University of Nebraska - Lincoln
DigitalCommons@University of Nebraska - Lincoln

Dissertations & Theses in Natural Resources   Natural Resources, School of

5-2020

Recreational Activity Dynamics at Valentine National Wildlife Refuge

Olivia A. DaRugna
University of Nebraska - Lincoln, olivia.darugna@huskers.unl.edu

Follow this and additional works at: https://digitalcommons.unl.edu/natresdiss

Part of the Leisure Studies Commons, Natural Resources and Conservation Commons, Natural Resources Management and Policy Commons, and the Other Environmental Sciences Commons

DaRugna, Olivia A., "Recreational Activity Dynamics at Valentine National Wildlife Refuge" (2020). *Dissertations & Theses in Natural Resources*. 311.
https://digitalcommons.unl.edu/natresdiss/311

This Article is brought to you for free and open access by the Natural Resources, School of at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Dissertations & Theses in Natural Resources by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

RECREATIONAL ACTIVITY DYNAMICS

AT VALENTINE NATIONAL WILDLIFE REFUGE

by

Olivia A. DaRugna

A THESIS

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Science

Major: Natural Resource Sciences

Under the supervision of Professors Mark A. Kaemingk and Kevin L. Pope

Lincoln, Nebraska

May 2020

RECREATIONAL ACTIVITY DYNAMICS

AT VALENTINE NATIONAL WILDLIFE REFUGE

Olivia A. DaRugna, M.S.

University of Nebraska, 2020

Advisors: Mark A. Kaemingk and Kevin L. Pope

Many parks and protected areas are managed for a dual purpose to conserve ecological systems and to provide wildlife-compatible recreational opportunities for visitors. Managing parks and protected areas to meet this dual goal entails progressive management approaches that incorporate information about social and ecological components of these systems. Current management regimes focus heavily on the ecological component with little or no information concerning the social component of parks and protected areas. Incorporating social information is essential for understanding and accounting for social conflicts and ecological impacts that result from a diversity of recreational activities. We examined recreational activities at Valentine National Wildlife Refuge (VNWR) in Nebraska to understand the social aspect of this social-ecological system. We distributed surveys onsite at VNWR during a one-year collection period. We examined the frequency, sociodemographics, and potential for social conflicts and ecological impacts of consumptive (i.e., hunting), intermediate-consumptive (i.e., fishing), and non-consumptive (i.e., wildlife watching, touring, hiking, photography, and environmental education) groups. Valentine National Wildlife Refuge supports heterogeneous recreational-activity groups, which vary in frequency and potential for social conflicts and ecological impacts. The intermediate-consumptive group was the

predominate recreational-activity group on VNWR. Delphi methodology was used to measure potential social conflicts and ecological impacts of different recreational activities. Based on the consensus reached using the Delphi method, the consumptive group had the greatest potential for social conflicts and ecological impacts. We subsequently applied the potential social conflicts and ecological impacts caused by different recreational-activity groups to evaluate social and ecological intensities across space and time on VNWR. Social and ecological intensities varied across lake types and seasons, highlighting intense impact areas and periods on the refuge. Valentine National Wildlife Refuge permits diverse recreational opportunities that necessitate a multi-faceted management regime to fulfil the dual purpose. Realizing and accounting for the different recreational activities and coinciding social and ecological intensities will allow parks and protected area managers the ability to concomitantly preserve ecological resources, prioritize conservation efforts, and minimize visitor conflicts.

ACKNOWLEDGEMENTS

The successful completion of this research would not have been accomplished without the exceptional guidance, support, and insight from many individuals. Dr. Kevin Pope and Dr. Mark Kaemingk, I cannot thank you both enough for this truly rewarding and enriching professional experience. Words cannot express how much I appreciated all the time, care, and commitment you both have put in to helping me grow professionally and personally. The continued encouragement, challenges, and intellectual freedom you both provided has allowed me to expand my professional abilities and become a better scientist. Mark and Kevin, I will forever be grateful to have learned, worked, and been advised by you both. I also thank the other members of my committee, Dr. Larkin Powell and Dr. Richard Holland, for your continued contribution and expertise from the development to the completion of this work. I greatly appreciate the commitment and insight you both have provided throughout the process. Thank you, Wilma and Caryl, for your essential support and always being there to answers all my questions.

Thank you, Dr. Chris Chizinski, for teaching one of the most valuable classes I have ever taken as a student. I greatly appreciated your continued patience and assistance while teaching me program R coding skills, answering all my coding questions, providing statistical and human dimensions insights, and adopting me on your lab conference trip. Dr. Mark Burbach, thank you for teaching valuable human dimensions and public organization classes, and for your input on questionnaire design.

Thank you to my awesome peers in the Nebraska Cooperative Fish and Wildlife Research Unit for your valuable input, encouragement, and much needed laughs. Nick Cole and Christine Bender, thank you for showing me the ropes and providing valuable input on my project, presentations, and graduate school. Derek Kane, thank you for your help and input with my writing and for being a great and dependable office mate when room 013 felt empty. Katherine Hogan, thank you for helping me with my writing, your company at coffee shops, and the laughs and inspirational mini breaks at work. To the wonderful and funny students in Chizinski's lab, thank you for your human dimensions and survey design insight, support at conferences, and valuable feedback during lab meetings.

To the staff at Valentine National Wildlife Refuge, thank you for all your assistance while I worked on the refuge. A special thanks to Juancarlos Giese and Mel Nenneman for the continued support and valuable insight throughout the project. I really appreciated hearing about the management of the refuge, and your knowledge of the unique ecosystem, birds, and other wildlife that lived on the refuge. June Chiu, thank you for being an amazing roommate at the refuge. I cannot thank you enough for all your encouragement when I was stressed, assistance with vehicle problems, awesome gardening skills, and just being an all-around great roommate.

Thank you to Keith Hurley at Nebraska Game and Parks Commission for all your assistance, insights, and patience with creating a database. Thank you to all the Delphi experts for your time and input throughout the process. Jerry Ryschon, thank you for all your hard work distributing surveys and collecting data, especially in the dead of winter. Thank you to all the visitors who took the time to complete and return surveys; without your responses this project would not have been possible.

A special thank you to my good friends from afar, Dr. Clara Cooper-Mullin and Jessica Rule, whom without their amazing support I would not be where I am today.

Clara, your assistance, encouragement, and continued belief in me is unfathomable. You taught me so much about graduate school, how to conduct good research, what it means to work hard on a project you are passionate about, and of course bird physiology. Jessica, I am so grateful to have you as my best friend. You have always encouraged me to follow my dreams and to keep working hard. I could always count on you to pick up the phone when I was most stressed and needed to talk or hear a funny story. To my aunt Cindy, thank you for providing so much support to continue to work hard and be curious about everything. Your anxiety-relieving advice and exercises got me through some stressful times, and I will forever appreciate your wisdom, stories, and guidance.

Thank you to my parents, Junus and Alison, for instilling in me at a young age the important values of wildlife, natural resources, and public lands. The memories and love I gained for the outdoors through all our family vacations to National Parks has undoubtably influenced the person I am today and the career path I continue to work towards. Thanks Mom and Dad for all your love, support, and encouragement.

Finally, thank you to my partner, Steve Brenner, for your undying support of me. Words cannot express how grateful I am for all that you have done for me, from moving to Nebraska to being there for me when I was frustrated with analysis. I am thankful every day to have you by my side, and for all your encouragement, patience, friendship, and love. Thank you for embarking on this adventure with me; I look forward to many more adventures together.

This project was funded by Federal Aid in Sport Fish Restoration project F-182-R, which was administered by the Nebraska Game and Parks Commission. The Institutional Review Board for the Protection of Human Subjects approved the research protocol (IRB Project ID 14051). Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government. References and citations are in APA-7 format.

TABLE OF CONTENTS

GLOSSARY

Term	Definition
Parks and protected areas	Public areas managed to balance the protection of an ecosystem and natural resources while providing opportunities for human use (e.g., national parks, forests and wildlife refuges, state parks).
Recreational activities	Things people do for fun and enjoyment that often take place on parks and protected areas.
Consumptive	A type of recreational activity in which recreationists intend to harvest animals (i.e., hunting).
Intermediate-consumptive	A type of recreational activity in which recreationists intend to capture animals that can be harvested or released (i.e., fishing).
Non-consumptive	A type of recreational activity in which recreationists do not intend to capture or harvest animals (e.g., wildlife watching).
Party	One or multiple individuals that travel and recreate together on a parks and protected area.
Group	One or multiple parties participating in the same recreational-activity type (i.e, consumptive, intermediate-consumptive, or non-consumptive).
Population type	A variable used to differentiate parties that resided in urban ($\geq$ 386 people per square kilometer [ppskm]) or rural areas (< 386 ppskm).
Vehicle type	A variable used to differentiate parties that drove two-wheel drive (2WD) or four-wheel drive (4WD) vehicles.

CHAPTER 1: SOCIODEMOGRAPHIC ATTRIBUTES OF CONSUMPTIVE AND NON-CONSUMPTIVE RECREATIONAL-ACTIVITY GROUPS WITHIN A PARK AND PROTECTED AREA

INTRODUCTION

The majority of parks and protected areas are important social-ecological systems that serve dual purposes: 1) to preserve and manage ecological systems and 2) to provide wildlife-compatible recreation opportunities for the public (Beeco & Brown, 2013; Dearden, 2010). Achieving both purposes is difficult. Certain recreational opportunities can interfere with managing and preserving ecological components of parks and protected areas. For example, outdoor recreational activities can directly influence wildlife through harvest, habitat modification, pollution, and disturbance (Knight & Cole, 1995). Social conflicts can also arise among different groups that recreate on shared parks and protected areas, such as negative interactions between hikers and hunters (Schuster et al., 2006). Record-high levels of visitation have been recorded at parks and protected areas with approximately 330 million people visiting U.S. National Parks during 2016 and again during 2017 (National Park Service, 2018). Increased use of parks and protected areas has led to soil erosion, damage to plants, and disturbances to wildlife (Taylor & Knight, 2003). Therefore, negative impacts on the ecological system may become more severe and social conflicts may become more frequent as the popularity and demands increase for recreating on parks and protected areas (U.S. Bureau of Land Management, 2019; U.S. Fish and Wildlife Service, 2016; U.S. Forest Service, 2016).

To effectively achieve the dual purpose of parks and protected areas, managers must account for both the ecological and recreational diversities on these shared lands

(Beeco & Brown, 2013). Most parks and protected areas suffer from a lack of social and recreation information due to limited resources and difficulty of gathering this information (Bushell & Griffin, 2006). Many parks and protected areas allow for multiple recreational opportunities, but few parks and protected areas have quantified the frequency of these activities. A lack of information on recreational use of parks and protected areas has, by default, led to managing recreationists as a single homogeneous group. Managing for a general recreational-activity group may have worked in the past during periods of low visitation; however, with the increase in visitation and more intensive use of parks and protected areas, managers need to identify and account for different and increasingly diverse recreationists. The dual goal of minimizing ecological impacts while maximizing recreational opportunities will only be met if managers have an increased understanding of the recreationists using parks and protected areas.

Most parks and protected areas allow for both consumptive and non-consumptive recreational activities (Kauffeld et al., 1999; U.S. Forest Service, 2016). These two recreational activities are expected to attract different sets of recreationists with varying attributes (Reis & Higham, 2009). Consumptive recreationists permanently extract (i.e., harvest) organisms from the environment (Vaske & Roemer, 2013). In contrast, non-consumptive recreationists do not intend to remove or permanently affect organisms (Duffus & Dearden, 1990). Non-consumptive recreationists typically have more general primary goals that can be achieved throughout the trip, such as experiencing nature, escaping everyday routine, or being with friends (Vaske & Roemer, 2013). Given these inherent differences, we expect that effective management actions need to consider the relative composition and frequency of recreational activities and the associated attributes of the recreationists that participate in these activities on parks and protected areas. Evaluating sociodemographic attributes (e.g., age, income) can further provide insight to potential limitations and opportunities for preserving and managing these social-ecological systems.

We surveyed recreationists on Valentine National Wildlife Refuge (VNWR) to evaluate the social component of this park and protected area. The refuge permits a wide range of recreational activities that can be categorized into consumptive (hunting), intermediate-consumptive (fishing), or non-consumptive (wildlife watching, photography, touring, hiking, environmental education, other) groups (Table 1-1). We compared six sociodemographic attributes among these three recreational-activity groups. Attribute differences would suggest that these recreational-activity groups attract different recreationists (i.e., heterogeneous), as opposed to the possibility of the same individuals participating in all activities (i.e., homogeneous). Therefore, sociodemographics attributes were used to infer whether different recreationists were participating in these three recreational activities. Our objectives were to 1) quantify the frequency of consumptive, intermediate-consumptive, and non-consumptive groups recreating on the refuge, and 2) evaluate differences in sociodemographic characteristics among these three recreational-activity groups.

We expected all three managed recreational-activity types to occur at VNWR, but given the accessibility and amount of resources (i.e., funding and construction of boat ramps, fishing docks, and aquatic restoration through the aquatic habitat plan) devoted to fishing (Brashears, 2016; Lindvall & Nenneman, 2012) we hypothesized the intermediate-consumptive group (i.e., fishing) to have the greatest frequency of participation. Previous research reported varying attribute differences among consumptive and non-consumptive groups (Reis & Higham, 2009; U.S. Department of the Interior et al., 2016). For example, consumptive- groups consisted of a greater percentage of male recreationists from rural areas than intermediate-consumptive or non-consumptive groups (U.S. Department of the Interior et al., 2016). Thus, we expected to document differences in attributes among the three recreational-activity groups. A greater understanding of the social component of parks and protected areas will aid management decision-making and lead to more informed and effective management actions, such as minimizing user conflicts, prioritizing conservation efforts, preserving ecological resources, and optimizing recreational opportunities.

METHODS

Study System

Valentine National Wildlife Refuge is located in north-central Nebraska and covers 28,941 hectares in the heart of the sandhill region (Appendix 1). The refuge manager and biologist determined which recreational activities were allowed on the VNWR based on their compatibility with wildlife (Kauffeld et al., 1999). These recreational activities included a consumptive activity (hunting), an intermediate-consumptive activity (fishing; anglers can harvest or release fish) (Kaemingk, Hurley, Chizinski, & Pope, 2020), and six non-consumptive activities (wildlife watching, touring, hiking, photography, environmental education, and other activities not listed on the survey [i.e., kayaking, break from driving, running, prospecting, ice checking, eclipse watching, and dog walking]).

Valentine National Wildlife Refuge strives to balance the preservation of the unique ecological diversity of the Sandhills while providing recreational opportunities. For example, of the 33 lakes on VNWR, waterfowl hunting is permitted at three lakes, and fishing is allowed at nine lakes. There are other hunting opportunities on VNWR (i.e., coyote [*Canis latrans*], white-tailed deer [*Odocoileus virginianus*] mule deer [*Odocoileus hemionus*], mourning dove [*Zenaida macroura*], greater prairie chicken [*Tympanuchus cupido*], ring-necked pheasant [*Phasianus colchicus*], and sharp-tailed grouse [*Tympanuchus phasianellus*]) that are restricted to designated hunting-seasons. The refuge is also closed to all recreationists from sunset to sunrise.

Recreational-Activity Surveys

We distributed windshield surveys to each recreating party throughout the course of a year (30 July 2017 to 26 July 2018; Appendix 2). We defined eight recreational activities that were permitted on VNWR. Parties selected activities (fishing, hunting, wildlife watching, touring, hiking, photography, environmental education, and other) in which they participated, and returned completed surveys at one of four drop boxes on the refuge or through the U.S. postal service with each survey prepaid, postmarked and addressed to the University of Nebraska-Lincoln. The date, time, GPS location, and vehicle type (two-wheel drive [2WD] or four-wheel drive [4WD]) for each windshield survey distributed was documented on a survey datasheet. Response bias was evaluated to ensure our returned surveys provided a representative sample of the temporal distribution of the recreational activities occurring on the refuge. We compared the temporal distribution of non-respondents to respondents using two-week sampling periods during the study. Seasonality of different recreational activities (e.g., hunting permitted in fall, fishing when lakes are frozen in winter, wildlife watching in spring and summer during bird migrations and breeding displays) should indicate bias among certain recreational-activity groups (Butler, 1994; Smallwood et al., 2011).

Distribution of surveys was stratified by two-week periods (fourteen days). Within each two-week period, days were stratified by day type (weekday [Monday through Friday] and weekend [Saturday and Sunday]). Six weekdays and two weekend days were randomly sampled within two-week sampling periods. Each day was further stratified into either a morning or an evening sampling period. Morning sampling periods were initiated at sunrise and evening sampling periods were initiated eight hours prior to sunset (e.g., 11:00 start with a 19:00 sunset). Sampling routes were predefined; the start (and end) location and route direction (clockwise or counterclockwise) were randomized for each sampling day. Additional "event" days were added to the sampling schedule, and included holidays and hunting openers (Appendix 3). We expected deviations from normal use during these events and thus wanted to account for potential increased activity. We did not sample on scheduled foul-weather days (e.g., blizzards) and assumed no recreational activities occurred during these adverse weather events (Spinney & Millward, 2011).

Quantifying Recreational-Activity Groups

Recreational activities were quantified based on hierarchically selected activities. Parties that selected hunting, regardless of the other selected recreational activities, were assigned to the consumptive group. Remaining parties that selected fishing, regardless of other selected recreational activities, were assigned to the intermediate-consumptive group. Remaining parties that selected wildlife watching, touring, hiking, photography, environmental education, or other were assigned to the non-consumptive group.

We collected sociodemographic attribute information for consumptive, intermediate-consumptive, and non-consumptive groups using information from the returned surveys. The recreational-activity surveys were used to gather information on the number of individuals in a party and in each age category (17 or younger, 18 to 64, and 65 years or older). The survey also included a question asking for each unique ZIP code in the party. We used the first ZIP code provided for our analyses. We assessed sociodemographic attributes including party size, senior (65 or older) present, distance traveled, average household income, population type (urban or rural residence), and vehicle type (Table 1-2). From these sociodemographic attributes, we can begin to understand potential influences and limitations recreationists have to participating in certain activities on VNWR. For example, seniors typically prefer non-consumptive recreational activities like touring or wildlife watching, which can be done with little physical effort and without leaving a vehicle (Schuett et al., 2010); thus, vehicle access is important for seniors. Previous research has also documented household income and population type (urban or rural) to influence participation in certain recreational activities. For example, hunting typically requires large expenditures on gear and travel, and tends to be comprised of individuals from rural areas (U.S. Department of the Interior et al., 2016).

The sociodemographic information was used to understand whether we had the same or different recreationists participating in the recreational activities. Understanding sociodemographic attributes of recreationists can help minimize social and ecological problems, such as large party sizes that cause crowding or disturb wildlife (Remacha et al., 2011). Furthermore, different sociodemographic attributes among the recreational-activity groups would suggest a heterogeneous group of recreationists; this information is important to understand for management and conservation decisions.

Statistical Analysis:

We used a Kolmogorov-Smirnov 2-sample test between respondents and non-respondents to evaluate temporal (2-week periods) response bias. We expected temporal bias could arise among the recreational-activity groups because many recreational activities are seasonally based. For example, hunting has specific seasons, and response-rate differences during these periods could reflect a misrepresentation of the consumptive group compared to the other recreational-activity groups. Thus, we attempted to evaluate response bias using a temporal approach that would expose seasonal deviates from a consistent response rate throughout the year.

The frequency of recreational activities was calculated by summing all returned surveys by recreational-activity group. Descriptive statistics were used to summarize the sociodemographic characteristics that were associated with the consumptive, intermediate-consumptive, and non-consumptive groups. The rank order of each sociodemographic attribute was reported with the recreational-activity group with the largest value reported first and the recreational-activity group with the smallest value reported last. Senior present attribute was categorized as either present (parties with at least one individual 65 years or older) or absent (parties without a senior). Distance traveled was calculated from the refuge headquarters to the center point of the recreationists' home ZIP codes using 'distHaversine' function in the R geosphere package (Hijmans, 2017). We used ZIP code to categorize each party by population type (urban [$\geq$ 386 people per square kilometer (ppskm)] or rural [< 386 ppskm]), and to determine average household income using the Esri 2018 demographics database (ArcGIS, 2018).

