TESTING PRESENCE, ASSESSING ATTITUDES: STUDY OF A VIRTUAL TOUR IN AN "AESTHETICALLY CHALLENGED" LANDSCAPE

by

STUART JAMES STEIDLE-NIX

A THESIS

Presented to the Department of Geography
and the Division of Graduate Studies of the University of Oregon
in partial fulfillment of the requirements
for the degree of

Master of Science

March 2022

THESIS APPROVAL PAGE

Student: Stuart James Steidle-Nix

Title: Testing Presence, Assessing Attitudes: Study of a Virtual Tour in an "Aesthetically Challenged" Landscape

This thesis has been accepted and approved in partial fulfillment of the requirements for the master of science degree in the department of geography by:

Dr. Melissa Lucash	Chairperson
Dr. Carolyn Fish	Member

And

Krista Chronister	Vice Provost for Graduate Studies

Original approval signatures are on file with the University of Oregon Division of Graduate Studies.

Degree awarded March 2022

THESIS ABSTRACT

Stuart James Steidle-Nix

Master of Science

Department of Geography

March 2022

Title: Testing Presence, Assessing Attitudes: Study of a Virtual Tour in an "Aesthetically Challenged" Landscape

This thesis investigates using immersive media to explain landscape restoration efforts where the means and ends of such projects may appear risky or unsightly. I built a desktop-based, virtual tour of fire-dependent Pine Barrens restoration practices in Wisconsin's Northwoods with 360º videos and video game software. I surveyed 73 Wisconsin and Minnesota residents who were presented with either the 3D tour or a 2D website to compare the impact of each media type on people's attitudes toward prescribed fire, clearcutting, and restoration of open pine barrens. Results showed people exposed to 2D media were as likely to change their attitudes as 3D participants, but that 3D participants experienced more of the "self-location" aspect of "spatial presence." Although global attitude enhancement suggests 2D media can be as impactful as 3D technologies, the immersive tour may hold promise for persuading people who initially indicate neutral or negative attitudes toward the restoration goals.

CURRICULUM VITAE

NAME OF AUTHOR: Stuart James Steidle-Nix

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

University of Oregon, Eugene
University of Wisconsin–Madison
Australian National University, Canberra
Reed College, Portland, Oregon

DEGREES AWARDED:

Master of Science, Geography, 2022, University of Oregon
Bachelor of Arts, Cultural Anthropology, 2014, Reed College

AREAS OF SPECIAL INTEREST:

Immersive Storytelling
Spatial Humanities
Science Communication

PROFESSIONAL EXPERIENCE:

Research Assistant, UO: Dr. Leigh Johnson, Jan 2022 – Mar 2022
Analysis of social inequity in international climate adaptation projects

Teaching Assistant, UO: Department of Geography, Sep 2021 – Mar 2022
GEOG 343: Society, Culture, & Place Winter 2022
GEOG 465/565: Environment & Development Fall 2021

Research Assistant, UO: Dr. Carolyn Fish, Sep 2020 – Jun 2021
Written literature review and analysis of narrative map communication

Teaching Assistant, UO: Department of Geography, Sep 2019 – Jun 2020
ENVS 203: Intro to Environmental Humanities Spring 2020
GEOG 441/541: Political Geography Winter 2020
GEOG 142: Intro to Human Geography Fall 2019

GRANTS, AWARDS, AND HONORS:

Student Travel Award, International Association of Landscape Ecologists, 2022

SCR Small Grant Award, UO Center for Science Communication Research, 2021

Emerging Interdisciplinary Scholar, UO Center for Science Communication Research, 2020

Foreign Language and Area Studies Grant, University of Wisconsin-Madison, 2020

Tuition Scholarship, UW-Madison Southeast Asian Studies Summer Institute, 2014

Presidential Commendation for Academic Excellence, Reed College, 2012, 2013

ACKNOWLEDGMENTS

In presenting this thesis, I am truly indebted to what feels like countless people who have helped me persevere and hone my work. Every thesis takes time, during which massive support often accumulates, and this support underwrites every claim to authorship. No doubt this project has been "in construction" for an extensive period, but it also occurred on a relatively expedited timeline as some close to the work know. Given the quickened time limits, I feel there is even more significance in every one of my supporter's efforts as I extended myself to realize a project that spans academic disciplines, departmental subfields, and geography itself. Herein I honor the attention and energies they shared, as these people not only ensured that I complete a thesis, but also enriched my life experience in ways that will endure long into the future.

