, 2004–2020.

		BMA	Non-BMA
Females	**Abundant**	6	12
	Scarce	2	2
Males	**Abundant**	11	12
	Scarce	3	3

Table C.11. Parameter estimates and 95% confidence intervals from the best-supported model for the BMA model suite for grizzly bears, by sex and season, in Yellowstone National Park, WY, USA, 2004–2020. We compared candidate models (Table 2.3) to test our hypotheses (Table 2.2) about grizzly bear responses to different levels of restrictions to human access (BMAs: non-BMA, unrestricted BMA, restricted BMA). We report estimates from the best supported model. TRI is Terrain Roughness Index, CRS is Carcass Redistribution Site, WBP is whitebark pine, BMA is Bear Management Area, PDSI is the Palmer Drought Severity Index, and WBP-Scarce is scarce whitebark pine abundance. All continuous variables are centered and scaled.

Sex	*Season*	*Parameter*	*Estimate*	*95% CI*	
Female	Mating	TRI	0.200	0.170	0.230
		Aspect - North	-0.235	-0.310	-0.159
		Aspect - East	-0.189	-0.260	-0.117
		Aspect - West	-0.182	-0.254	-0.109
		Landcover - Wet Forest	0.210	0.107	0.312
		Landcover - Shrub	0.183	0.107	0.259
		Landcover - Dry Meadow	0.284	0.175	0.393
		Landcover - Subalpine Fir	-0.040	-0.155	0.076
		Landcover - Douglas Fir	0.155	0.045	0.266
		Landcover - Wet Meadow	0.213	0.081	0.345
		Landcover - Rock	-0.260	-0.485	-0.035
		Landcover - Water	-0.909	-1.084	-0.735
		Landcover - WBP	0.084	-0.059	0.226
		Distance to Anthropogenic	-0.303	-0.559	-0.048
		CRS	0.243	0.007	0.480
		BMA	0.271	-0.023	0.565
	Summer	Distance to Forest Edge	0.099	0.049	0.149
		Aspect - North	0.142	0.051	0.233
		Aspect - East	-0.009	-0.098	0.080
		Aspect - West	0.073	-0.007	0.153
		Landcover - Wet Forest	0.422	0.296	0.547
		Landcover - Shrub	0.182	0.081	0.284
		Landcover - Dry Meadow	0.382	0.265	0.499
		Landcover - Subalpine Fir	-0.009	-0.139	0.122
		Landcover - Douglas Fir	0.341	0.177	0.505
		Landcover - Wet Meadow	0.718	0.585	0.852
		Landcover - Rock	0.359	0.141	0.578
		Landcover - Water	-1.205	-1.713	-0.697
		Landcover - WBP	0.079	-0.068	0.227
		Distance to Anthropogenic	-0.200	-0.391	-0.009
		CRS	0.423	0.095	0.750

Sex	*Season*	*Parameter*	*Estimate*	*95% CI*	
		BMA	0.220	-0.240	0.680
	Whitebark Pine	Distance to Forest Edge	0.110	0.045	0.176
		TRI	0.044	0.006	0.083
		Distance to Water	0.054	-0.005	0.113
		Aspect - North	0.122	0.028	0.215
		Aspect - East	0.084	-0.006	0.174
		Aspect - West	-0.093	-0.189	0.003
		Landcover - Wet Forest	0.468	0.337	0.598
		Landcover - Shrub	-0.100	-0.216	0.016
		Landcover - Dry Meadow	0.115	-0.028	0.259
		Landcover - Subalpine Fir	0.127	0.021	0.233
		Landcover - Douglas Fir	-0.061	-0.323	0.200
		Landcover - Wet Meadow	0.515	0.353	0.677
		Landcover - Rock	-0.140	-0.416	0.137
		Landcover - Water	-0.308	-0.649	0.034
		Landcover - WBP	0.251	0.125	0.377
		Distance to Anthropogenic	-0.163	-0.359	0.034
		CRS	0.796	0.383	1.209
		BMA	0.184	-0.253	0.621
Male	Mating	Distance to Forest Edge	-0.040	-0.078	-0.003
		Distance to Water	-0.040	-0.075	-0.005
		TRI	-0.127	-0.162	-0.092
		Aspect - North	-0.168	-0.245	-0.091
		Aspect - East	-0.113	-0.183	-0.042
		Aspect - West	-0.205	-0.275	-0.135
		Landcover - Wet Forest	0.418	0.307	0.529
		Landcover - Shrub	0.238	0.153	0.323
		Landcover - Dry Meadow	0.173	0.074	0.271
		Landcover - Subalpine Fir	-0.089	-0.204	0.027
		Landcover - Douglas Fir	0.318	0.200	0.436
		Landcover - Wet Meadow	0.313	0.197	0.428
		Landcover - Rock	0.447	0.256	0.638
		Landcover - Water	-0.051	-0.217	0.115
		Landcover - WBP	0.047	-0.100	0.193
		Distance to Anthropogenic	-0.029	-0.308	0.250
		CRS	0.448	0.145	0.751
		BMA	0.161	-0.120	0.443
	Summer	Distance to Water	-0.112	-0.161	-0.062
		TRI	-0.260	-0.313	-0.207

Sex	*Season*	*Parameter*	*Estimate*	*95% CI*	
		Aspect - North	0.164	0.070	0.258
		Aspect - East	0.044	-0.048	0.136
		Aspect - West	0.025	-0.068	0.117
		Landcover - Wet Forest	0.636	0.521	0.751
		Landcover - Shrub	0.114	0.011	0.216
		Landcover - Dry Meadow	0.234	0.114	0.354
		Landcover - Subalpine Fir	0.142	0.016	0.267
		Landcover - Douglas Fir	-0.063	-0.330	0.203
		Landcover - Wet Meadow	0.555	0.441	0.670
		Landcover - Rock	-0.142	-0.379	0.095
		Landcover - Water	0.004	-0.213	0.220
		Landcover - WBP	0.253	0.100	0.407
		Distance to Anthropogenic	0.272	-0.408	0.952
		CRS	0.405	-0.405	1.215
		Restricted BMA	0.197	-0.093	0.487
		Unrestricted BMA	0.572	0.259	0.885
	Whitebark Pine	TRI	-0.249	-0.312	-0.187
		Aspect - North	0.017	-0.094	0.128
		Aspect - East	0.109	0.004	0.215
		Aspect - West	-0.196	-0.312	-0.081
		Landcover - Wet Forest	0.225	0.073	0.377
		Landcover - Shrub	-0.352	-0.478	-0.226
		Landcover - Dry Meadow	-0.273	-0.435	-0.110
		Landcover - Subalpine Fir	0.201	0.077	0.325
		Landcover - Douglas Fir	0.053	-0.180	0.287
		Landcover - Wet Meadow	0.331	0.177	0.484
		Landcover - Rock	-0.939	-1.314	-0.565
		Landcover - Water	-0.028	-0.257	0.201
		Landcover - WBP	0.059	-0.087	0.205
		CRS	0.584	0.144	1.025
		Restricted BMA	0.172	-0.115	0.459
		Unrestricted BMA	0.629	0.139	1.118

APPENDIX D

MODEL SELECTION RESULTS, PARAMETER ESTIMATES, AND SUMMARY TABLES FOR ECOLOGICAL AND RECREATION MODELS

Table D.1. Results of model selection for ecological resource selection by female grizzly bears during the mating season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to trails in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-117349.0	234733.9	0.00	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-117350.5	234734.9	0.98	17
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-117350.6	234735.2	1.30	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117348.9	234735.8	1.89	19
Landcover + Aspect + TRI + Distance to Anthropogenic	-117352.1	234736.2	2.22	16
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-117350.4	234736.8	2.85	18
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117350.6	234737.2	3.28	18
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-117352.1	234738.1	4.19	17
Landcover + Aspect + TRI + CRS	-117356.7	234743.3	9.37	15
Landcover + Aspect + TRI + Distance to Water + CRS	-117355.8	234743.6	9.67	16
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-117356.6	234745.2	11.23	16
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-117355.7	234745.3	11.39	17
Landcover + Aspect + TRI	-117358.9	234745.7	11.77	14
Landcover + Aspect + TRI + Distance to Water	-117358.1	234746.1	12.17	15
Landcover + Aspect + TRI + Distance to Forest Edge	-117358.7	234747.5	13.55	15
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-117357.9	234747.7	13.79	16
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-117375.8	234781.6	47.65	15
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-117377.3	234782.6	48.61	14
Landcover + TRI + Distance to Anthropogenic + CRS	-117377.4	234782.7	48.79	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117375.6	234783.2	49.25	16

Table D.1 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Anthropogenic	-117378.8	234783.6	49.70	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-117377.1	234784.1	50.17	15
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117377.3	234784.6	50.62	15
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-117378.7	234785.4	51.49	14
Landcover + TRI + CRS	-117383.4	234790.8	56.88	12
Landcover + TRI + Distance to Water + CRS	-117382.6	234791.3	57.33	13
Landcover + TRI + Distance to Forest Edge + CRS	-117383.2	234792.4	58.44	13
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-117382.3	234792.6	58.66	14
Landcover + TRI	-117385.6	234793.2	59.27	11
Landcover + TRI + Distance to Water	-117384.9	234793.8	59.80	12
Landcover + TRI + Distance to Forest Edge	-117385.3	234794.6	60.70	12
Landcover + TRI + Distance to Water + Distance to Forest Edge	-117384.5	234794.9	60.99	13
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-117464.4	234962.9	228.91	17
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117464.4	234964.8	230.90	18
Landcover + Aspect + Distance to Anthropogenic + CRS	-117466.9	234965.8	231.83	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-117466.0	234965.9	231.98	17
Landcover + Aspect + Distance to Anthropogenic	-117468.4	234966.8	232.85	15
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117466.9	234967.8	233.81	17
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-117468.4	234968.8	234.84	16
Landcover + Aspect + CRS	-117470.8	234969.6	235.65	14
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-117469.2	234970.4	236.46	16
Landcover + Aspect + Distance to Water	-117471.4	234970.7	236.77	14
Landcover + Aspect + Distance to Forest Edge + CRS	-117470.8	234971.6	237.65	15
Landcover + Aspect	-117472.9	234971.7	237.77	13
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-117471.3	234972.6	238.65	15
Landcover + Aspect + Distance to Forest Edge	-117472.8	234973.7	239.75	14
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-117492.0	235012.0	278.04	14

Table D.1 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Water + Distance to Anthropogenic	-117493.5	235013.1	279.13	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117491.9	235013.8	279.85	15
Landcover + Distance to Anthropogenic + CRS	-117494.4	235014.8	280.89	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-117493.4	235014.9	280.90	14
Landcover + Distance to Anthropogenic	-117495.9	235015.9	281.91	12
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117494.4	235016.8	282.86	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117494.4	235016.8	282.86	14
Landcover + Distance to Water + CRS	-117496.8	235017.5	283.56	12
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-117495.9	235017.8	283.86	13
Landcover + CRS	-117498.3	235018.5	284.59	11
Landcover + Distance to Water + Distance to Forest Edge + CRS	-117496.6	235019.2	285.26	13
Landcover + Distance to Water	-117498.9	235019.7	285.79	11
Landcover + Distance to Forest Edge + CRS	-117498.2	235020.4	286.48	12
Landcover	-117500.3	235020.6	286.70	10
Landcover + Distance to Water + Distance to Forest Edge	-117498.7	235021.3	287.38	12
Landcover + Distance to Forest Edge	-117500.2	235022.5	288.51	11
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-117514.6	235047.1	313.18	9
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-117517.2	235050.5	316.51	8
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-117517.1	235052.2	318.21	9
Aspect + TRI + Distance to Water + CRS	-117525.6	235065.1	331.19	7
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-117525.3	235066.7	332.74	8
Aspect + TRI + Distance to Anthropogenic + CRS	-117526.1	235068.1	334.17	8
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117525.8	235069.6	335.69	9
Aspect + TRI + Distance to Anthropogenic	-117528.7	235071.4	337.44	7
Aspect + TRI + Distance to Water	-117529.7	235071.4	337.50	6
Aspect + TRI + Distance to Water + Distance to Forest Edge	-117529.4	235072.8	338.86	7

Table D.1 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-117528.5	235073.0	339.03	8
Aspect + TRI + CRS	-117534.5	235081.0	347.02	6
Aspect + TRI + Distance to Forest Edge + CRS	-117534.4	235082.8	348.86	7
Aspect + TRI	-117538.5	235087.1	353.15	5
Aspect + TRI + Distance to Forest Edge	-117538.5	235089.0	355.07	6
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117551.2	235116.3	382.37	7
TRI + Distance to Water + Distance to Anthropogenic	-117554.6	235119.1	385.16	5
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-117553.9	235119.8	385.82	6
TRI + Distance to Water + CRS	-117563.3	235134.5	400.57	4
TRI + Distance to Water + Distance to Forest Edge + CRS	-117562.5	235134.9	400.97	5
TRI + Distance to Anthropogenic + CRS	-117563.4	235136.7	402.80	5
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117563.4	235138.7	404.78	6
TRI + Distance to Anthropogenic	-117566.1	235140.3	406.35	4
TRI + Distance to Water	-117567.6	235141.2	407.30	3
TRI + Distance to Water + Distance to Forest Edge	-117566.7	235141.3	407.36	4
TRI + Distance to Anthropogenic + Distance to Forest Edge	-117566.1	235142.3	408.34	5
TRI + CRS	-117572.2	235150.3	416.39	3
TRI + Distance to Forest Edge + CRS	-117572.2	235152.3	418.37	4
TRI	-117576.5	235156.9	422.97	2
TRI + Distance to Forest Edge	-117576.4	235158.9	424.91	3
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-117639.1	235294.3	560.32	8
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-117639.1	235294.3	560.32	8
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117639.0	235296.0	562.06	9
Aspect + Distance to Water + Distance to Anthropogenic	-117641.9	235297.9	563.94	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-117641.8	235299.6	565.62	8
Aspect + Distance to Water + CRS	-117647.1	235306.1	572.16	6
Aspect + Distance to Water + Distance to Forest Edge + CRS	-117646.9	235307.7	573.80	7
Aspect + Distance to Water	-117651.0	235312.1	578.14	5
Aspect + Distance to Water + Distance to Forest Edge	-117650.8	235313.5	579.60	6
Aspect + Distance to Anthropogenic + CRS	-117653.1	235320.2	586.24	7

Table D.1 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117652.8	235321.6	587.61	8
Aspect + Distance to Anthropogenic	-117655.9	235323.8	589.82	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-117655.6	235325.2	591.27	7
Aspect + CRS	-117658.4	235326.9	592.93	5
Aspect + Distance to Forest Edge + CRS	-117658.3	235328.5	594.57	6
Aspect	-117662.3	235332.6	598.70	4
Aspect + Distance to Forest Edge	-117662.2	235334.4	600.48	5
Distance to Water + Distance to Anthropogenic + CRS	-117676.9	235363.9	629.93	5
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-117676.3	235364.6	630.66	6
Distance to Water + Distance to Anthropogenic	-117679.9	235367.8	633.81	4
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-117679.2	235368.4	634.42	5
Distance to Water + CRS	-117685.2	235376.4	642.50	3
Distance to Water + Distance to Forest Edge + CRS	-117684.5	235377.0	643.07	4
Distance to Water	-117689.4	235382.8	648.87	2
Distance to Water + Distance to Forest Edge	-117688.5	235383.1	649.11	3
Distance to Anthropogenic + CRS	-117691.2	235390.4	656.45	4
Distance to Anthropogenic	-117694.1	235394.3	660.35	3
Distance to Anthropogenic + Distance to Forest Edge	-117694.1	235396.3	662.30	4
CRS	-117696.8	235397.6	663.61	2
Distance to Forest Edge + CRS	-117696.8	235399.6	665.61	3
Distance to Forest Edge	-117700.9	235405.8	671.83	2

Table D.2. Results of model selection for ecological resource selection by female grizzly bears during the summer season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to trails in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88923.5	177882.9	0.00	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88923.5	177884.9	2.00	19
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88926.2	177886.5	3.55	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88926.2	177888.5	5.55	18
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-88929.3	177890.7	7.76	16
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-88928.9	177891.8	8.89	17
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88929.3	177892.6	9.70	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-88929.3	177892.7	9.76	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88928.9	177893.8	10.88	18
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88929.3	177894.5	11.60	18
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-88932.1	177896.2	13.27	16
Landcover + Aspect + TRI + Distance to Anthropogenic	-88932.1	177896.2	13.28	16
Landcover + Aspect + TRI + Distance to Forest Edge	-88933.5	177896.9	13.99	15
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88932.0	177898.1	15.14	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-88932.1	177898.2	15.27	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-88933.5	177898.9	15.98	16
Landcover + Aspect + TRI + CRS	-88935.0	177900.0	17.09	15
Landcover + Aspect + Distance to Forest Edge + CRS	-88935.5	177901.1	18.15	15
Landcover + Aspect + Distance to Anthropogenic + CRS	-88934.9	177901.9	18.97	16
Landcover + Aspect + TRI + Distance to Water + CRS	-88935.0	177902.0	19.09	16

Table D.2 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88936.2	177902.5	19.56	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-88935.5	177903.0	20.04	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-88934.9	177903.8	20.84	17
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88936.2	177904.5	21.55	16
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88939.0	177906.1	23.13	14
Landcover + Aspect + Distance to Anthropogenic	-88938.2	177906.3	23.40	15
Landcover + Aspect + Distance to Forest Edge	-88939.7	177907.4	24.42	14
Landcover + Aspect + TRI	-88939.8	177907.6	24.66	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88939.0	177908.0	25.10	15
Landcover + TRI + Distance to Anthropogenic + CRS	-88940.1	177908.2	25.31	14
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-88939.6	177909.2	26.28	15
Landcover + Aspect + TRI + Distance to Water	-88939.8	177909.6	26.65	15
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88940.1	177910.2	27.28	15
Landcover + Aspect + CRS	-88941.4	177910.8	27.87	14
Landcover + TRI + Distance to Forest Edge + CRS	-88942.6	177911.3	28.34	13
Landcover + TRI + Distance to Anthropogenic	-88943.3	177912.5	29.58	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88942.3	177912.6	29.69	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88942.3	177912.6	29.69	14
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-88942.6	177913.3	30.33	14
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88942.2	177914.4	31.52	15
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-88943.2	177914.5	31.54	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-88945.1	177916.2	33.26	13
Landcover + TRI + CRS	-88946.7	177917.4	34.45	12
Landcover + TRI + Distance to Forest Edge	-88946.8	177917.7	34.72	12
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88945.0	177918.0	35.05	14
Landcover + Aspect	-88946.2	177918.4	35.51	13