We used one-way permutational multivariate analysis of variance (PERMANOVA) to evaluate differences in sociodemographic attributes among consumptive, intermediate-consumptive, and non-consumptive groups. The ‘adonis2’ function in the vegan package was used to conduct the PERMANOVA with 999 permutations (Oksanen et al., 2018). The PERMANOVA is robust, handling several variables together, including both continuous and categorical data (Anderson, 2017). The continuous sociodemographic attributes, which included party size, distance traveled, and average household income, were scaled zero to one using:

$$x' = \frac{x - x_{min}}{x_{max} - x_{min}}$$

where x' is the normalized value. After a significant PERMANOVA result, post-hoc pairwise comparisons were conducted using ‘pairwise.perm.manova’ function in the vegan package to determine differences in recreational-activity groups mean dispersions (Oksanen et al., 2018). We also conducted *a posteriori* univariate comparison for each sociodemographic attribute to understand which attributes were contributing to the significant PERMANOVA result. We tested for the PERMANOVA assumption regarding homogeneity of multivariate dispersion between recreational-activity groups (consumptive vs intermediate-consumptive, consumptive vs non-consumptive, and intermediate-consumptive vs non-consumptive) using the ‘betadisper’ function in the vegan package (Oksanen et al., 2018). Differences among recreational-activity groups were visualized using a nonmetric multideminsional scaling (nMDS) plot, with 95% confidence ellipses associated with each recreational-activity group; we used the ‘envfit’ function to plot the direction and strength of the significant ($\alpha = 0.05$) sociodemographic attributes (Oksanen et al., 2018). All statistical testing was completed using R open-source software (R Development Core Team, 2014).

RESULTS:

We distributed 2,251 surveys and 861 were returned (38% return rate). There was a similar temporal distribution between respondents and non-respondents (Kolmogorov-Smirnov test: $D = 0.26$, $p > 0.32$), therefore we did not have response bias. Of the 861 returned surveys, 789 were completed (35% functional return rate) and used for subsequent analysis, with all recreational-activity groups present on the refuge. The intermediate-consumptive group was predominate with 616 (78%) parties representing this group, followed by 95 (12%) parties representing the consumptive group and 78 (10%) parties representing the non-consumptive group.

Sociodemographic attributes varied across the three recreational-activity groups (Figure 1-1). The intermediate-consumptive group had the greatest rank order for party size and traveling in 4WD vehicles (mean party size = 3; 4WD = 96%), followed by the consumptive group (mean party size = 2; 4WD = 94%) and the non-consumptive group (mean party size = 2; 4WD = 72%). The non-consumptive group had the greatest rank order for seniors present and residing in urban areas (seniors present = 44%; urban = 31%), followed by the intermediate-consumptive group (seniors present = 31%; urban =

14%) and the consumptive group (seniors present = 28%; urban = 11%). The non-consumptive group also had the greatest rank order for average distance traveled and household income (mean distance traveled = 863 km; mean income = $83,695), followed by the consumptive group (mean distance traveled = 818 km; mean income = $78,968) and the intermediate-consumptive group (mean distance traveled = 260 km; mean income = $70,253).

We discovered significant sociodemographic differences among the recreational-activity groups (Pseudo-F = 15.961, df = 2, P_{perm}= 0.001); pairwise comparisons revealed all recreational-activity groups were significantly different from each other ($P_{perm} <$ 0.001). Post hoc univariate PERMANOVA revealed significant differences among the three recreational-activity groups for each sociodemographic attribute, except for the 'seniors present' attribute (Table 1-3). Analysis of homogeneity of multivariate dispersion between recreational-activity groups was significant. There was greater dispersion in sociodemographic attributes among the non-consumptive group compared to the consumptive and intermediate-consumptive groups (Figure 1-2). Although PERMANOVA tests are susceptible to differences in dispersion (Anderson & Walsh, 2013), we interpret our findings to indicate that sociodemographic attributes vary both across and within recreational-activity groups.

DISCUSSION

Valentine National Wildlife Refuge supports heterogeneous groups of recreationists that participate in consumptive, intermediate-consumptive, and non-consumptive recreational activities. We inferred based on the sociodemographic variation among the recreational-activity groups that different recreationists were participating in different recreational-activity types. The recreationists differed across most sociodemographic attributes, including party size, distance traveled, household income, population type, and vehicle type. This has important implications for management of VNWR and the ability to support diverse recreational-activity groups. Although diverse, we identified that VNWR primarily supports the intermediate-consumptive group. Overlooking the recreational diversity and the predominance of one recreational-activity group could be problematic when designing and implementing different management actions. For instance, catering to the predominate recreational-activity group by providing infrastructure (i.e., parking lots and lake access) at the lakes open to fishing may lead to non-consumptive groups also using these areas, and thus potentially creating congestion and social conflicts among the different recreational-activity groups, and high ecological impacts. Our results highlight different recreationists are participating in different recreational-activity types. Thus, it is important to identify and manage for these heterogeneous activities and recreationists.

Valentine National Wildlife Refuge manages for and offers a variety of recreational opportunities, and we found recreationists participated in each of the three managed recreational-activity types. Documenting the frequency of occurrence allowed us to understand that the intermediate-consumptive group (i.e., anglers) was the predominate recreational-activity group on the refuge, surpassing the consumptive and non-consumptive groups. This supported our hypothesis that because of the large amount of resources, from the aquatic habitat project (e.g., NGPC funded, construction of boat ramps, boat docks, removal of common carp), allocated to managing the nine lakes open to fishing the intermediate-consumptive group would have the greatest frequency of participation. Identifying the frequency of each recreational-activity group is essential for managers to understand so that management resources can be distributed accordingly. For example, opening more lakes to fishing may increase the participation by the intermediate-consumptive group on the refuge, whereas providing more 2WD access for wildlife viewing may increase participation by the non-consumptive group on the refuge. The different frequency among the recreational-activity groups may be due to the rural location of VNWR. Consistent with results from previous studies, VNWR's distance from an urban center leads to less visitation by recreationists that reside in urban areas, which was more likely to be non-consumptive recreationists (Hanink & Stutts, 2002; Schuett et al., 2010). Understanding the frequency of use of each recreational-activity group can provide managers the ability to set management goals in accordance to the diversity of recreational-activity groups that occur on parks and protected areas.

Increasing or decreasing the frequency of different recreational-activity groups may enable managers to achieve their dual goal of conserving the ecological system and providing recreational opportunities. Management decisions that do not account for a heterogeneous user group on parks and protected areas could exacerbate social and ecological issues (Knight & Cole, 1995; Pickering et al., 2010; Taylor & Knight, 2003). Therefore, recognizing the differences in frequency and sociodemographic attributes among the recreational-activity groups can aid in management decisions to accommodate for more or less recreationists depending on their relative ecological impacts. Previous studies identified that birds have a reduced tolerance for large recreating parties (Remacha et al., 2011) and recreational activities that go off-trail can impact sensitive flora and fauna (Schultz & Bailey, 1978; Taylor & Knight, 2003). Consequently, managers may want to only provide access to areas with minimally sensitive species for the enjoyment of bird watchers and hunters by creating small parking areas and trails to limit uncontrolled dispersal (Geneletti & van Duren, 2008; Monz et al., 2010). Smaller parking areas and spatially separated recreational opportunities, such as providing non-consumptive recreational activities away from the lakes open to fishing, could ease crowding and social conflicts among different recreational-activity groups (Eadens et al., 2009; Miller et al., 2017). We contend that a better understanding of potential social conflicts at parks and protected areas, would allow managers to make more informed management decisions to effectively reach the dual goal of parks and protected areas.

Managers need to effectively allocate resources both spatially and temporally to meet the dual goal of managing for the ecological system and recreational opportunities. Increasing the number of anglers at VNWR may not cause crowding or lead to negative ecological impacts if angling effort is distributed across the nine lakes throughout the year. Current management actions at VNWR are allocating resources to restore aquatic habitats by improving the ecological system through removal of invasive species (e.g., common carp [*Cyprinus carpio*]) and creating a more productive fishery for the intermediate-consumptive recreationists to enjoy. However, we may expect more intensive use of certain lakes by anglers that could lead to crowding and ecological harm. Thus, it is important to understand how current and future management actions may affect the spatial and temporal use of each recreational-activity group. Without the knowledge of spatial and temporal use by different recreational-activity groups, management actions may cause unforeseen ecological and social consequences. For instance, increased soil compaction, off-trail use, and crowding could occur at a recently renovated lake because we expect increased use by waterfowl (attract more hunters [consumptive group] and birdwatchers [non-consumptive group]), and better fishing opportunities (intermediate-consumptive group; Kaemingk et al., 2017; Martin, Daizaburo, Chizinski, & Pope, 2017). Accounting for spatial and temporal use, along with the frequency and sociodemographics of the different recreational-activity groups, will continue to be important for parks and protected area mangers to consider in their management plans (see chapter 2).

Many parks and protected areas, including VNWR, offer diverse recreational activities; identifying the heterogeneity among the recreational-activity groups is essential to provide a multi-faceted management regime that fulfils the dual goal of preserving ecological systems and providing recreational opportunities. This dual goal may be viewed as competing goals by parks and protected area managers as they face an increase in visitation (Cottrell et al., 2005). With more intensive use of these public lands and fewer resources, there is an urgency to understand the recreationists and how they differ in their use of these lands. In addition, parks and protected areas continue to face a decline in funding and resources, thus making management of these valuable areas even more difficult (Watson et al., 2014). Future research should expand our efforts to examine other parks and protected areas (e.g., National Wildlife Refuges, National Forests, and State Parks). Recognizing and accounting for diverse recreationists and activities will afford parks and protected area managers the ability to concomitantly manage for diverse recreational-activity groups, prioritize conservation efforts, and preserve ecological resources with limited resources.

REFERENCES

Anderson, M. J. (2017). Permutational multivariate analysis of variance (PERMANOVA). *Wiley StatsRef: Statistics Reference Online*, 1–15. https://doi.org/10.1002/9781118445112.stat07841

Anderson, M. J., & Walsh, D. C. I. (2013). PERMANOVA , ANOSIM , and the Mantel test in the face of heterogeneous dispersions: What null hypothesis are you testing? *Ecological Monographs*, *83*(4), 557–574.

Apodaca, M., Tippie, M., Verde, A. M., & Barandino, V. J. (2012). *Guidelines for road maintenance levels* (Issue June).

ArcGIS. (2018). *Popular demographics in the United States (beta)*. https://www.arcgis.com/home/item.html?id=2718975e52e24286acf8c3882b7ceb18&sortOrder=true&sortField=defaultFSOrder&view=list#data

Arrowsmith, C., & Chhetri, P. (2003). *Port Campbell National Park: Patterns of use* (Issue June).

Beeco, J. A., & Brown, G. (2013). Integrating space, spatial tools, and spatial analysis into the human dimensions of parks and outdoor recreation. *Applied Geography*, *38*(1), 76–85. https://doi.org/10.1016/j.apgeog.2012.11.013

Brashears, Z. (2016). *Valentine National Wildlife Refuge 2016 Fish Survey Report*.

Bushell, R., & Griffin, T. (2006). Monitoring visitor experiences in protected areas. *Parks*, *16*(2), 25–33.

Butler, R. (1994). Seasonality in tourism: Issues and problems. In A. V. Seaton (Ed.), *Tourism: The Status of the Art* (pp. 332–339). Wiley.

Cottrell, S. P., Lengkeek, J., & Van Marwijk, R. (2005). Typology of recreation experiences: Application in a Dutch forest service visitor monitoring survey. *Managing Leisure*, *10*(1), 54–72. https://doi.org/10.1080/13606710500086827

Dearden, P. (2010). Parks and Protected Areas. In B. Mitchell (Ed.), *Resource and environmental management in Canada: Addressing conflict and uncertainty* (4th ed., pp. 363–393). Oxford University Press.

Duffus, D. A., & Dearden, P. (1990). Non-consumptive wildlife-oriented recreation : A conceptual framework. *Biological Conservation*, *53*(December), 213–231. https://doi.org/10.1016/0006-3207(90)90087-6

Eadens, L. M., Jacobson, S. K., Stein, T. V., Confer, J. J., Gape, L., & Sweeting, M. (2009). Stakeholder mapping for recreation planning of a Bahamian National Park. *Society and Natural Resources*, *22*(2), 111–127. https://doi.org/10.1080/08941920802191696

Geneletti, D., & van Duren, I. (2008). Protected area zoning for conservation and use: A combination of spatial multicriteria and multiobjective evaluation. *Landscape and Urban Planning*, *85*(2), 97–110. https://doi.org/10.1016/j.landurbplan.2007.10.004

Hanink, D. M., & Stutts, M. (2002). Spatial demand for national battlefield parks. *Annals of Tourism Research*, *29*(3), 707–719. https://doi.org/10.1016/S0160-7383(01)00085-8

Hijmans, R. J. (2017). *geosphere: Spherical Trigonometry* (R package version 1.5-7). https://cran.r-project.org/package=geosphere

Kaemingk, M. A., Hurley, K. L., Chizinski, C. J., & Pope, K. L. (2020). Harvest-release decisions in recreational fisheries. *Canadian Journal of Fisheries and Aquatic Sciences*, *77*, 194–201. https://doi.org/10.1139/cjfas-2019-0119

Kaemingk, M. A., Jolley, J. C., Paukert, C. P., Willis, D. W., Henderson, K., Holland, R. S., Wanner, G. A., & Lindvall, M. L. (2017). Common carp disrupt ecosystem structure and function through middle-out effects. *Marine and Freshwater Research*, *68*, 718–731. https://doi.org/10.1071/MF15068

Kauffeld, J., Garza, B., McPeak, K., Lindvall, M., Sellers, J., Len, M., & Staller, D. (1999). *Valentine National Wildlife Refuge Comprehensive Conservation Plan*. (Issue September).

Knight, R. L., & Cole, D. N. (1995). Wildlife responses to recreationists. In R. L. Knight & K. J. Gutzwiller (Eds.), *Wildlife and Recreationists: Coexistence Through Management and Research* (pp. 51–69). Island Press. http://books.google.com/books?hl=en&lr=&id=BRbBAvLwQlAC&oi=fnd&pg=PR2&dq=Wildlife+and+Recreationists+Coexistence+through+management+and+research&ots=tLxWRTHxBC&sig=tGeL7wgT3G4a6dZOTZo3gFrx7Lg

Lindvall, M., & Nenneman, M. (2012). *Valentine National Wildlife Refuge: Annual narrative report*.

Martin, D. R., Daizaburo, S., Chizinski, C. J., & Pope, K. L. (2017). Network analysis of a regional fishery: Implications for management of natural resources, and recruitment and retention of anglers. *Fisheries Research*, *194*, 31–41.

Miller, A. D., Vaske, J. J., Squires, J. R., Olson, L. E., & Roberts, E. K. (2017). Does zoning winter recreationists reduce recreation conflict? *Environmental Management*, *59*(1), 50–67. https://doi.org/10.1007/s00267-016-0777-0

Monz, C. A., Cole, D. N., Leung, Y. F., & Marion, J. L. (2010). Sustaining visitor use in protected areas: Future opportunities in recreation ecology research based on the USA experience. *Environmental Management*, *45*(3), 551–562. https://doi.org/10.1007/s00267-009-9406-5

National Park Service. (2018). *Annual visitation summary report for 2017*. https://irma.nps.gov/Stats/SSRSReports/National Reports/Annual Visitation Summary Report (1979 - Last Calendar Year)

Nyaupane, G. P., Graefe, A., & Burns, R. C. (2003). Does distance matter? Differences in characteristics, behaviors, and attitudes of visitors based on travel distance. In J. J. Murdy (Ed.), *Proceedings of the 2003 Northeastern Recreation Research Symposium* (pp. 95–100).

Oksanen, J., Blanchet, G. F., Friendly, M., Kindt, R., Legendre, P., McGlinn, D., Minchin, P. R., O’Hara, R. B., & Gavin, L. (2018). *vegan: Community ecology package* (R package version 2.5-3). https://cran.r-project.org/package=vegan

Pickering, C. M., Hill, W., Newsome, D., & Leung, Y. (2010). Comparing hiking, mountain biking and horse riding impacts on vegetation and soils in Australia and the United States of America. *Journal of Environmental Management*, *91*(3), 551–562. https://doi.org/10.1016/j.jenvman.2009.09.025

R Development Core Team. (2014). *R: A language and environment for statistical computing*.

Reis, A. C., & Higham, J. E. S. (2009). Recreation conflict and sport hunting: Moving beyond goal interference towards social sustainability. *Journal of Sport and Tourism*, *14*(2–3), 83–107. https://doi.org/10.1080/14775080902965025

Remacha, C., Pérez-tris, J., & Antonio, J. (2011). Reducing visitors' group size increases the number of birds during educational activities: Implications for management of nature-based recreation. *Journal of Environmental Management*, *92*(6), 1564–1568. https://doi.org/10.1016/j.jenvman.2011.01.006

Schuett, M. A., Le, L., & Hollenhorst, S. J. (2010). Who visits the U.S. National Parks? An analysis of park visitors and visitation: 1990–2008. *World Leisure Journal*, *52*(3), 200–210. https://doi.org/10.1080/04419057.2010.9728283

Schultz, R. D., & Bailey, J. A. (1978). Responses of National Park elk to human activity. *The Journal of Wildlife Management*, *42*(1), 91–100.

Schuster, R. M., Hammitt, W. E., Moore, D. W., & Schneider, I. (2006). Coping with stress resulting from social value conflict: Non-Hunters' response to anticipated social interaction with hunters. *Human Dimensions of Wildlife*, *11*(2), 101–113. https://doi.org/10.1080/10871200600572417

Smallwood, C. B., Beckley, L. E., Moore, S. A., & Kobryn, H. T. (2011). Assessing patterns of recreational use in large marine parks: A case study from Ningaloo Marine Park, Australia. *Ocean and Coastal Management*, *54*(4), 330–340. https://doi.org/10.1016/j.ocecoaman.2010.11.007

Spinney, J. E. L., & Millward, H. (2011). Weather impacts on leisure activities in Halifax, Nova Scotia. *International Journal of Biometeorology*, *55*(2), 133–145. https://doi.org/10.1007/s00484-010-0319-z

Taylor, A. R., & Knight, R. L. (2003). Wildlife responses to recreation and associated visitor perceptions. *Ecological Applications*, *13*(4), 951–963. https://doi.org/10.1890/1051-0761(2003)13[951:WRTRAA]2.0.CO;2

U.S. Bureau of Land Management. (2019). *BLM recreation strategy: Connecting with communities*. http://tedcantle.co.uk/pdf/connectingwithcommunitiesTedCantleOct2009.pdf

U.S. Department of the Interior, U.S. Fish and Wildlife Service, U.S. Department of Commerce, & U.S. Census Bureau. (2016). *2016 National survey of fishing, hunting, and wildlife-associated recreation*.

U.S. Fish and Wildlife Service. (2016). *Annual Performance Report FY2015: National Wildlife Refuge System*.

U.S. Forest Service. (2016). *U.S. Forest Service National visitor use monitoring survey results National summary report*.

Vaske, J. J., & Roemer, J. M. (2013). Differences in overall satisfaction by consumptive and nonconsumptive recreationists: A comparative analysis of three decades of research. *Human Dimensions of Wildlife*, *18*(3), 159–180. https://doi.org/10.1080/10871209.2013.777819

Watson, J. E. M., Dudley, N., Segan, D. B., & Hockings, M. (2014). The performance and potential of protected areas. *Nature*, *515*, 67–73. https://doi.org/10.1038/nature13947

Table 1-1. Descriptions of recreational activities permitted and managed for on Valentine National Wildlife Refuge (VNWR), Nebraska during 2017-2018.

Recreational Activity	Activity Type	Description
Hunting	Consumptive	Hunting is permitted on most of the refuge during Nebraska-designated seasons for waterfowl, deer, sharp-tailed grouse, prairie chickens, pheasants, dove, and coyote.
Fishing	Intermediate-consumptive	Fishing is permitted year-round at nine designated refuge lakes (Clear, Dewey, Duck, Hackberry, Pelican, Rice, Watts, West Long, Willow). Anglers can fish from bank, dock or by boat (no gas-powered boats allowed).
Hiking	Non-consumptive	Hiking is permitted year-round on and off trail.
Touring	Non-consumptive	Driving is permitted year-round on designated roads.
Wildlife watching	Non-consumptive	Observing wildlife is permitted year-round across the refuge.
Photography	Non-consumptive	Taking photos is permitted year-round across the refuge.
Environmental education	Non-consumptive	Viewing interpretive displays and brochures is permitted year-round across the refuge.
Other	Non-consumptive	Activities not specifically permitted or managed for on VNWR (i.e., kayaking, rest from driving, running, prospecting, ice checking, eclipse watching, and dog walking).

Table 1-2. Sociodemographic attributes and social-ecological inferences derived from analyzed attributes.