I wish to express my deepest gratitude to my advisor Dr. Melissa Lucash for her veritable sponsorship of my studies since "day 1" of this project. Melissa not only endorsed my ideas and interests, but strengthened my resolve to realize them in this thesis despite unexpected setbacks and prolonged pandemic uncertainties that already undermined my confidence in completing graduate school. She leads an incredibly supportive lab environment where colleagues work and learn together, and promotes collaboration across fields and universities. Two of the most awesome and effective parts of her mentorship include her welcoming me to become a member of the interdisciplinary Visualizing Forest Futures (ViFF) team, and her introducing me to other colleagues and collaborators in Wisconsin who facilitated my fieldwork. She is a communicative, kind, engaged, patient, trusting, and understanding champion of her students. Thank you, Melissa, for directing my efforts, for funding me, for sculpting this thesis, and inspiring

me to not lose hope. You have had a formative impact on my academic tenure and where it leads me.

Secondly, I wish to thank Dr. Carolyn Fish for her assistance on this thesis and for previously hiring me as a research assistant to investigate spatial storytelling from a cartographic perspective. Although this thesis was not even an idea during the time that I assisted Carolyn, the research I conducted on narrative and story were incredibly valuable for my own creative production of the immersive tour, and the lessons will serve me in the future. Thank you for your guidance as I prepared to redistribute my user study and for all the productive comments that shape this thesis and the ensuing paper. Thank you, also, for being a faculty member who is receptive to hearing creative ideas at the intersection between geography and storytelling.

Dr. Erica Smithwick, who leads the ViFF team that I was adopted into, is another creative champion of interdisciplinary science who valued and aided my work. Thank you, Erica, for wielding both vision and patience as you guide ViFF's diverse research team, and for the connections you fostered between other members and myself. I know many lives are enhanced by your commitment to comprehensive research and building partnerships within and beyond academia.

As part of the ViFF team, I also want to thank Elham (Ellie) Nasr Azadani, Jiawei Huang, and Dr. Alexander Klippel, for all of the conversations and assistance you lent me during the project design. I am grateful to Ellie for numerous zoom calls where she and I deliberated on questionnaire design and strategies for conducting the participant study. I really appreciated her collegial solidarity, her encouragement, and am honored that she wants to use my immersive tour in her research project. I want to thank Jiawei for sharing

features of her 3D forests with me – some of which I used to beautify the backdrop of the tour – and for guidance troubleshooting issues as I began to learn Unreal Engine. I want to thank Dr. Alex Klippel for feedback – including sharing examples and in-press publications – on ideas for how to construct an immersive tour quickly and efficiently.

The immersive tour would never have happened if I hadn't been able to understand and visit pine barrens first-hand with John Lampereur and colleagues of the US Forest Service. John showcased an open willingness to explain pine barrens ecology, history, and management activities. His communication and field coordination prevented many of the headaches that can easily plague a researcher pursuing new questions in an unfamiliar place. Moreover, the time in the field was fun and engaging – I savored learning the different facets of pine barrens and Northwoods natural history with him while being introduced to personnel responsible for fire management in this rare habitat. To top it off, John even volunteered time to act in a scene of the immersive tour.

Two US Forest Service fire managers – Scott Lynn and Tym Sauter – also were critical facilitators of the fieldwork for this project. Thanks to Scott for willingly discussing prescribed fire treatments, the social dimension of stakeholder input, and for plugging me into opportunities to film a live burn under the supervision of Tym Sauter! My day filming the fire with Tym and his crews was one of the most exciting things I have done in my life. I am super grateful for Tym and his crews for accepting my presence with camera gear on the site of a prescribed burn, and for ensuring that I could capture multiple angles and even aerial footage of the activities. Tym also willingly gave his time to act for a scene in the immersive tour, and we had engaging conversations on Northwoods ecology when the cameras weren't rolling.