Table D.2 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Anthropogenic + CRS	-88946.3	177918.7	35.73	13
Landcover + TRI + Distance to Water + CRS	-88946.7	177919.4	36.43	13
Landcover + TRI + Distance to Water + Distance to Forest Edge	-88946.8	177919.6	36.70	13
Landcover + Aspect + Distance to Water	-88946.1	177920.3	37.33	14
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-88946.2	177920.5	37.53	14
Landcover + Distance to Forest Edge + CRS	-88949.0	177922.1	39.17	12
Landcover + Distance to Anthropogenic	-88949.5	177923.0	40.03	12
Landcover + Distance to Water + Distance to Forest Edge + CRS	-88949.0	177923.9	40.98	13
Landcover + Distance to Water + Distance to Anthropogenic	-88949.4	177924.7	41.79	13
Landcover + TRI	-88951.5	177924.9	41.97	11
Landcover + TRI + Distance to Water	-88951.4	177926.9	43.95	12
Landcover + Distance to Forest Edge	-88953.3	177928.5	45.59	11
Landcover + CRS	-88953.3	177928.5	45.59	11
Landcover + Distance to Water + Distance to Forest Edge	-88953.1	177930.3	47.37	12
Landcover + Distance to Water + CRS	-88953.2	177930.3	47.37	12
Landcover	-88958.0	177936.1	53.17	10
Landcover + Distance to Water	-88957.9	177937.8	54.92	11
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89068.8	178155.6	272.69	9
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-89073.3	178162.7	279.75	8
Aspect + TRI + Distance to Forest Edge + CRS	-89075.2	178164.5	281.56	7
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-89073.3	178164.7	281.73	9
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-89075.2	178166.5	283.55	8
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89080.2	178172.4	289.45	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89078.6	178173.2	290.28	8
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89080.2	178174.3	291.39	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89078.5	178174.9	292.01	9
Aspect + TRI + Distance to Forest Edge	-89081.5	178175.0	292.09	6
Aspect + TRI + Distance to Water + Distance to Forest Edge	-89081.5	178177.0	294.07	7

Table D.2 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
TRI + Distance to Anthropogenic + Distance to Forest Edge	-89084.7	178179.4	296.42	5
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-89083.1	178180.3	297.37	7
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-89084.6	178181.3	298.33	6
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-89083.0	178182.0	299.05	8
TRI + Distance to Forest Edge + CRS	-89087.0	178182.1	299.17	4
Aspect + Distance to Forest Edge + CRS	-89085.5	178183.0	300.04	6
TRI + Distance to Water + Distance to Forest Edge + CRS	-89087.0	178184.0	301.11	5
Aspect + Distance to Water + Distance to Forest Edge + CRS	-89085.3	178184.7	301.73	7
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89089.9	178191.8	308.88	6
TRI + Distance to Forest Edge	-89093.3	178192.7	309.72	3
Aspect + Distance to Forest Edge	-89091.8	178193.5	310.62	5
TRI + Distance to Water + Distance to Forest Edge	-89093.3	178194.6	311.66	4
Aspect + TRI + Distance to Anthropogenic + CRS	-89089.5	178195.1	312.17	8
Aspect + Distance to Water + Distance to Forest Edge	-89091.6	178195.2	312.28	6
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-89089.4	178196.8	313.84	9
Distance to Anthropogenic + Distance to Forest Edge	-89094.6	178197.3	314.32	4
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-89094.4	178198.7	315.80	5
Distance to Forest Edge + CRS	-89097.5	178200.9	317.98	3
Distance to Water + Distance to Forest Edge + CRS	-89097.2	178202.4	319.47	4
TRI + Distance to Anthropogenic + CRS	-89096.6	178203.2	320.27	5
Aspect + TRI + Distance to Anthropogenic	-89095.3	178204.7	321.74	7
TRI + Distance to Water + Distance to Anthropogenic + CRS	-89096.4	178204.8	321.85	6
Aspect + TRI + CRS	-89096.5	178205.0	322.12	6
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-89095.1	178206.3	323.33	8
Aspect + TRI + Distance to Water + CRS	-89096.4	178206.8	323.84	7
Distance to Forest Edge	-89103.7	178211.5	328.56	2
TRI + Distance to Anthropogenic	-89102.2	178212.4	329.47	4
Distance to Water + Distance to Forest Edge	-89103.5	178212.9	330.01	3
TRI + CRS	-89103.9	178213.8	330.85	3
TRI + Distance to Water + Distance to Anthropogenic	-89101.9	178213.9	330.96	5
Aspect + Distance to Anthropogenic + CRS	-89100.6	178215.1	332.22	7

Table D.2 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
TRI + Distance to Water + CRS	-89103.7	178215.4	332.47	4
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-89100.0	178216.1	333.15	8
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-89100.0	178216.1	333.15	8
Aspect + TRI	-89104.6	178219.2	336.28	5
Aspect + TRI + Distance to Water	-89104.4	178220.9	337.94	6
Distance to Anthropogenic + CRS	-89107.6	178223.3	340.36	4
Distance to Water + Distance to Anthropogenic + CRS	-89107.0	178224.1	341.12	5
Aspect + Distance to Anthropogenic	-89106.4	178224.8	341.91	6
Aspect + Distance to Water + Distance to Anthropogenic	-89105.8	178225.6	342.70	7
Aspect + CRS	-89107.9	178225.9	342.96	5
Aspect + Distance to Water + CRS	-89107.4	178226.8	343.88	6
TRI	-89111.8	178227.5	344.62	2
TRI + Distance to Water	-89111.6	178229.1	346.18	3
Distance to Anthropogenic	-89113.3	178232.6	349.65	3
Distance to Water + Distance to Anthropogenic	-89112.6	178233.2	350.27	4
CRS	-89115.4	178234.7	351.78	2
Distance to Water + CRS	-89114.7	178235.4	352.51	3
Aspect	-89116.1	178240.2	357.28	4
Aspect + Distance to Water	-89115.5	178241.0	358.09	5
Distance to Water	-89122.6	178249.2	366.29	2

Table D.3. Results of model selection for ecological resource selection by female grizzly bears during the whitebark pine season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to trails in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-79406.9	158847.8	0.00	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-79406.8	158849.7	1.92	18
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79406.9	158849.8	1.98	18
Landcover + Aspect + Distance to Forest Edge + CRS	-79408.9	158849.9	2.10	16
Landcover + Aspect + TRI + CRS	-79409.8	158851.6	3.85	16
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79406.8	158851.7	3.90	19
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-79408.9	158851.9	4.08	17
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79408.9	158851.9	4.08	17
Landcover + Aspect + CRS	-79411.7	158853.5	5.72	15
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-79409.8	158853.6	5.82	17
Landcover + Aspect + TRI + Distance to Water + CRS	-79409.8	158853.6	5.85	17
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79408.9	158853.8	6.06	18
Landcover + Aspect + TRI + Distance to Forest Edge	-79412.7	158855.3	7.53	15
Landcover + Aspect + Distance to Anthropogenic + CRS	-79411.7	158855.5	7.70	16
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-79409.8	158855.6	7.82	18
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-79412.6	158857.2	9.43	16
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-79412.7	158857.3	9.53	16
Landcover + Aspect + Distance to Forest Edge	-79414.7	158857.5	9.67	14
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-79411.7	158857.5	9.70	17
Landcover + Aspect + TRI	-79415.1	158858.2	10.47	14
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79412.6	158859.2	11.43	17

Table D.3 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-79414.7	158859.4	11.58	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-79414.7	158859.4	11.65	15
Landcover + Aspect + TRI + Distance to Anthropogenic	-79415.1	158860.1	12.35	15
Landcover + Aspect + TRI + Distance to Water	-79415.1	158860.2	12.41	15
Landcover + Aspect	-79417.1	158860.2	12.41	13
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79414.7	158861.3	13.56	16
Landcover + Aspect + Distance to Water	-79417.0	158862.1	14.28	14
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-79415.0	158862.1	14.29	16
Landcover + Aspect + Distance to Anthropogenic	-79417.0	158862.1	14.30	14
Landcover + TRI + Distance to Forest Edge + CRS	-79425.3	158878.5	30.74	14
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-79425.3	158880.5	32.73	15
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79425.3	158880.5	32.73	15
Landcover + Distance to Forest Edge + CRS	-79427.5	158881.1	33.32	13
Landcover + TRI + CRS	-79428.0	158881.9	34.14	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79425.2	158882.5	34.73	16
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79427.5	158883.1	35.31	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79427.5	158883.1	35.31	14
Landcover + Distance to Water + Distance to Forest Edge + CRS	-79427.5	158883.1	35.31	14
Landcover + TRI + Distance to Water + CRS	-79427.9	158883.9	36.11	14
Landcover + TRI + Distance to Anthropogenic + CRS	-79428.0	158883.9	36.13	14
Landcover + CRS	-79430.1	158884.3	36.50	12
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79427.5	158885.1	37.31	15
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-79427.9	158885.9	38.11	15
Landcover + Distance to Water + CRS	-79430.1	158886.2	38.42	13
Landcover + Distance to Anthropogenic + CRS	-79430.1	158886.3	38.49	13
Landcover + TRI + Distance to Forest Edge	-79431.6	158887.2	39.44	12
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-79430.1	158888.2	40.41	14

Table D.3 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-79431.6	158889.2	41.37	13
Landcover + TRI + Distance to Water + Distance to Forest Edge	-79431.6	158889.2	41.38	13
Landcover + TRI	-79433.8	158889.7	41.90	11
Landcover + Distance to Forest Edge	-79433.9	158889.8	42.07	11
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79431.5	158891.1	43.32	14
Landcover + TRI + Distance to Water	-79433.7	158891.5	43.70	12
Landcover + TRI + Distance to Anthropogenic	-79433.8	158891.6	43.82	12
Landcover + Distance to Water + Distance to Forest Edge	-79433.8	158891.7	43.92	12
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-79433.9	158891.8	44.01	12
Landcover	-79436.1	158892.1	44.33	10
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-79433.7	158893.4	45.62	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79433.8	158893.6	45.87	13
Landcover + Distance to Water	-79435.9	158893.8	46.00	11
Landcover + Distance to Anthropogenic	-79436.0	158894.0	46.25	11
Landcover + Distance to Water + Distance to Anthropogenic	-79435.9	158895.7	47.93	12
Aspect + TRI + CRS	-79476.8	158967.7	119.89	7
Aspect + TRI + Distance to Forest Edge + CRS	-79476.5	158968.9	121.13	8
Aspect + TRI + Distance to Water + CRS	-79476.8	158969.7	121.89	8
Aspect + TRI + Distance to Anthropogenic + CRS	-79476.8	158969.7	121.89	8
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-79476.5	158970.9	123.13	9
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79476.5	158970.9	123.13	9
Aspect + CRS	-79479.6	158971.2	123.45	6
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-79476.8	158971.7	123.88	9
Aspect + Distance to Forest Edge + CRS	-79479.3	158972.5	124.74	7
Aspect + Distance to Water + CRS	-79479.6	158973.2	125.40	7
Aspect + Distance to Anthropogenic + CRS	-79479.6	158973.2	125.45	7
Aspect + TRI	-79482.0	158974.0	126.20	5
Aspect + Distance to Water + Distance to Forest Edge + CRS	-79479.3	158974.5	126.72	8
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79479.3	158974.5	126.74	8

Table D.3 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-79479.6	158975.2	127.40	8
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-79479.6	158975.2	127.40	8
Aspect + TRI + Distance to Forest Edge	-79481.8	158975.5	127.73	6
Aspect + TRI + Distance to Water	-79481.9	158975.9	128.10	6
Aspect + TRI + Distance to Anthropogenic	-79482.0	158975.9	128.16	6
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79479.3	158976.5	128.72	9
Aspect + TRI + Distance to Water + Distance to Forest Edge	-79481.7	158977.5	129.68	7
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-79481.7	158977.5	129.70	7
Aspect	-79484.8	158977.6	129.85	4
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-79481.9	158977.8	130.07	7
Aspect + Distance to Forest Edge	-79484.6	158979.2	131.42	5
Aspect + Distance to Water	-79484.7	158979.4	131.62	5
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79481.7	158979.4	131.65	8
Aspect + Distance to Anthropogenic	-79484.8	158979.6	131.81	5
Aspect + Distance to Water + Distance to Forest Edge	-79484.5	158981.0	133.26	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-79484.6	158981.2	133.38	6
Aspect + Distance to Water + Distance to Anthropogenic	-79484.7	158981.4	133.59	6
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79484.5	158983.0	135.23	7
TRI + CRS	-79499.3	159006.6	158.80	4
TRI + Distance to Forest Edge + CRS	-79499.2	159008.3	160.54	5
TRI + Distance to Water + CRS	-79499.3	159008.5	160.74	5
TRI + Distance to Anthropogenic + CRS	-79499.3	159008.6	160.80	5
TRI + Distance to Water + Distance to Forest Edge + CRS	-79499.1	159010.3	162.51	6
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79499.2	159010.3	162.54	6
TRI + Distance to Water + Distance to Anthropogenic + CRS	-79499.3	159010.5	162.73	6
CRS	-79502.3	159010.6	162.80	3
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79499.1	159012.3	164.51	7
Distance to Forest Edge + CRS	-79502.2	159012.3	164.56	4
Distance to Water + CRS	-79502.2	159012.4	164.62	4

Table D.3 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Distance to Anthropogenic + CRS	-79502.3	159012.6	164.79	4
TRI	-79505.1	159014.2	166.40	2
Distance to Water + Distance to Forest Edge + CRS	-79502.1	159014.2	166.43	5
Distance to Water + Distance to Anthropogenic + CRS	-79502.2	159014.4	166.61	5
TRI + Distance to Water	-79505.0	159015.9	168.13	3
TRI + Distance to Forest Edge	-79505.0	159016.1	168.30	3
TRI + Distance to Anthropogenic	-79505.1	159016.2	168.38	3
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79502.1	159016.2	168.43	6
TRI + Distance to Water + Distance to Forest Edge	-79504.9	159017.9	170.07	4
TRI + Distance to Water + Distance to Anthropogenic	-79504.9	159017.9	170.12	4
TRI + Distance to Anthropogenic + Distance to Forest Edge	-79505.0	159018.1	170.29	4
Distance to Water	-79507.9	159019.8	172.00	2
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79504.9	159019.8	172.06	5
Distance to Forest Edge	-79508.1	159020.2	172.40	2
Distance to Anthropogenic	-79508.1	159020.2	172.47	2
Distance to Water + Distance to Forest Edge	-79507.9	159021.7	173.97	3
Distance to Water + Distance to Anthropogenic	-79507.9	159021.8	174.00	3
Distance to Anthropogenic + Distance to Forest Edge	-79508.1	159022.2	174.39	3
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79507.9	159023.7	175.96	4

Table D.4. Results of model selection for ecological resource selection by male grizzly bears during the mating season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to trails in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-133964.3	267966.7	0.00	19
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-133963.8	267967.7	1.00	20
Landcover + Aspect + TRI + Distance to Water + CRS	-133968.0	267970.0	3.29	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-133967.5	267971.0	4.29	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-133969.3	267972.6	5.87	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-133968.8	267973.5	6.82	18
Landcover + Aspect + TRI + Distance to Water	-133973.6	267977.1	10.45	15
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-133973.0	267978.1	11.41	16
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-133975.2	267982.4	15.70	16
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-133974.8	267983.7	16.99	17
Landcover + TRI + Distance to Water + CRS	-133978.7	267985.5	18.82	14
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-133975.2	267986.4	19.69	18
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-133978.4	267986.8	20.11	15
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-133980.0	267988.0	21.31	14
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-133975.2	267988.3	21.65	19
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-133979.6	267989.2	22.55	15
Landcover + Aspect + TRI + CRS	-133979.5	267991.0	24.29	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-133977.9	267991.9	25.20	18
Landcover + TRI + Distance to Water	-133984.2	267992.4	25.68	12

Table D.4 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Anthropogenic	-133980.3	267992.6	25.91	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-133977.3	267992.7	26.02	19
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-133979.5	267992.9	26.26	17
Landcover + TRI + Distance to Water + Distance to Forest Edge	-133983.8	267993.6	26.93	13
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-133980.3	267994.5	27.86	17
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-133981.2	267996.3	29.63	17
Landcover + Aspect + TRI	-133985.3	267998.6	31.95	14
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-133982.6	267999.2	32.48	17
Landcover + Aspect + TRI + Distance to Forest Edge	-133985.3	268000.6	33.93	15
Landcover + TRI + Distance to Anthropogenic + CRS	-133986.3	268002.6	35.88	15
Landcover + Aspect + Distance to Water	-133987.7	268003.4	36.68	14
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-133987.1	268004.2	37.47	15
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-133986.3	268004.6	37.87	16
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-133988.5	268006.9	40.23	15
Landcover + TRI + CRS	-133990.5	268006.9	40.24	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-133988.0	268008.0	41.36	16
Landcover + TRI + Distance to Anthropogenic	-133991.3	268008.5	41.82	13
Landcover + TRI + Distance to Forest Edge + CRS	-133990.5	268008.9	42.24	14
Landcover + Distance to Water + CRS	-133992.2	268010.3	43.65	13
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-133991.2	268010.5	43.82	14
Landcover + Distance to Water + Distance to Forest Edge + CRS	-133991.7	268011.5	44.78	14
Landcover + Distance to Water + Distance to Anthropogenic	-133993.6	268013.2	46.50	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-133993.1	268014.2	47.56	14
Landcover + TRI	-133996.1	268014.3	47.61	11
Landcover + Aspect + Distance to Anthropogenic + CRS	-133990.2	268014.5	47.78	17
Landcover + TRI + Distance to Forest Edge	-133996.1	268016.3	49.61	12
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-133990.2	268016.4	49.72	18
Landcover + Distance to Water	-133998.0	268017.9	51.24	11