Attribute	Data type	Data source	Units	Inference
Party size	Continuous	Survey	People	Party size is related to ecological impacts (Remacha et al., 2011).
Senior present	Categorical (present or absent)	Survey		Age influences participation in recreational activities and spatial use (Arrowsmith & Chhetri, 2003).
Distance traveled	Continuous	Survey (ZIP code) and Geosphere package (program R)	km	Distance traveled is an important indicator of visitor behavior; recreationists that travel shorter distances are significantly more likely to visit the parks and protected area multiple times, feel more crowded, and spend less money than those that travel longer distances (Nyaupane et al., 2003).
Average household income	Continuous	Survey (ZIP code) and ESRI	U.S. dollars	Income influences participation in recreational activities, such as hunting, which requires more money for equipment and trip expenditures than non-consumptive activities (U.S. Department of the Interior et al., 2016).
Population type	Categorical (urban or rural)	Survey (ZIP code) and ESRI		Population type can influence participation in recreational activities. Recreationists from urban areas are more likely to participate in non-consumptive activities, whereas recreationists from rural areas are more likely to participate in consumptive activities, such as hunting (U.S. Department of the Interior et al., 2016).
Vehicle type	Categorical (2WD or 4WD)	Survey datasheet		Vehicle Type can influence areas where recreationists can access (Apodaca et al., 2012)

Table 1-3. Univariate results of PERMANOVA examining sociodemographic attribute variation among consumptive, intermediate-consumptive, and non-consumptive groups at Valentine National Wildlife Refuge, Nebraska during 2017-2018 (degrees of freedom [Df]; sum of squares [SS]; Pseudo-F value by permutation; p-values based on 999 permutations [Pperm]).

Sociodemographic attribute	Df	SS	Pseudo-F	P_{perm}
Party size	2	0.50	14.14	0.001
Senior present	2	1.23	2.84	0.055
Distance traveled	2	5.94	168.07	0.001
Average income	2	0.62	23.89	0.001
Population type	2	2.08	8.09	0.002
Vehicle type	2	4.04	34.96	0.001

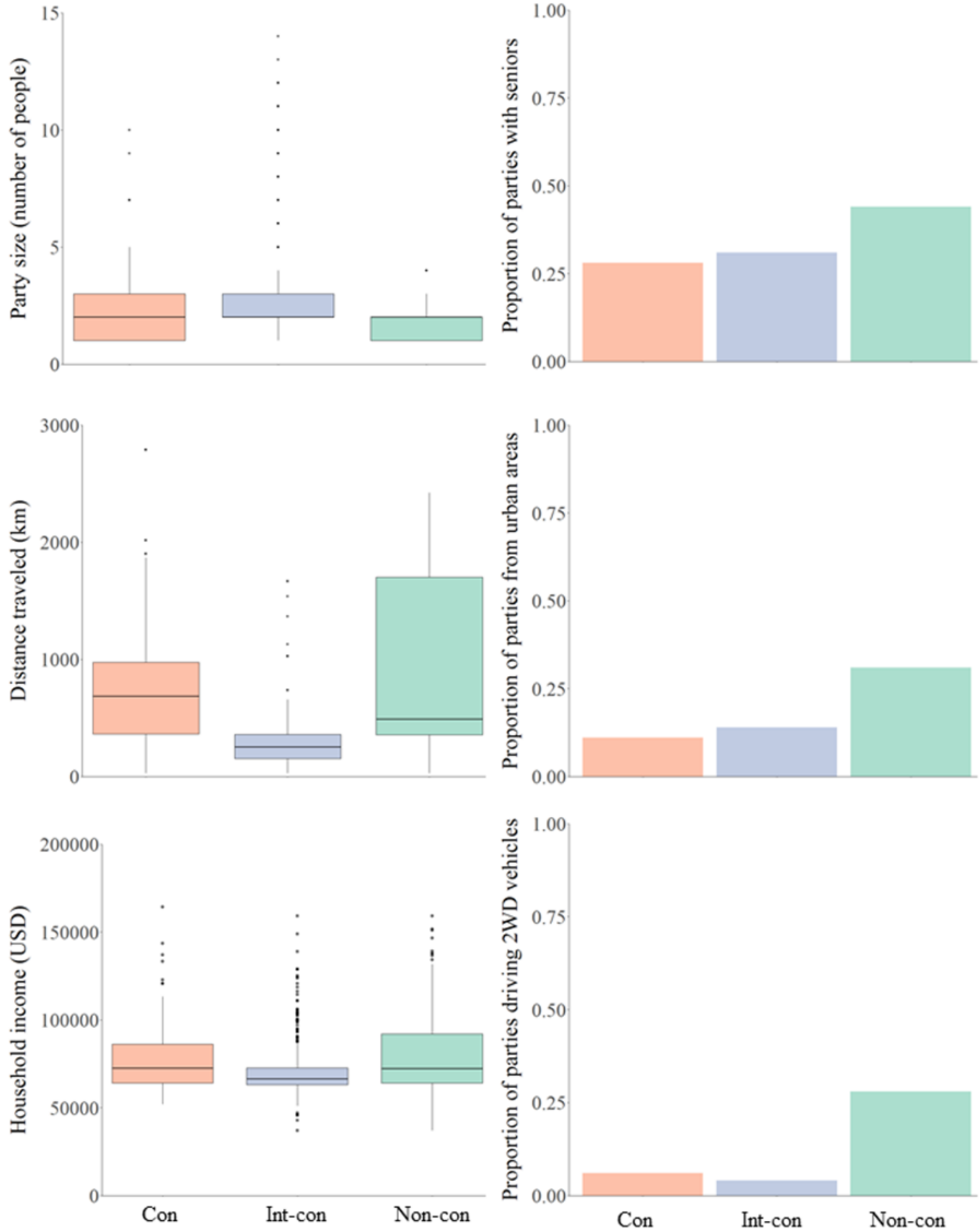


Figure 1-1. Box plots and bar graphs of the sociodemographic attributes of the consumptive (orange), intermediate-consumptive (blue), and non-consumptive (green) recreational-activity groups surveyed at Valentine National Wildlife Refuge, Nebraska

during 2017-2018. Box plots illustrate sociodemographic variability for party size, distance traveled (km), and household income (USD) among the surveyed consumptive (Con), intermediate-consumptive (Int-con), and non-consumptive (Non-con) recreational-activity groups. Distance traveled was calculated from the center of the home ZIP code of the parties to geographic coordinates of Valentine National Wildlife Refuge headquarters. Horizontal black lines represent the median, boxes represent the range from 25th to 75th percentile, upper whiskers extend from the box to the largest value at most 1.5 * IQR (interquartile range), the lower whiskers extend to the lowest value no further than 1.5 *IQR, and the points represent outliers. Bar graphs illustrate the proportions of surveyed parties with seniors present (65 years or older), from urban areas (≥ 386 people per square kilometer [ppskm], and driving two-wheel drive (2WD) vehicles for the surveyed consumptive (Con), intermediate-consumptive (Int-con), and non-consumptive (Non-con) recreational-activity groups.

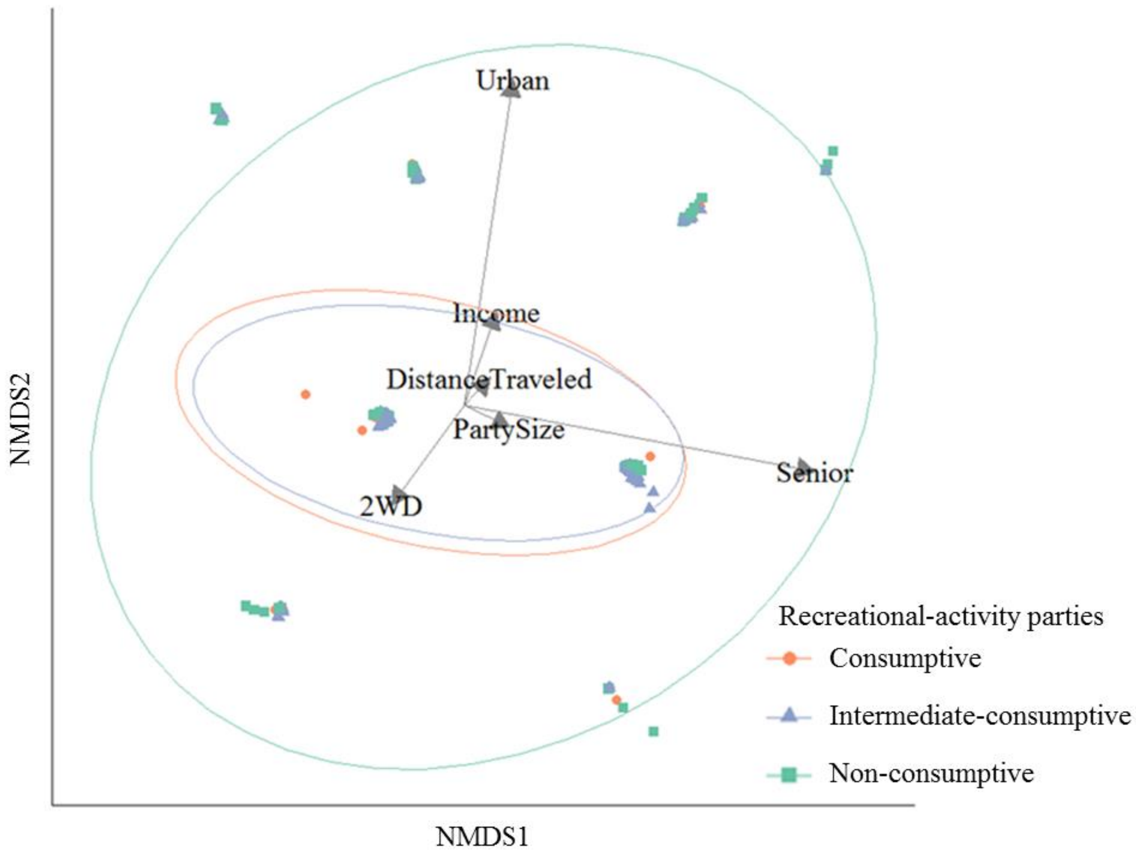


Figure 1-2. Non-metric multidimensional scaling (NMDS) ordination plot to visualize sociodemographic differences among consumptive (orange circles), intermediate-consumptive (blue triangles), and non-consumptive (green squares) parties surveyed on Valentine National Wildlife Refuge, Nebraska during 2017-2018, and are plotted such that parties with more similar attributes are closer in space. Ellipses (with associated colors) represent 95% confidence intervals for the centroids of recreational-activity groups. Arrows represent strength and point in the direction of increasing sociodemographic attributes. The NMDS represented well (stress = 0.083) the variation in sociodemographic attributes among recreational-activity groups.

CHAPTER 2: ASSESSING SPATIOTEMPORAL VARIABILITY OF POTENTIAL SOCIAL AND ECOLOGICAL INTENSITIES WITHIN A PARK AND PROTECTED AREA

INTRODUCTION

Most parks and protected areas are important social-ecological systems that serve a dual purpose: 1) to manage and conserve ecological systems and 2) to provide the public with opportunities for recreation (Beeco & Brown, 2013; Dearden, 2010). Achieving both purposes is difficult and in some cases these goals may be competing. Management of parks and protected areas often focuses on the ecological system, and little effort is made to understand the social component of these valued social-ecological systems (Eadens et al., 2009).

Understanding the social component of parks and protected areas involves knowledge of the spatial and temporal distribution of recreational activities and the types of recreational activities that occur on parks and protected areas (Kulczyk et al., 2018). Recreational activities that overlap in space and time may lead to social conflicts within and among recreational-activity groups and to negative ecological impacts (Leung & Marion, 2000; Miller et al., 2017). The cumulative social conflicts and ecological impacts can lead to greater social and ecological intensities at parks and protected areas, which will likely be even more important to understand as the use of parks and protected areas continues to increase (Cordell et al., 2008; U.S. Bureau of Land Management, 2019; U.S. Fish and Wildlife Service, 2016; U.S. Forest Service, 2016). Managers must therefore understand which recreational activities are present and the potential social and ecological intensities across space and time on parks and protected areas.

The majority of parks and protected areas offer opportunities for a variety of recreational opportunities, which can be categorized along a consumptive to non-consumptive hierarchical gradient (Kauffeld et al., 1999; U.S. Forest Service, 2016; Vaske & Roemer, 2013). Consumptive parties permanently extract (i.e., harvest) organisms from the environment, such as hunting (Vaske & Roemer, 2013). In contrast, non-consumptive parties do not intend to remove or permanently affect organisms (Duffus & Dearden, 1990), such as wildlife watching, photography, and hiking. Typically, parks and protected areas allow consumptive and non-consumptive recreational activities to occur in the same areas, which can be problematic particularly when these two recreational-activity types consist of parties seeking different experiences and have different sociodemographics (see chapter 1; Wing & Johnson, 2001). This overlap of recreational-activity groups can lead to social conflicts due to direct contacts, goal interference, and moral differences towards wildlife (Mann & Absher, 2008; Schuster et al., 2006). Direct contacts and goal interference can also occur from high concentrations of recreational-activity parties, which can lead to parties becoming upset at crowds or others using their favorite spot (D. N. Cole, 2001). Moral differences may occur among consumptive and non-consumptive groups, which are often at opposing ends of the moral domain continuum (N. W. Cole, 2018). Consumptive groups value wildlife as it relates to the benefit of people, whereas non-consumptive groups extend inherent value to all living things (N. W. Cole, 2018). Management of recreational opportunities needs to account for the diverse recreational-activity groups, as overlap among consumptive and non-consumptive groups generally leads to more social conflicts (Eadens et al., 2009).

Recreational activities can have detrimental impacts on the ecological systems of parks and protected areas, and thus be counter to the dual goals of parks and protected areas (Monz et al., 2010). Therefore, accounting for the potential ecological impacts caused by all recreational-activity groups present on a parks and protected area is essential for management (Monz et al., 2013). Both consumptive and non-consumptive groups can cause negative impacts on the ecological system. Consumptive groups can have direct population effects on game species through harvest and indirect effects on the behavior of wildlife (Kays et al., 2017). Non-consumptive groups can have detrimental impacts on natural resources, such as disturbing wildlife during temporally important behaviors like breeding displays and feeding (Frid & Dill, 2002; Mallord et al., 2007; Remacha et al., 2016). Non-consumptive groups, like hikers or photographers, may continually disturb wildlife and cause wildlife to abandon certain habitats, and thus becomes counter to the goal of parks and protected areas of providing wildlife-compatible recreation opportunities (Remacha et al., 2011). Additionally, areas with high concentrations of recreational-activity groups can lead to bank erosion along waterbodies, trampled vegetation, and other indirect impacts on wildlife populations (Knight & Cole, 1995). Managers must understand potential ecological impacts caused by a variety of recreational activities to effectively manage parks and protected areas to conserve ecological systems and provide wildlife-compatible recreation opportunities.

Social conflicts and ecological impacts are expected to vary across space and time and further escalate the challenges of managing parks and protected areas (Beeco et al., 2013; Schuster et al., 2006). The spatial and temporal variation of social conflicts and ecological impacts may be caused by changes in the recreational activities present and the frequencies of recreational-activity parties. Different combinations of recreational-activity groups may have different potentials for social conflicts and ecological impacts. For instance, spatial and temporal overlap of consumptive and non-consumptive groups may have a higher potential for social conflicts in contrast to only the non-consumptive group present (Eadens et al., 2009). The frequencies of recreational-activity parties will also affect the potential for social conflicts and ecological impacts (Leung & Marion, 2000). The cumulative social conflicts and ecological impacts from many recreational-activity parties present can belie the social and ecological impacts caused by a single recreational-activity party (Dearden & Hall, 1983). Thus, managing for each recreational-activity group and party in isolation is insufficient to meet the dual goals of parks and protected areas.

Understanding the social conflicts and ecological impacts caused by overlapping recreational-activity groups, the frequencies of recreational-activity parties, and the size of the managed area where these groups overlap can help managers understand the potential social and ecological intensities. Unfortunately, social and ecological intensities of recreation use remain poorly understood as the majority of studies focus on social conflicts among two specific recreational activities (Mann & Absher, 2008; Miller et al., 2017; Vaske et al., 2013) or specific ecological impacts (Pickering et al., 2010; Taylor & Knight, 2003) and rarely take a holistic approach to understand these social-ecological dynamics. Expert input can be used to evaluate and assign social and ecological impact values to different recreational-activity groups when either social-intensity or ecological-intensity information is lacking (Skulmoski et al., 2007).

Knowledge of the spatial and temporal variation of social and ecological intensities of recreation use is important for planning and management of parks and protected areas. A thorough understanding of social and ecological intensities requires incorporating the most appropriate spatial and temporal scales at which to measure intensities (Raudsepp-Hearne & Peterson, 2016). Different spatial and temporal management objectives (e.g., specific areas for hunting during the fall), social variations (e.g., differences in visitation from weekends to weekdays), and ecological variations (e.g., wildlife more vulnerable to disturbance during breeding seasons) should be considered when selecting the appropriate spatial and temporal scales for measuring social and ecological intensities (Scholes et al., 2013). For example, parks and protected areas may have high social and ecological intensities in areas with recreation infrastructures (e.g., management units with bathrooms, roads, and trails) and during the summer when families vacation (Jones & Scott, 2006). Therefore, managers of parks and protected areas may want to examine social and ecological intensities at the management-unit scale (i.e., spatial scale) and season scale (i.e., temporal scale). Additionally, parks and protected areas that offer waterfowl hunting may want to consider differences in social and ecological intensities of recreation use at different lake types (e.g., lakes with waterfowl hunting versus lakes without waterfowl hunting), and for various day types (e.g., hunting openers versus weekends). Knowledge of the spatial and temporal changes in social and ecological intensities is becoming more important to understand as recreation use continues to increase on parks and protected areas, and recreational-activity groups compete for use of the same areas (U.S. Bureau of Land Management, 2019; U.S. Fish and Wildlife Service, 2016; U.S. Forest Service, 2016). Mapping the social and ecological intensity of recreation use at different spatial and temporal scales is necessary to identify “hotspots” such as high-use areas near sensitive flora and fauna, and relatively low impacted areas, both areas of which could warrant prioritization of management (Smallwood et al., 2011).

We surveyed parties recreating on Valentine National Wildlife Refuge (VNWR) to evaluate the social component of this parks and protected area. The refuge permits a wide range of recreational activities that can be categorized into consumptive (hunting), intermediate-consumptive (fishing), or non-consumptive (wildlife watching, photography, touring, hiking, environmental education, other) groups. Management of recreational-activity groups on VNWR occurs at two spatial scales including management units (i.e., seven management units) and lake types (i.e., fishing, fishing and hunting, no fishing or hunting). Often management regimes at parks and protected areas, such as VNWR, influence where and when certain recreational activities can occur. For instance, at VNWR consumptive-recreational activities are permitted on all management units and the fishing and hunting lake type, but have temporal restrictions (i.e., regulated hunting seasons); the intermediate-consumptive recreational activities are only permitted at one management unit and two lake types (fishing, and fishing and hunting); and non-consumptive recreational activities are permitted at all management units and lake types (Kauffeld et al., 1999). Additionally, there are temporal influences on recreational activities, including seasons (i.e., winter, spring, summer, and fall) and day types (weekday, weekend, and event days). Seasonal weather and social norms often influence recreational-activity groups, such as ice fishing during winter or family vacations during summer (Jang, 2004). Day types may influence frequency of recreational activities, however, there are no restrictions for weekdays, weekends, or event days for when recreational activities can occur. Therefore, different spatial and temporal scales may influence the recreational activities present and their frequencies, and thus influence the social and ecological intensities of recreation use.

Our objectives were to quantify and evaluate the social and ecological intensities of recreation use at two spatial and two temporal scales at VNWR (Table 2-1). We assessed social intensities and ecological intensities at the management-unit scale (i.e., seven management units) and lake-type scale (i.e., fishing lakes, fishing and hunting lakes, no fishing or hunting lakes) and at the season scale (i.e., winter, spring, summer, and fall) and day-type scale (weekday, weekend, and event days). We hypothesized overlap of consumptive and non-consumptive recreational activities will have the greatest potential for social conflicts, as demonstrated earlier (Eadens et al., 2009). Consumptive recreational activities cause many ecological impacts including altering wildlife populations and trampling vegetation (Leung & Marion, 2000); thus, we hypothesize consumptive recreational activities at VNWR will have the greatest ecological impacts. The majority of consumptive and non-consumptive recreational activities are managed at the management-unit scale and are more likely influenced by seasons than day types (e.g., most hunting seasons occur during fall, whereas spring bird migration attracts non-consumptive parties). Therefore, we hypothesize the management-unit scale and season scale will be the best spatial and temporal scales to understand variations in social and ecological intensities of recreation use at VNWR. Our study will provide parks and protected area managers with a greater understanding of the social component of parks and protected areas, which will aid in effectively reducing the potential social and ecological intensity of recreation use.

METHODS

Study System

Valentine National Wildlife Refuge is located in north-central Nebraska and covers 28,941 ha in the heart of the Sandhill region. The refuge is open to the public and allows for consumptive, intermediate-consumptive, and non-consumptive recreational activities. The refuge manager and biologist determined which recreational activities were allowed on VNWR based on their compatibility with wildlife (Kauffeld et al., 1999). These recreational activities included a consumptive activity (hunting), an intermediate-consumptive activity (fishing; anglers can harvest or release fish), and non-consumptive activities (wildlife watching, touring, hiking, photography, and environmental education, and other activities not listed on the survey [i.e., kayaking, break from driving, running, prospecting, ice checking, eclipse watching, and dog walking]).