I want to thank Brian Sturtevant for so much collegial guidance, hands-on help, and unforgettable hospitality in the Northwoods. Thank you firstly for the initial conversations that helped shape this thesis. Thank you also for facilitating a special aerial tour of the woods and lakes surrounding Rhinelander – I could never experience such thrills by just my drone alone! Thank you for sharing fire footage and encouraging my participation in the Step into Fire experience at the Great Lakes Visitor Center. Thank you for the bonfire dinner, the lakeside camping, and the hot tip on where to camp for sharp-tailed grouse sightings! Without your help I wouldn't have this crucial wildlife footage in the tour; and like the prescribed fire, filming the grouse was a personal and professional experience I'll never forget.

I want to thank researchers Paul Gobster and Kristin Floress for our exploratory conversations about the social perceptions of pine barrens in Wisconsin and their encouragement to study immersive tours for science communication. I look forward to sharing these results with you.

I want to thank Carly Lapin of Wisconsin Department of Natural Resources for sharing pine barrens insights, including where to film the enchanting "dawn chorus" of birdsong that is included in the tour. Thank you, also, for putting me in touch with graduate student and researcher Nicole Shutt, who likewise directed me toward prolific wildflower blooms near Waubee Barrens that I would never have experienced otherwise. Big thanks to Nicole, I hope her research blossoms!

Let it be known that all of the Wisconsin researchers and ecologists who directed me to different field sites also gifted me with extraordinary outdoor experiences. Wildlife don't necessarily operate on a 9-5, and I am the adventurous type who really savors the

tracking-like sensation of tuning myself to the environment to witness its riches. Some highlights include waking before dawn to hear myriad birdsong evolve for hours; nearly freezing under innumerable layers as I sat stock-still to film sharp-tailed grouse during a bone-chilling daybreak; following monarchs in blooming seas of milkweed; hearing the call of the Moquah wolf pack late one night while camping; and the perennial sense of being on a wild goose chase only to slowly encounter wild beauty all around me.

This thesis also undoubtedly relied on the awesome multimedia storytelling instruction from several professors at University of Oregon's School of Journalism. I want to thank Nikki Dunsire and Wes Pope, who spent time during and outside of classroom hours lending their expertise to my project. Thank you, Nikki, for your classes on Unreal Engine and for accommodating my extracurricular projects into your syllabus. Thank you, Wes, for your class that gave me the opportunity to think through 360º storytelling. I appreciate your instructing me on how to rig my drone in order to capture 360º footage from the sky. Thanks also for exploratory conversations and all your enthusiasm for my project. I want to thank Maxwell Foxman for our conversation early in my thesis that helped me conceive of how to motivate and direct participants in an immersive tour. I want to also thank Torsten Kjellstrand who, as a masterful storyteller, always made my ideas feel supported even when he admitted that the media at hand was beyond his expertise. He allowed me to conduct fieldwork for this project during his class, and for that I'm grateful.

I extend my deep gratitude also to the UO School of Journalism's Center for Science Communication Research, who awarded me with grant money to pursue data collection. Thank you for recognizing the merits of my research and identifying me as an

emerging scholar of interdisciplinary theory and practice in scientific communication. I would have been hard-pressed to complete this thesis without your generous support.

I am grateful to several Wisconsinites who lent valuable help even after I returned to Oregon. Thank you, Dr. David Mladenoff for your correspondence as I collected data to make the map of present-vs-historic pine barrens habitats. Thank you, also, to professors Dr. William Gartner, Dr. Qunying Huang, Dr. Jack Williams, and correspondent Joel Gruely, all at University of Wisconsin-Madison, who helped me on my trial run of distributing the user study to students at UW.

In a more personal vein, there are several people near and far whom I would like to thank for likewise nurturing me and my progress during the stages when I was both *deep in* my thesis, and *deep under* it. This support network again spans place and time, from Midwest to Pacific Northwest.