Table D.4 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Water + Distance to Forest Edge	-133997.5	268019.0	52.32	12
Landcover + Aspect + CRS	-133994.7	268019.5	52.81	15
Landcover + Aspect + Distance to Anthropogenic	-133995.7	268021.4	54.71	15
Landcover + Aspect + Distance to Forest Edge + CRS	-133994.7	268021.5	54.77	16
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-133995.7	268023.3	56.64	16
Landcover + Aspect	-134001.0	268028.0	61.29	13
Landcover + Distance to Anthropogenic + CRS	-134001.0	268029.9	63.24	14
Landcover + Aspect + Distance to Forest Edge	-134001.0	268029.9	63.25	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-134001.0	268031.9	65.23	15
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-134001.0	268031.9	65.23	15
Landcover + CRS	-134005.3	268034.7	68.01	12
Landcover + Distance to Anthropogenic	-134006.3	268036.6	69.91	12
Landcover + Distance to Forest Edge + CRS	-134005.3	268036.7	70.01	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-134006.3	268038.6	71.90	13
Landcover	-134011.4	268042.9	76.20	10
Landcover + Distance to Forest Edge	-134011.4	268044.9	78.20	11
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-134040.5	268101.0	134.34	10
Aspect + TRI + Distance to Water + CRS	-134044.3	268104.5	137.82	8
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-134043.6	268105.1	138.46	9
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-134046.0	268108.1	141.40	8
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-134045.4	268108.8	142.08	9
Aspect + TRI + Distance to Water	-134050.5	268113.0	146.31	6
Aspect + TRI + Distance to Water + Distance to Forest Edge	-134049.8	268113.6	146.94	7
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-134050.9	268121.7	155.05	10
Aspect + TRI + Distance to Anthropogenic + CRS	-134053.4	268124.7	158.05	9
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-134055.2	268126.3	159.66	8
Aspect + TRI + Distance to Forest Edge + CRS	-134055.3	268126.6	159.94	8
TRI + Distance to Water + Distance to Anthropogenic + CRS	-134056.6	268127.2	160.54	7
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-134054.7	268127.3	160.63	9

Table D.4 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-134054.7	268127.3	160.63	9
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-134054.1	268128.1	161.44	10
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-134056.5	268128.9	162.26	8
TRI + Distance to Water + Distance to Forest Edge + CRS	-134058.8	268129.6	162.96	6
Aspect + TRI + CRS	-134058.0	268130.0	163.30	7
TRI + Distance to Water + CRS	-134060.3	268130.5	163.87	5
Aspect + Distance to Water + CRS	-134058.6	268131.3	164.57	7
Aspect + TRI + Distance to Anthropogenic	-134059.0	268131.9	165.23	7
Aspect + Distance to Water + Distance to Forest Edge + CRS	-134058.0	268132.0	165.36	8
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-134060.6	268133.2	166.50	6
TRI + Distance to Water + Distance to Anthropogenic	-134062.0	268134.0	167.30	5
Aspect + Distance to Water + Distance to Anthropogenic	-134060.5	268135.1	168.40	7
Aspect + TRI + Distance to Forest Edge	-134061.7	268135.4	168.68	6
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-134060.0	268135.9	169.23	8
TRI + Distance to Water + Distance to Forest Edge	-134064.9	268137.8	171.16	4
TRI + Distance to Water	-134066.4	268138.7	172.03	3
Aspect + TRI	-134064.4	268138.8	172.08	5
Aspect + Distance to Water	-134065.3	268140.6	173.88	5
Aspect + Distance to Water + Distance to Forest Edge	-134064.7	268141.3	174.66	6
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-134065.9	268145.7	179.02	7
TRI + Distance to Forest Edge + CRS	-134070.2	268150.3	183.64	5
TRI + Distance to Anthropogenic + CRS	-134069.7	268151.5	184.77	6
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-134069.1	268152.2	185.55	7
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-134067.2	268152.4	185.67	9
TRI + Distance to Anthropogenic + Distance to Forest Edge	-134071.3	268152.7	185.97	5
Distance to Water + Distance to Anthropogenic + CRS	-134070.4	268152.8	186.15	6
Aspect + Distance to Anthropogenic + CRS	-134069.7	268155.5	188.77	8
Distance to Water + Distance to Forest Edge + CRS	-134073.0	268156.0	189.28	5
TRI + CRS	-134074.2	268156.5	189.80	4
Distance to Water + CRS	-134074.3	268156.6	189.92	4
Aspect + Distance to Forest Edge + CRS	-134071.9	268157.9	191.21	7
TRI + Distance to Anthropogenic	-134075.1	268158.3	191.59	4
TRI + Distance to Forest Edge	-134076.4	268158.8	192.07	3

Table D.4 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-134074.9	268159.8	193.10	5
Distance to Water + Distance to Anthropogenic	-134076.2	268160.3	193.63	4
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-134073.2	268160.4	193.69	7
Aspect + CRS	-134074.7	268161.4	194.70	6
Aspect + Distance to Anthropogenic	-134075.7	268163.4	196.74	6
TRI	-134080.4	268164.9	198.19	2
Distance to Water + Distance to Forest Edge	-134079.5	268165.0	198.30	3
Distance to Water	-134080.8	268165.6	198.91	2
Aspect + Distance to Forest Edge	-134078.8	268167.6	200.88	5
Aspect	-134081.5	268171.1	204.41	4
Distance to Forest Edge + CRS	-134086.4	268180.8	214.13	4
Distance to Anthropogenic + CRS	-134085.7	268181.4	214.69	5
Distance to Anthropogenic + Distance to Forest Edge	-134087.7	268183.3	216.67	4
CRS	-134090.5	268187.0	220.36	3
Distance to Anthropogenic	-134091.5	268189.0	222.30	3
Distance to Forest Edge	-134093.1	268190.2	223.50	2

Table D.5. Results of model selection for ecological resource selection by male grizzly bears during the summer season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to trails in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88629.9	177297.8	0.00	19
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88629.7	177299.4	1.67	20
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88637.0	177306.0	8.25	16
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88636.7	177307.3	9.59	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-88638.9	177311.9	14.12	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88638.8	177313.7	15.90	18
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-88646.1	177320.2	22.39	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88645.8	177321.6	23.89	15
Landcover + Aspect + TRI + Distance to Water + CRS	-88645.8	177325.6	27.85	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-88645.7	177327.4	29.64	18
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-88647.8	177331.6	33.85	18
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88647.8	177333.5	35.79	19
Landcover + TRI + Distance to Water + CRS	-88653.0	177334.1	36.34	14
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-88652.8	177335.6	37.83	15
Landcover + TRI + Distance to Anthropogenic + CRS	-88654.9	177339.8	42.09	15
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88654.9	177341.8	44.09	16
Landcover + Aspect + TRI + Distance to Water	-88656.1	177342.1	44.36	15
Landcover + Aspect + TRI + Distance to Anthropogenic	-88655.7	177343.4	45.64	16
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-88656.0	177344.0	46.27	16

Table D.5 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88655.6	177345.3	47.54	17
Landcover + TRI + Distance to Water	-88663.3	177350.6	52.85	12
Landcover + TRI + Distance to Anthropogenic	-88662.8	177351.6	53.88	13
Landcover + TRI + Distance to Water + Distance to Forest Edge	-88663.2	177352.3	54.55	13
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88662.8	177353.6	55.88	14
Landcover + Aspect + TRI + CRS	-88661.5	177355.0	57.26	16
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-88661.5	177356.9	59.17	17
Landcover + TRI + CRS	-88668.7	177363.5	65.71	13
Landcover + TRI + Distance to Forest Edge + CRS	-88668.7	177365.5	67.71	14
Landcover + Aspect + TRI	-88670.5	177369.0	71.23	14
Landcover + Aspect + TRI + Distance to Forest Edge	-88670.4	177370.8	73.06	15
Landcover + TRI	-88677.7	177377.4	79.66	11
Landcover + TRI + Distance to Forest Edge	-88677.7	177379.4	81.63	12
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-88706.8	177449.6	151.82	18
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88706.5	177450.9	153.19	19
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-88714.9	177459.9	162.13	15
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88714.4	177460.8	163.01	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88716.0	177466.1	168.30	17
Landcover + Distance to Water + Distance to Anthropogenic	-88724.4	177474.9	177.11	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88724.0	177475.9	178.19	14
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-88723.3	177480.7	182.91	17
Landcover + Distance to Water + CRS	-88731.8	177489.7	191.91	13
Landcover + Distance to Water + Distance to Forest Edge + CRS	-88731.4	177490.8	193.00	14
Landcover + Aspect + Distance to Water	-88734.3	177496.6	198.89	14
Landcover + Aspect + Distance to Anthropogenic + CRS	-88732.1	177498.2	200.40	17
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-88734.2	177498.4	200.62	15
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88732.1	177500.1	202.38	18
Landcover + Distance to Water	-88742.6	177507.2	209.42	11

Table D.5 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Water + Distance to Forest Edge	-88742.3	177508.6	210.80	12
Landcover + Distance to Anthropogenic + CRS	-88740.3	177508.7	210.90	14
Landcover + Aspect + Distance to Anthropogenic	-88740.2	177510.3	212.58	15
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88740.3	177510.6	212.88	15
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88740.3	177510.6	212.88	15
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-88740.1	177512.3	214.53	16
Landcover + Distance to Anthropogenic	-88748.4	177520.8	223.05	12
Landcover + Aspect + CRS	-88746.3	177522.6	224.79	15
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-88748.4	177522.8	225.05	13
Landcover + Aspect + Distance to Forest Edge + CRS	-88746.3	177524.5	226.75	16
Landcover + CRS	-88754.6	177533.2	235.48	12
Landcover + Distance to Forest Edge + CRS	-88754.6	177535.2	237.48	13
Landcover + Aspect	-88755.5	177537.0	239.24	13
Landcover + Aspect + Distance to Forest Edge	-88755.4	177538.9	241.13	14
Landcover	-88763.8	177547.6	249.89	10
Landcover + Distance to Forest Edge	-88763.8	177549.6	251.89	11
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88783.1	177586.2	288.47	10
TRI + Distance to Water + Distance to Anthropogenic + CRS	-88791.8	177597.5	299.76	7
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88791.3	177598.6	300.87	8
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-88793.0	177602.0	304.20	8
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88792.9	177603.9	306.11	9
TRI + Distance to Water + Distance to Anthropogenic	-88801.7	177613.3	315.57	5
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88801.3	177614.6	316.84	6
Aspect + TRI + Distance to Water + CRS	-88800.5	177616.9	319.19	8
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-88800.4	177618.9	321.15	9
TRI + Distance to Water + CRS	-88809.3	177628.5	330.79	5
TRI + Distance to Water + Distance to Forest Edge + CRS	-88809.0	177630.0	332.20	6
Aspect + TRI + Distance to Water	-88811.8	177635.6	337.80	6
Aspect + TRI + Distance to Anthropogenic + CRS	-88808.9	177635.8	338.00	9
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88808.5	177636.9	339.17	10

Table D.5 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + TRI + Distance to Water + Distance to Forest Edge	-88811.8	177637.6	339.80	7
TRI + Distance to Anthropogenic + CRS	-88817.2	177646.5	348.73	6
TRI + Distance to Water	-88820.6	177647.2	349.44	3
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88817.2	177648.3	350.59	7
Aspect + TRI + Distance to Anthropogenic	-88817.3	177648.5	350.76	7
TRI + Distance to Water + Distance to Forest Edge	-88820.4	177648.8	351.05	4
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88816.8	177649.6	351.85	8
TRI + Distance to Anthropogenic	-88825.6	177659.3	361.53	4
Aspect + TRI + CRS	-88823.5	177661.0	363.29	7
TRI + Distance to Anthropogenic + Distance to Forest Edge	-88825.6	177661.1	363.36	5
Aspect + TRI + Distance to Forest Edge + CRS	-88823.0	177662.0	364.23	8
TRI + CRS	-88832.0	177672.0	374.26	4
TRI + Distance to Forest Edge + CRS	-88831.9	177673.8	376.03	5
Aspect + TRI	-88833.2	177676.3	378.57	5
Aspect + TRI + Distance to Forest Edge	-88832.5	177677.1	379.32	6
TRI	-88841.6	177687.3	389.54	2
TRI + Distance to Forest Edge	-88841.5	177689.0	391.22	3
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-88893.2	177804.5	506.74	9
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-88893.2	177804.5	506.74	9
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88893.2	177806.3	508.59	10
Distance to Water + Distance to Anthropogenic + CRS	-88902.7	177817.4	519.67	6
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88902.2	177818.4	520.69	7
Aspect + Distance to Water + Distance to Anthropogenic	-88903.7	177821.4	523.65	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88903.7	177823.3	525.56	8
Distance to Water + Distance to Anthropogenic	-88913.2	177834.4	536.66	4
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88912.8	177835.6	537.85	5
Aspect + Distance to Water + CRS	-88912.2	177838.3	540.56	7
Aspect + Distance to Water + Distance to Forest Edge + CRS	-88912.1	177840.3	542.52	8
Distance to Water + CRS	-88921.8	177851.5	553.77	4
Distance to Water + Distance to Forest Edge + CRS	-88921.4	177852.9	555.12	5
Aspect + Distance to Water	-88924.2	177858.4	560.69	5
Aspect + Distance to Water + Distance to Forest Edge	-88924.2	177860.4	562.69	6
Distance to Water	-88933.8	177871.7	573.93	2

Table D.5 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Distance to Water + Distance to Forest Edge	-88933.6	177873.3	575.50	3
Aspect + Distance to Anthropogenic + CRS	-88933.7	177883.4	585.60	8
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88933.0	177883.9	586.18	9
Distance to Anthropogenic + CRS	-88943.0	177896.0	598.23	5
Aspect + Distance to Anthropogenic	-88942.3	177896.5	598.77	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-88941.5	177897.0	599.25	7
Distance to Anthropogenic	-88951.6	177909.2	611.42	3
Aspect + CRS	-88949.4	177910.8	613.01	6
Distance to Anthropogenic + Distance to Forest Edge	-88951.4	177910.8	613.01	4
Aspect + Distance to Forest Edge + CRS	-88948.5	177911.0	613.20	7
CRS	-88958.8	177923.6	625.81	3
Distance to Forest Edge + CRS	-88958.5	177925.0	627.28	4
Aspect + Distance to Forest Edge	-88958.3	177926.6	628.86	5
Aspect	-88959.3	177926.7	628.90	4
Distance to Forest Edge	-88968.4	177940.8	643.01	2

Table D.6. Results of model selection for ecological resource selection by male grizzly bears during the whitebark pine season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to trails in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-64863.9	129759.7	0.00	16
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64863.5	129761.0	1.29	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-64863.8	129761.6	1.86	17
Landcover + Aspect + TRI + CRS	-64866.4	129762.8	3.07	15
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64863.4	129762.9	3.15	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64863.4	129762.9	3.15	18
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-64866.2	129764.3	4.56	16
Landcover + Aspect + TRI + Distance to Water + CRS	-64866.4	129764.8	5.07	16
Landcover + TRI + Distance to Forest Edge + CRS	-64869.4	129764.9	5.13	13
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64869.1	129766.1	6.38	14
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-64866.2	129766.3	6.56	17
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-64869.4	129766.7	7.00	14
Landcover + TRI + CRS	-64871.7	129767.4	7.61	12
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64869.0	129768.0	8.24	15
Landcover + TRI + Distance to Anthropogenic + CRS	-64871.4	129768.8	9.05	13
Landcover + TRI + Distance to Water + CRS	-64871.7	129769.4	9.60	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-64871.4	129770.8	11.05	14
Landcover + Aspect + TRI + Distance to Forest Edge	-64872.4	129774.8	15.09	15
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-64871.7	129775.5	15.75	16
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-64872.4	129776.8	17.00	16
Landcover + Aspect + TRI	-64875.0	129778.0	18.24	14

Table D.6 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Anthropogenic	-64874.5	129778.9	19.19	15
Landcover + TRI + Distance to Forest Edge	-64877.6	129779.3	19.52	12
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-64876.9	129779.9	20.13	13
Landcover + Aspect + TRI + Distance to Water	-64875.0	129780.0	20.25	15
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-64874.5	129780.9	21.19	16
Landcover + TRI + Distance to Water + Distance to Forest Edge	-64877.6	129781.2	21.43	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64876.9	129781.8	22.05	14
Landcover + TRI	-64879.9	129781.9	22.12	11
Landcover + TRI + Distance to Anthropogenic	-64879.4	129782.8	23.00	12
Landcover + TRI + Distance to Water	-64879.9	129783.9	24.12	12
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-64879.4	129784.8	25.00	13
Landcover + Aspect + Distance to Forest Edge + CRS	-64902.0	129834.1	74.34	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-64901.6	129835.1	75.36	16
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64901.6	129835.2	75.47	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64901.1	129836.2	76.48	17
Landcover + Aspect + CRS	-64904.9	129837.9	78.12	14
Landcover + Distance to Forest Edge + CRS	-64907.4	129838.9	79.15	12
Landcover + Aspect + Distance to Anthropogenic + CRS	-64904.6	129839.2	79.48	15
Landcover + Distance to Water + Distance to Forest Edge + CRS	-64907.0	129839.9	80.20	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64907.0	129840.0	80.24	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64907.0	129840.0	80.24	13
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-64904.4	129840.8	81.08	16
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64906.5	129841.0	81.27	14
Landcover + CRS	-64910.0	129842.0	82.23	11
Landcover + Distance to Anthropogenic + CRS	-64909.6	129843.3	83.54	12
Landcover + Distance to Water + CRS	-64909.8	129843.6	83.81	12
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-64909.4	129844.9	85.12	13

Table D.6 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + Distance to Forest Edge	-64911.2	129850.3	90.59	14
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-64910.4	129850.7	91.00	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-64910.7	129851.5	91.76	15
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64909.9	129851.9	92.15	16
Landcover + Aspect	-64914.1	129854.2	94.45	13
Landcover + Distance to Forest Edge	-64916.2	129854.4	94.69	11
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-64915.4	129854.8	95.05	12
Landcover + Aspect + Distance to Anthropogenic	-64913.5	129854.9	95.19	14
Landcover + Distance to Water + Distance to Forest Edge	-64915.8	129855.6	95.87	12
Landcover + Aspect + Distance to Water	-64913.9	129855.9	96.14	14
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64915.0	129856.0	96.22	13
Landcover	-64918.8	129857.6	97.89	10
Landcover + Distance to Anthropogenic	-64918.2	129858.3	98.56	11
Landcover + Distance to Water	-64918.7	129859.3	99.56	11
Landcover + Distance to Water + Distance to Anthropogenic	-64918.0	129860.0	100.24	12
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-64967.0	129950.0	190.28	8
Aspect + TRI + Distance to Forest Edge + CRS	-64968.8	129951.6	191.84	7
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64968.7	129953.3	193.59	8
TRI + Distance to Water + Distance to Forest Edge + CRS	-64971.9	129953.7	193.98	5
TRI + Distance to Forest Edge + CRS	-64973.6	129955.3	195.52	4
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64971.7	129955.4	195.69	6
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64973.5	129957.0	197.24	5
Aspect + TRI + Distance to Water + Distance to Forest Edge	-64976.0	129966.0	206.21	7
Aspect + TRI + Distance to Forest Edge	-64977.6	129967.3	207.51	6
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64975.6	129967.3	207.52	8
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-64977.3	129968.6	208.84	7
TRI + Distance to Water + Distance to Forest Edge	-64980.6	129969.2	209.48	4
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64980.2	129970.5	210.75	5
TRI + Distance to Forest Edge	-64982.3	129970.5	210.77	3