Valentine National Wildlife Refuge strives to balance the preservation of the unique ecological diversity of the Sandhills while providing recreational opportunities for visitors. Spatial management occurs at two primary scales: management units and lake types (Figure 2-1). The seven management units (i.e., fishing lakes, wilderness, marsh lakes, pony lake, east end, king flats, and hay flats) are based on location and management regime. For instance, all the lakes open to fishing and waterfowl hunting are in the fishing lakes management unit. The wilderness management unit has very little infrastructure and has restricted vehicle use. There are 34 lakes on VNWR, which consist of three lake types: fishing and hunting (fishing and waterfowl hunting permitted), fishing (fishing permitted), and no fishing or hunting (fishing and waterfowl hunting are not permitted). There are three fishing and hunting lakes, six fishing lakes, and twenty-five no fishing or hunting lakes. There are other hunting opportunities on VNWR (i.e., coyote [*Canis latrans*], white-tailed deer [*Odocoileus virginianus*], mule deer [*Odocoileus hemionus*], mourning dove [*Zenaida macroura*], greater prairie chicken [*Tympanuchus cupido*], ring-necked pheasant [*Phasianus colchicus*], and sharp-tailed grouse [*Tympanuchus phasianellus*]) that are restricted to designated hunting-seasons. The refuge is closed to all recreational-activity groups from sunset to sunrise.

<u>Recreational-Activity Surveys</u>

To understand the types and frequencies of recreational activities, we distributed windshield surveys to recreational-activity parties throughout the course of a year (30 July 2017 to 26 July 2018; Appendix 1). We defined seven recreational activities that were permitted on VNWR (Kauffeld et al., 1999). Parties selected the recreational activities (fishing, hunting, wildlife watching, touring, hiking, photography, and environmental education, other) in which they participated, the lakes they visited, and recorded their party size. Parties returned completed surveys at one of four onsite drop boxes or through the U.S. postal service with each survey prepaid, postmarked and addressed to the University of Nebraska-Lincoln. We recorded the date, time, and GPS location for each distributed windshield survey.

Distribution of surveys was stratified by two-week periods (fourteen days). Within each two-week period, days were further stratified by day type (weekday

[Monday through Friday] and weekend [Saturday and Sunday]). Six weekdays and two weekend days were randomly sampled within each two-week sampling period. Each day was then stratified into either a morning or an evening sampling period. Morning sampling periods were initiated at sunrise and evening sampling periods were initiated eight hours prior to sunset (e.g., 11:00 start with a 19:00 sunset). Sampling routes were predefined; the start (and end) location and route direction (clockwise or counterclockwise) were randomized for each sampling day. Additional “event” days were added to the sampling schedule that included holidays and hunting openers (Appendix 2). We expected deviations from normal use during these events and thus wanted to account for potential increased activity. We did not sample on scheduled days with foul weather (e.g., blizzards) and assumed no recreational activity occurred during these adverse weather conditions (Spinney & Millward, 2011).

We used a Kolmogorov-Smirnov 2-sample test between respondents and non-respondents to evaluate temporal (2-week periods) response bias. Seasonality of different recreational activities (e.g., hunting permitted during fall, fishing during winter when lakes are frozen, bird watching during spring waterfowl migrations) should indicate potential bias among certain recreational-activity groups (Butler, 1994; Smallwood et al., 2011). For example, hunting has specific seasons and response-rate differences during these periods could reflect a misrepresentation of the consumptive group compared to the other recreational-activity groups. Thus, we attempted to evaluate response bias using a temporal approach that would expose seasonal deviates from a consistent response rate throughout the year.

The recreational activities were subsequently categorized based on a consumptive hierarchical gradient and assigned to one of three recreational-activity types: consumptive, intermediate-consumptive, or non-consumptive. Parties that selected hunting, regardless of the other selected activities, were assigned to the consumptive group. Remaining parties that selected fishing, regardless of other selected activities, were assigned to the intermediate-consumptive group. Remaining parties that selected wildlife watching, touring, hiking, photography, environmental education, or other were assigned to the non-consumptive group.

Quantifying Social and Ecological Intensity

We used the Delphi method (Habibi et al., 2014; Okoli & Pawlowski, 2004) to quantify the social and ecological intensities of recreation use at VNWR. The Delphi method is a continuous process that uses a series of questionnaires followed by expert feedback to collect and distill the anonymous judgements of experts until consensus is reached (Okoli & Pawlowski, 2004). The Delphi method, based on expert consensus, was used to assess daily potential social-conflict values and daily potential ecological-impact values for consumptive, intermediate-consumptive and non-consumptive groups. The Delphi method is often used to facilitate problem solving and decision making, particularly in regards to environmental assessment and monitoring programs that lack information about a problem or phenomena (Kreisel, 1984; Nae-wen & Yue-hwa, 1999; Richey et al., 1985; Skulmoski et al., 2007).

We selected ten experts based on their professional experience managing or researching natural resources and people (Habibi et al., 2014). Five experts were chosen based on their experience managing or conducting research at VNWR. The remaining five experts were chosen to provide a diverse group of professionals from various natural resource disciplines (e.g., terrestrial, aquatic, game species, non-game species, or recreation management) to more fully capture the potential social conflict and potential ecological impact of consumptive, intermediate-consumptive, and non-consumptive groups. The surveyed experts had a minimum of nine years professionally managing or researching natural resources and people. To prevent any personal bias towards a recreational-activity group, these experts personally participated in consumptive, intermediate-consumptive, and non-consumptive recreational activities (Powell, 2003).

Before beginning the questionnaire, experts were asked to envision a 129.5 ha (320-acre or half section) park and protected area that included opportunities for consumptive, intermediate-consumptive, and non-consumptive recreational activities. Experts completed a questionnaire about the daily potential social-conflict or ecological-impact value for each combination of consumptive, intermediate-consumptive, or non-consumptive groups and their value-selection rationale (Appendix 5 and 6). Daily potential social conflict refers to the varying levels of discord among parties (both within and among recreational-activity groups) that are recreating within a given spatial area on the same day. Daily potential ecological impact is the potential damages to natural resources that are caused by recreational-activity groups within the parks and protected area on the same day. The number of parties was held constant, but the composition varied (single or multiple recreational-activity groups). Experts were asked to use a continuous scale (0 = no potential, 10 = highest potential) with equal increments to assign a value for the daily potential social conflict or ecological impact for each recreational-activity scenario.

We calculated the median and interquartile range (IQR) for each recreational-activity scenario after the first and second round of questions (Argyrous, 2005; Murphy et al., 1998). The median and IQR are useful for scales with many values, and thus, more robust than mean, mode, and other measures of dispersion (Argyrous, 2005). Consensus is reached when the median value of each recreational-activity scenario has an IQR ≤ 2 (Scheibe et al., 1975; von der Gracht, 2012). Thus, each recreational-activity scenario with an IQR > 2 was further assessed with additional rounds of questionnaires with the median provided as a controlled feedback. Three rounds of questionnaires is usually sufficient for reaching a consensus (Fan & Cheng, 2006). Therefore, by the third round if the IQR ≤ 2 is not reached then consensus will be reached based on the most frequent value assigned by the experts (Powell, 2003).

We used the expert-generated social conflict and ecological impact values to develop social and ecological intensity indices. The intensity indices provided insight to the range (minimum and maximum) of potential social and ecological intensities that occur over space (management unit, lake type) and time (season, day type), revealing opportunities to manage previously overlooked intensities. We used the concept of the marine potential conflict index presented by Freeman et al. (2016) to develop our equations for calculating 1) daily social intensity and 2) daily ecological intensity indices. Social and ecological intensity indices were developed to include impact-weighted densities.

$$1)\ \text{Daily Social Intensity} = P_t * S_r$$

where

P_t = density of parties (number / 100 km^2) based on returned surveys on a given day within a specified “area” (e.g., management unit or lake type);

S_r = daily potential social-conflict value for the recreational-activity scenario based on the expert consensus values; and

$$2)\ \text{Daily Ecological Intentsity} = (P_c * E_c) + (P_i * E_i) + (P_n * E_n)$$

where

P_c = density of consumptive parties (number / 100 km^2) based on returned surveys on a given day within a specified “area” (e.g., management unit or lake type);

P_i = density of intermediate-consumptive parties (number / 100 km^2) based on returned surveys on a given day within a specified “area” (e.g., management unit or lake type);

P_n = density of non-consumptive parties (number / 100 km^2) based on returned surveys on a given day within a specified “area” (e.g., management unit or lake type);

E_c = daily potential ecological-impact value of the consumptive-group scenario based on the expert consensus values;

E_i = daily potential ecological-impact value of the intermediate-consumptive-group scenario based on the expert consensus values;

E_n = daily potential ecological-impact value of the non-consumptive-group scenario based on the expert consensus values; and

To understand the social and ecological intensities at different spatial and temporal scales, we summed the daily social intensities for each season and each day type for each management unit and each lake type. We also summed the daily ecological intensities for each season and each day type for each management unit and each lake type.

Analysis

We used the returned windshield surveys to quantify the number of parties recreating at different spatial and temporal scales. We used the location of the returned distributed windshield surveys (GPS coordinates) and the lakes selected by the party to assign each party to management units and lake types. Temporal scales included season and day type. Seasons were defined as winter (15 December to 22 March), spring (23 March to 14 June), summer (15 June to 21 September), or fall (22 September to 14 December). Days surveyed were subsequently categorized by day type, which included weekday, weekend, or event day.

We used linear models to evaluate social and ecological intensities across space and time on VNWR. We developed a set of models for social intensities and a set of models for ecological intensities of recreation use at the daily level (experimental unit; Table 2-3). The independent variables included one spatial scale (i.e., management unit or lake type) and one temporal scale (i.e., season, day type) and the dependent variables included social intensities or ecological intensities. We used an information theoretic approach (Akaike Information Criterion [AIC]) to evaluate model performance and selected the "best" model among the eight candidate models for social intensity and again for ecological intensity. We considered candidate models with $\Delta AIC \leq 2$ as important for explaining variation of social and ecological intensities of recreation use (Burnham & Anderson, 1998). We then visualized spatial and temporal intensity of the most supported models using heat maps. Analyses were performed in R (R Development Core Team, 2014).

To aid in interpretation of the results from our equations, we plotted the daily densities (parties per area of the given spatial scale) by daily potential social intensities and daily potential ecological intensities at the spatial and temporal scales of the most supported model. We visualized the maximum potential social-conflict and ecological-impact values (value = 10) for the daily social intensity and daily ecological intensity equations for maximum parties surveyed at a specified spatial scale (100 km^2; i.e., management units or lake types).

RESULTS

We distributed 2,251 surveys and 861 were returned (38% return rate). There was a similar temporal distribution between respondents and non-respondents (Kolmogorov-Smirnov test: $D = 0.26$, $p > 0.32$), therefore we did not detect a response bias. Of the 861 returned surveys, 789 were completed (35% functional return rate) and used for subsequent analysis, with all recreational-activity groups present on the refuge.

Social-conflict values and ecological-impact values varied across recreational-activity scenario. Expert consensus was reached after two rounds of questionnaires for all social-conflict and ecological-impact values assigned to the recreational-activity scenario ($IQR \leq 2.00$). The recreational-activity scenario with only the consumptive group was assigned the greatest potential social-conflict (7.50) and ecological-impact (6.00) values.

The recreational-activity scenario with only the non-consumptive group was assigned the least potential social-conflict (1.50) and ecological-impact (1.50) values (Table 2-3).

Social Intensity

The most supported model to explain social intensities included lake-type and season scales (Table 2-4). Social intensities of recreation use varied across the lake types and seasons (Figure 2-2). The fishing and hunting lake type had the greatest social intensities (range: 0 - 2,263) of all lake types across all four seasons with winter having the greatest intensities (mean = 489) and summer having the least intensities (mean = 188). Following the social intensities of the fishing and hunting lake type was the fishing lake type (range: 0 - 1,114), with winter having the greatest intensities (mean = 204) and summer having the least intensities (mean = 49). The no fishing or hunting lake type received the least social intensity (range: 0 - 312) of all lake types across all four seasons with fall having the greatest intensities (mean = 19) summer having the least intensities (mean = 1). Heat maps illustrated the lake type and seasonal changes in social intensity of recreation use at VNWR (Figure 2-3). The social intensities fluctuated daily with the variations in density at different lake types and seasons (Figure 2-4).

Ecological Intensity

The most supported model to explain ecological intensities included lake-type and season scales (Table 2-4). Ecological intensities of recreation use varied across the lake types and seasons (Figure 2-5). The fishing and hunting lake type had the greatest ecological intensities (range: 0 - 2,263) of all lake types across all four seasons, with winter having the greatest intensities (mean = 480) and summer having the least intensities (mean = 195). The ecological intensities of the fishing and hunting lake type was followed by the fishing lake type (range: 0 - 759), with winter having the greatest intensities (mean = 199) and summer having the least intensities (mean = 52). The no fishing or hunting lake type received the least ecological intensity (range: 0 - 250) of all lake types across all four seasons with fall having the greatest intensities (mean = 15) summer having the least intensities (mean = 1). Heat maps illustrated the lake type and seasonal changes in ecological intensity of recreation use at VNWR (Figure 2-6). The ecological intensities fluctuated daily with the variations in density at different lake types and seasons (Figure 2-7).

DISCUSSION

Planning and management of a parks and protected area requires knowledge and integration of both social and ecological systems of the parks and protected area. Our study contributes to the knowledge of the social components of VNWR by providing a better understanding of the spatial and temporal variations of social and ecological intensities of recreation use. We predicted that social and ecological intensities would be best explained by management-unit and season scales; however, we demonstrate that social and ecological intensities were best explained by lake-type and season scales on VNWR. Identifying the composition and potential social conflicts and ecological impacts of recreational-activity groups present, the frequencies of the recreational-activity types and the area of the lake type is essential for understanding the spatial and temporal variations in social and ecological intensities. Understanding the spatial and temporal changes of the social and ecological intensities of recreation use can aid in management of parks and protected areas by helping managers determine resource needs of a parks and protected area, effective allocation of resources, and protection of fragile resources.

The composition of recreational-activity groups is an important predictor of social and ecological intensities. Areas that are managed for and attract multiple recreational-activity groups are expected to have greatest potential for social conflicts and ecological impacts (Miller et al., 2017; Monz et al., 2013), thus leading to the greatest social and ecological intensities. However, counter to previous studies and what we predicted, we determined the greatest potential for social conflicts occurs when only the consumptive group is present. The consumptive group may need more space to recreate due to intraspecific competitive for limited resources (Eagles et al., 2002). Thus, greater densities of consumptive parties may cause more social conflicts among parties, and as we predicted, greater ecological impacts as consumptive parties seek to harvest natural resources. Although an overlap of consumptive and non-consumptive groups can lead to some social conflicts and ecological impacts, these two recreational-activity groups seek different experiences and potentially different resources (e.g., hunting deer versus photographing scenery; Vaske et al., 1982); thus alleviating the potential for the greatest social conflicts and ecological impacts.

We predicted management unit and season to be the most influential scales because the intermediate-consumptive activity type was only permitted at the fishing lakes management unit, and consumptive and non-consumptive recreational activities were permitted at any management unit. Counter to our prediction, lake type and season were the most influential scales. The lake-type scale’s influence could be due to the management regulations of different lake types for different recreational activities, such as waterfowl hunting is only permitted at the fishing and hunting lake type, and fishing is only permitted at the fishing and hunting and fishing lake types. The season scale's influence conformed to our prediction, as different recreational activities occur most often during different seasons. The spatial (i.e., lake type) and temporal (i.e., season) scales at which regulations are applied (e.g., fishing lakes, hunting season) was the most revealing for social and ecological intensities.

Understanding the composition of recreational-activity groups present is also important for understanding the mechanisms contributing to variation of social and ecological intensities at different lake types and seasons. The consumptive group had the greatest potential for social conflicts and ecological impacts; however, due to the temporal restrictions (i.e., fall hunting seasons) and lower frequencies of consumptive parties, this recreational-activity group mostly contributed to the social and ecological intensities during fall at all lake types. Winter had the greatest social and ecological intensities at the fishing and hunting and fishing lake types. Although the intermediate-consumptive group had less potential for social conflicts and ecological impacts than the consumptive group, the high densities of the intermediate-consumptive parties (i.e., ice anglers) during winter at the lake types that permit fishing caused the greatest social and ecological intensities. Even though two different areas and seasons may have similar social and ecological intensities, the similar intensities may be caused by different compositions and frequencies of recreational-activity groups. Thus, to effectively manage for recreational activities, it is important to understand all the components that contribute to these social and ecological scores.

The fishing and hunting lake type had the greatest social and ecological intensities for all seasons. The small spatial area of the three lakes that comprise this lake type contributed to these great social and ecological intensities. Winter by far had the greatest social and ecological intensities at this lake type, likely due to greater densities of intermediate-consumptive parties. The spring and fall social and ecological intensities at the fishing and hunting lake type were similar, however the composition of recreational-activity groups was not. During spring the fishing and hunting lake type was mostly intermediate-consumptive parties, whereas the fall had an even mix of consumptive and intermediate-consumptive parties. Therefore to alleviate the social and ecological intensities at this lake type, managers could open more lakes to fishing to disperse the intermediate-consumptive group across a larger spatial area and designate certain lakes to only hunting to alleviate the intensities caused by the overlap of consumptive and intermediate-consumptive groups during fall.

Social and ecological intensities were the least at the no fishing or hunting lake type across all seasons, which could indicate this lake type is important for providing reduced-conflict and minimal-ecological-impact recreational opportunities, such as non-consumptive recreational activities. Management strategies to provide more non-consumptive recreational opportunities, such as wildlife watching or environmental education, may want to focus efforts around areas with low social and ecological intensities. However, this should be planned in conjunction with ecological evaluations to prevent further degradation of natural resources (van Riper et al., 2012). There was little seasonal social or ecological variation for the no fishing or hunting lake type; therefore, there should be little impact to seasonally important ecological processes, such as breeding bird displays during spring. The greatest social and ecological intensities at the no fishing or hunting lake type occurred during fall. Thus, this lake type supports the consumptive group, such as deer hunters along the banks. However, the intensity during fall at the no fishing or hunting lake type was less than the intensity during any seasons at the fishing or hunting or fishing lake types. Managing for non-consumptive groups should include providing more opportunities and infrastructure around the no fishing or hunting lake type.

Mapping both social and ecological intensities of recreation use provides managers an important tool in developing and managing recreation zones for specific recreational-activity groups (Eadens et al., 2009; van Riper et al., 2012). This information can be used in conjunction with maps of sensitive species to understand areas where the species are most vulnerable to disturbance or destruction. This is particularly important in areas where consumptive groups occur due to their great social conflict and ecological impacts, which could lead to interference of recreation or conservation management objectives (Eadens et al., 2009).

We made several assumptions with our intensity indices that could have influenced our results. We treated each recreational-activity group as a homogenous group by assigning a single social-conflict value to each of the recreational-activity scenarios, which potentially ignores within group variation that could influence intensities. For instance, the ecological impact of the intermediate-consumptive group could vary among parties given variation in their propensity to harvest fish (Kaemingk et al., 2020). We also assumed that party behavior was constant through time and did not vary by season.

Our results are useful for highlighting areas and times that may require special allocation of resources and management to minimize social and ecological intensities. This approach and information are currently lacking for managers that are responsible for achieving the dual goal of many parks and protected areas. We acknowledge that our results represent potential intensities, and future research should seek to validate our conclusions by collecting additional information, such as interactions between recreational-activity groups, parties feelings of perceived conflicts, measuring disturbances to wildlife and trampling of vegetation (Confer et al., 2005; Kays et al., 2017; Pickering et al., 2010). Our method is beneficial because of its simplicity and ability to detect potentially problematic areas and times, with direct application to management of parks and protected areas. This method we presented treats recreational activities that overlap spatially and temporally as potentially having social conflicts and cumulative ecological impacts. However, this method does not imply that all overlap of recreational-activity groups constitutes actual conflict or cumulative ecological impacts. We did not measure actual social conflicts or ecological impacts of the recreational-activity groups. The intent of this study is to provide a method that allows managers to understand where and when to allocate resources to manage for potential social or ecological impacts. Furthermore, this study laid the groundwork for future research to test whether the spatial and temporal scales we identified have high and low social and ecological intensities. We would predict the spatial (i.e., fishing and hunting lake type) and temporal scale with the highest density of consumptive parties would have high social intensities and high ecological intensities.