I want to thank Scott "Heggs" Hegrenes for bringing me into his home in Antioch, Illinois, which was a true retreat that allowed me to venture northward on fieldwork, to focus deeply, and to blow off steam to the beat of my own drum. I'm forever grateful for your supreme hospitality, adoption into your band, your friendship, your playful and upbeat demeanor, and for the invitation to the best wedding I've been to yet! I hope the fish are biting, Big Gulp!

I want to similarly thank Lexi Lyons and the ever endearing Eloyse Lyons who never batted an eye at making me feel like family during my sojourn to and from the Midwest. You both have such incredible generosity of spirit, humility, and a world-roving eclecticism that always resonated deeply with me. I cherish that summer in La Grange with you. Additionally, I'll never forget your unique presence, your golden

company, and your gregarious yet tender nature, Eloyse – you leave a legacy in a society bereft of relationships with elders, and I am honored to have been graced by it. Blessings to your family.

I want to thank the inimitable Leilagh Boyle who was my confidante and bridge to so much in the Midwest and beyond. You sent me heel-clicking to Chicagoland and back, and showed up in the best ways that you could throughout our journeys. Though I'm open to wearing the hat of a scientific storyteller, I'm always touched by a mystery – thanks for weaving one with me. I carry many a touchstone of our adventures forward. Thank you for letting me rove in your Subaru through many miles of fieldwork on and off-road. May the road less traveled expand before you.

I want to thank current Geographers and friends in Eugene who embodied such positivity and generosity in cheering me on and lending a hand to see this work come to fruition. Thank you, James Lamping, Shelby Weiss, Alison Deak, Thomas Brussel, Teagan Furbish, Neil Williams, and Janice Chen for your camaraderie and support at UO during this time. Tom joined me in my first field excursion and was a willing and helpful assistant as I conducted interviews and tried to keep track of photo points during a full-day tour with John Lampereur and Scott Lynn. Tom and Shelby also provided great brainstorming partners when pouring over the data from the analysis, thank you, both! Alison, you helped me *immensely* with wrapping my head around R in order to make some (dare I say?) stunning charts – thank you! Thank you, James for kickstarting my first data forays with R; thank you, also, Janice, for sharing your time and expertise with coding when I was a fretful novice at data wrangling. Thank you, Teagan, for helping me as I designed the 2D stimuli and assembled the questionnaire. Thank you, James, again

for also helping with the 2D website set-up and initial map creation. Thank you, Neil, for your kind, collegial support, I hope we get to enjoy the outdoors on your return to Oregon!

Additionally, I am so grateful to the friends who supported me when (ie. always) schoolwork spilled over far beyond the bounds of campus. I can always find safe harbor amidst choppy seas by the reliable love and support of Nate Douglass, Ian Connelly, and Emma Levy. I'm grateful that each one of you helps me put the beat in my feet, that we share and grow our worlds with sincerity, humility, and joy. I'm glad each of you are in my life to see me through this crucible! *Here's to many more bonfires, sparkles, and adventures!*

Thank you to these friends and colleagues and others within UO Geography who trialed the initial versions of the immersive tour and provided helpful input from an audience perspective.

Thank you to my brother, who always has my back and who sets the bar as a personal champion, who celebrates my experiments, my new attempts, my u-turns, and budding visions, no matter how eclectic. He's the one who put a camera in my hand so many years ago, and we are the closest of kin.

This is dedicated to the land, from which we come and to which we all shall return.

It is also dedicated to you, “Baba,” since you fostered my bond with the lands and the waters.

TABLE OF CONTENTS

Chapter Page

Chapter Page

LIST OF FIGURES

Figure Page

LIST OF TABLES

CHAPTER I

INTRODUCTION

This thesis is a novel methodological intervention into the efforts of state and federal natural resource managers working to communicate and gain public approval for restoration of a unique yet underappreciated habitat in the woods of northern Wisconsin. The challenge of restoration revolves around building approval for intensive procedures like clear-cutting and prescribed burning, even as these practices and the open habitats they produce may disrupt stakeholders' sense of place given their attachments to a forested landscape. The study combines the new media tools of 360º videos and video game software with place-based scientific narrative to virtually guide people through fire-fueled landscape restoration practices in Wisconsin's Northwoods. Specifically, this study investigates the ability of immersive geovisualization – in the form of a virtual tour – to enhance approval of landscape management in a national forest where commonly held "aesthetic values" often conflict with restoration goals and "ecological values" (Gobster 1996; Pukis 1997).