Table D.6 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
TRI + Distance to Anthropogenic + Distance to Forest Edge	-64981.9	129971.8	212.05	4
Aspect + TRI + CRS	-64984.7	129981.3	221.58	6
Aspect + TRI + Distance to Water + CRS	-64984.2	129982.4	222.68	7
Aspect + TRI + Distance to Anthropogenic + CRS	-64984.7	129983.3	223.57	7
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-64984.2	129984.4	224.67	8
TRI + CRS	-64989.4	129984.8	225.07	3
TRI + Distance to Water + CRS	-64989.0	129985.9	226.17	4
TRI + Distance to Anthropogenic + CRS	-64989.4	129986.8	227.05	4
TRI + Distance to Water + Distance to Anthropogenic + CRS	-64988.9	129987.9	228.15	5
Aspect + TRI	-64993.9	129997.9	238.11	5
Aspect + TRI + Distance to Water	-64993.5	129999.1	239.35	6
Aspect + TRI + Distance to Anthropogenic	-64993.8	129999.7	239.92	6
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-64993.5	130000.9	241.16	7
TRI	-64998.6	130001.2	241.45	2
TRI + Distance to Water	-64998.2	130002.4	242.70	3
TRI + Distance to Anthropogenic	-64998.5	130003.0	243.23	3
TRI + Distance to Water + Distance to Anthropogenic	-64998.1	130004.2	244.48	4
Aspect + Distance to Water + Distance to Forest Edge + CRS	-65024.7	130063.4	303.61	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-65024.5	130065.0	305.24	8
Distance to Water + Distance to Forest Edge + CRS	-65029.1	130066.1	306.37	4
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-65028.9	130067.7	307.96	5
Aspect + Distance to Forest Edge + CRS	-65028.6	130069.3	309.54	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-65028.5	130070.9	311.19	7
Distance to Forest Edge + CRS	-65033.0	130072.0	312.25	3
Aspect + Distance to Water + Distance to Forest Edge	-65034.5	130080.9	321.19	6
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-65034.0	130082.0	322.29	7
Distance to Water + Distance to Forest Edge	-65038.6	130083.3	323.50	3
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-65038.2	130084.3	324.55	4
Aspect + Distance to Forest Edge	-65038.2	130086.4	326.68	5
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-65037.8	130087.6	327.81	6
Distance to Forest Edge	-65042.4	130088.7	328.96	2
Distance to Anthropogenic + Distance to Forest Edge	-65041.9	130089.8	330.03	3
Aspect + Distance to Water + CRS	-65043.8	130099.6	339.87	6

Table D.6 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + CRS	-65045.5	130101.1	341.33	5
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-65043.8	130101.6	341.83	7
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-65043.8	130101.6	341.83	7
Distance to Water + CRS	-65047.9	130101.8	342.10	3
Aspect + Distance to Anthropogenic + CRS	-65045.5	130103.0	343.29	6
CRS	-65049.6	130103.3	343.53	2
Distance to Water + Distance to Anthropogenic + CRS	-65047.9	130103.8	344.04	4
Distance to Anthropogenic + CRS	-65049.6	130105.2	345.47	3
Aspect + Distance to Water	-65054.0	130118.0	358.23	5
Aspect	-65055.6	130119.1	359.38	4
Aspect + Distance to Water + Distance to Anthropogenic	-65053.8	130119.7	359.93	6
Distance to Water	-65058.0	130120.1	360.34	2
Aspect + Distance to Anthropogenic	-65055.4	130120.8	361.08	5
Distance to Water + Distance to Anthropogenic	-65057.9	130121.8	362.00	3
Distance to Anthropogenic	-65059.4	130122.9	363.11	2

Table D.7. Results of model selection for ecological resource selection by female grizzly bears during the mating season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to backcountry campsites in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-107649.3	215334.5	0.00	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-107650.8	215335.6	1.05	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107649.3	215336.5	1.99	19
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-107650.8	215337.6	3.05	18
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-107654.7	215343.4	8.88	17
Landcover + Aspect + TRI + Distance to Anthropogenic	-107656.2	215344.3	9.79	16
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107654.6	215345.3	10.71	18
Landcover + Aspect + TRI + Distance to Water + CRS	-107656.7	215345.3	10.79	16
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-107656.1	215346.2	11.66	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-107656.7	215347.3	12.77	17
Landcover + Aspect + TRI + Distance to Water	-107658.9	215347.8	13.30	15
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-107658.9	215349.8	15.26	16
Landcover + Aspect + TRI + CRS	-107660.3	215350.6	16.08	15
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-107660.3	215352.6	18.06	16
Landcover + Aspect + TRI	-107662.5	215352.9	18.37	14
Landcover + Aspect + TRI + Distance to Forest Edge	-107662.5	215354.9	20.37	15
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-107680.0	215390.1	55.55	15
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-107681.5	215391.1	56.52	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107680.0	215392.0	57.47	16
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-107681.5	215393.0	58.42	15

Table D.7 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Anthropogenic + CRS	-107685.3	215398.6	64.07	14
Landcover + TRI + Distance to Anthropogenic	-107686.7	215399.5	64.91	13
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107685.3	215400.6	66.07	15
Landcover + TRI + Distance to Water + CRS	-107687.6	215401.2	66.62	13
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-107686.7	215401.5	66.91	14
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-107687.5	215402.9	68.40	14
Landcover + TRI + Distance to Water	-107689.8	215403.6	69.06	12
Landcover + TRI + Distance to Water + Distance to Forest Edge	-107689.6	215405.3	70.74	13
Landcover + TRI + CRS	-107691.0	215406.0	71.50	12
Landcover + TRI + Distance to Forest Edge + CRS	-107691.0	215408.0	73.46	13
Landcover + TRI	-107693.1	215408.3	73.73	11
Landcover + TRI + Distance to Forest Edge	-107693.1	215410.2	75.64	12
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-107741.2	215516.5	181.93	17
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107741.1	215518.3	183.74	18
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-107742.8	215519.6	185.00	17
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-107746.8	215525.7	191.11	16
Landcover + Aspect + Distance to Water	-107749.1	215526.1	191.57	14
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-107749.0	215528.1	193.53	15
Landcover + Aspect + Distance to Anthropogenic + CRS	-107748.7	215529.4	194.87	16
Landcover + Aspect + Distance to Anthropogenic	-107750.2	215530.5	195.93	15
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107748.4	215530.7	196.20	17
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-107749.9	215531.9	197.34	16
Landcover + Aspect + CRS	-107752.4	215532.8	198.26	14
Landcover + Aspect + Distance to Forest Edge + CRS	-107752.2	215534.4	199.85	15
Landcover + Aspect	-107754.4	215534.9	200.35	13
Landcover + Aspect + Distance to Forest Edge	-107754.3	215536.6	202.07	14
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-107772.6	215573.3	238.73	14
Landcover + Distance to Water + Distance to Anthropogenic	-107774.2	215574.4	239.88	13

Table D.7 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107772.6	215575.3	240.73	15
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-107774.2	215576.4	241.88	14
Landcover + Distance to Water + CRS	-107778.4	215580.7	246.18	12
Landcover + Distance to Water + Distance to Forest Edge + CRS	-107778.4	215582.7	248.18	13
Landcover + Distance to Water	-107780.5	215583.0	248.46	11
Landcover + Distance to Water + Distance to Forest Edge	-107780.5	215585.0	250.43	12
Landcover + Distance to Anthropogenic + CRS	-107780.0	215586.0	251.41	13
Landcover + Distance to Anthropogenic	-107781.5	215587.0	252.40	12
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107779.9	215587.8	253.22	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107779.9	215587.8	253.22	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-107781.4	215588.8	254.25	13
Landcover + CRS	-107783.7	215589.4	254.88	11
Landcover + Distance to Forest Edge + CRS	-107783.7	215591.4	256.81	12
Landcover	-107785.7	215591.4	256.89	10
Landcover + Distance to Forest Edge	-107785.7	215593.4	258.87	11
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-107815.9	215649.8	315.29	9
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-107818.6	215653.3	318.74	8
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-107818.6	215655.2	320.68	9
Aspect + TRI + Distance to Water + CRS	-107828.3	215670.7	336.13	7
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-107828.3	215672.7	338.11	8
Aspect + TRI + Distance to Water	-107832.5	215677.1	342.51	6
Aspect + TRI + Distance to Water + Distance to Forest Edge	-107832.5	215679.1	344.51	7
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107837.4	215692.9	358.31	9
Aspect + TRI + Distance to Anthropogenic + CRS	-107839.4	215694.9	360.33	8
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-107840.2	215696.4	361.87	8
Aspect + TRI + Distance to Anthropogenic	-107842.1	215698.2	363.69	7
Aspect + TRI + Distance to Forest Edge + CRS	-107846.0	215706.1	371.52	7
Aspect + TRI + CRS	-107847.5	215707.1	372.51	6
Aspect + TRI + Distance to Forest Edge	-107850.3	215712.6	378.03	6

Table D.7 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + TRI	-107851.6	215713.1	378.57	5
TRI + Distance to Water + Distance to Anthropogenic + CRS	-107856.1	215724.2	389.67	6
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107856.0	215726.0	391.44	7
TRI + Distance to Water + Distance to Anthropogenic	-107858.9	215727.8	393.28	5
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-107858.8	215729.6	395.01	6
TRI + Distance to Water + CRS	-107869.2	215746.4	411.88	4
TRI + Distance to Water + Distance to Forest Edge + CRS	-107869.0	215748.1	413.51	5
TRI + Distance to Water	-107873.6	215753.2	418.62	3
TRI + Distance to Water + Distance to Forest Edge	-107873.3	215754.6	420.07	4
TRI + Distance to Anthropogenic + CRS	-107879.5	215769.0	434.41	5
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107878.6	215769.2	434.69	6
TRI + Distance to Anthropogenic	-107882.3	215772.6	438.01	4
TRI + Distance to Anthropogenic + Distance to Forest Edge	-107881.5	215773.0	438.41	5
TRI + CRS	-107888.1	215782.2	447.61	3
TRI + Distance to Forest Edge + CRS	-107887.5	215783.1	448.53	4
TRI	-107892.3	215788.6	454.10	2
TRI + Distance to Forest Edge	-107891.9	215789.8	455.27	3
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-107914.5	215844.9	510.38	8
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-107914.5	215844.9	510.38	8
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107914.4	215846.7	512.19	9
Aspect + Distance to Water + Distance to Anthropogenic	-107917.4	215848.7	514.18	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-107917.3	215850.6	516.04	8
Aspect + Distance to Water + CRS	-107924.2	215860.4	525.90	6
Aspect + Distance to Water + Distance to Forest Edge + CRS	-107924.2	215862.3	527.77	7
Aspect + Distance to Water	-107928.3	215866.6	532.05	5
Aspect + Distance to Water + Distance to Forest Edge	-107928.3	215868.6	534.01	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107940.1	215896.1	561.58	8
Aspect + Distance to Anthropogenic + CRS	-107942.7	215899.4	564.81	7
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-107943.1	215900.1	565.57	7
Aspect + Distance to Anthropogenic	-107945.5	215903.1	568.53	6
Aspect + Distance to Forest Edge + CRS	-107945.8	215903.7	569.13	6
Aspect + CRS	-107948.0	215906.1	571.50	5

Table D.7 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + Distance to Forest Edge	-107950.0	215910.1	575.50	5
Aspect	-107951.9	215911.8	577.30	4
Distance to Water + Distance to Anthropogenic + CRS	-107954.9	215919.8	585.22	5
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-107954.8	215921.6	587.10	6
Distance to Water + Distance to Anthropogenic	-107957.9	215923.7	589.20	4
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-107957.8	215925.6	591.03	5
Distance to Water + CRS	-107965.2	215936.4	601.90	3
Distance to Water + Distance to Forest Edge + CRS	-107965.1	215938.3	603.74	4
Distance to Water	-107969.5	215942.9	608.38	2
Distance to Water + Distance to Forest Edge	-107969.3	215944.6	610.08	3
Distance to Anthropogenic + CRS	-107983.1	215974.3	639.71	4
Distance to Anthropogenic + Distance to Forest Edge	-107984.9	215977.9	643.34	4
Distance to Anthropogenic	-107986.1	215978.2	643.70	3
CRS	-107988.9	215981.7	647.16	2
Distance to Forest Edge + CRS	-107987.9	215981.7	647.19	3
Distance to Forest Edge	-107992.2	215988.3	653.76	2

Table D.8. Results of model selection for ecological resource selection by female grizzly bears during the summer season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to backcountry campsites in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88923.5	177882.9	0.00	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88923.5	177884.9	2.00	19
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88926.2	177886.5	3.55	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88926.2	177888.5	5.55	18
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-88929.3	177890.7	7.76	16
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-88928.9	177891.8	8.89	17
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88929.3	177892.6	9.70	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-88929.3	177892.7	9.76	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88928.9	177893.8	10.88	18
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88929.3	177894.5	11.60	18
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-88932.1	177896.2	13.27	16
Landcover + Aspect + TRI + Distance to Anthropogenic	-88932.1	177896.2	13.28	16
Landcover + Aspect + TRI + Distance to Forest Edge	-88933.5	177896.9	13.99	15
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88932.0	177898.1	15.14	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-88932.1	177898.2	15.27	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-88933.5	177898.9	15.98	16
Landcover + Aspect + TRI + CRS	-88935.0	177900.0	17.09	15
Landcover + Aspect + Distance to Forest Edge + CRS	-88935.5	177901.1	18.15	15
Landcover + Aspect + Distance to Anthropogenic + CRS	-88934.9	177901.9	18.97	16
Landcover + Aspect + TRI + Distance to Water + CRS	-88935.0	177902.0	19.09	16

Table D.8 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88936.2	177902.5	19.56	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-88935.5	177903.0	20.04	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-88934.9	177903.8	20.84	17
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88936.2	177904.5	21.55	16
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88939.0	177906.1	23.13	14
Landcover + Aspect + Distance to Anthropogenic	-88938.2	177906.3	23.40	15
Landcover + Aspect + Distance to Forest Edge	-88939.7	177907.4	24.42	14
Landcover + Aspect + TRI	-88939.8	177907.6	24.66	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88939.0	177908.0	25.10	15
Landcover + TRI + Distance to Anthropogenic + CRS	-88940.1	177908.2	25.31	14
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-88939.6	177909.2	26.28	15
Landcover + Aspect + TRI + Distance to Water	-88939.8	177909.6	26.65	15
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88940.1	177910.2	27.28	15
Landcover + Aspect + CRS	-88941.4	177910.8	27.87	14
Landcover + TRI + Distance to Forest Edge + CRS	-88942.6	177911.3	28.34	13
Landcover + TRI + Distance to Anthropogenic	-88943.3	177912.5	29.58	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88942.3	177912.6	29.69	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88942.3	177912.6	29.69	14
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-88942.6	177913.3	30.33	14
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88942.2	177914.4	31.52	15
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-88943.2	177914.5	31.54	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-88945.1	177916.2	33.26	13
Landcover + TRI + CRS	-88946.7	177917.4	34.45	12
Landcover + TRI + Distance to Forest Edge	-88946.8	177917.7	34.72	12
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88945.0	177918.0	35.05	14
Landcover + Aspect	-88946.2	177918.4	35.51	13

Table D.8 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Anthropogenic + CRS	-88946.3	177918.7	35.73	13
Landcover + TRI + Distance to Water + CRS	-88946.7	177919.4	36.43	13
Landcover + TRI + Distance to Water + Distance to Forest Edge	-88946.8	177919.6	36.70	13
Landcover + Aspect + Distance to Water	-88946.1	177920.3	37.33	14
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-88946.2	177920.5	37.53	14
Landcover + Distance to Forest Edge + CRS	-88949.0	177922.1	39.17	12
Landcover + Distance to Anthropogenic	-88949.5	177923.0	40.03	12
Landcover + Distance to Water + Distance to Forest Edge + CRS	-88949.0	177923.9	40.98	13
Landcover + Distance to Water + Distance to Anthropogenic	-88949.4	177924.7	41.79	13
Landcover + TRI	-88951.5	177924.9	41.97	11
Landcover + TRI + Distance to Water	-88951.4	177926.9	43.95	12
Landcover + Distance to Forest Edge	-88953.3	177928.5	45.59	11
Landcover + CRS	-88953.3	177928.5	45.59	11
Landcover + Distance to Water + Distance to Forest Edge	-88953.1	177930.3	47.37	12
Landcover + Distance to Water + CRS	-88953.2	177930.3	47.37	12
Landcover	-88958.0	177936.1	53.17	10
Landcover + Distance to Water	-88957.9	177937.8	54.92	11
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89068.8	178155.6	272.69	9
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-89073.3	178162.7	279.75	8
Aspect + TRI + Distance to Forest Edge + CRS	-89075.2	178164.5	281.56	7
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-89073.3	178164.7	281.73	9
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-89075.2	178166.5	283.55	8
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89080.2	178172.4	289.45	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89078.6	178173.2	290.28	8
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89080.2	178174.3	291.39	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89078.5	178174.9	292.01	9
Aspect + TRI + Distance to Forest Edge	-89081.5	178175.0	292.09	6
Aspect + TRI + Distance to Water + Distance to Forest Edge	-89081.5	178177.0	294.07	7
TRI + Distance to Anthropogenic + Distance to Forest Edge	-89084.7	178179.4	296.42	5