Although this study was focused on understanding the social component of the social-ecological system at VNWR, the methods applied in this study can be used at other parks and protected areas in need of finding a balance to conserve the ecological systems and provide compatible recreation opportunities. Management agencies can use this information to compare the social component of VNWR to other systems and expand on our knowledge of social-ecological systems. We used the Delphi method, which was beneficial for determining the social-conflict values and ecological-impacts values. We had a heterogeneous group of experts and generalized questionnaire, which allows our results to be broadly applied to other parks and protected areas. Continued monitoring of recreational activities on-site could be used to evaluate the success of recreation management, such as pre-and post-lake renovations. For instance, did the lake renovations increase the frequency of the intermediate-consumptive group, or did it attract a more heterogeneous group of anglers that seek trophy bluegill? Future research can incorporate results from this study with ecological data, to evaluate the compatibility of the management goals to conserve the ecological system and provide recreation opportunities.

REFERENCES

Argyrous, G. (2005). *Statistics for Research* (2nd ed.). Sage Publications.

Beeco, J. A., & Brown, G. (2013). Integrating space, spatial tools, and spatial analysis into the human dimensions of parks and outdoor recreation. *Applied Geography*, *38*(1), 76–85. https://doi.org/10.1016/j.apgeog.2012.11.013

Beeco, J. A., Hallo, J. C., English, W. R., & Giumetti, G. W. (2013). The importance of spatial nested data in understanding the relationship between visitor use and landscape impacts. *Applied Geography*, *45*, 147–157. https://doi.org/10.1016/j.apgeog.2013.09.001

Burnham, K. P., & Anderson, D. R. (1998). Practical use of the information-theoretic approach. In *Model Selection and Inference* (pp. 75–117). Springer.

Butler, R. (1994). Seasonality in tourism: Issues and problems. In A. V. Seaton (Ed.), *Tourism: The Status of the Art* (pp. 332–339). Wiley.

Cole, D. N. (2001). Visitor use density and wilderness experiences: A historical review of research the concept of recreation carrying capacity. *USDA Forest Service Proceedings RMRS-P-20*, 11–20.

Cole, N. W. (2018). *Values of consumptive outdoor-recreation participants*. University of Nebraska-Lincoln.

Confer, J. J., Thapa, B., & Mendelsohn, J. L. (2005). Exploring a typology of recreation conflict in outdoor environments. *World Leisure Journal*, *47*(1), 12–23. https://doi.org/10.1080/04419057.2005.9674382

Cordell, H. K., Betz, C. J., & Green, G. T. (2008). Nature-based Outdoor Recreation Trends and Wilderness. *International Journal of Wilderness*, *14*(2), 7–10.

Dearden, P. (2010). Parks and Protected Areas. In B. Mitchell (Ed.), *Resource and environmental management in Canada: Addressing conflict and uncertainty* (4th ed., pp. 363–393). Oxford University Press.

Dearden, P., & Hall, C. (1983). *Non-consumptive recreation pressures and the case of the Vancouver Island marmot (Marmota vancouverensis)*. *10*(1), 63–66.

Duffus, D. A., & Dearden, P. (1990). Non-consumptive wildlife-oriented recreation : A conceptual framework. *Biological Conservation*, *53*(December), 213–231. https://doi.org/10.1016/0006-3207(90)90087-6

Eadens, L. M., Jacobson, S. K., Stein, T. V., Confer, J. J., Gape, L., & Sweeting, M. (2009). Stakeholder mapping for recreation planning of a Bahamian National Park. *Society and Natural Resources*, *22*(2), 111–127. https://doi.org/10.1080/08941920802191696

Eagles, P. F. J., McCool, S. F., & Haynes, C. D. (2002). *Sustainable tourism in protected areas: Guidelines for planning and management* (A. Phillips (ed.); Vol. 8). IUCN. https://doi.org/10.1111/j.1755-3768.1951.tb07631.x

Fan, C. K., & Cheng, C. (2006). A study to identify the training needs of life insurance sales representatives in Taiwan using the Delphi approach. *International Journal of Training and Development*, *10*(3), 212–226.

Freeman, M. C., Whiting, L., & Kelly, R. P. (2016). Assessing potential spatial and temporal conflicts in Washington's marine waters. *Marine Policy*, *70*, 137–144. https://doi.org/10.1016/j.marpol.2016.04.050

Frid, A., & Dill, L. (2002). Human-caused disturbance stimuli as a form of predation risk. *Conservation Ecology*, *6*(1), 11–26. https://doi.org/ARTN 11

Habibi, A., Sarafrazi, A., & Izadyar, S. (2014). Delphi Technique Theoretical Framework in Qualitative Research. *The International Journal Of Engineering And Science (IJES)* ||, 8–13. www.theijes.com

Jang, S. C. (2004). Mitigating tourism seasonality - A quantitative approach. *Annals of Tourism Research*, *31*(4), 819–836. https://doi.org/10.1016/j.annals.2004.02.007

Jones, B., & Scott, D. (2006). Climate change, seasonality and visitation to Canada's National Parks. *Journal of Park and Recreation Administration*, *24*(2), 42–62.

Kauffeld, J., Garza, B., McPeak, K., Lindvall, M., Sellers, J., Len, M., & Staller, D. (1999). *Valentine National Wildlife Refuge Comprehensive Conservation Plan*. (Issue September).

Kaemingk, M. A., Hurley, K. L., Chizinski, C. J., & Pope, K. L. (2020). Harvest-release decisions in recreational fisheries. *Canadian Journal of Fisheries and Aquatic Sciences*, *77*, 194–201. https://doi.org/10.1139/cjfas-2019-0119

Kays, R., Parsons, A. W., Baker, M. C., Kalies, E. L., Forrester, T., Costello, R., Rota, C. T., Millspaugh, J. J., & McShea, W. J. (2017). Does hunting or hiking affect wildlife communities in protected areas? *Journal of Applied Ecology*, *54*(1), 242–252. https://doi.org/10.1111/1365-2664.12700

Knight, R. L., & Cole, D. N. (1995). Wildlife responses to recreationists. In R. L. Knight & K. J. Gutzwiller (Eds.), *Wildlife and Recreationists: Coexistence Through Management and Research* (pp. 51–69). Island Press. http://books.google.com/books?hl=en&lr=&id=BRbBAvLwQlAC&oi=fnd&pg=PR2&dq=Wildlife+and+Recreationists+Coexistence+through+management+and+research&ots=tLxWRTHxBC&sig=tGeL7wgT3G4a6dZOTZo3gFrx7Lg

Kreisel, W. E. (1984). Representation of the environmental qualityprofile of a metropolitan area. *Environmental Monitoring & Assessment*, *4*, 15–33.

Kulczyk, S., Woźniak, E., & Derek, M. (2018). Landscape, facilities and visitors: An integrated model of recreational ecosystem services. *Ecosystem Services*. https://doi.org/10.1016/j.ecoser.2018.02.016

Leung, Y., & Marion, J. L. (2000). Recreation impacts and management in wilderness: A state-of-knowledge review. *USDA Forest Service Proceedings RMRS-P-15*, *5*, 23–48. https://doi.org/10.1515/rtuect-2016-0010

Mallord, J. W., Dolman, P. M., Brown, A. F., & Sutherland, W. J. (2007). Linking recreational disturbance to population size in a ground-nesting passerine. *Journal of Applied Ecology*, *44*(1), 185–195. https://doi.org/10.1111/j.1365-2664.2006.01242.x

Mann, C., & Absher, J. (2008). Recreation conflict potential and management implications in the northern/central Black Forest Nature Park. *Journal of Environmental Planning and Management*, *51*(3), 363–380. https://doi.org/10.1080/09640560801979527

Miller, A. D., Vaske, J. J., Squires, J. R., Olson, L. E., & Roberts, E. K. (2017). Does zoning winter recreationists reduce recreation conflict? *Environmental Management*, *59*(1), 50–67. https://doi.org/10.1007/s00267-016-0777-0

Monz, C. A., Cole, D. N., Leung, Y. F., & Marion, J. L. (2010). Sustaining visitor use in protected areas: Future opportunities in recreation ecology research based on the USA experience. *Environmental Management*, *45*(3), 551–562. https://doi.org/10.1007/s00267-009-9406-5

Monz, C. A., Pickering, C. M., & Hadwen, W. L. (2013). Recent advances in recreation ecology and the implications of different relationships between recreation use and ecological impacts. *Frontiers in Ecology and the Environment*, *11*(8), 441–446. https://doi.org/10.1890/120358

Murphy, M. K., Sanderson, C. F. B., Black, N. A., Askham, J., Lamping, D. L., Marteau, T., & McKee, C. M. (1998). Consensus development methods, and their use in clinical guidelines development. *Health Technology Assessment*, *2*(3).

Nae-wen, K., & Yue-hwa, Y. (1999). An Evaluation System for National Park Selection in Taiwan. *Journal of Environmental Planning and Management*, *42*(5), 735–745. https://doi.org/10.1080/09640569910975

Okoli, C., & Pawlowski, S. D. (2004). The Delphi method as a research tool: An example, design considerations and applications. *Information & Management*, *42*, 15–29.

Pickering, C. M., Hill, W., Newsome, D., & Leung, Y. (2010). Comparing hiking, mountain biking and horse riding impacts on vegetation and soils in Australia and the United States of America. *Journal of Environmental Management*, *91*(3), 551–562. https://doi.org/10.1016/j.jenvman.2009.09.025

Powell, C. (2003). The Delphi technique: myths and realities. *Journal of Advanced Nursing*, *41*(4), 376–382.

R Development Core Team. (2014). *R: A language and environment for statistical computing*.

Raudsepp-Hearne, C., & Peterson, G. D. (2016). Scale and ecosystem services: How do observation, management, and analysis shift with scale—lessons from Québec. *Ecology and Society*, *21*(3), 16. https://doi.org/10.5751/ES-08605-210316

Remacha, C., Delgado, J. A., Bulaic, M., & Pérez-Tris, J. (2016). Human disturbance during early life impairs nestling growth in birds inhabiting a nature recreation area. *PLoS ONE*, *11*(11), 1–16. https://doi.org/10.1371/journal.pone.0166748

Remacha, C., Pérez-tris, J., & Antonio, J. (2011). Reducing visitors’ group size increases the number of birds during educational activities: Implications for management of nature-based recreation. *Journal of Environmental Management*, *92*(6), 1564–1568. https://doi.org/10.1016/j.jenvman.2011.01.006

Richey, J. S., Mar, B. W., & Horner, R. R. (1985). The Delphi technique in environmental assessment. I. Implementation and effectiveness. *Journal of Environmental Management*, *21*, 135–146.

Scheibe, M., Skutsch, M., & Schofer, J. (1975). Experiments in Delphi methodology. In *The Delphi Method - Thechniques and Applications* (H.A. Linst, pp. 262–287). Addison-Wesley.

Scholes, R. J., Reyers, B., Biggs, R., Spierenburg, M. J., & Duriappah, A. (2013). Multi-scale and cross-scale assessments of social – ecological systems and their ecosystem services. *Current Opinion in Environmental Sustainability*, *5*(1), 16–25. https://doi.org/10.1016/j.cosust.2013.01.004

Schuster, R. M., Hammitt, W. E., Moore, D. W., & Schneider, I. (2006). Coping with stress resulting from social value conflict: Non-Hunters’ response to anticipated social interaction with hunters. *Human Dimensions of Wildlife*, *11*(2), 101–113. https://doi.org/10.1080/10871200600572417

Skulmoski, G. J., Hartman, F. T., & Krahn, J. (2007). The Delphi method for graduate research. *Journal of Information Technology Education*, *6*.

Smallwood, C. B., Beckley, L. E., Moore, S. A., & Kobryn, H. T. (2011). Assessing patterns of recreational use in large marine parks: A case study from Ningaloo Marine Park, Australia. *Ocean and Coastal Management*, *54*(4), 330–340. https://doi.org/10.1016/j.ocecoaman.2010.11.007

Spinney, J. E. L., & Millward, H. (2011). Weather impacts on leisure activities in Halifax, Nova Scotia. *International Journal of Biometeorology*, *55*(2), 133–145. https://doi.org/10.1007/s00484-010-0319-z

Taylor, A. R., & Knight, R. L. (2003). Wildlife responses to recreation and associated visitor perceptions. *Ecological Applications*, *13*(4), 951–963. https://doi.org/10.1890/1051-0761(2003)13[951:WRTRAA]2.0.CO;2

U.S. Bureau of Land Management. (2019). *BLM recreation strategy: Connecting with communities*. http://tedcantle.co.uk/pdf/connectingwithcommunitiesTedCantleOct2009.pdf

U.S. Fish and Wildlife Service. (2016). *Annual Performance Report FY2015: National Wildlife Refuge System*.

U.S. Fish and Wildlife Service, & Valentine National Wildlife Refuge. (n.d.). *Valentine National Wildlife Refuge hunting and fishing brochure map*. Retrieved October 28, 2019, from https://www.fws.gov/uploadedFiles/Hunting and Fishing Brochure Map Page.pdf

U.S. Forest Service. (2016). *U.S. Forest Service National visitor use monitoring survey results National summary report*.

van Riper, C. J., Kyle, G. T., Sutton, S. G., Barnes, M., & Sherrouse, B. C. (2012). Mapping outdoor recreationists' perceived social values for ecosystem services at Hinchinbrook Island National Park, Australia. *Applied Geography*, *35*(1–2), 164–173. https://doi.org/10.1016/j.apgeog.2012.06.008

Vaske, J. J., Donnelly, M. P., Heberlein, T. A., & Shelby, B. (1982). Differences in reported satisfaction ratings by consumptive and nonconsumptive recreationists. *Journal of Leisure Research*, *14*(3), 195–206.

Vaske, J. J., Heesemann, L. M., Loomis, D. K., & Cottrell, S. C. (2013). Measuring variability in encounter norms among scuba divers and snorkelers: An application of the potential for conflict index2. *Tourism in Marine Environments*, *9*(1–2), 69–80. https://doi.org/10.3727/154427313X13659574650027

Vaske, J. J., & Roemer, J. M. (2013). Differences in overall satisfaction by consumptive and nonconsumptive recreationists: A comparative analysis of three decades of research. *Human Dimensions of Wildlife*, *18*(3), 159–180. https://doi.org/10.1080/10871209.2013.777819

von der Gracht, H. A. (2012). Consensus measurement in Delphi studies. Review and implications for future quality assurance. *Technological Forecasting and Social Change*, *79*(8), 1525–1536. https://doi.org/10.1016/j.techfore.2012.04.013

Wing, M. G., & Johnson, R. (2001). Quantifying forest visibility with spatial data. *Environmental Management*, *27*(3411–420).

Table 2-1. List of variables, abbreviations, descriptions, and options used in linear models to explain spatial and temporal differences in social and ecological intensities of recreation use at Valentine National Wildlife Refuge, Nebraska during 2017-2018.

Variable	Abbreviation	Description	Option
Lake Type	LT	The type of lake where the party recreated.	Fishing, fishing and hunting, no fishing or hunting
Management Unit	MU	The management unit where the party recreated.	Fishing lakes, wilderness, marsh lakes, pony lake, east end, king flats, hay flats
Day Type	DT	The type of day when the party recreated.	Weekday, weekend, event
Season	SE	The season when the party recreated.	Winter, spring, summer, fall

Table 2-2. All candidate models used to evaluate differences in social intensities (SI) and ecological intensities (EI) across space and time at Valentine National Wildlife Refuge, Nebraska during 2017-2018. Independent variables included spatial scales (lake type [LT] and management unit [MU]) and temporal scales (day type [DT] and season [SE]). Dependent variables were social intensities and ecological intensities.

Model	Model Equation
Social Intensities	
LT	SI ~ LT
MU	SI ~ MU
DT	SI ~ DT
SE	SI ~ SE
LT + DT	SI ~ LT + DT
MU + DT	SI ~ MU + DT
LT + SE	SI ~ LT + SE
MU + SE	SI ~ MU + SE
Ecological Intensities	
LT	EI ~ LT
MU	EI ~ MU
DT	EI ~ DT
SE	EI ~ SE
LT + DT	EI ~ LT + DT
MU + DT	EI ~ MU + DT
LT + SE	EI ~ LT + SE
MU + SE	EI ~ MU + SE

Table 2-3. The expert consensus median values for the daily potential social conflicts and daily potential ecological impacts caused by the given recreational-activity groups and the rationale provided by the experts for the value selection.

Recreational-activity groups	Median Value	Rationale
	Social Conflict	
Consumptive only	7.5	Hunters actively try to avoid other hunting parties due to dangerous activity and competition for resources.
Intermediate-consumptive only	4.0	May have little conflict if trying to fish same area or use the boat ramp.
Non-consumptive only	1.5	Low competition for space or resources.
Consumptive and intermediate-consumptive	6.0	Anglers may feel uncomfortable if hunters shoot near the lake, and hunters may be upset if anglers scare their target species.
Consumptive and non-consumptive	6.0	Could disturb the wildlife the other groups seek to hunt or photograph.
Intermediate-consumptive and non-consumptive	2.0	Little interaction among groups with no threat to safety.
Consumptive, intermediate-consumptive and non-consumptive	6.0	Each group has a different goal, and thus has a potential for conflict, especially if competing for the same space or resources.
	Ecological Impact	
Consumptive	6.0	Harvest-oriented goal can impact populations or displace wildlife.
Intermediate-consumptive	4.0	Could cause impacts along banks, pollution from gas leaks, littering, or disturbance to wildlife.
Non-consumptive	1.5	Potential to disturb wildlife.

Table 2-4. Model selection results for Akaike's Information Criteria (AICc), to evaluate social intensities and ecological intensities at different spatial and temporal scales at Valentine National Wildlife Refuge, Nebraska during 2017-2018. Models include spatial scales (lake type [LT] and management unit [MU]) and temporal scales (day type [DT] and season [SE]).

Model	k	AIC_c	ΔAIC_c	$wAIC_c$
Social				
LT + SE	7	7,478	0	1
LT + DT	6	7,489	10	0
LT	4	7,498	19	0
MU + SE	11	10,229	2,751	0
MU + DT	10	10,237	2,758	0
MU	8	10,260	2,781	0
SE	5	23,432	15,953	0
DT	4	23,428	15,960	0
Ecological				
LT + SE	7	7,459	0	1
LT + DT	6	7,471	12	0
LT	4	7,478	19	0
MU + SE	11	9,888	2,429	0
MU + DT	10	9,888	2,429	0
MU	8	9,908	2,449	0
SE	5	23,390	15,930	0
DT	4	23,397	15,938	0

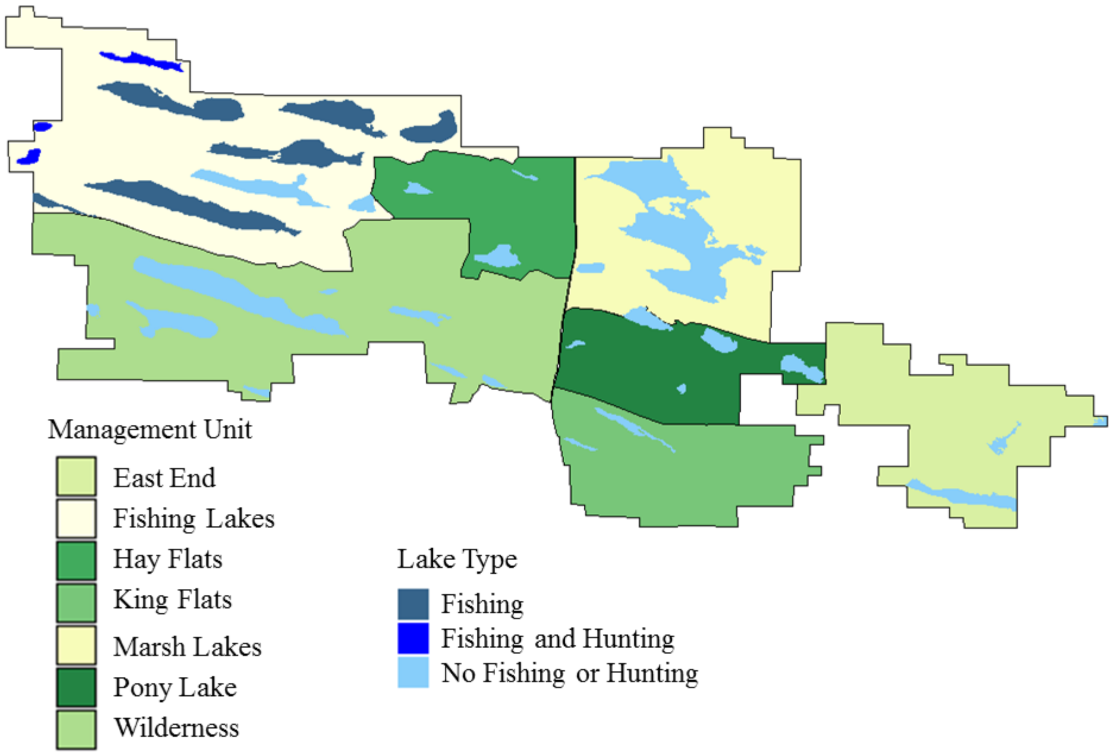


Figure 2-1. Map of management units and lake types on Valentine National Wildlife Refuge, Nebraska during 2017-2018.