1.1 Pine Barrens Restoration

In pockets of the densely forested and fabled Northwoods, Wisconsin resource managers recognize the state's unique opportunities to re-introduce an endangered habitat known as Pine Barrens. Historically predominant across the sandy glacial deposits of northern and central Wisconsin, pine barrens are open habitats dependent on low-intensity fires. Although at times punctuated by fire-pruned pine groves, they generally only harbor a few trees per acre. Pine barrens once covered an estimated 7% (Curtis

1959) of the state, yet their footprint has reduced by 99% due to a century of fire suppression and afforestation (Figure 1.1).

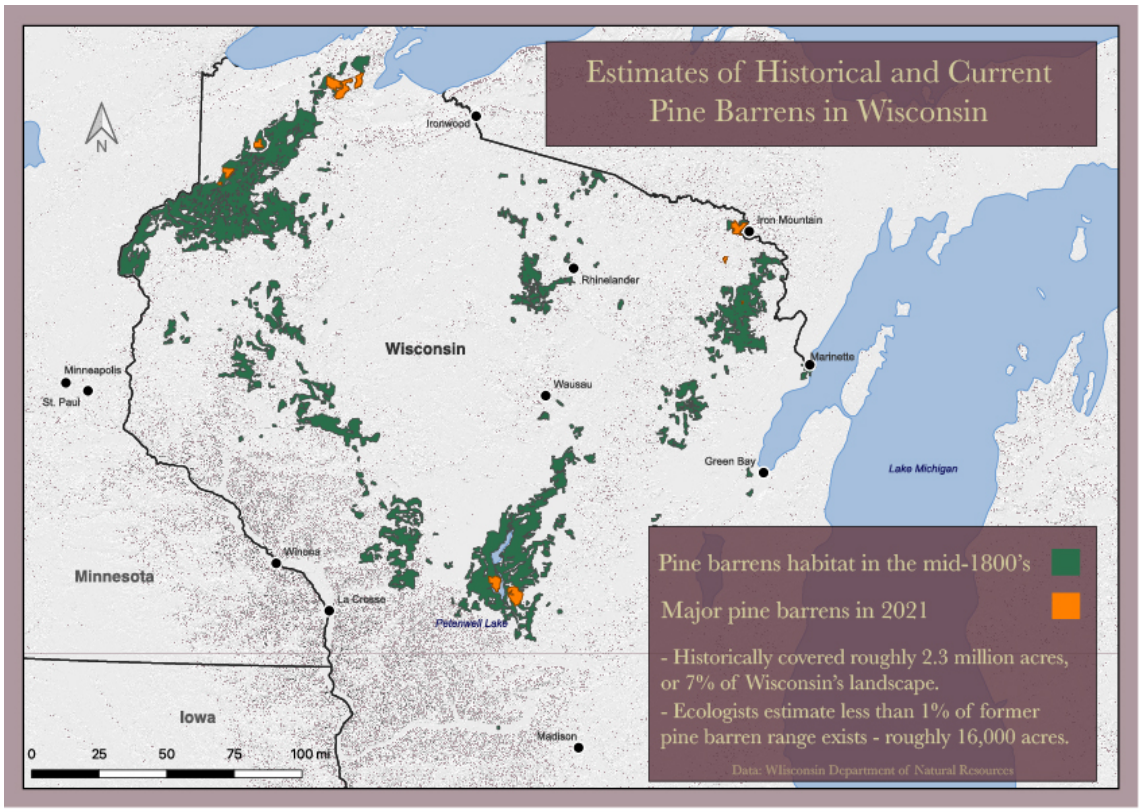

Figure 1.1 Map indicating estimated current spatial extent of pine barrens and their range in the mid-1800's before full European settlement. Map by: James Lamping and author.