Table D.8 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-89083.1	178180.3	297.37	7
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-89084.6	178181.3	298.33	6
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-89083.0	178182.0	299.05	8
TRI + Distance to Forest Edge + CRS	-89087.0	178182.1	299.17	4
Aspect + Distance to Forest Edge + CRS	-89085.5	178183.0	300.04	6
TRI + Distance to Water + Distance to Forest Edge + CRS	-89087.0	178184.0	301.11	5
Aspect + Distance to Water + Distance to Forest Edge + CRS	-89085.3	178184.7	301.73	7
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-89089.9	178191.8	308.88	6
TRI + Distance to Forest Edge	-89093.3	178192.7	309.72	3
Aspect + Distance to Forest Edge	-89091.8	178193.5	310.62	5
TRI + Distance to Water + Distance to Forest Edge	-89093.3	178194.6	311.66	4
Aspect + TRI + Distance to Anthropogenic + CRS	-89089.5	178195.1	312.17	8
Aspect + Distance to Water + Distance to Forest Edge	-89091.6	178195.2	312.28	6
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-89089.4	178196.8	313.84	9
Distance to Anthropogenic + Distance to Forest Edge	-89094.6	178197.3	314.32	4
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-89094.4	178198.7	315.80	5
Distance to Forest Edge + CRS	-89097.5	178200.9	317.98	3
Distance to Water + Distance to Forest Edge + CRS	-89097.2	178202.4	319.47	4
TRI + Distance to Anthropogenic + CRS	-89096.6	178203.2	320.27	5
Aspect + TRI + Distance to Anthropogenic	-89095.3	178204.7	321.74	7
TRI + Distance to Water + Distance to Anthropogenic + CRS	-89096.4	178204.8	321.85	6
Aspect + TRI + CRS	-89096.5	178205.0	322.12	6
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-89095.1	178206.3	323.33	8
Aspect + TRI + Distance to Water + CRS	-89096.4	178206.8	323.84	7
Distance to Forest Edge	-89103.7	178211.5	328.56	2
TRI + Distance to Anthropogenic	-89102.2	178212.4	329.47	4
Distance to Water + Distance to Forest Edge	-89103.5	178212.9	330.01	3
TRI + CRS	-89103.9	178213.8	330.85	3
TRI + Distance to Water + Distance to Anthropogenic	-89101.9	178213.9	330.96	5
Aspect + Distance to Anthropogenic + CRS	-89100.6	178215.1	332.22	7
TRI + Distance to Water + CRS	-89103.7	178215.4	332.47	4
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-89100.0	178216.1	333.15	8

Table D.8 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-89100.0	178216.1	333.15	8
Aspect + TRI	-89104.6	178219.2	336.28	5
Aspect + TRI + Distance to Water	-89104.4	178220.9	337.94	6
Distance to Anthropogenic + CRS	-89107.6	178223.3	340.36	4
Distance to Water + Distance to Anthropogenic + CRS	-89107.0	178224.1	341.12	5
Aspect + Distance to Anthropogenic	-89106.4	178224.8	341.91	6
Aspect + Distance to Water + Distance to Anthropogenic	-89105.8	178225.6	342.70	7
Aspect + CRS	-89107.9	178225.9	342.96	5
Aspect + Distance to Water + CRS	-89107.4	178226.8	343.88	6
TRI	-89111.8	178227.5	344.62	2
TRI + Distance to Water	-89111.6	178229.1	346.18	3
Distance to Anthropogenic	-89113.3	178232.6	349.65	3
Distance to Water + Distance to Anthropogenic	-89112.6	178233.2	350.27	4
CRS	-89115.4	178234.7	351.78	2
Distance to Water + CRS	-89114.7	178235.4	352.51	3
Aspect	-89116.1	178240.2	357.28	4
Aspect + Distance to Water	-89115.5	178241.0	358.09	5
Distance to Water	-89122.6	178249.2	366.29	2

Table D.9. Results of model selection for ecological resource selection by female grizzly bears during the whitebark pine season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to backcountry campsites in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-79406.9	158847.8	0.00	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-79406.8	158849.7	1.92	18
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79406.9	158849.8	1.98	18
Landcover + Aspect + Distance to Forest Edge + CRS	-79408.9	158849.9	2.10	16
Landcover + Aspect + TRI + CRS	-79409.8	158851.6	3.85	16
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79406.8	158851.7	3.90	19
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-79408.9	158851.9	4.08	17
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79408.9	158851.9	4.08	17
Landcover + Aspect + CRS	-79411.7	158853.5	5.72	15
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-79409.8	158853.6	5.82	17
Landcover + Aspect + TRI + Distance to Water + CRS	-79409.8	158853.6	5.85	17
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79408.9	158853.8	6.06	18
Landcover + Aspect + TRI + Distance to Forest Edge	-79412.7	158855.3	7.53	15
Landcover + Aspect + Distance to Anthropogenic + CRS	-79411.7	158855.5	7.70	16
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-79409.8	158855.6	7.82	18
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-79412.6	158857.2	9.43	16
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-79412.7	158857.3	9.53	16
Landcover + Aspect + Distance to Forest Edge	-79414.7	158857.5	9.67	14
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-79411.7	158857.5	9.70	17
Landcover + Aspect + TRI	-79415.1	158858.2	10.47	14
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79412.6	158859.2	11.43	17

Table D.9 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-79414.7	158859.4	11.58	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-79414.7	158859.4	11.65	15
Landcover + Aspect + TRI + Distance to Anthropogenic	-79415.1	158860.1	12.35	15
Landcover + Aspect + TRI + Distance to Water	-79415.1	158860.2	12.41	15
Landcover + Aspect	-79417.1	158860.2	12.41	13
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79414.7	158861.3	13.56	16
Landcover + Aspect + Distance to Water	-79417.0	158862.1	14.28	14
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-79415.0	158862.1	14.29	16
Landcover + Aspect + Distance to Anthropogenic	-79417.0	158862.1	14.30	14
Landcover + TRI + Distance to Forest Edge + CRS	-79425.3	158878.5	30.74	14
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-79425.3	158880.5	32.73	15
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79425.3	158880.5	32.73	15
Landcover + Distance to Forest Edge + CRS	-79427.5	158881.1	33.32	13
Landcover + TRI + CRS	-79428.0	158881.9	34.14	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79425.2	158882.5	34.73	16
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79427.5	158883.1	35.31	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79427.5	158883.1	35.31	14
Landcover + Distance to Water + Distance to Forest Edge + CRS	-79427.5	158883.1	35.31	14
Landcover + TRI + Distance to Water + CRS	-79427.9	158883.9	36.11	14
Landcover + TRI + Distance to Anthropogenic + CRS	-79428.0	158883.9	36.13	14
Landcover + CRS	-79430.1	158884.3	36.50	12
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79427.5	158885.1	37.31	15
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-79427.9	158885.9	38.11	15
Landcover + Distance to Water + CRS	-79430.1	158886.2	38.42	13
Landcover + Distance to Anthropogenic + CRS	-79430.1	158886.3	38.49	13
Landcover + TRI + Distance to Forest Edge	-79431.6	158887.2	39.44	12
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-79430.1	158888.2	40.41	14

Table D.9 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-79431.6	158889.2	41.37	13
Landcover + TRI + Distance to Water + Distance to Forest Edge	-79431.6	158889.2	41.38	13
Landcover + TRI	-79433.8	158889.7	41.90	11
Landcover + Distance to Forest Edge	-79433.9	158889.8	42.07	11
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79431.5	158891.1	43.32	14
Landcover + TRI + Distance to Water	-79433.7	158891.5	43.70	12
Landcover + TRI + Distance to Anthropogenic	-79433.8	158891.6	43.82	12
Landcover + Distance to Water + Distance to Forest Edge	-79433.8	158891.7	43.92	12
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-79433.9	158891.8	44.01	12
Landcover	-79436.1	158892.1	44.33	10
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-79433.7	158893.4	45.62	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79433.8	158893.6	45.87	13
Landcover + Distance to Water	-79435.9	158893.8	46.00	11
Landcover + Distance to Anthropogenic	-79436.0	158894.0	46.25	11
Landcover + Distance to Water + Distance to Anthropogenic	-79435.9	158895.7	47.93	12
Aspect + TRI + CRS	-79476.8	158967.7	119.89	7
Aspect + TRI + Distance to Forest Edge + CRS	-79476.5	158968.9	121.13	8
Aspect + TRI + Distance to Water + CRS	-79476.8	158969.7	121.89	8
Aspect + TRI + Distance to Anthropogenic + CRS	-79476.8	158969.7	121.89	8
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-79476.5	158970.9	123.13	9
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79476.5	158970.9	123.13	9
Aspect + CRS	-79479.6	158971.2	123.45	6
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-79476.8	158971.7	123.88	9
Aspect + Distance to Forest Edge + CRS	-79479.3	158972.5	124.74	7
Aspect + Distance to Water + CRS	-79479.6	158973.2	125.40	7
Aspect + Distance to Anthropogenic + CRS	-79479.6	158973.2	125.45	7
Aspect + TRI	-79482.0	158974.0	126.20	5
Aspect + Distance to Water + Distance to Forest Edge + CRS	-79479.3	158974.5	126.72	8
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79479.3	158974.5	126.74	8
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-79479.6	158975.2	127.40	8

Table D.9 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-79479.6	158975.2	127.40	8
Aspect + TRI + Distance to Forest Edge	-79481.8	158975.5	127.73	6
Aspect + TRI + Distance to Water	-79481.9	158975.9	128.10	6
Aspect + TRI + Distance to Anthropogenic	-79482.0	158975.9	128.16	6
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79479.3	158976.5	128.72	9
Aspect + TRI + Distance to Water + Distance to Forest Edge	-79481.7	158977.5	129.68	7
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-79481.7	158977.5	129.70	7
Aspect	-79484.8	158977.6	129.85	4
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-79481.9	158977.8	130.07	7
Aspect + Distance to Forest Edge	-79484.6	158979.2	131.42	5
Aspect + Distance to Water	-79484.7	158979.4	131.62	5
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79481.7	158979.4	131.65	8
Aspect + Distance to Anthropogenic	-79484.8	158979.6	131.81	5
Aspect + Distance to Water + Distance to Forest Edge	-79484.5	158981.0	133.26	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-79484.6	158981.2	133.38	6
Aspect + Distance to Water + Distance to Anthropogenic	-79484.7	158981.4	133.59	6
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79484.5	158983.0	135.23	7
TRI + CRS	-79499.3	159006.6	158.80	4
TRI + Distance to Forest Edge + CRS	-79499.2	159008.3	160.54	5
TRI + Distance to Water + CRS	-79499.3	159008.5	160.74	5
TRI + Distance to Anthropogenic + CRS	-79499.3	159008.6	160.80	5
TRI + Distance to Water + Distance to Forest Edge + CRS	-79499.1	159010.3	162.51	6
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79499.2	159010.3	162.54	6
TRI + Distance to Water + Distance to Anthropogenic + CRS	-79499.3	159010.5	162.73	6
CRS	-79502.3	159010.6	162.80	3
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79499.1	159012.3	164.51	7
Distance to Water + CRS	-79502.2	159012.4	164.62	4
Distance to Anthropogenic + CRS	-79502.3	159012.6	164.79	4
TRI	-79505.1	159014.2	166.40	2
Distance to Water + Distance to Forest Edge + CRS	-79502.1	159014.2	166.43	5
Distance to Water + Distance to Anthropogenic + CRS	-79502.2	159014.4	166.61	5
Distance to Forest Edge + CRS	-79504.8	159015.7	167.88	3

Table D.9 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
TRI + Distance to Water	-79505.0	159015.9	168.13	3
TRI + Distance to Forest Edge	-79505.0	159016.1	168.30	3
TRI + Distance to Anthropogenic	-79505.1	159016.2	168.38	3
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-79502.1	159016.2	168.43	6
TRI + Distance to Water + Distance to Forest Edge	-79504.9	159017.9	170.07	4
TRI + Distance to Water + Distance to Anthropogenic	-79504.9	159017.9	170.12	4
TRI + Distance to Anthropogenic + Distance to Forest Edge	-79505.0	159018.1	170.29	4
Distance to Water	-79507.9	159019.8	172.00	2
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79504.9	159019.8	172.06	5
Distance to Forest Edge	-79508.1	159020.2	172.40	2
Distance to Anthropogenic	-79508.1	159020.2	172.47	2
Distance to Water + Distance to Forest Edge	-79507.9	159021.7	173.97	3
Distance to Water + Distance to Anthropogenic	-79507.9	159021.8	174.00	3
Distance to Anthropogenic + Distance to Forest Edge	-79508.1	159022.2	174.39	3
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-79507.9	159023.7	175.96	4

Table D.10. Results of model selection for ecological resource selection by male grizzly bears during the mating season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to backcountry campsites in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-132780.6	265599.2	0.00	19
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132780.1	265600.1	0.95	20
Landcover + Aspect + TRI + Distance to Water + CRS	-132784.2	265602.5	3.34	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-132783.7	265603.4	4.29	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-132785.4	265604.8	5.68	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-132784.9	265605.7	6.58	18
Landcover + Aspect + TRI + Distance to Water	-132789.7	265609.4	10.23	15
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-132789.2	265610.3	11.15	16
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-132790.8	265613.5	14.35	16
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132790.4	265614.8	15.61	17
Landcover + TRI + Distance to Water + CRS	-132794.3	265616.7	17.51	14
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-132794.0	265617.9	18.76	15
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-132791.2	265618.3	19.19	18
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-132795.5	265618.9	19.77	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-132795.1	265620.1	20.97	15
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132791.1	265620.3	21.13	19
Landcover + Aspect + TRI + CRS	-132795.5	265623.0	23.82	16
Landcover + TRI + Distance to Water	-132799.6	265623.3	24.11	12
Landcover + Aspect + TRI + Distance to Anthropogenic	-132796.2	265624.4	25.20	16

Table D.10 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + TRI + Distance to Water + Distance to Forest Edge	-132799.2	265624.5	25.32	13
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-132795.5	265624.9	25.78	17
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-132794.9	265625.8	26.61	18
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-132796.1	265626.3	27.13	17
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132794.3	265626.5	27.37	19
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-132798.1	265630.2	31.04	17
Landcover + Aspect + TRI	-132801.2	265630.4	31.20	14
Landcover + Aspect + TRI + Distance to Forest Edge	-132801.2	265632.3	33.16	15
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-132799.4	265632.8	33.66	17
Landcover + TRI + Distance to Anthropogenic + CRS	-132801.6	265633.2	34.07	15
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132801.6	265635.2	36.07	16
Landcover + Aspect + Distance to Water	-132804.5	265637.1	37.90	14
Landcover + TRI + CRS	-132805.8	265637.6	38.46	13
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-132803.9	265637.8	38.64	15
Landcover + TRI + Distance to Anthropogenic	-132806.5	265639.0	39.82	13
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-132804.7	265639.4	40.27	15
Landcover + TRI + Distance to Forest Edge + CRS	-132805.8	265639.6	40.46	14
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132804.3	265640.5	41.35	16
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-132806.5	265641.0	41.81	14
Landcover + Distance to Water + CRS	-132808.4	265642.9	43.73	13
Landcover + Distance to Water + Distance to Forest Edge + CRS	-132808.0	265644.0	44.81	14
Landcover + TRI	-132811.4	265644.7	45.55	11
Landcover + Distance to Water + Distance to Anthropogenic	-132809.8	265645.5	46.37	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-132809.3	265646.5	47.38	14
Landcover + TRI + Distance to Forest Edge	-132811.4	265646.7	47.55	12
Landcover + Aspect + Distance to Anthropogenic + CRS	-132807.0	265647.9	48.75	17
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132806.9	265649.8	50.67	18

Table D.10 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Water	-132814.1	265650.3	51.09	11
Landcover + Distance to Water + Distance to Forest Edge	-132813.6	265651.3	52.12	12
Landcover + Aspect + CRS	-132811.5	265653.0	53.82	15
Landcover + Aspect + Distance to Anthropogenic	-132812.3	265654.7	55.50	15
Landcover + Aspect + Distance to Forest Edge + CRS	-132811.5	265654.9	55.77	16
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-132812.3	265656.6	57.41	16
Landcover + Aspect	-132817.6	265661.2	62.04	13
Landcover + Distance to Anthropogenic + CRS	-132817.0	265662.0	62.88	14
Landcover + Aspect + Distance to Forest Edge	-132817.6	265663.1	63.98	14
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132817.0	265664.0	64.87	15
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132817.0	265664.0	64.87	15
Landcover + CRS	-132821.4	265666.9	67.70	12
Landcover + Distance to Anthropogenic	-132822.3	265668.5	69.38	12
Landcover + Distance to Forest Edge + CRS	-132821.4	265668.8	69.69	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-132822.3	265670.5	71.36	13
Landcover	-132827.4	265674.8	75.63	10
Landcover + Distance to Forest Edge	-132827.4	265676.8	77.62	11
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-132856.4	265732.9	133.70	10
Aspect + TRI + Distance to Water + CRS	-132860.2	265736.3	137.16	8
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-132859.6	265737.3	138.12	9
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-132861.9	265739.8	140.62	8
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-132861.4	265740.8	141.60	9
Aspect + TRI + Distance to Water	-132866.3	265744.6	145.43	6
Aspect + TRI + Distance to Water + Distance to Forest Edge	-132865.8	265745.5	146.38	7
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132866.5	265753.0	153.82	10
Aspect + TRI + Distance to Anthropogenic + CRS	-132868.6	265755.3	156.10	9
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132870.4	265756.9	157.71	8
TRI + Distance to Water + Distance to Anthropogenic + CRS	-132871.6	265757.3	158.09	7
Aspect + TRI + Distance to Forest Edge + CRS	-132870.9	265757.8	158.67	8
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-132872.0	265760.0	160.87	8

Table D.10 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
TRI + Distance to Water + Distance to Forest Edge + CRS	-132874.1	265760.1	160.98	6
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-132871.2	265760.4	161.21	9
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-132871.2	265760.4	161.21	9
Aspect + TRI + CRS	-132873.2	265760.4	161.26	7
TRI + Distance to Water + CRS	-132875.3	265760.5	161.39	5
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132870.7	265761.5	162.32	10
Aspect + TRI + Distance to Anthropogenic	-132874.1	265762.3	163.12	7
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-132875.8	265763.6	164.40	6
TRI + Distance to Water + Distance to Anthropogenic	-132876.9	265763.9	164.71	5
Aspect + Distance to Water + CRS	-132875.1	265764.3	165.13	7
Aspect + Distance to Water + Distance to Forest Edge + CRS	-132874.7	265765.4	166.22	8
Aspect + TRI + Distance to Forest Edge	-132877.2	265766.3	167.16	6
Aspect + Distance to Water + Distance to Anthropogenic	-132877.0	265768.0	168.87	7
TRI + Distance to Water + Distance to Forest Edge	-132880.1	265768.1	168.96	4
TRI + Distance to Water	-132881.2	265768.5	169.34	3
Aspect + TRI	-132879.5	265769.0	169.80	5
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-132876.6	265769.2	169.99	8
Aspect + Distance to Water	-132881.7	265773.4	174.25	5
Aspect + Distance to Water + Distance to Forest Edge	-132881.2	265774.5	175.33	6
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132880.7	265775.4	176.26	7
TRI + Distance to Forest Edge + CRS	-132885.0	265780.0	180.82	5
TRI + Distance to Anthropogenic + CRS	-132884.1	265780.2	181.06	6
TRI + Distance to Anthropogenic + Distance to Forest Edge	-132886.1	265782.2	183.05	5
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132885.0	265783.9	184.79	7
Distance to Water + Distance to Anthropogenic + CRS	-132886.0	265784.1	184.92	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-132883.4	265784.8	185.68	9
TRI + CRS	-132888.6	265785.2	186.01	4
TRI + Distance to Anthropogenic	-132889.4	265786.9	187.73	4
Aspect + Distance to Anthropogenic + CRS	-132885.6	265787.2	188.04	8
Distance to Water + Distance to Forest Edge + CRS	-132888.8	265787.7	188.49	5
Distance to Water + CRS	-132889.9	265787.8	188.65	4
TRI + Distance to Forest Edge	-132891.1	265788.2	189.02	3
Aspect + Distance to Forest Edge + CRS	-132888.2	265790.3	191.16	7