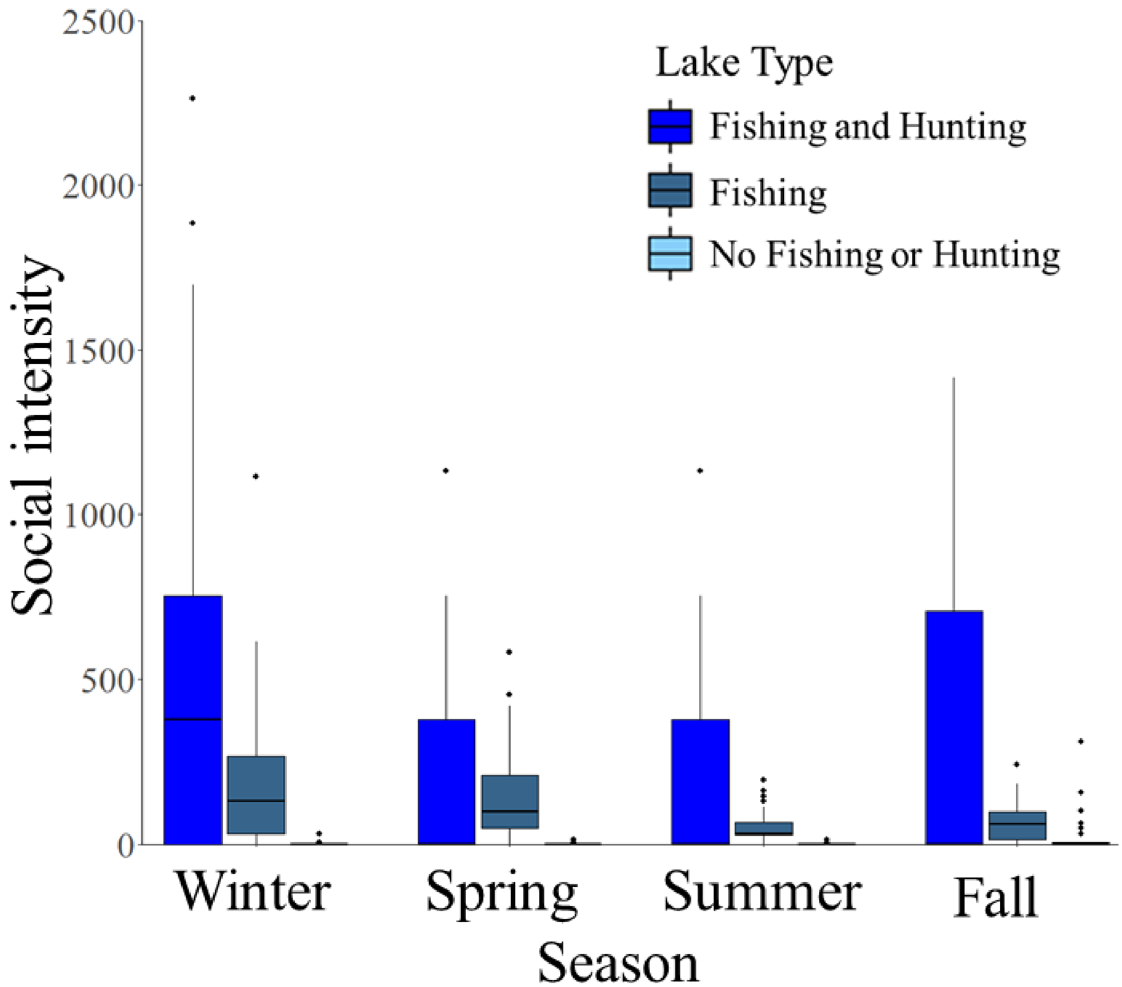


Figure 2-2. Box plot of social intensity at the fishing (steel blue), fishing and hunting (blue), and no fishing or hunting (light blue) lake types across winter, spring, summer and fall on Valentine National Wildlife Refuge, Nebraska, during 2017-2018. Horizontal black lines represent the median, boxes represent the range from 25th to 75th percentile, upper whiskers extend from the box to the largest value at most 1.5 * IQR (interquartile range), the lower whiskers extend to the lowest value no further than 1.5 *IQR, and the points represent outliers.

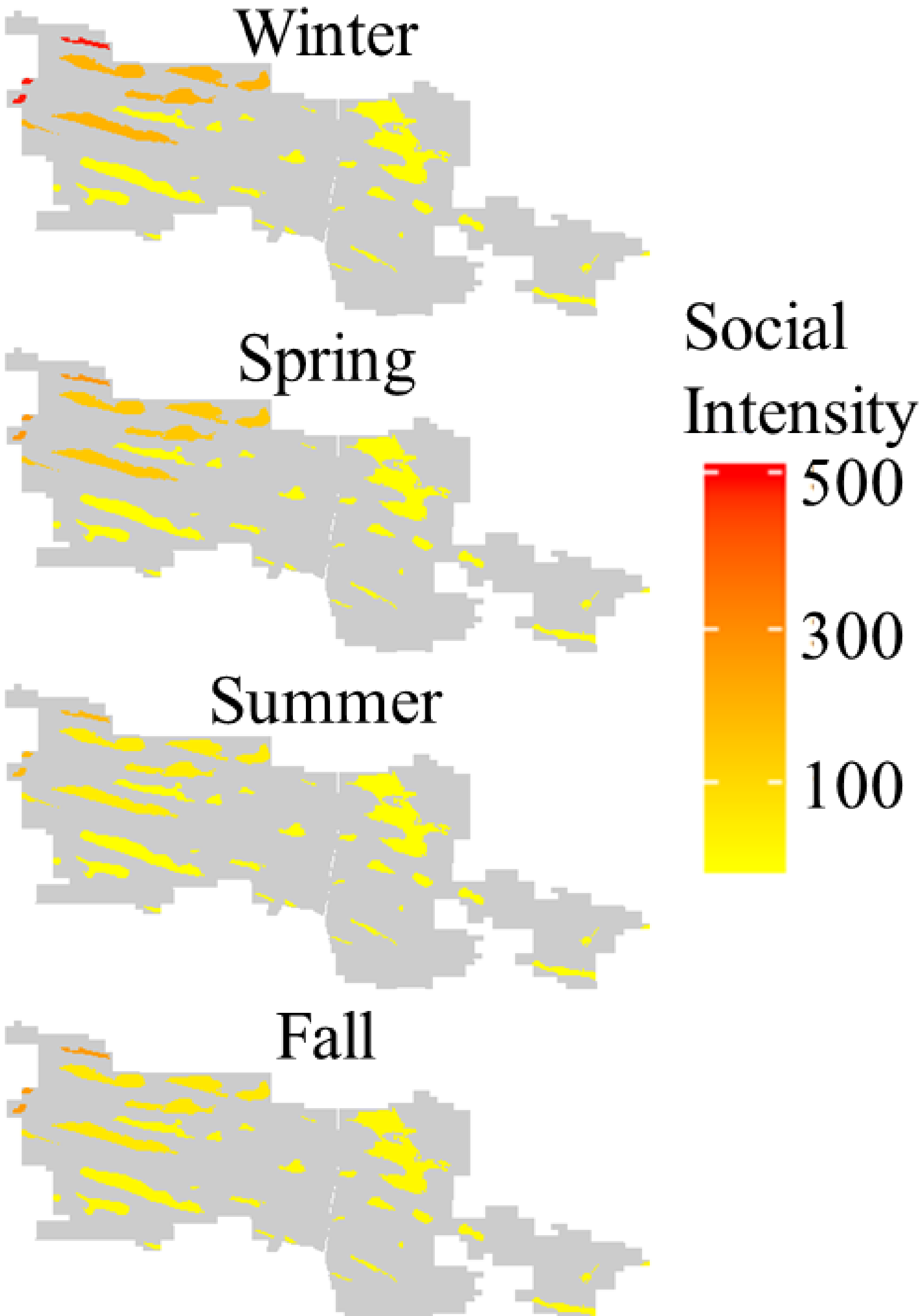


Figure 2-3. The heat maps depict the seasonal average for social intensities across lake types on Valentine National Wildlife Refuge, Nebraska, during 2017-2018. The greatest intensities occurred at the fishing and hunting lakes, followed by the fishing lakes and then the no fishing or hunting lakes.

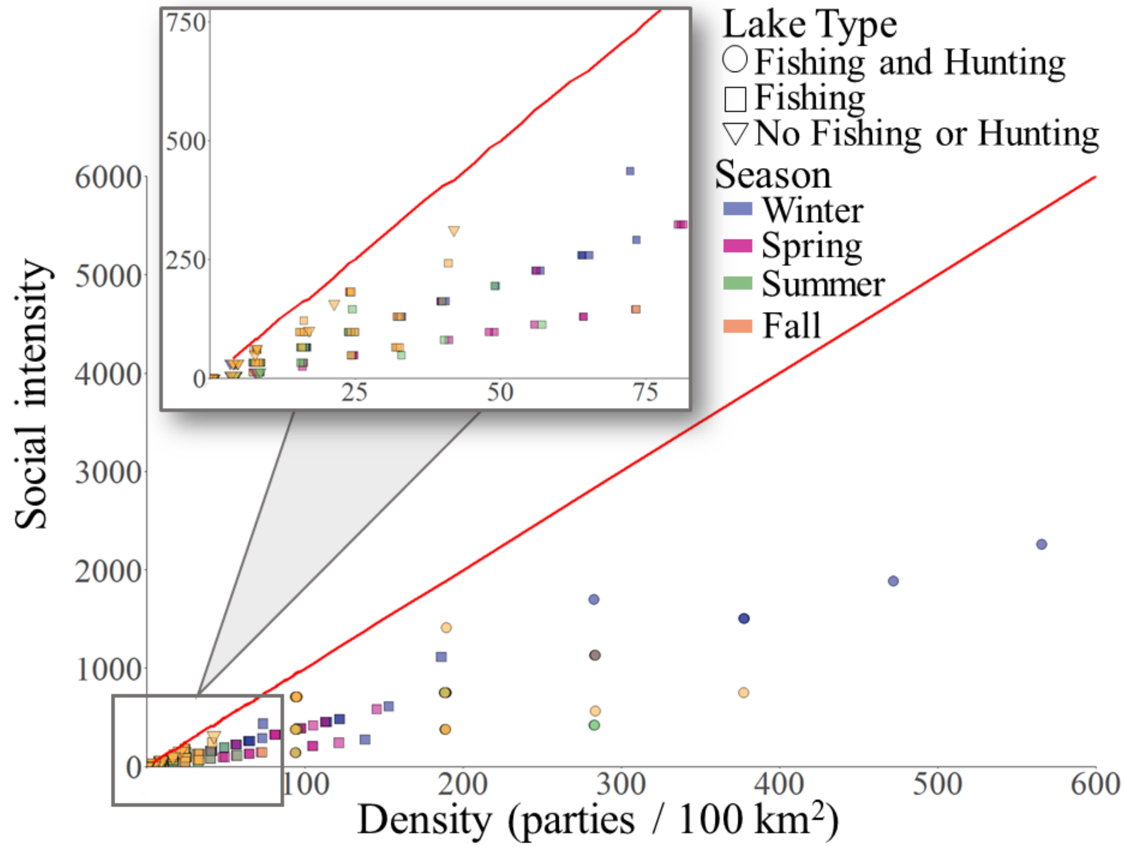


Figure 2-4. Visualization of the density (parties / 100 km^2) by daily potential social intensity (points) at the spatial (i.e., lake type) and temporal (i.e., season) scales on Valentine National Wildlife Refuge, Nebraska, during 2017-2018. Density is the number of parties based on returned surveys on a given day within a specified "area" (e.g., management unit or lake type). The inset zooms to the lower left corner of the plot to allow for better visualization of each point. Each point represents a lake type (fishing and hunting [circle], fishing [square], and no fishing or hunting [upside-down triangles]) and season (winter [blue], spring [pink], summer [green], and fall [orange]). The red line indicates the daily potential social intensity at the maximum social-conflict value of 10.

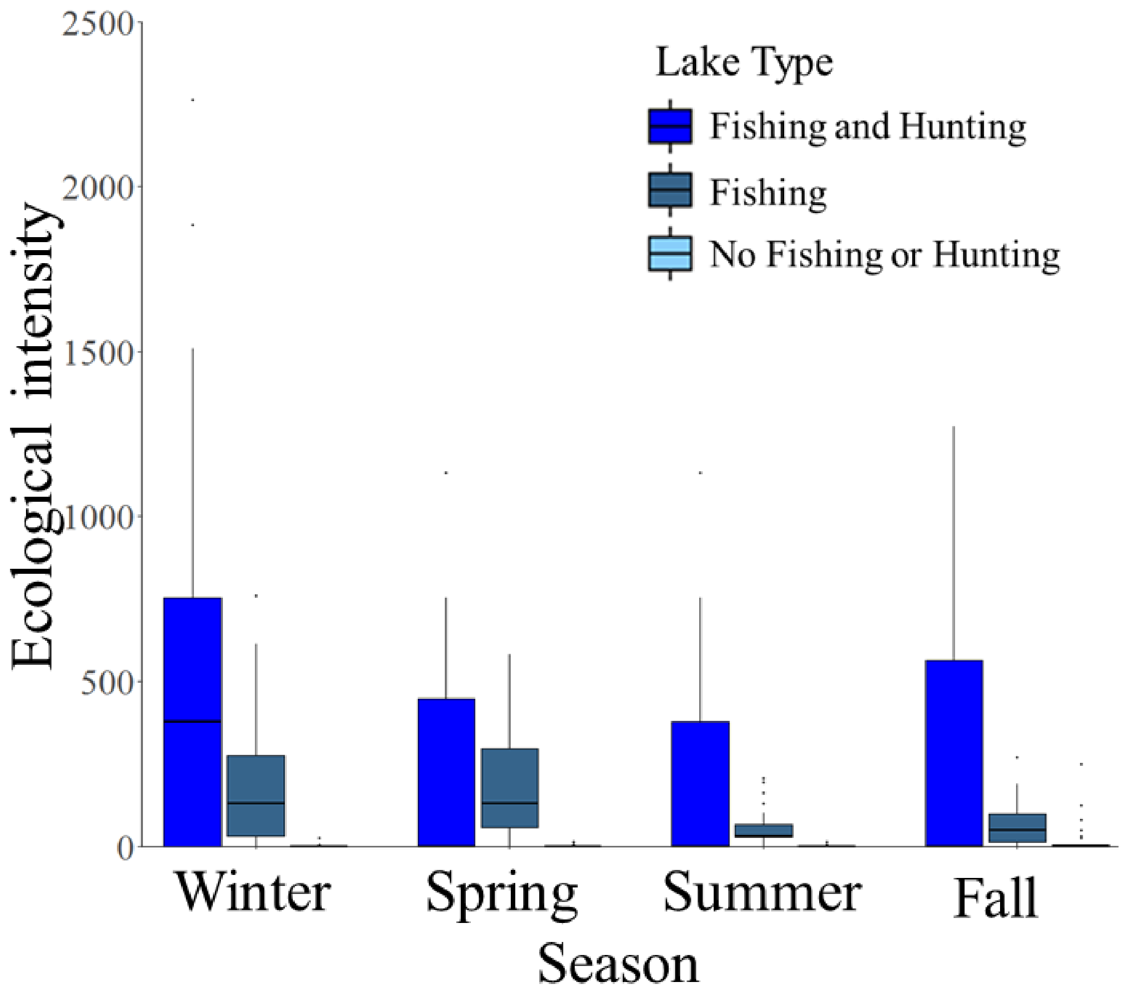


Figure 2-5. Box plot of ecological intensity at the fishing (steel blue), fishing and hunting (blue), and no fishing or hunting (light blue) lake types across winter, spring, summer and fall on Valentine National Wildlife Refuge, Nebraska, during 2017-2018. Horizontal black lines represent the median, boxes represent the range from 25th to 75th percentile, upper whiskers extend from the box to the largest value at most 1.5 * IQR (interquartile range), the lower whiskers extend to the lowest value no further than 1.5 *IQR, and the points represent outliers.

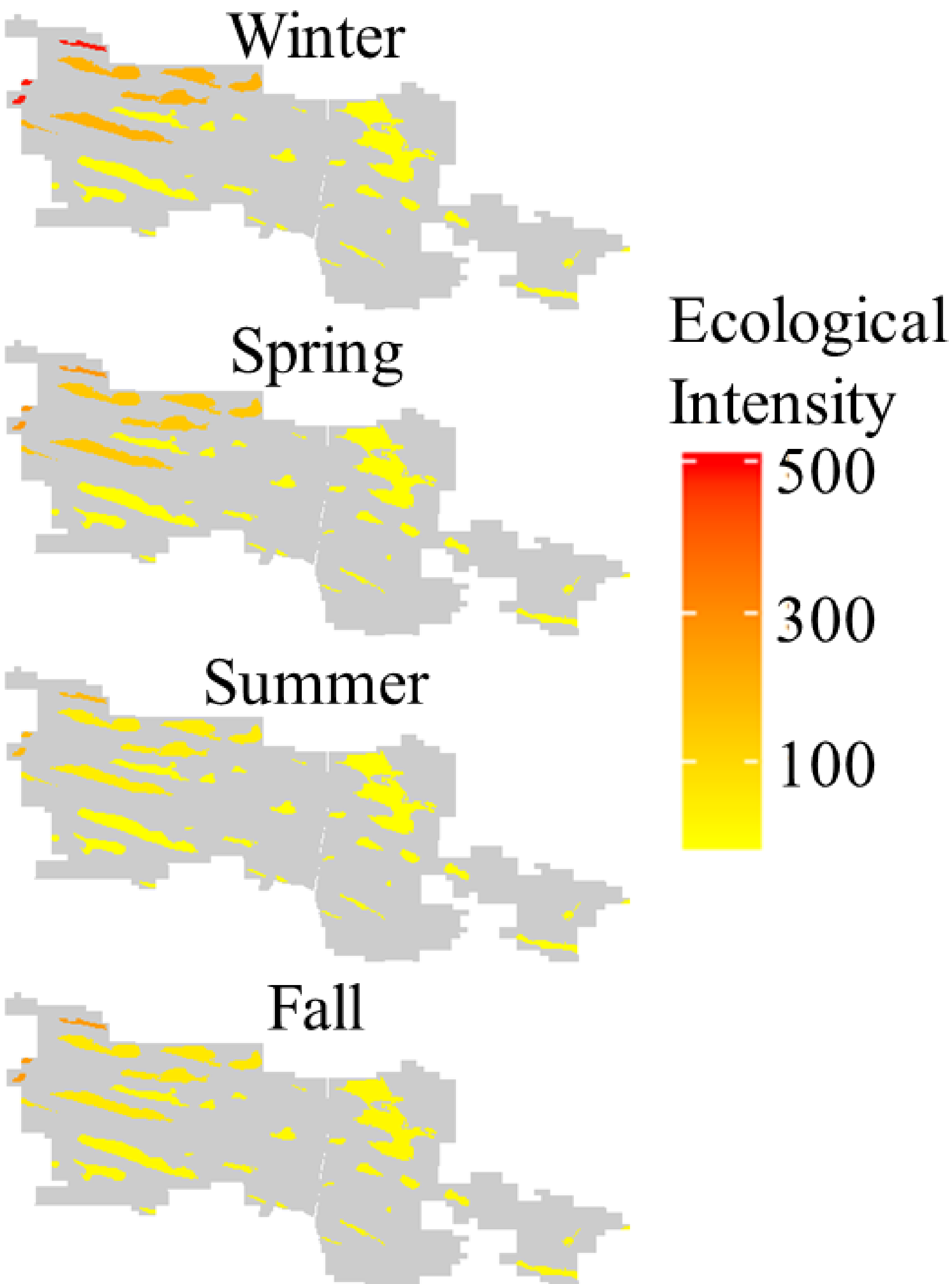


Figure 2-6. The heat maps depict the seasonal average for ecological intensities across lake types on Valentine National Wildlife Refuge, Nebraska, during 2017-2018. The greatest intensities occurred at the fishing and hunting lakes, followed by the fishing lakes and then the no fishing or hunting lakes.