Table D.10 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-132890.7	265791.4	192.22	5
Distance to Water + Distance to Anthropogenic	-132891.7	265791.4	192.29	4
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-132889.4	265792.7	193.56	7
Aspect + CRS	-132890.5	265793.0	193.88	6
TRI	-132894.7	265793.3	194.17	2
Aspect + Distance to Anthropogenic	-132891.5	265795.0	195.89	6
Distance to Water + Distance to Forest Edge	-132895.2	265796.5	197.33	3
Distance to Water	-132896.3	265796.6	197.46	2
Aspect + Distance to Forest Edge	-132894.9	265799.8	200.62	5
Aspect	-132897.3	265802.5	203.39	4
Distance to Anthropogenic + CRS	-132900.7	265811.4	212.19	5
Distance to Forest Edge + CRS	-132901.8	265811.7	212.53	4
Distance to Anthropogenic + Distance to Forest Edge	-132903.1	265814.2	214.99	4
CRS	-132905.5	265816.9	217.79	3
Distance to Anthropogenic	-132906.4	265818.8	219.69	3
Distance to Forest Edge	-132908.4	265820.9	221.69	2

Table D.11. Results of model selection for ecological resource selection by male grizzly bears during the summer season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to backcountry campsites in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88629.9	177297.8	0.00	19
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88629.7	177299.4	1.67	20
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88637.0	177306.0	8.25	16
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88636.7	177307.3	9.59	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-88638.9	177311.9	14.12	17
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88638.8	177313.7	15.90	18
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-88646.1	177320.2	22.39	14
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88645.8	177321.6	23.89	15
Landcover + Aspect + TRI + Distance to Water + CRS	-88645.8	177325.6	27.85	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-88645.7	177327.4	29.64	18
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-88647.8	177331.6	33.85	18
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88647.8	177333.5	35.79	19
Landcover + TRI + Distance to Water + CRS	-88653.0	177334.1	36.34	14
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-88652.8	177335.6	37.83	15
Landcover + TRI + Distance to Anthropogenic + CRS	-88654.9	177339.8	42.09	15
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88654.9	177341.8	44.09	16
Landcover + Aspect + TRI + Distance to Water	-88656.1	177342.1	44.36	15
Landcover + Aspect + TRI + Distance to Anthropogenic	-88655.7	177343.4	45.64	16
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-88656.0	177344.0	46.27	16

Table D.11 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88655.6	177345.3	47.54	17
Landcover + TRI + Distance to Water	-88663.3	177350.6	52.85	12
Landcover + TRI + Distance to Anthropogenic	-88662.8	177351.6	53.88	13
Landcover + TRI + Distance to Water + Distance to Forest Edge	-88663.2	177352.3	54.55	13
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88662.8	177353.6	55.88	14
Landcover + Aspect + TRI + CRS	-88661.5	177355.0	57.26	16
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-88661.5	177356.9	59.17	17
Landcover + TRI + CRS	-88668.7	177363.5	65.71	13
Landcover + TRI + Distance to Forest Edge + CRS	-88668.7	177365.5	67.71	14
Landcover + Aspect + TRI	-88670.5	177369.0	71.23	14
Landcover + Aspect + TRI + Distance to Forest Edge	-88670.4	177370.8	73.06	15
Landcover + TRI	-88677.7	177377.4	79.66	11
Landcover + TRI + Distance to Forest Edge	-88677.7	177379.4	81.63	12
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-88706.8	177449.6	151.82	18
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88706.5	177450.9	153.19	19
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-88714.9	177459.9	162.13	15
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88714.4	177460.8	163.01	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88716.0	177466.1	168.30	17
Landcover + Distance to Water + Distance to Anthropogenic	-88724.4	177474.9	177.11	13
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88724.0	177475.9	178.19	14
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-88723.3	177480.7	182.91	17
Landcover + Distance to Water + CRS	-88731.8	177489.7	191.91	13
Landcover + Distance to Water + Distance to Forest Edge + CRS	-88731.4	177490.8	193.00	14
Landcover + Aspect + Distance to Water	-88734.3	177496.6	198.89	14
Landcover + Aspect + Distance to Anthropogenic + CRS	-88732.1	177498.2	200.40	17
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-88734.2	177498.4	200.62	15
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88732.1	177500.1	202.38	18
Landcover + Distance to Water	-88742.6	177507.2	209.42	11

Table D.11 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Distance to Water + Distance to Forest Edge	-88742.3	177508.6	210.80	12
Landcover + Distance to Anthropogenic + CRS	-88740.3	177508.7	210.90	14
Landcover + Aspect + Distance to Anthropogenic	-88740.2	177510.3	212.58	15
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88740.3	177510.6	212.88	15
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88740.3	177510.6	212.88	15
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-88740.1	177512.3	214.53	16
Landcover + Distance to Anthropogenic	-88748.4	177520.8	223.05	12
Landcover + Aspect + CRS	-88746.3	177522.6	224.79	15
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-88748.4	177522.8	225.05	13
Landcover + Aspect + Distance to Forest Edge + CRS	-88746.3	177524.5	226.75	16
Landcover + CRS	-88754.6	177533.2	235.48	12
Landcover + Distance to Forest Edge + CRS	-88754.6	177535.2	237.48	13
Landcover + Aspect	-88755.5	177537.0	239.24	13
Landcover + Aspect + Distance to Forest Edge	-88755.4	177538.9	241.13	14
Landcover	-88763.8	177547.6	249.89	10
Landcover + Distance to Forest Edge	-88763.8	177549.6	251.89	11
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-88783.1	177586.2	288.47	10
TRI + Distance to Water + Distance to Anthropogenic + CRS	-88791.8	177597.5	299.76	7
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88791.3	177598.6	300.87	8
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-88793.0	177602.0	304.20	8
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88792.9	177603.9	306.11	9
TRI + Distance to Water + Distance to Anthropogenic	-88801.7	177613.3	315.57	5
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88801.3	177614.6	316.84	6
Aspect + TRI + Distance to Water + CRS	-88800.5	177616.9	319.19	8
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-88800.4	177618.9	321.15	9
TRI + Distance to Water + CRS	-88809.3	177628.5	330.79	5
TRI + Distance to Water + Distance to Forest Edge + CRS	-88809.0	177630.0	332.20	6
Aspect + TRI + Distance to Water	-88811.8	177635.6	337.80	6
Aspect + TRI + Distance to Anthropogenic + CRS	-88808.9	177635.8	338.00	9
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88808.5	177636.9	339.17	10

Table D.11 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + TRI + Distance to Water + Distance to Forest Edge	-88811.8	177637.6	339.80	7
TRI + Distance to Anthropogenic + CRS	-88817.2	177646.5	348.73	6
TRI + Distance to Water	-88820.6	177647.2	349.44	3
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88817.2	177648.3	350.59	7
Aspect + TRI + Distance to Anthropogenic	-88817.3	177648.5	350.76	7
TRI + Distance to Water + Distance to Forest Edge	-88820.4	177648.8	351.05	4
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-88816.8	177649.6	351.85	8
TRI + Distance to Anthropogenic	-88825.6	177659.3	361.53	4
Aspect + TRI + CRS	-88823.5	177661.0	363.29	7
TRI + Distance to Anthropogenic + Distance to Forest Edge	-88825.6	177661.1	363.36	5
Aspect + TRI + Distance to Forest Edge + CRS	-88823.0	177662.0	364.23	8
TRI + CRS	-88832.0	177672.0	374.26	4
TRI + Distance to Forest Edge + CRS	-88831.9	177673.8	376.03	5
Aspect + TRI	-88833.2	177676.3	378.57	5
Aspect + TRI + Distance to Forest Edge	-88832.5	177677.1	379.32	6
TRI	-88841.6	177687.3	389.54	2
TRI + Distance to Forest Edge	-88841.5	177689.0	391.22	3
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-88893.2	177804.5	506.74	9
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-88893.2	177804.5	506.74	9
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88893.2	177806.3	508.59	10
Distance to Water + Distance to Anthropogenic + CRS	-88902.7	177817.4	519.67	6
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88902.2	177818.4	520.69	7
Aspect + Distance to Water + Distance to Anthropogenic	-88903.7	177821.4	523.65	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88903.7	177823.3	525.56	8
Distance to Water + Distance to Anthropogenic	-88913.2	177834.4	536.66	4
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-88912.8	177835.6	537.85	5
Aspect + Distance to Water + CRS	-88912.2	177838.3	540.56	7
Aspect + Distance to Water + Distance to Forest Edge + CRS	-88912.1	177840.3	542.52	8
Distance to Water + CRS	-88921.8	177851.5	553.77	4
Distance to Water + Distance to Forest Edge + CRS	-88921.4	177852.9	555.12	5
Aspect + Distance to Water	-88924.2	177858.4	560.69	5
Aspect + Distance to Water + Distance to Forest Edge	-88924.2	177860.4	562.69	6
Distance to Water	-88933.8	177871.7	573.93	2

Table D.11 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Distance to Water + Distance to Forest Edge	-88933.6	177873.3	575.50	3
Aspect + Distance to Anthropogenic + CRS	-88933.7	177883.4	585.60	8
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-88933.0	177883.9	586.18	9
Distance to Anthropogenic + CRS	-88943.0	177896.0	598.23	5
Aspect + Distance to Anthropogenic	-88942.3	177896.5	598.77	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-88941.5	177897.0	599.25	7
Distance to Anthropogenic	-88951.6	177909.2	611.42	3
Aspect + CRS	-88949.4	177910.8	613.01	6
Distance to Anthropogenic + Distance to Forest Edge	-88951.4	177910.8	613.01	4
Aspect + Distance to Forest Edge + CRS	-88948.5	177911.0	613.20	7
CRS	-88958.8	177923.6	625.81	3
Distance to Forest Edge + CRS	-88958.5	177925.0	627.28	4
Aspect + Distance to Forest Edge	-88958.3	177926.6	628.86	5
Aspect	-88959.3	177926.7	628.90	4
Distance to Forest Edge	-88968.4	177940.8	643.01	2

Table D.12. Results of model selection for ecological resource selection by male grizzly bears during the whitebark pine season in Yellowstone National Park, WY, USA, 2004–2020. The top ecological model was used as a benchmark model to assess grizzly bear response to backcountry campsites in areas with varying levels of human access (Chapter 3). Landcover includes 10 categories (lodgepole pine forest, wet forest, subalpine fir forest, whitebark pine forest, Douglas fir forest, shrub, dry meadow, wet meadow, rock, water), Aspect includes 4 categories (North, South, East, West), TRI is Terrain Roughness Index, CRS is carcass redistribution site, and k is the number of parameters.

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Forest Edge + CRS	-64863.9	129759.7	0.00	16
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64863.5	129761.0	1.29	17
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-64863.8	129761.6	1.86	17
Landcover + Aspect + TRI + CRS	-64866.4	129762.8	3.07	15
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64863.4	129762.9	3.15	18
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64863.4	129762.9	3.15	18
Landcover + Aspect + TRI + Distance to Anthropogenic + CRS	-64866.2	129764.3	4.56	16
Landcover + Aspect + TRI + Distance to Water + CRS	-64866.4	129764.8	5.07	16
Landcover + TRI + Distance to Forest Edge + CRS	-64869.4	129764.9	5.13	13
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64869.1	129766.1	6.38	14
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-64866.2	129766.3	6.56	17
Landcover + TRI + Distance to Water + Distance to Forest Edge + CRS	-64869.4	129766.7	7.00	14
Landcover + TRI + CRS	-64871.7	129767.4	7.61	12
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64869.0	129768.0	8.24	15
Landcover + TRI + Distance to Anthropogenic + CRS	-64871.4	129768.8	9.05	13
Landcover + TRI + Distance to Water + CRS	-64871.7	129769.4	9.60	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic + CRS	-64871.4	129770.8	11.05	14
Landcover + Aspect + TRI + Distance to Forest Edge	-64872.4	129774.8	15.09	15
Landcover + Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-64871.7	129775.5	15.75	16
Landcover + Aspect + TRI + Distance to Water + Distance to Forest Edge	-64872.4	129776.8	17.00	16
Landcover + Aspect + TRI	-64875.0	129778.0	18.24	14

Table D.12 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + TRI + Distance to Anthropogenic	-64874.5	129778.9	19.19	15
Landcover + TRI + Distance to Forest Edge	-64877.6	129779.3	19.52	12
Landcover + TRI + Distance to Anthropogenic + Distance to Forest Edge	-64876.9	129779.9	20.13	13
Landcover + Aspect + TRI + Distance to Water	-64875.0	129780.0	20.25	15
Landcover + Aspect + TRI + Distance to Water + Distance to Anthropogenic	-64874.5	129780.9	21.19	16
Landcover + TRI + Distance to Water + Distance to Forest Edge	-64877.6	129781.2	21.43	13
Landcover + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64876.9	129781.8	22.05	14
Landcover + TRI	-64879.9	129781.9	22.12	11
Landcover + TRI + Distance to Anthropogenic	-64879.4	129782.8	23.00	12
Landcover + TRI + Distance to Water	-64879.9	129783.9	24.12	12
Landcover + TRI + Distance to Water + Distance to Anthropogenic	-64879.4	129784.8	25.00	13
Landcover + Aspect + Distance to Forest Edge + CRS	-64902.0	129834.1	74.34	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge + CRS	-64901.6	129835.1	75.36	16
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64901.6	129835.2	75.47	16
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64901.1	129836.2	76.48	17
Landcover + Aspect + CRS	-64904.9	129837.9	78.12	14
Landcover + Distance to Forest Edge + CRS	-64907.4	129838.9	79.15	12
Landcover + Aspect + Distance to Anthropogenic + CRS	-64904.6	129839.2	79.48	15
Landcover + Distance to Water + Distance to Forest Edge + CRS	-64907.0	129839.9	80.20	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64907.0	129840.0	80.24	13
Landcover + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64907.0	129840.0	80.24	13
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + CRS	-64904.4	129840.8	81.08	16
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64906.5	129841.0	81.27	14
Landcover + CRS	-64910.0	129842.0	82.23	11
Landcover + Distance to Anthropogenic + CRS	-64909.6	129843.3	83.54	12
Landcover + Distance to Water + CRS	-64909.8	129843.6	83.81	12
Landcover + Distance to Water + Distance to Anthropogenic + CRS	-64909.4	129844.9	85.12	13

Table D.12 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Landcover + Aspect + Distance to Forest Edge	-64911.2	129850.3	90.59	14
Landcover + Aspect + Distance to Anthropogenic + Distance to Forest Edge	-64910.4	129850.7	91.00	15
Landcover + Aspect + Distance to Water + Distance to Forest Edge	-64910.7	129851.5	91.76	15
Landcover + Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64909.9	129851.9	92.15	16
Landcover + Aspect	-64914.1	129854.2	94.45	13
Landcover + Distance to Forest Edge	-64916.2	129854.4	94.69	11
Landcover + Distance to Anthropogenic + Distance to Forest Edge	-64915.4	129854.8	95.05	12
Landcover + Aspect + Distance to Anthropogenic	-64913.5	129854.9	95.19	14
Landcover + Distance to Water + Distance to Forest Edge	-64915.8	129855.6	95.87	12
Landcover + Aspect + Distance to Water	-64913.9	129855.9	96.14	14
Landcover + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64915.0	129856.0	96.22	13
Landcover	-64918.8	129857.6	97.89	10
Landcover + Distance to Anthropogenic	-64918.2	129858.3	98.56	11
Landcover + Distance to Water	-64918.7	129859.3	99.56	11
Landcover + Distance to Water + Distance to Anthropogenic	-64918.0	129860.0	100.24	12
Aspect + TRI + Distance to Water + Distance to Forest Edge + CRS	-64967.0	129950.0	190.28	8
Aspect + TRI + Distance to Forest Edge + CRS	-64968.8	129951.6	191.84	7
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64968.7	129953.3	193.59	8
TRI + Distance to Water + Distance to Forest Edge + CRS	-64971.9	129953.7	193.98	5
TRI + Distance to Forest Edge + CRS	-64973.6	129955.3	195.52	4
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64971.7	129955.4	195.69	6
TRI + Distance to Anthropogenic + Distance to Forest Edge + CRS	-64973.5	129957.0	197.24	5
Aspect + TRI + Distance to Water + Distance to Forest Edge	-64976.0	129966.0	206.21	7
Aspect + TRI + Distance to Forest Edge	-64977.6	129967.3	207.51	6
Aspect + TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64975.6	129967.3	207.52	8
Aspect + TRI + Distance to Anthropogenic + Distance to Forest Edge	-64977.3	129968.6	208.84	7
TRI + Distance to Water + Distance to Forest Edge	-64980.6	129969.2	209.48	4
TRI + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-64980.2	129970.5	210.75	5
TRI + Distance to Forest Edge	-64982.3	129970.5	210.77	3

Table D.12 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
TRI + Distance to Anthropogenic + Distance to Forest Edge	-64981.9	129971.8	212.05	4
Aspect + TRI + CRS	-64984.7	129981.3	221.58	6
Aspect + TRI + Distance to Water + CRS	-64984.2	129982.4	222.68	7
Aspect + TRI + Distance to Anthropogenic + CRS	-64984.7	129983.3	223.57	7
Aspect + TRI + Distance to Water + Distance to Anthropogenic + CRS	-64984.2	129984.4	224.67	8
TRI + CRS	-64989.4	129984.8	225.07	3
TRI + Distance to Water + CRS	-64989.0	129985.9	226.17	4
TRI + Distance to Anthropogenic + CRS	-64989.4	129986.8	227.05	4
TRI + Distance to Water + Distance to Anthropogenic + CRS	-64988.9	129987.9	228.15	5
Aspect + TRI	-64993.9	129997.9	238.11	5
Aspect + TRI + Distance to Water	-64993.5	129999.1	239.35	6
Aspect + TRI + Distance to Anthropogenic	-64993.8	129999.7	239.92	6
Aspect + TRI + Distance to Water + Distance to Anthropogenic	-64993.5	130000.9	241.16	7
TRI	-64998.6	130001.2	241.45	2
TRI + Distance to Water	-64998.2	130002.4	242.70	3
TRI + Distance to Anthropogenic	-64998.5	130003.0	243.23	3
TRI + Distance to Water + Distance to Anthropogenic	-64998.1	130004.2	244.48	4
Aspect + Distance to Water + Distance to Forest Edge + CRS	-65024.7	130063.4	303.61	7
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-65024.5	130065.0	305.24	8
Distance to Water + Distance to Forest Edge + CRS	-65029.1	130066.1	306.37	4
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge + CRS	-65028.9	130067.7	307.96	5
Aspect + Distance to Forest Edge + CRS	-65028.6	130069.3	309.54	6
Aspect + Distance to Anthropogenic + Distance to Forest Edge + CRS	-65028.5	130070.9	311.19	7
Distance to Forest Edge + CRS	-65033.0	130072.0	312.25	3
Aspect + Distance to Water + Distance to Forest Edge	-65034.5	130080.9	321.19	6
Aspect + Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-65034.0	130082.0	322.29	7
Distance to Water + Distance to Forest Edge	-65038.6	130083.3	323.50	3
Distance to Water + Distance to Anthropogenic + Distance to Forest Edge	-65038.2	130084.3	324.55	4
Aspect + Distance to Forest Edge	-65038.2	130086.4	326.68	5
Aspect + Distance to Anthropogenic + Distance to Forest Edge	-65037.8	130087.6	327.81	6
Distance to Forest Edge	-65042.4	130088.7	328.96	2
Distance to Anthropogenic + Distance to Forest Edge	-65041.9	130089.8	330.03	3
Aspect + Distance to Water + CRS	-65043.8	130099.6	339.87	6

Table D.12 Continued

Model Structure	***logLik***	***AICc***	***ΔAICc***	***k***
Aspect + CRS	-65045.5	130101.1	341.33	5
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-65043.8	130101.6	341.83	7
Aspect + Distance to Water + Distance to Anthropogenic + CRS	-65043.8	130101.6	341.83	7
Distance to Water + CRS	-65047.9	130101.8	342.10	3
Aspect + Distance to Anthropogenic + CRS	-65045.5	130103.0	343.29	6
CRS	-65049.6	130103.3	343.53	2
Distance to Water + Distance to Anthropogenic + CRS	-65047.9	130103.8	344.04	4
Distance to Anthropogenic + CRS	-65049.6	130105.2	345.47	3
Aspect + Distance to Water	-65054.0	130118.0	358.23	5
Aspect	-65055.6	130119.1	359.38	4
Aspect + Distance to Water + Distance to Anthropogenic	-65053.8	130119.7	359.93	6
Distance to Water	-65058.0	130120.1	360.34	2
Aspect + Distance to Anthropogenic	-65055.4	130120.8	361.08	5
Distance to Water + Distance to Anthropogenic	-65057.9	130121.8	362.00	3
Distance to Anthropogenic	-65059.4	130122.9	363.11	2

Table D.13. Summary of the number of bears in the trail analysis with at least one used location per Bear Management Area (BMA) status (Restricted BMA, Unrestricted BMA, Non-BMA) for all sex-season combinations in Yellowstone National Park, WY, USA, 2004–2020. We used these variables to test our hypotheses (Table 3.1) about grizzly bear response to trails and access restrictions (Table 3.2).

		Restricted BMA	Unrestricted BMA	Non-BMA
Females	Mating	14	4	24
	Summer	11	11	19
	Whitebark Pine	7	9	19
Males	Mating	27	23	37
	Summer	22	26	28
	Whitebark Pine	17	19	26

Table D.14. Summary of the number of bears in the trail analysis with at least one used location during each time of day (Day, Crepuscular, Night) for all sex-season combinations in Yellowstone National Park, WY, USA, 2004–2020. We used these variables to test our hypotheses (Table 3.1) about grizzly bear response to trails and time of day (Table 3.2).

		Day	Crepuscular	Night
Females	**Mating**	24	24	24
	Summer	19	19	19
	Whitebark Pine	19	19	19
Males	**Mating**	37	37	37
	Summer	29	29	29
	Whitebark Pine	26	26	26

Table D.15. Summary of the number of bears in the trail analysis with at least one used location per Bear Management Area (BMA) status (Restricted BMA, Unrestricted BMA, Non-BMA) during each time of day (Day, Crepuscular, Night) for all sex-season combinations in Yellowstone National Park, WY, USA, 2004–2020. We used these variables to test our hypotheses (Table 3.1) about grizzly bear response to trails, access restrictions, and time of day (Table 3.2).

			Restricted BMA	Unrestricted BMA	Non-BMA
Females		**Mating**	14	4	24
	Day	**Summer**	11	11	18
		Whitebark Pine	7	8	19
		Mating	14	4	24
	Crepuscular	**Summer**	11	10	19
		Whitebark Pine	7	8	19
		Mating	13	2	14
	Night	**Summer**	11	8	19
		Whitebark Pine	7	8	19
Males		**Mating**	15	18	25
	Day	**Summer**	22	22	27
		Whitebark Pine	15	18	25
		Mating	17	18	25
	Crepuscular	**Summer**	21	20	27
		Whitebark Pine	17	18	25
		Mating	17	15	26
	Night	**Summer**	20	20	28
		Whitebark Pine	17	26	15

Table D.16. Summary of the number of bears in the backcountry campsite analysis with at least one used location per Bear Management Area (BMA) status (Restricted BMA, Unrestricted BMA, Non-BMA) for all sex-season combinations in Yellowstone National Park, WY, USA, 2004–2020. We used these variables to test our hypotheses (Table 3.1) about grizzly bear response to backcountry campsites and BMA access restrictions (Table 3.2).

		Restricted BMA	Unrestricted BMA	Non-BMA
Females	Mating	14	4	24
	Summer	11	11	19
	Whitebark Pine	7	9	19
Males	Mating	27	23	37
	Summer	22	26	28
	Whitebark Pine	17	19	26

Table D.17. Summary of the number of bears in the backcountry campsite analysis with at least one used location during each time of day (Day, Crepuscular, Night) for all sex-season combinations in Yellowstone National Park, WY, USA, 2004–2020. We used these variables to test our hypotheses (Table 3.1) about grizzly bear response to backcountry campsites and time of day (Table 3.2).

		Day	Crepuscular	Night
Females	**Mating**	24	24	24
	Summer	19	19	19
	Whitebark Pine	19	19	19
Males	**Mating**	37	37	37
	Summer	29	29	29
	Whitebark Pine	26	26	26

Table D.18. Summary of the number of bears in the backcountry campsite analysis with at least one used location per Bear Management Area (BMA) status (Restricted BMA, Unrestricted BMA, Non-BMA) during each time of day (Day, Crepuscular, Night) for all sex-season combinations in Yellowstone National Park, WY, USA, 2004–2020. We used these variables to test our hypotheses (Table 3.1) about grizzly bear response to backcountry campsites, access restrictions, and time of day (Table 3.2).

			Restricted BMA	**Unrestricted BMA**	**Non-BMA**
Females		**Mating**	14	4	24
	Day	**Summer**	11	11	18
		Whitebark Pine	7	8	19
		Mating	14	4	24
	Crepuscular	**Summer**	11	10	19
		Whitebark Pine	7	8	19
		Mating	13	2	24
	Night	**Summer**	11	8	19
		Whitebark Pine	7	8	19
Males		**Mating**	27	21	36
	Day	**Summer**	22	22	27
		Whitebark Pine	15	18	25
		Mating	26	31	37
	Crepuscular	**Summer**	21	20	27
		Whitebark Pine	17	18	25
		Mating	23	17	37
	Night	**Summer**	20	20	28
		Whitebark Pine	17	15	26

Table D.19. Results of model selection describing selection of trails (sporadic recreation) by grizzly bears for females during the mating season, Yellowstone National Park, WY, USA, 2004–2020. We compared 8 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to trails. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Trail is distance to trail and TOD is time of day (day, crepuscular, night), and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	***k***	***AICc***	***ΔAICc***	***Weight***
ecological + BMA X Trail	26	287295.2	0.00	1.00
ecological + BMA X Trail X TOD	36	287307.6	12.34	0.00
ecological + BMA + Trail	24	287307.7	12.52	0.00
ecological + BMA + Trail X TOD	26	287311.7	16.44	0.00
ecological + BMA	22	287318.1	22.85	0.00
ecological + Trail	20	287320.6	25.43	0.00
ecological + Trail X TOD	22	287324.6	29.36	0.00
ecological	18	287329.5	34.25	0.00

Table D.20. Results of model selection describing selection of trails (sporadic recreation) by grizzly bears for females during the summer season, Yellowstone National Park, WY, USA, 2004–2020. We compared 8 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to trails. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Trail is distance to trail and TOD is time of day (day, crepuscular, night), and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	***k***	***AICc***	***ΔAICc***	***Weight***
ecological + BMA X Trail X TOD	36	217693.7	0.00	0.86
ecological + BMA	23	217698.3	4.53	0.09
ecological + BMA + Trail	24	217700.2	6.51	0.03
ecological + BMA X Trail	26	217702.3	8.53	0.01
ecological + BMA + Trail X TOD	26	217702.9	9.16	0.01
ecological	18	217708.3	14.58	0.00
ecological + Trail	20	217711.3	17.61	0.00
ecological + Trail X TOD	22	217714.0	20.23	0.00

Table D.21. Results of model selection describing selection of trails (sporadic recreation) by grizzly bears for females during the whitebark pine season, Yellowstone National Park, WY, USA, 2004–2020. We compared 8 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to trails. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Trail is distance to trail and TOD is time of day, and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	***k***	***AICc***	***ΔAICc***	***Weight***
ecological + BMA X Trail	25	194350.2	0.00	0.96
ecological + BMA + Trail	23	194358.4	8.23	0.02
ecological + BMA + Trail X TOD	25	194359.3	9.19	0.01
ecological + BMA X Trail X TOD	35	194359.6	9.41	0.01
ecological + Trail	19	194360.3	10.18	0.00
ecological + Trail X TOD	21	194361.4	11.22	0.00
ecological	17	194376.6	26.44	0.00
ecological + BMA	21	194377.1	26.98	0.00

Table D.22. Results of model selection describing selection of trails (sporadic recreation) by grizzly bears for males during the mating season, Yellowstone National Park, WY, USA, 2004–2020. We compared 8 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to trails. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Trail is distance to trail and TOD is time of day (day, crepuscular, night), and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	***k***	***AICc***	***ΔAICc***	***Weight***
ecological + BMA + Trail X TOD	27	327755.5	0.00	0.94
ecological + BMA + Trail	25	327762.6	7.17	0.03
ecological + BMA X Trail X TOD	37	327763.4	7.92	0.02
ecological + BMA X Trail	27	327763.4	7.95	0.02
ecological + Trail X TOD	23	327794.3	38.84	0.00
ecological + Trail	21	327801.0	45.47	0.00
ecological + BMA	23	327845.2	89.75	0.00
ecological	19	327889.0	133.55	0.00

Table D.23. Results of model selection describing selection of trails (sporadic recreation) by grizzly bears for males during the summer season, Yellowstone National Park, WY, USA, 2004–2020. We compared 8 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to trails. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Trail is distance to trail and TOD is time of day (day, crepuscular, night), and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	***k***	***AICc***	***ΔAICc***	***Weight***
ecological + BMA + Trail X TOD	27	216934.5	0.00	0.96
ecological + BMA X Trail X TOD	37	216940.9	6.40	0.04
ecological + Trail X TOD	23	216973.8	39.25	0.00
ecological + BMA + Trail	25	216976.9	42.35	0.00
ecological + BMA X Trail	27	216980.3	45.81	0.00
ecological + BMA	23	216995.9	61.34	0.00
ecological + Trail	21	217015.7	81.21	0.00
ecological	19	217054.1	119.52	0.00

Table D.24 Results of model selection describing selection of trails (sporadic recreation) by grizzly bears for males during the whitebark pine season, Yellowstone National Park, WY, USA, 2004–2020. We compared 8 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to trails. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Trail is distance to trail and TOD is time of day (day, crepuscular, night), and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	***k***	***AICc***	***ΔAICc***	***Weight***
ecological + BMA + Trail X TOD	24	158722.6	0.00	0.74
ecological + BMA X Trail X TOD	34	158724.7	2.06	0.26
ecological + Trail X TOD	20	158752.5	29.88	0.00
ecological + BMA + Trail	22	158754.8	32.21	0.00
ecological + BMA X Trail	24	158757.6	34.98	0.00
ecological + Trail	18	158784.2	61.58	0.00
ecological + BMA	20	158789.9	67.32	0.00
ecological	16	158832.1	109.51	0.00

Table D.25. Results of model selection describing selection of backcountry campsites (predictable recreation) by grizzly bears for females during the mating season, Yellowstone National Park, WY, USA, 2004–2020. We compared 14 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to BMAs. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Camp is distance to backcountry campsite, CampOcc is the distance to occupied backcountry campsite, and TOD is time of day (day, crepuscular, night), and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	*k*	*AICc*	*ΔAICc*	*Weight*
ecological + BMA + TOD X Camp	26	263568.9	0.00	0.76
ecological + BMA + Camp	24	263571.6	2.70	0.20
ecological + BMA X Camp	26	263574.6	5.69	0.04
ecological + TOD X Camp	22	263580.8	11.94	0.00
ecological + BMA	22	263583.1	14.16	0.00
ecological + Camp	20	263583.8	14.88	0.00
ecological + BMA X TOD X Camp	36	263584.6	15.74	0.00
ecological + BMA + TOD X CampOcc	26	263584.7	15.79	0.00
ecological + BMA + CampOcc	24	263585.3	16.44	0.00
ecological + BMA X CampOcc	26	263586.2	17.28	0.00
ecological	18	263592.0	23.11	0.00
ecological + TOD X CampOcc	22	263593.2	24.33	0.00
ecological + CampOcc	20	263593.8	24.89	0.00
ecological + BMA X TOD X CampOcc	36	263595.7	26.81	0.00

Table D.26. Results of model selection describing selection of backcountry campsites (predictable recreation) by grizzly bears for females during the summer season, Yellowstone National Park, WY, USA, 2004–2020. We compared 14 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to BMAs. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Camp is distance to backcountry campsite, CampOcc is the distance to occupied backcountry campsite, and TOD is time of day (day, crepuscular, night), and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	***k***	***AICc***	***ΔAICc***	***Weight***
ecological + BMA	22	217696.9	0.00	0.33
ecological + BMA X CampOcc	26	217697.8	0.89	0.21
ecological + BMA X TOD X CampOcc	36	217698.5	1.62	0.15
ecological + BMA X TOD X Camp	36	217699.2	2.31	0.10
ecological + BMA + CampOcc	24	217700.2	3.36	0.06
ecological + BMA + Camp	24	217700.4	3.50	0.06
ecological + BMA X Camp	26	217701.2	4.27	0.04
ecological + BMA + TOD X Camp	26	217701.6	4.74	0.03
ecological + BMA + TOD X CampOcc	26	217702.5	5.61	0.02
ecological	18	217708.3	11.44	0.00
ecological + CampOcc	20	217711.8	15.00	0.00
ecological + Camp	20	217712.0	15.15	0.00
ecological + TOD X Camp	22	217713.2	16.31	0.00
ecological + TOD X CampOCC	22	217714.1	17.22	0.00

Table D.27. Results of model selection describing selection of backcountry campsites (predictable recreation) by grizzly bears for females during the whitebark pine season, Yellowstone National Park, WY, USA, 2004–2020. We compared 14 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to BMAs. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Camp is distance to backcountry campsite, CampOcc is the distance to occupied backcountry campsite, and TOD is time of day (day, crepuscular, night), and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	*k*	*AICc*	*ΔAICc*	*Weight*
ecological + BMA + Camp	23	194362.9	0.00	0.53
ecological + Camp	19	194364.4	1.50	0.25
ecological + BMA X Camp	25	194366.3	3.49	0.09
ecological + BMA + TOD X Camp	25	194366.4	3.53	0.09
ecological + TOD X Camp	21	194367.8	4.98	0.04
ecological	17	194376.6	13.74	0.00
ecological + BMA	21	194377.1	14.27	0.00
ecological + BMA + TOD X Camp	35	194378.4	15.55	0.00
ecological + BMA + CampOcc	23	194379.5	16.64	0.00
ecological + CampOcc	19	194379.6	16.74	0.00
ecological + BMA + TOD X CampOcc	25	194381.4	18.53	0.00
ecological + TOD X CampOcc	21	194381.5	18.68	0.00
ecological + BMA X CampOcc	25	194382.1	19.29	0.00
ecological + BMA X TOD X CampOcc	35	194390.2	27.33	0.00

Table D.28. Results of model selection describing selection of backcountry campsites (predictable recreation) by grizzly bears for males during the mating season, Yellowstone National Park, WY, USA, 2004–2020. We compared 14 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to BMAs. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Camp is distance to backcountry campsite, CampOcc is the distance to occupied backcountry campsite, and TOD is time of day (day, crepuscular, night), and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	***k***	***AICc***	***ΔAICc***	***Weight***
ecological + BMA + Camp	25	324917.6	0.00	0.46
ecological + BMA X Camp	27	324918.1	0.46	0.36
ecological + BMA + TOD X Camp	27	324920.0	2.30	0.15
ecological + BMA X TOD X Camp	37	324923.2	5.52	0.03
ecological + BMA + CampOcc	25	324943.1	25.47	0.00
ecological + BMA X CampOcc	27	324943.3	25.65	0.00
ecological + BMA + TOD X CampOcc	27	324946.0	28.32	0.00
ecological + BMA	23	324948.1	30.42	0.00
ecological + BMA X TOD X CampOcc	37	324951.1	33.44	0.00
ecological + Camp	21	324959.0	41.34	0.00
ecological + TOD X Camp	23	324961.2	43.60	0.00
ecological + CampOcc	21	324987.6	69.98	0.00
ecological + TOD X CampOcc	23	324990.4	72.77	0.00
ecological	19	324991.9	74.26	0.00

Table D.29. Results of model selection describing selection of backcountry campsites (predictable recreation) by grizzly bears for males during the summer season, Yellowstone National Park, WY, USA, 2004–2020. We compared 14 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to BMAs. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Camp is distance to backcountry campsite, CampOcc is the distance to occupied backcountry campsite, and TOD is time of day (day, crepuscular, night), and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	***k***	***AICc***	***ΔAICc***	***Weight***
ecological + BMA + TOD X Camp	27	216965.5	0.00	0.38
ecological + BMA X TOD X Camp	37	216965.8	0.27	0.33
ecological + BMA + Camp	25	216967.1	1.53	0.18
ecological + BMA X Camp	27	216968.0	2.47	0.11
ecological + BMA	23	216995.9	30.34	0.00
ecological + BMA + CampOcc	25	216996.9	31.33	0.00
ecological + BMA X CampOcc	27	216997.8	32.29	0.00
ecological + BMA + TOD X CampOcc	27	216999.1	33.57	0.00
ecological + BMA X TOD X CampOcc	37	216999.6	34.04	0.00
ecological + TOD X Camp	23	217017.9	52.41	0.00
ecological + Camp	21	217019.9	54.39	0.00
ecological	19	217054.1	88.52	0.00
ecological + CampOcc	21	217055.4	89.90	0.00
ecological + TOD X CampOcc	23	217057.5	91.95	0.00

Table D.30. Results of model selection describing selection of backcountry campsites (predictable recreation) by grizzly bears for males during the whitebark pine season, Yellowstone National Park, WY, USA, 2004–2020. We compared 14 candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to BMAs. We used conditional Poisson regression to compare paired used and available locations (1 used:10 available). The number of parameters in the model is k, weight is the model weight, Camp is distance to backcountry campsite, CampOcc is the distance to occupied backcountry campsite, and TOD is time of day (day, crepuscular, night), and ecological is the best supported ecological model structure for this sex-season combination (Table 3.3).