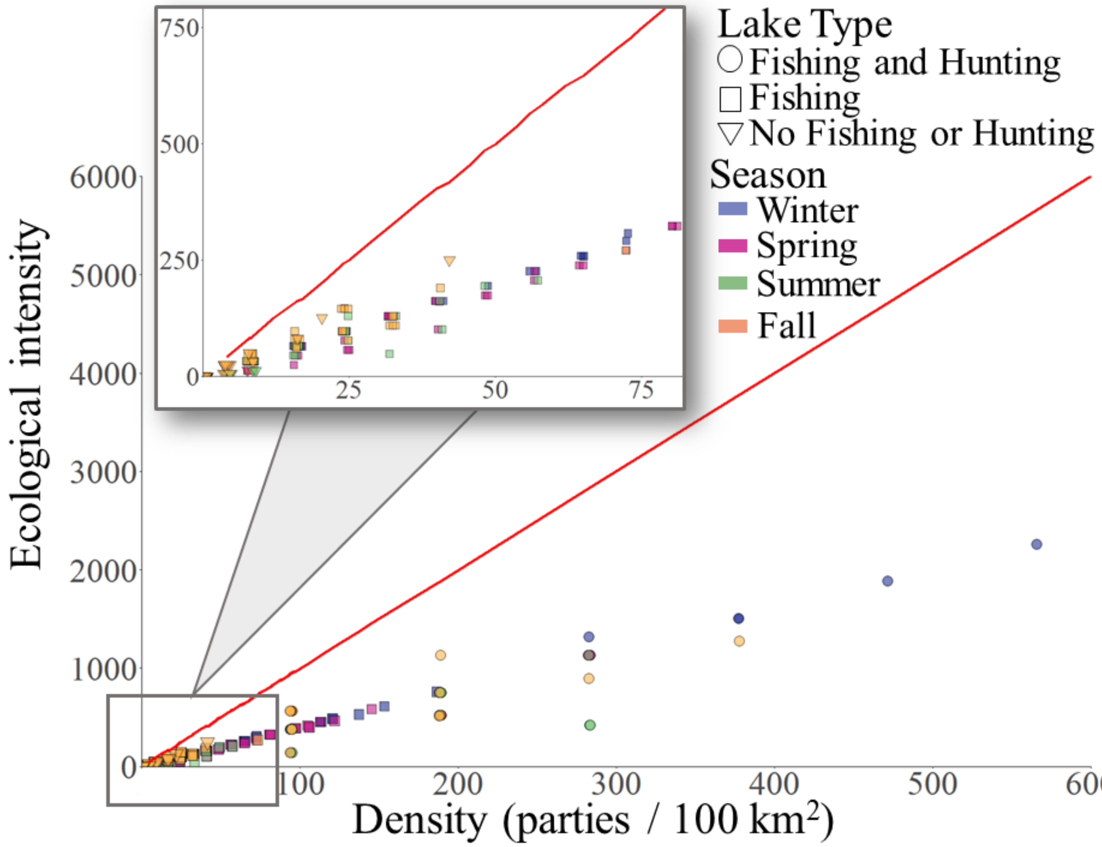


Figure 2-7. Visualization of the density (parties / 100 km^2) by daily potential ecological intensity (points) at the spatial (i.e., lake type) and temporal (i.e., season) scales on Valentine National Wildlife Refuge, Nebraska, during 2017-2018. Density is the number of parties based on returned surveys on a given day within a specified "area" (e.g., management unit or lake type). The inset zooms to the lower left corner of the plot to allow for better visualization of each point. Each point represents a lake type (fishing and hunting [circle], fishing [square], and no fishing or hunting [upside down triangles]) and season (winter [blue], spring [pink], summer [green], and fall [orange]). The red line indicates the daily potential ecological intensity at the maximum ecological-impact value of 10.

CHAPTER 3: MANAGEMENT RECOMMENDATIONS AND RESEARCH NEEDS

Managing parks and protected areas to meet the dual goal of conserving ecological systems and providing wildlife-compatible recreation opportunities requires progressive management approaches that incorporate information about social and ecological components of these systems. Current management regimes focus heavily on the ecological component with little or no information concerning the social component of parks and protected areas. Incorporating social information is essential for managing recreational activities to prevent social conflicts and detrimental impacts to the natural resources. Therefore, meeting the dual goal of parks and protected areas requires knowledge of the recreational activities that occur on parks and protected areas. Managers of parks and protected areas can apply recreational activity information to anticipate current and future management needs that are expected to change as a result of variations in use and environmental conditions. As a result of our research, we propose management recommendations and highlight needs for future research to incorporate social components into the management of parks and protected areas.

A thorough understanding of recreational activities requires knowledge of the frequency of occurrence, recognition of heterogeneity among recreational-activity groups, and the spatial and temporal changes in the social and ecological intensities of recreation use (Hadwen et al., 2007). There were significant sociodemographic differences among consumptive, intermediate-consumptive, and non-consumptive groups. Thus, Valentine National Wildlife Refuge (VNWR) supports a heterogeneous user group. The intermediate-consumptive group was the most frequent recreational-activity group to occur on VNWR. Additionally, lakes open to fishing and waterfowl hunting (i.e., fishing and hunting lake type) had the greatest social and ecological intensities, with the greatest intensities occurring during winter. Lakes that are not open to fishing or waterfowl hunting (i.e., no fishing or hunting lake type) had the least social and ecological intensities for all seasons, with the least intensities occurring during summer.

Although social and ecological intensities are important to understand, managers must understand what components contribute to these intensities, such as the frequency and composition of recreational-activity groups. As we discovered, hundreds of intermediate-consumptive parties during winter created similar social and ecological intensities as the consumptive and intermediate-consumptive groups during fall. Although we mapped general intensities, managers need to evaluate what contributes to these intensities to prescribe management actions appropriate for the different spatial and temporal scales (Hadwen et al., 2007). Managers could incorporate social and ecological information to effectively execute management actions to alleviate social and ecological intensities, as not all social and ecological intensities are the same.

Based on the knowledge we gained during our research, we provide the following recommendations for management of parks and protected areas. The recommendations focus on applications to VNWR and the Nebraska Game and Parks Commission (NGPC) with an emphasis on the importance of continuing this research; even so, these recommendations can be broadly applied to other social-ecological systems and management entities.

MANAGEMENT RECOMENDATIONS

Managers of parks and protected areas could modify management objectives to maintain heterogeneous recreational-activity groups to achieve the dual goal. To appease the predominate recreational-activity group (i.e., the intermediate-consumptive group) managers could provide more infrastructure at the lakes open to fishing. Managers could provide larger and child-friendly boat docks for families to use, which could contribute to more satisfied angling parties that seek time with family (Gerald et al., 2013). Consumptive parties travel a great distance to hunt on the refuge. Therefore, to guarantee hunters a space and opportunity to hunt waterfowl, VNWR could provide established waterfowl hunting blinds, like other natural resource agencies have provided, in which hunters could reserve in advance (Colorado Parks & Wildlife, 2020). Additionally, to appease the non-consumptive parties, which drove a higher proportion of two-wheel drive vehicles, mangers could provide educational and wildlife watching opportunities along a paved auto tour road. Management of parks and protected areas should strive to maintain these heterogeneous recreational-activity groups.

Management could spatially and temporally expand and separate recreational opportunities to alleviate inter-activity and intra-activity social conflicts (Eagles et al., 2002). Managers could expand waterfowl hunting to no fishing or hunting lake type and no longer permit waterfowl hunting at the fishing and hunting lake type. Offering more waterfowl hunting opportunities that are spatially separated (i.e., different lakes) from the intermediate-consumptive group could alleviate social conflicts among the two groups and reduce intra-activity social conflicts among the hunters competing for space and resources at the three lakes that currently permit waterfowl hunting at VNWR. To alleviate intra-activity social conflicts among the predominate group (i.e., the intermediate-consumptive group) during peak social and ecological intensities (e.g., winter), managers could open more lakes to fishing to disperse the parties out across a larger spatial area. Dispersing recreational-activity groups across a larger area will reduce the potential for social intensities (Leung & Marion, 2000), however, dispersion of recreation use should be strategically planned and be compatible with conservation objectives.

Managers could also implement education programs to prevent social conflicts within and among recreational-activity groups (Eagles et al., 2002). Education programs can help establish behavior norms and codes of conduct within recreational-activity groups, and increase the tolerance for other recreational-activity groups by informing parties on the different values and commonalities among the recreational-activity groups (Watson et al., 2016). Managers could provide educational programs in areas and seasons with the greatest social intensities. For instance, at VNWR, mangers could implement education programs at the fishing and hunting lake type during fall to alleviate social conflicts among the consumptive and intermediate-consumptive groups. Additionally, educational programs could be implemented at the lakes open to fishing during winter to inform the intermediate-consumptive group of the social etiquette and norms to prevent inter-activity conflicts.

The consumptive group had the highest potential for ecological impacts; therefore, management could limit hunting opportunities to only a few species, such as waterfowl, deer and upland game. Limiting recreational activities with high potential for ecological impacts can lessen detrimental impacts to the ecological system, such as reducing the trampling of vegetation and disturbance to wildlife (Hadwen et al., 2007). Lakes open to fishing had great ecological intensities; therefore, managers could implement strategies to alleviate the great ecological intensity. For example, managers, could provide an established path along a section of the bank at the lakes that permit fishing. An established path would limit the unintended ecological impacts caused by bank anglers, such as trampling of vegetation and bank erosion (Leung & Marion, 2000). Additionally, managers could provide fishing-line disposal canisters, to prevent littering and endangering wildlife that can get tangled in discarded fishing line. Non-consumptive activities were more dispersed across space and time and not as prevalent on VNWR; therefore, the ecological impacts caused by the non-consumptive group was minimal. However, parks and protected areas that have predominantly non-consumptive activities may have great ecological intensities (Eadens et al., 2009), and thus could focus efforts on non-consumptive opportunities, such as hiking trails, in areas away from known sensitive species.

Many conventional management strategies do not account for the diverse demands of heterogeneous recreational-activity groups, and thus may fail to alleviate potential social conflicts within and among recreational-activity groups (Mann & Absher, 2008). Therefore, management plans could account for the heterogeneous recreational-activity groups. Management plans that aim to keep certain recreational-activity groups spatially and temporally separated (e.g., consumptive and non-consumptive groups) and that provide more areas for the predominate recreational-activity types could prevent areas and seasons with high social intensities.

NEED FOR CONTINUED RESEARCH

Although we gained much-needed baseline knowledge on the social component of VNWR, further research is needed to understand the social-ecological effects that management decisions have on recreational-activity dynamics. The information we gained at VNWR is unique in that we collected data prior to a major management action. Nebraska Game and Parks Commission in collaboration with U.S. Fish and Wildlife Service (USFWS), closed a popular fishing lake (Pelican Lake) to remove invasive common carp (*Cyprinus carpio*). We predict the fishing use will increase with the improved fishery after management is complete and fish grow to optimal lengths. Thus, continuation of this research to collect post-lake renovation recreational-activity data would be extremely valuable. Very few studies collect information regarding all recreational-activity groups using a park and protected area, and even fewer collect information pre-and post-management renovations on parks and protected areas. Therefore, there is a unique opportunity to evaluate the effects of large-scale management actions, specifically lake renovations, on recreational-activity dynamics. The information gained from the continuation of this research could be applied to optimize management actions that achieve the dual goals of parks and protected areas.

Furthermore, understanding the effects that management actions have on recreational-activity dynamics is important information that many natural resource agencies could use to reach their management objectives to recruit, retain, and reactivate consumptive (i.e., hunters) and intermediate-consumptive (i.e., anglers) parties (R3). To reach the R3 objectives, we must have a thorough understanding of the social component and the potential impacts that management actions have on the recreational-activity groups using parks and protected areas. Continuation of this research would allow us to understand whether the Pelican Lake renovation attracts more intermediate-consumptive parties to the refuge and whether these are different intermediate-consumptive parties (i.e., have different sociodemographics). The lake renovation and removal of common carp could improve the quality of the fishing (Kaemingk et al., 2017) and likely attract more waterfowl (Bajer et al., 2009). This potential abundance of waterfowl could attract more consumptive groups that seek waterfowl hunting opportunities and non-consumptive groups that seek bird watching opportunities. The lake renovation could also have a negative impact on the recreational-activity groups. With a loss of a Northern Pike (*Esox lucius*) fishery (i.e., Pelican Lake), there may be fewer intermediate-consumptive groups fishing on the refuge. Additionally, the renovated lake may attract multiple recreational-activity groups, and therefore could cause greater social intensity around the lake.

It is important to understand how management actions, like the renovation of Pelican Lake, will affect recreational-activity groups as negative effects may cause management agencies to be further from reaching their R3 objectives. With more renovations planned for other lakes on VNWR, it is essential to understand how they may affect the social component of this social-ecological system. The knowledge gained from continuation of this research would be applicable to other parks and protected areas with renovations planned and provide insight to the benefits or impacts these renovations have on achieving agency objectives set for parks and protected areas.

Additionally, we recognize other parks and protected areas may have different recreational-activity types, such as motorized (e.g., snowmobiling) and non-motorized (skiing) recreational activities, which also cause social conflicts and ecological impacts (Miller et al., 2017). Further research is needed to thoroughly understand the social and ecological intensities of other recreational-activity groups on parks and protected areas. Furthermore, future research could also collect on-site social conflict and ecological impact data to validate the consensus values reached using the Delphi methodology. For instance, evaluating perceived crowding (Vaske & Shelby, 2008) and measuring trampled vegetation, soil compaction, bank erosion, and disturbance to wildlife caused by different recreational-activity groups (Knight & Cole, 1995; Taylor & Knight, 2003). The information collected from continued research would provide further knowledge of the social component of these important social-ecological systems.

Future research of parks and protected areas could overlay the ecological intensities with sensitive ecological resources, to understand which areas and species are most vulnerable to ecological impacts (Eadens et al., 2009; Lyon et al., 2011). For example, overlaying maps of ecological intensity with maps of where endangered blowout penstemon (*Penstemon haydenii*) occurs would allow managers to understand if plans need to be implemented to keep recreational-activity groups away, to prevent unintentional damage to the few remaining plants. Research to evaluate areas with great ecological intensities and sensitive species would be valuable for understanding the effects recreational activities are having on vulnerable species.

The research in this thesis laid the groundwork of understanding the complex social component of VNWR. Valentine National Wildlife Refuge supports heterogeneous recreational activities, which vary in frequencies and potentials for social conflicts and ecological impacts. The social and ecological intensities were best examined at the lake-type and season scales. The methods described here are not limited to VNWR or to consumptive, intermediate-consumptive, and non-consumptive recreational-activity types, but could be applied to other recreational activities on other parks and protected areas. Managing parks and protected areas to reach their dual goal of conserving ecological systems while also providing wildlife-compatible recreation opportunities requires knowledge of the heterogeneous and dynamic recreational activities.

REFERENCES

Bajer, P. G., Sullivan, G., & Sorensen, P. W. (2009). Effects of a rapidly increasing population of common carp on vegetative cover and waterfowl in a recently restored Midwestern shallow lake. *Hydrobiologia*, *632*(1), 235–245. https://doi.org/10.1007/s10750-009-9844-3

Colorado Parks & Wildlife. (2020). *Hunting*. https://cpw.state.co.us/placestogo/parks/barrlake/Pages/Hunting.aspx

Eadens, L. M., Jacobson, S. K., Stein, T. V., Confer, J. J., Gape, L., & Sweeting, M. (2009). Stakeholder mapping for recreation planning of a Bahamian National Park. *Society and Natural Resources*, *22*(2), 111–127. https://doi.org/10.1080/08941920802191696

Eagles, P. F. J., McCool, S. F., & Haynes, C. D. (2002). *Sustainable tourism in protected areas: Guidelines for planning and management* (A. Phillips (ed.); Vol. 8). IUCN. https://doi.org/10.1111/j.1755-3768.1951.tb07631.x

Gerald, K. T., Schuett, M. A., Lee, K., Yoon, J. I., Ding, C., & Wallen, K. (2013). Demographics, participation, attitudes, and management preferences of Texas anglers. In *Department of Recreation, Park & Tourism Sciences* (Issue August). https://doi.org/10.13140/RG.2.1.3580.8166

Hadwen, W. L., Hill, W., & Pickering, C. M. (2007). Icons under threat: Why monitoring visitors and their ecological impacts in protected areas matters. *Ecological Management and Restoration*, *8*(3), 177–181. https://doi.org/10.1111/j.1442-8903.2007.00364.x

Kaemingk, M. A., Jolley, J. C., Paukert, C. P., Willis, D. W., Henderson, K., Holland, R. S., Wanner, G. A., & Lindvall, M. L. (2017). Common carp disrupt ecosystem structure and function through middle-out effects. *Marine and Freshwater Research*, *68*, 718–731. https://doi.org/10.1071/MF15068

Knight, R. L., & Cole, D. N. (1995). Wildlife responses to recreationists. In R. L. Knight & K. J. Gutzwiller (Eds.), *Wildlife and Recreationists: Coexistence Through Management and Research* (pp. 51–69). Island Press. http://books.google.com/books?hl=en&lr=&id=BRbBAvLwQlAC&oi=fnd&pg=PR2&dq=Wildlife+and+Recreationists+Coexistence+through+management+and+research&ots=tLxWRTHxBC&sig=tGeL7wgT3G4a6dZOTZo3gFrx7Lg

Leung, Y., & Marion, J. L. (2000). Recreation impacts and management in wilderness: A state-of-knowledge review. *USDA Forest Service Proceedings RMRS-P-15*, *5*, 23–48. https://doi.org/10.1515/rtuect-2016-0010

Lyon, K., Cottrell, S. P., Siikamäki, P., & Marwijk, R. Van. (2011). Biodiversity hotspots and visitor flows in Oulanka National Park, Finland. *Scandinavian Journal of Hospitality and Tourism*, *11*(sup1), 100–111. https://doi.org/10.1080/15022250.2011.629909

Mann, C., & Absher, J. (2008). Recreation conflict potential and management implications in the northern/central Black Forest Nature Park. *Journal of Environmental Planning and Management*, *51*(3), 363–380. https://doi.org/10.1080/09640560801979527

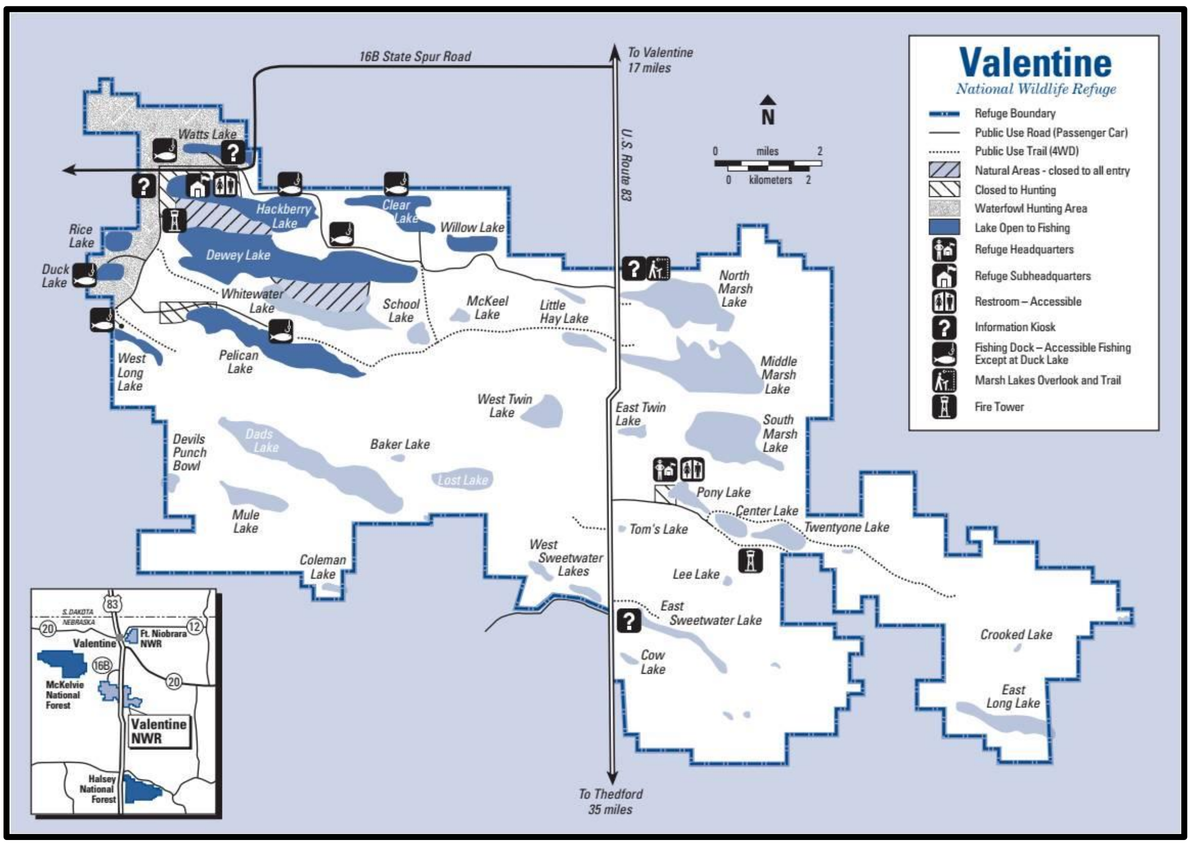
Miller, A. D., Vaske, J. J., Squires, J. R., Olson, L. E., & Roberts, E. K. (2017). Does zoning winter recreationists reduce recreation conflict? *Environmental Management*, *59*(1), 50–67. https://doi.org/10.1007/s00267-016-0777-0

Taylor, A. R., & Knight, R. L. (2003). Wildlife responses to recreation and associated visitor perceptions. *Ecological Applications*, *13*(4), 951–963. https://doi.org/10.1890/1051-0761(2003)13[951:WRTRAA]2.0.CO;2

Vaske, J. J., & Shelby, L. B. (2008). Crowding as a descriptive indicator and an evaluative standard: Results from 30 years of research. *Leisure Sciences, 30*(2), 111–126. https://doi.org/10.1080/01490400701881341

Watson, A. E., Cordell, K. E., Manning, R., & Martin, S. (2016). The evolution of wilderness social science and future research to protect experiences, resources, and societal benefits. *Journal of Forestry*, *114*(3), 329–338.