Model Structure	*k*	*AICc*	*ΔAICc*	*Weight*
ecological + BMA	20	158789.9	0.00	0.64
ecological + BMA + CampOcc	22	158793.5	3.59	0.11
ecological + BMA X CampOcc	24	158793.7	3.78	0.10
ecological + BMA + Camp	22	158793.9	4.01	0.09
ecological + BMA + TOD X Camp	24	158796.6	6.65	0.02
ecological + BMA + TOD X CampOcc	24	158797.5	7.54	0.01
ecological + BMA X Camp	24	158797.6	7.69	0.01
ecological + BMA X TOD X CampOcc	34	158798.3	8.30	0.01
ecological + BMA X TOD X Camp	34	158799.1	9.14	0.01
ecological + TOD X Camp	22	158800.7	10.76	0.00
ecological + TOD X CampOcc	22	158801.8	11.90	0.00
ecological	16	158832.1	42.18	0.00
ecological + Camp	18	158835.4	45.48	0.00
ecological + CampOcc	18	158835.9	45.98	0.00

Table D.31. Parameter estimates and 95% confidence intervals from the best-supported model for the trail model suite for grizzly bears, by sex and season, Yellowstone National Park, WY, USA, 2004–2020. We compared candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to sporadic (trail) recreation in areas with different levels of restrictions to human access (BMAs: non-BMA, unrestricted BMA, restricted BMA). We report estimates from the best supported model. TRI is Terrain Roughness Index, CRS is Carcass Redistribution Site, WBP is whitebark pine, and BMA is Bear Management Area. All continuous variables are centered and scaled. Distance to trail is log-transformed.

Sex	***Season***	***Parameter***	***Estimate***	***95% CI***	
Female	Mating	Distance to Water	0.032	-0.004	0.068
		TRI	0.207	0.181	0.234
		Aspect - North	-0.233	-0.302	-0.164
		Aspect - East	-0.174	-0.238	-0.111
		Aspect - West	-0.178	-0.243	-0.113
		Landcover - Wet Forest	0.195	0.098	0.291
		Landcover - Shrub	0.294	0.224	0.364
		Landcover - Dry Meadow	0.322	0.227	0.418
		Landcover - Subalpine Fir	-0.124	-0.226	-0.022
		Landcover - Douglas Fir	0.181	0.078	0.284
		Landcover - Wet Meadow	0.231	0.108	0.353
		Landcover - Rock	0.043	-0.114	0.201
		Landcover - Water	-0.856	-1.033	-0.679
		Landcover - WBP	-0.116	-0.231	0.000
		Distance to Anthropogenic	-0.568	-1.049	-0.086
		CRS	0.208	-0.028	0.444
		Distance to Trail	0.071	-0.023	0.165
		Unrestricted BMA	0.875	0.093	1.657
		Restricted BMA	0.098	-0.235	0.431
		Distance to Trail: Unrestricted BMA	0.697	0.335	1.058
		Distance to Trail: Restricted BMA	0.033	-0.139	0.204
	Summer	Distance to Forest Edge	0.073	0.031	0.115
		TRI	-0.059	-0.094	-0.024
		Aspect - North	0.181	0.104	0.259
		Aspect - East	0.014	-0.062	0.089
		Aspect - West	0.031	-0.040	0.102
		Landcover - Wet Forest	0.431	0.320	0.541
		Landcover - Shrub	0.172	0.082	0.261
		Landcover - Dry Meadow	0.365	0.264	0.467
		Landcover - Subalpine Fir	0.016	-0.091	0.122

Table D.31 Continued

Sex	*Season*	*Parameter*	*Estimate*	*95% CI*	
		Landcover - Rock	0.361	0.192	0.529
		Landcover - Water	-1.034	-1.474	-0.593
		Landcover - WBP	0.053	-0.065	0.171
		Distance to Anthropogenic	-0.494	-1.121	0.133
		CRS	0.395	0.064	0.725
		Distance to Trail	-0.022	-0.113	0.068
		Unrestricted BMA	0.537	0.025	1.048
		Restricted BMA	0.178	-0.161	0.517
		Distance to Trail: Unrestricted BMA	0.246	0.010	0.482
		Distance to Trail:Night	0.091	-0.049	0.232
		Unrestricted BMA:Night	0.369	-0.306	1.045
		Distance to Trail: Restricted BMA	0.088	-0.095	0.271
		Restricted BMA:Night	0.219	-0.204	0.642
		Distance to Trail:Crepuscular	-0.052	-0.207	0.102
		Unrestricted BMA:Crepuscular	-0.114	-0.936	0.708
		Restricted BMA:Crepuscular	-0.181	-0.658	0.297
		Distance to Trail: Unrestricted BMA:Night	-0.402	-0.711	-0.094
		Distance to Trail: Restricted BMA:Night	-0.031	-0.338	0.275
		Distance to Trail: Unrestricted BMA:Crepuscular	0.160	-0.266	0.586
		Distance to Trail: Restricted BMA:Crepuscular	-0.343	-0.674	-0.013
		Distance to Forest Edge	0.077	0.024	0.131
	Whitebark Pine	TRI	-0.035	-0.069	0.000
		Aspect - North	0.144	0.064	0.224
		Aspect - East	0.067	-0.011	0.145
		Aspect - West	-0.088	-0.170	-0.006
		Landcover - Wet Forest	0.359	0.241	0.476
		Landcover - Shrub	-0.092	-0.190	0.007
		Landcover - Dry Meadow	0.049	-0.072	0.170
		Landcover - Subalpine Fir	0.177	0.087	0.267
		Landcover - Douglas Fir	0.074	-0.099	0.247
		Landcover - Wet Meadow	0.377	0.235	0.518
		Landcover - Rock	-0.264	-0.475	-0.052
		Landcover - Water	-0.246	-0.547	0.055
		Landcover - WBP	0.264	0.163	0.364

Table D.31 Continued

Sex	*Season*	*Parameter*	*Estimate*	*95% CI*	
		CRS	0.417	-0.223	1.057
		Distance to Trail	0.064	-0.072	0.200
		Unrestricted BMA	0.597	0.179	1.014
		Restricted BMA	0.009	-0.241	0.258
		Distance to Trail:Unrestricted BMA	0.304	0.135	0.474
		Distance to Trail:Restricted BMA	-0.047	-0.232	0.139
Male	Mating	Distance to Water	-0.049	-0.079	-0.019
		TRI	-0.063	-0.09	-0.037
		Aspect - North	-0.097	-0.159	-0.035
		Aspect - East	-0.067	-0.123	-0.011
		Aspect - West	-0.126	-0.183	-0.069
		Landcover - Wet Forest	0.343	0.259	0.428
		Landcover - Shrub	0.152	0.090	0.214
		Landcover - Dry Meadow	0.126	0.051	0.201
		Landcover - Subalpine Fir	-0.084	-0.18	0.011
		Landcover - Douglas Fir	0.132	0.030	0.234
		Landcover - Wet Meadow	0.274	0.188	0.360
		Landcover - Rock	0.327	0.161	0.493
		Landcover - Water	-0.108	-0.226	0.009
		Landcover - WBP	-0.047	-0.171	0.078
		Distance to Anthropogenic	-0.076	-0.252	0.101
		CRS	0.294	-0.128	0.716
		Unrestricted BMA	0.249	-0.042	0.540
		Restricted BMA	0.310	0.133	0.488
		Distance to Trail	-0.080	-0.136	-0.023
		Distance to Trail:Night	-0.107	-0.175	-0.038
		Distance to Trail:Crepuscular	-0.093	-0.174	-0.012
	Summer	Distance to Water	-0.135	-0.185	-0.085
		TRI	-0.226	-0.267	-0.185
		Aspect - North	0.131	0.055	0.207
		Aspect - East	0.015	-0.060	0.090
		Aspect - West	0.044	-0.029	0.117
		Landcover - Wet Forest	0.635	0.546	0.725
		Landcover - Shrub	0.045	-0.036	0.127
		Landcover - Dry Meadow	0.198	0.102	0.294
		Landcover - Subalpine Fir	0.121	0.019	0.223
		Landcover - Douglas Fir	0.125	-0.022	0.273
		Landcover - Wet Meadow	0.457	0.363	0.552

Table D.31 Continued

Sex	***Season***	***Parameter***	***Estimate***	***95% CI***	
		Landcover - Rock	-0.047	-0.250	0.156
		Landcover - Water	-0.067	-0.235	0.102
		Landcover - WBP	0.201	0.073	0.329
		Distance to Anthropogenic	0.330	-0.199	0.859
		CRS	0.550	-0.323	1.423
		Unrestricted BMA	0.492	0.215	0.770
		Restricted BMA	0.346	0.033	0.658
		Distance to Trail	0.066	-0.006	0.138
		Distance to Trail:Night	-0.292	-0.378	-0.206
		Distance to Trail:Crepuscular	-0.200	-0.306	-0.094
	Whitebark pine	Distance to Forest Edge	-0.050	-0.102	0.003
		TRI	-0.184	-0.230	-0.138
		Aspect - North	-0.006	-0.095	0.083
		Aspect - East	0.031	-0.054	0.116
		Aspect - West	-0.108	-0.197	-0.018
		Landcover - Wet Forest	0.361	0.246	0.477
		Landcover - Shrub	-0.364	-0.471	-0.257
		Landcover - Dry Meadow	-0.335	-0.471	-0.198
		Landcover - Subalpine Fir	0.137	0.039	0.236
		Landcover - Douglas Fir	-0.097	-0.290	0.096
		Landcover - Wet Meadow	0.251	0.120	0.381
		Landcover - Rock	-0.437	-0.667	-0.208
		Landcover - Water	0.054	-0.140	0.248
		Landcover - WBP	0.003	-0.118	0.124
		CRS	0.767	0.376	1.157
		Restricted BMA	0.169	-0.056	0.393
		Unrestricted BMA	0.498	0.140	0.857
		Distance to Trail	0.063	-0.036	0.161
		Distance to Trail:Night	-0.315	-0.420	-0.211
		Distance to Trail:Crepuscular	-0.165	-0.298	-0.032

Table D.32. Parameter estimates and 95% confidence intervals from the best-supported model for the campsite model suite for grizzly bears, by sex and season, Yellowstone National Park, WY, USA, 2004–2020. We compared candidate models (Table 3.2) to test our hypotheses about grizzly bear responses to predictable (backcountry campsite) recreation in areas with different levels of restrictions to human access (BMAs: non-BMA, unrestricted BMA, restricted BMA). We report estimates from the best supported model. TRI is Terrain Roughness Index, CRS is Carcass Redistribution Site, WBP is whitebark pine, and BMA is Bear Management Area. All continuous variables are centered and scaled. Distance to camp is log-transformed.

Sex	***Season***	***Parameter***	***Estimate***	***95% CI***	
Female	Mating	Distance to Water	0.070	0.031	0.109
		TRI	0.196	0.168	0.224
		Aspect - North	-0.267	-0.340	-0.195
		Aspect - East	-0.165	-0.230	-0.100
		Aspect - West	-0.208	-0.277	-0.139
		Landcover - Wet Forest	0.169	0.069	0.270
		Landcover - Shrub	0.285	0.212	0.359
		Landcover - Dry Meadow	0.302	0.199	0.404
		Landcover - Subalpine Fir	-0.131	-0.236	-0.025
		Landcover - Douglas Fir	0.228	0.118	0.338
		Landcover - Wet Meadow	0.220	0.094	0.345
		Landcover - Rock	0.070	-0.093	0.233
		Landcover - Water	-1.022	-1.228	-0.816
		Landcover - WBP	-0.150	-0.270	-0.029
		Distance to Anthropogenic	-0.570	-1.073	-0.068
		CRS	0.214	-0.022	0.449
		Unrestricted BMA	-0.248	-1.221	0.724
		Restricted BMA	0.102	-0.221	0.425
		Distance to Camp	0.137	-0.088	0.363
		Distance to Camp:Night	-0.259	-0.466	-0.053
		Distance to Camp:Crepuscular	-0.194	-0.433	0.045
	Summer	Distance to Forest Edge	0.073	0.031	0.115
		TRI	-0.059	-0.094	-0.025
		Aspect - North	0.184	0.106	0.261
		Aspect - East	0.014	-0.061	0.089
		Aspect - West	0.033	-0.038	0.104
		Landcover - Wet Forest	0.429	0.318	0.540
		Landcover - Shrub	0.171	0.081	0.261
		Landcover - Dry Meadow	0.367	0.265	0.468
		Landcover - Subalpine Fir	0.014	-0.093	0.120

Table D.32 Continued

Sex	***Season***	***Parameter***	***Estimate***	***95% CI***	
		Landcover - Douglas Fir	0.306	0.169	0.442
		Landcover - Wet Meadow	0.734	0.619	0.849
		Landcover - Rock	0.362	0.194	0.530
		Landcover - Water	-1.055	-1.497	-0.613
		Landcover - WBP	0.055	-0.062	0.173
		Distance to Anthropogenic	-0.477	-1.087	0.132
		CRS	0.388	0.059	0.717
		Unrestricted BMA	0.429	0.028	0.829
		Restricted BMA	0.177	-0.132	0.487
	Whitebark Pine	Distance to Forest Edge	0.071	0.017	0.124
		TRI	-0.036	-0.070	-0.002
		Aspect - North	0.141	0.061	0.221
		Aspect - East	0.066	-0.011	0.144
		Aspect - West	-0.085	-0.167	-0.003
		Landcover - Wet Forest	0.351	0.233	0.468
		Landcover - Shrub	-0.087	-0.186	0.011
		Landcover - Dry Meadow	0.056	-0.064	0.177
		Landcover - Subalpine Fir	0.177	0.087	0.267
		Landcover - Douglas Fir	0.070	-0.102	0.243
		Landcover - Wet Meadow	0.366	0.225	0.508
		Landcover - Rock	-0.258	-0.469	-0.046
		Landcover - Water	-0.320	-0.625	-0.015
		Landcover - WBP	0.267	0.166	0.367
		CRS	0.411	-0.235	1.057
		Distance to Camp	-0.005	-0.196	0.187
		Restricted BMA	-0.005	-0.231	0.221
		Unrestricted BMA	-0.138	-0.689	0.413
Male	Mating	Distance to Water	-0.058	-0.087	-0.028
		TRI	-0.068	-0.095	-0.041
		Aspect - North	-0.102	-0.164	-0.040
		Aspect - East	-0.069	-0.126	-0.013
		Aspect - West	-0.124	-0.182	-0.067
		Landcover - Wet Forest	0.347	0.263	0.432
		Landcover - Shrub	0.157	0.095	0.220
		Landcover - Dry Meadow	0.130	0.054	0.205
		Landcover - Subalpine Fir	-0.081	-0.177	0.015
		Landcover - Douglas Fir	0.136	0.033	0.238
		Landcover - Wet Meadow	0.277	0.191	0.364

Table D.32 Continued

Sex	*Season*	*Parameter*	*Estimate*	*95% CI*	
		Landcover - Rock	0.335	0.169	0.501
		Landcover - Water	-0.143	-0.262	-0.025
		Landcover - WBP	-0.038	-0.163	0.086
		Distance to Anthropogenic	-0.131	-0.337	0.075
		CRS	0.265	-0.149	0.679
		Distance to Camp	-0.104	-0.189	-0.02
		Unrestricted BMA	0.323	0.022	0.625
		Restricted BMA	0.297	0.118	0.477
	Summer	Distance to Water	-0.133	-0.182	-0.083
		TRI	-0.222	-0.263	-0.181
		Aspect - North	0.126	0.050	0.202
		Aspect - East	0.017	-0.058	0.092
		Aspect - West	0.042	-0.031	0.115
		Landcover - Wet Forest	0.629	0.539	0.719
		Landcover - Shrub	0.047	-0.034	0.129
		Landcover - Dry Meadow	0.201	0.105	0.297
		Landcover - Subalpine Fir	0.123	0.021	0.225
		Landcover - Douglas Fir	0.123	-0.024	0.271
		Landcover - Wet Meadow	0.457	0.363	0.552
		Landcover - Rock	-0.044	-0.247	0.159
		Landcover - Water	-0.100	-0.269	0.070
		Landcover - WBP	0.207	0.078	0.335
		Distance to Anthropogenic	0.281	-0.277	0.840
		CRS	0.532	-0.308	1.372
		Unrestricted BMA	0.564	0.285	0.843
		Restricted BMA	0.329	0.016	0.641
		Distance to Camp	-0.051	-0.192	0.089
		Distance to Camp:Night	-0.183	-0.338	-0.029
		Distance to Camp:Crepuscular	-0.063	-0.245	0.120
	Whitebark Pine	Distance to Forest Edge	-0.053	-0.105	-0.001
		TRI	-0.188	-0.234	-0.142
		Aspect - North	-0.012	-0.101	0.077
		Aspect - East	0.030	-0.055	0.114
		Aspect - West	-0.110	-0.199	-0.020
		Landcover - Wet Forest	0.366	0.250	0.481
		Landcover - Shrub	-0.362	-0.469	-0.255
		Landcover - Dry Meadow	-0.331	-0.468	-0.195

Table D.32 Continued

Sex	*Season*	*Parameter*	*Estimate*	*95% CI*	
		Landcover - Subalpine Fir	0.134	0.035	0.232
		Landcover - Douglas Fir	-0.098	-0.291	0.095
		Landcover - Wet Meadow	0.254	0.124	0.384
		Landcover - Rock	-0.434	-0.663	-0.206
		Landcover - Water	0.048	-0.146	0.241
		Landcover - WBP	0.003	-0.118	0.124
		CRS	0.790	0.400	1.180
		Unrestricted BMA	0.565	0.198	0.931
		Restricted BMA	0.150	-0.092	0.393