Appendix 1. Valentine National Wildlife Refuge Map (U.S. Fish and Wildlife Service, & Valentine National Wildlife Refuge. (n.d.). *Valentine National Wildlife Refuge hunting and fishing brochure map*. Retrieved October 28, 2019, from https://www.fws.gov/uploadedFiles/Hunting and Fishing Brochure Map Page.pdf)



Appendix 2. Vehicle windshield survey distributed to recreationists at the party level on Valentine National Wildlife Refuge, Nebraska during 2017-2018.

VALENTINE NATIONAL WILDLIFE REFUGE
RECREATIONAL EXPERIENCE SURVEY

NEBRASKA COOPERATIVE FISH & WILDLIFE RESEARCH UNIT

Hello! We left this **voluntary** research survey on ____/____/____ at ____:____. Your participation will help us understand use of Valentine National Wildlife Refuge. Participant information is available at *http://FishHunt.unl.edu*.

PLEASE TELL US ABOUT YOUR VISIT TODAY.
Your responses on **today's activities** are valued, *even if you completed this survey on a **prior** visit.*

INFORMATION ABOUT YOUR GROUP

❶ **Recreational activities** today at this refuge (*check all that apply*)
☐ Fishing ☐ Hiking ☐ Wildlife Watching ☐ Other__________________
☐ Hunting ☐ Touring ☐ Photography ☐ Environmental Education

❷ **Refuge lakes** visited today? (*check all that apply*)

☐ No lake visited

open to waterfowl hunting and fishing: ☐ Duck ☐ Rice ☐ Watts

open to fishing: ☐ Clear ☐ Dewey ☐ Hackberry ☐ Pelican ☐ West Long ☐ Willow

☐ Baker ☐ Center ☐ Coleman ☐ Cow ☐ Crooked ☐ Dads
☐ Devils Punch Bowl ☐ East Long ☐ East Sweetwater ☐ West Sweetwater ☐ East Twin ☐ West Twin
☐ Lee ☐ Little Hay ☐ Lost ☐ McKeel ☐ Mule ☐ Pony
☐ North Marsh ☐ Middle Marsh ☐ South Marsh ☐ School ☐ Tom's ☐ Whitewater

❸ Number of **people** in your group (*1 = you alone*)? ________

❹ **Number** of group members: 17 years or younger? _______ 18-64 years? _______ 65 years or older? _______

❺ **Zip codes** of home residences for group members? __________ __________ __________ __________

INFORMATION ABOUT FISHING, HUNTING AND WILDLIFE WATCHING

❻ If you **fished** on this refuge today:

Lake Name:	1.__________		2.__________		3.__________	
Time fished:	___hrs	___mins	___hrs	___mins	___hrs	___mins
Number of people:	______		______		______	
Number of fish:	Released	Kept	Released	Kept	Released	Kept
Black crappie	____	____	____	____	____	____
Bluegill	____	____	____	____	____	____
Largemouth bass	____	____	____	____	____	____
Northern pike	____	____	____	____	____	____
Yellow perch	____	____	____	____	____	____
Common carp	____	____	____	____	____	____
Other __________	____	____	____	____	____	____

❼ If you **hunted** on this refuge today:
Time hunted: ____hrs ____mins
Number of people: _____
Number of animals harvested?
(*0 = hunted but none harvested; NA = did not hunt*)
Waterfowl _____
Prairie grouse _____
Pheasants _____
Dove _____
Deer _____
Coyote _____

❽ If you **watched wildlife** on this refuge today: Time spent: ____ hrs ____mins Number of people: _____
Rank, in order of preference, the groups of animals that you watched? (*1 = most preferred; NA = did not watch*)
Insects ______ Fish _____ Amphibians _____ Reptiles _____ Birds _____ Mammals _____

COMMENTS

PLACE COMPLETED SURVEY IN DESIGNATED BOX — look for gold star ★ — **OR IN THE U.S. MAIL.**
Thank you for completing this survey! Your responses will help improve management of our natural resources.

Appendix 3. Additionally sampled “event” days at Valentine National Wildlife Refuge, Nebraska during 2017-2018.

Date	Day-type	Event
19 August 2017	weekend	Eclipse
20 August 2017	weekend	Eclipse
21 August 2017	weekday	Eclipse
01 September 2017	weekday	Grouse opener
02 September 2017	weekend	Labor Day and early teal opener
04 September 2017	weekday	Labor Day
07 October 2017	weekend	Duck and goose opener
08 October 2017	weekend	Duck and goose opener
09 October 2017	weekday	Columbus Day
28 October 2017	weekend	Pheasant opener
29 October 2017	weekend	Pheasant opener
10 November 2017	weekday	Veterans day
11 November 2017	weekend	Deer firearm opener
12 November 2017	weekend	Deer firearm opener
30 December 2017	weekend	New Year’s Day
31 December 2017	weekend	New Year’s Eve
01 January 2018	weekday	New Year's Day
13 January 2018	weekend	Martin Luther King, Jr. Day
15 January 2018	weekday	Martin Luther King, Jr. Day
27 May 2018	weekend	Memorial Day
28 May 2018	weekday	Memorial Day
30 June 2018	weekend	Independence Day
04 July 2018	weekday	Independence Day

Appendix 4. Descriptive statistics of sociodemographic attributes (see Table 1-2 for attribute descriptions) of consumptive, intermediate-consumptive, and non-consumptive groups surveyed on Valentine National Wildlife Refuge, Nebraska during 2017-2018.

	Consumptive					Intermediate-consumptive					Non-consumptive				
Attribute	n	%	Mean	SE	Range	n	%	Mean	SE	Range	n	%	Mean	SE	Range
Party Size	95		2	0	1 - 10	616		3	0	1 - 14	78		2	0	1 - 4
Seniors (≥65 years) in Party															
Present	27	28				191	31				34	44			
Absent	68	72				425	69				44	56			
Distance Traveled (km)	95		818	679	28 – 2,788	617		260	7	28 – 1,666	78		863	85	28 – 2,420
Average Household Income (U.S. Dollars)	95		78,968	21,931	51,802 – 164,365	616		70,253	665	37,084 – 159,167	78		83,695	3,280	37,084 – 159,167
Population Type															
Urban	11	12				87	14				24	31			
Rural	84	88				529	86				54	69			
Vehicle Type															
2WD	6	6				25	4				22	28			
4WD	89	94				592	96				56	72			

88

Appendix 5. The first round of the Delphi questionnaire provided to the experts to gather daily potential social-conflict values and daily potential ecological-impact values caused by different recreational-activity groups. The questionnaire contained sections asking experts for their personal recreation experience and professional experience researching and managing different aspects of natural resources.

Social Conflicts and Ecological Impacts of Recreational Activities

We are seeking your professional input on potential social conflicts and potential ecological impacts caused by different recreational activities on any given day at a Park or Protected Area.

The following terms are defined for the purpose of this survey.

Park or Protected Area (PPA): Public land (e.g., state park, National park, National wildlife refuge) managed to protect natural resources and provide recreational opportunities for people.

Recreational activities: Things people do for fun, enjoyment, and leisure (e.g., fishing, hunting, and photography) that can occur on PPAs.

Party: A group of individuals that travel and recreate together on a PPA. An average party size is 2 - 3 individuals.

Social conflicts: Disputes or feelings of discomfort that occur between recreating parties on a PPA, which can arise from competition for resources, interference, behaviors, morals regarding wildlife, and perceptions of crowding.

Ecological impacts: Damages caused by recreating parties on a PPA, which can include harvest or disturbance to wildlife, soil compaction, trampling of vegetation, and air, water, and noise pollution.

For the purpose of this survey, please envision a 320-acre PPA (e.g., 1/2 section) that includes a lake open to hunting and fishing, a rolling prairie, a nature trail adjacent to the lake and prairie, a road, and two parking lots. Please consider six parties recreating on this PPA simultaneously. There could be multiple parties of anglers (bass, bluegill, or catfish), hunters (waterfowl, deer, or pheasant), and photographers (wildlife, wildflowers, or landscapes) independently visiting and simultaneously recreating on this PPA. This is meant to be generalized, so use your imagination and past experiences working on public lands to guide your vision on how this PPA would look. Use this PPA to answer the questions on the following pages.

We want you to consider the daily potential social conflicts between parties (could be participating in the same recreational activity or different recreational activities). We also want you to consider the daily potential ecological impacts of parties participating in the different recreational activities.

Appendix 5. Continued.

INSTRUCTIONS:
After reading the previous page, please circle one value for each of the following statements using a continuous scale with equal increments between values, 0 = None to 10 = Highest potential for social conflicts and ecological impacts. You may use the same value for multiple statements. After each statement, please briefly explain your rationale for your value selection.

POTENTIAL SOCIAL CONFLICT VALUE
We want you to consider the daily potential social conflicts between parties (could be participating in the same recreational activity or different recreational activities). Please imagine the worst (value = 10) social conflict between recreational parties. Use this image to help guide your value selection for the following statements.

1. What is the daily potential for social conflict caused by:	None										Highest
a. Six parties of **anglers**?	0	1	2	3	4	5	6	7	8	9	10
Rationale:											
b. Six parties of **hunters**?	0	1	2	3	4	5	6	7	8	9	10
Rationale:											
c. Six parties of **photographers**?	0	1	2	3	4	5	6	7	8	9	10
Rationale:											
d. Three parties of **anglers** and three parties of **hunters**?	0	1	2	3	4	5	6	7	8	9	10
Rationale:											
e. Three parties of **anglers** and three parties of **photographers**?	0	1	2	3	4	5	6	7	8	9	10
Rationale:											
f. Three parties of **hunters** and three parties of **photographers**?	0	1	2	3	4	5	6	7	8	9	10
Rationale:											
g. Two parties of **anglers**, two parties of **hunters**, and two parties of **photographers**?	0	1	2	3	4	5	6	7	8	9	10
Rationale:											

Appendix 5. Continued.

POTENTIAL ECOLOGICAL IMPACT VALUE

We want you to consider the daily potential ecological impacts of parties participating in the different recreational activities. Please imagine the worst (value = 10) ecological impact that recreational parties could cause on a PPA. Use this image to help guide your value selection for the following statements.

1. What is the daily potential ecological impacts caused by:

	None										Highest
a. Six parties of **anglers**?	0	1	2	3	4	5	6	7	8	9	10
Rationale:											
b. Six parties of **hunters**?	0	1	2	3	4	5	6	7	8	9	10
Rationale:											
c. Six parties of **photographers**?	0	1	2	3	4	5	6	7	8	9	10
Rationale:											

INFORMATION ABOUT YOUR PERSONAL RECREATION EXPERIENCE

1. Which recreational activities have you participated in (select all that apply)?

- ☐ Hunting
- ☐ Fishing
- ☐ Photography
- ☐ Hiking
- ☐ Wildlife Watching

2. Which recreational activities have you participated in on public land (select all that apply)?

- ☐ Hunting
- ☐ Fishing
- ☐ Photography
- ☐ Hiking
- ☐ Wildlife Watching

Appendix 5. Continued.

INFORMATION ABOUT YOUR PROFESSIONAL EXPERIENCE

1. How many years have you worked in this profession? ☐☐

2. How many years have you focused professionally on:

a. Graduate research (Your M.S., M.A., and Ph.D. research)? ☐☐

b. Research outside of your graduate research? ☐☐

c. Management (e.g., game, fisheries, land)? ☐☐

d. Administration? ☐☐

e. Other, specify: ________ ☐☐

3. How many years have you researched or managed:

a. Public land? ☐☐

b. Public waterbody? ☐☐

c. Recreation? ☐☐

d. Fisheries? ☐☐

e. Wildlife? ☐☐

f. Non-game species? ☐☐

g. Game species? ☐☐

h. Environmental impact assessments? ☐☐

i. Multiple groups of stakeholders? ☐☐

4. Which recreational activities have you researched or managed (select all that apply)?

☐ Hunting
☐ Fishing
☐ Photography
☐ Hiking
☐ Wildlife watching
☐ Other, specify: ________

Thank you for completing this questionnaire!

Appendix 6. The second round of the Delphi questionnaire provided to the experts to reach a consensus on daily potential social-conflict values and daily potential ecological-impact values caused by different recreational-activity groups.

Social Conflicts and Ecological Impacts of Recreational Activities Second Round

Please note for each question we have included results from round one (*in blue text*) including the median value, the percent of folks who selected each value, and the generalized rationale written and percent of respondents in parenthesis for each rationale. Please use these results to help guide your value selection for this second round of questions.

The following terms are defined for the purpose of this survey.

Park or Protected Area (PPA): Public land (e.g., state park, National park, National wildlife refuge) managed to protect natural resources and provide recreational opportunities for people.

Recreational activities: Things people do for fun, enjoyment, and leisure (e.g., fishing, hunting, and photography) that can occur on PPAs.

Party: A group of individuals that travel and recreate together on a PPA. An average party size is 2 - 3 individuals.

Social conflicts: Disputes or feelings of discomfort that occur between recreating parties on a PPA, which can arise from competition for resources, interference, behaviors, morals regarding wildlife, and perceptions of crowding.

Ecological impacts: Damages caused by recreating parties on a PPA, which can include harvest or disturbance to wildlife, soil compaction, trampling of vegetation, and air, water, and noise pollution.

For the purpose of this questionnaire, please envision a 320-acre PPA (e.g., 1/2 section) that includes a lake open to hunting and fishing, a rolling prairie, a nature trail adjacent to the lake and prairie, a road, and two parking lots. Please consider six parties recreating on this PPA simultaneously. There could be multiple parties of anglers (bass, bluegill, or catfish), hunters (waterfowl, deer, or pheasant), and photographers (wildlife, wildflowers, or landscapes) independently visiting and simultaneously recreating on this PPA. This is meant to be generalized, so use your imagination and past experiences working on public lands to guide your vision on how this PPA would look. Use this PPA to answer the questions on the following pages.

We want you to consider the daily potential social conflicts between parties (could be participating in the same recreational activity or different recreational activities). We also want you to consider the daily potential ecological impacts of parties participating in the different recreational activities.

Appendix 6. Continued.

INSTRUCTIONS:
After reading the previous page, please circle one value for each of the following statements using a continuous scale with equal increments between values, 0 = None to 10 = Highest potential for social conflicts and ecological impacts. You may use the same value for multiple statements.

POTENTIAL SOCIAL CONFLICT VALUE
We want you to consider the daily potential social conflicts between parties (could be participating in the same recreational activity or different recreational activities). Please imagine the worst (value = 10) social conflict between recreational parties. Use this image to help guide your value selection for the following statements. In blue is the results from the first round of questions.

1. What is the daily potential for social conflict caused by: **None** … **Highest**

a. Six parties of **anglers**?

	0	1	2	3	4	5	6	7	8	9	10
Median value: *4.5* — Responses (%):	*0*	*0*	*10*	*30*	*10*	*20*	*10*	*0*	*10*	*10*	*0*

Generalized comments and percent of respondents in parenthesis:

Not much crowding but still taking up space (37)
May have little conflict if trying to fish in the same spot or use the boat ramp (45)
Parties would be actively trying to avoid each other (18)

b. Six parties of **hunters**?

	0	1	2	3	4	5	6	7	8	9	10
Median value: *7.5* — Responses (%):	*0*	*0*	*0*	*0*	*0*	*10*	*10*	*30*	*30*	*20*	*0*

Generalized comments and percent of respondents in parenthesis:

Good at partitioning space/ avoiding each other due to dangerous sport (22)
Potential to cross sight line of other hunters (14)
Potential to scare the wildlife others sought (7)
Feeling crowded (43)
Upset if someone is in their favorite hunting spot (14)

c. Six parties of **photographers**?

	0	1	2	3	4	5	6	7	8	9	10
Median value: *1.5* — Responses (%):	*0*	*50*	*10*	*20*	*0*	*10*	*0*	*0*	*10*	*0*	*0*

Generalized comments and percent of respondents in parenthesis:

Low conflict or competition for space (43)
Could scare wildlife other sought to photograph (21)
Could have conflict if trying to photograph same thing (36)

d. Three parties of **anglers** and three parties of **hunters**?

	0	1	2	3	4	5	6	7	8	9	10
Median value: *5.5* — Responses (%):	*0*	*0*	*0*	*30*	*0*	*20*	*30*	*10*	*0*	*0*	*10*

Generalized comments and percent of respondents in parenthesis:

Only some interference (29)
Able to spread out and avoid each other (13)
Anglers could be uncomfortable if hunters are nearby or shoot near the lake (29)
Deer or waterfowl hunters may be disrupted by anglers (29)

e. Three parties of **anglers** and three parties of **photographers**?

	0	1	2	3	4	5	6	7	8	9	10
Median value: *2* — Responses (%):	*0*	*40*	*40*	*10*	*0*	*0*	*10*	*0*	*0*	*0*	*0*

Generalized comments and percent of respondents in parenthesis:

Little interaction or conflict with no threat to safety (82)
Conflict if photographing waterfowl anglers scare away (18)

Appendix 6. Continued

f. Three parties of **hunters** and three parties of **photographers**?

0	1	2	3	4	5	6	7	8	9	10
0	0	0	0	20	10	40	20	10	0	0

Median value: *6* Responses (%)

Generalized comments and percent of respondents in parenthesis:

Photographers feel uncomfortable near hunters (25)
High potential for impacting or disturbing each others photo or hunting opportunity (67)
With three parties hunting they can spread out more than with the previous 6 parties hunting (8)

g. Two parties of **anglers**, two parties of **hunters**, and two parties of **photographers**?

0	1	2	3	4	5	6	7	8	9	10
0	0	20	10	10	10	20	10	20	0	0

Median value: *5.5* Responses (%)

Generalized comments and percent of respondents in parenthesis:

Still other parties around to mess with solitude experience and potentially cause conflicts (25)
Low potential for disturbing wildlife other parties seek with only 2 parties in each activity type (17)
Photographers and anglers may still be uncomfortable with hunters around (25)
Each group has a different priority and thus have a high potential for conflict, especially if competing for same space or resource (33)

POTENTIAL ECOLOGICAL IMPACT VALUE

We want you to consider the daily potential ecological impacts of parties participating in the different recreational activities. Please imagine the worst (value = 10) ecological impact that recreational parties could cause on a PPA. Use this image to help guide your value selection for the following statements. In blue is the results from the first round of questions.

1. What is the daily potential ecological impacts caused by: (None – Highest)

a. Six parties of **anglers**?

0	1	2	3	4	5	6	7	8	9	10
0	0	10	20	40	10	0	10	0	10	0

Median value: *4* Responses (%)

Generalized comments and percent of respondents in parenthesis:

According to fisheries management theory, hook and line has little effect on fish populations (17)
Overall low ecological impacts, but could cause impacts along banks, littering, pollution (gas leaks), or disturbance to wildlife (49)
Cause stress to fish or migrating waterfowl (17)
Harvesting fish can impact size structure of fish populations (17)

b. Six parties of **hunters**?

0	1	2	3	4	5	6	7	8	9	10
0	0	0	20	20	10	20	20	0	10	0

Median value: *5.5* Responses (%)

Generalized comments and percent of respondents in parenthesis:

Hunting is seasonal, so not constant pressure (8)
Harvest oriented and can alter and impact populations or displace wildlife (54)
Potential littering (leaving shells), trampling vegetation, or disturbing wildlife (30)
Hunting bag limits are based on replaceable resource (8)

c. Six parties of **photographers**?

0	1	2	3	4	5	6	7	8	9	10
0	50	10	20	0	0	20	0	0	0	0

Median value: *1.5* Responses (%)

Generalized comments and percent of respondents in parenthesis:

Low impact and disturbance to wildlife (40)
Low potential for littering, trampling vegetation(20)
Low impact unless photographing sensitive or endangered species (20)
Potential to disturb or alter plants or wildlife to get the best picture (20)

Thank you for completing this questionnaire!