Pine barrens are an imperiled niche habitat rich with biodiversity whose restoration potential relies on collaborations between both public stakeholders and professional conservation ecologists, forest managers, and fire wardens. The Wisconsin Department of Natural Resources recognizes 52 rare species of wildlife that are heavily or seasonally associated with barrens in combination with 14 rare native plants[1] – all of these are considered "species of greatest conservation need" by the Wisconsin DNR

[1] An additional 37 rare animals and 4 rare plants are ranked as having a "low association" with pine barrens.

(Wisconsin Department of Natural Resources 2021). This scope of flora and fauna is one reason that different groups within the Wisconsin DNR, local county agencies, and federal staff of the US Forest Service are all engaged in various pine barrens restoration projects across Wisconsin, mostly in the Northwest and Northeast Sands ecological regions where pine barrens once predominated. Their historic presence and biological assets, though, are undercut by a century of afforestation and fire suppression that has informed public perceptions of the Northwoods as densely forested. Making space for pine barrens restoration relies on clear-cutting portions of forest and subjecting the cleared land to a natural disturbance that relatively few in upper Wisconsin view as a natural or regular component of the landscape: that is, fire. Yet as tree scars reveal, fire return intervals historically averaged between 6-30 years in different barrens locations (Guyette et al. 2016). Hence, prescribed fire must be applied regularly on timetables set by managers in order to ensure pine barrens' long-term viability. The lack of public familiarity with fire in northern Wisconsin is mirrored by regional gaps in the state's fire applications where agencies could conduct more prescribed burns according to scientific analyses (Hmielowski et al. 2016). Moreover, Wisconsin's densely stocked forests – much like fire-suppressed areas of western states and elsewhere in the US – would be less vulnerable to wildfires if treated with low-intensity prescribed fire. Introducing open habitats like pine barrens with less woody fuel into the landscape would doubly serve this purpose while also restoring a diminished and important habitat. As such, this restoration case study's potential relies on winning public approval for drastic landscape change and re-calibrating local notions of "appropriate" ecological processes (see Gobster 1996).

This thesis spawns from understanding that forest managers and scientists alike are negotiating these social determinants of forest character through dialogue and research. Social factors are central variables given contemporary forest management policies premised upon multiple-use objectives meant to satisfy variable, at times divergent, public needs and values. In February 2021 I spoke with Chequamegon-Nicolet National Forest (CNNF) silviculturist John Lampereur of the Lakewood District on exactly this issue. He explained that his staff's 2014 efforts to introduce plans for restoring and modifying ~36,000 acres of mixed-forest habitat in the CNNF – at least 800 acres of which were devoted to pine barrens restoration – met harsh criticism from landowners opposed to prescribed fire on nearby national forest land. Lampereur and others saw that efforts to broadcast their plans with full transparency and disclosure of the ecological rationale and practical benefits did not incur strong public support. Subsequent public research done in collaboration with social scientists Paul Gobster, Kristin Floress, and others found that pine barrens were "aesthetically challenged" in the eyes of local stakeholders compared with more mixed- and full-canopy landscapes (Floress, Haines, et al. 2018b; Gobster, Arnberger, et al. 2021). Moreover, their surveys indicated that a relative minority felt comfortable with communication efforts, planning efficacy, and the restoration vision of USFS agency personnel (Floress, Haines, et al. 2018b, 20–22).

Gobster and Floress both agreed – as did USFS research ecologist Brian Sturtevant working in NW Wisconsin's Moquah Barrens – that interactive, 3D-media would be a boon for conveying the assets of pine barrens while broadening spatial perception beyond 2D images. As such, **this thesis investigates attitudinal change through novel geovisualization as a case study on the tension between ecological**

values and aesthetic preference in nationally-managed forests. It specifically focuses on **understanding benefits of immersive media to explain landscape restoration where the mechanisms and outcomes of such projects may appear unfamiliar, risky, or unnatural to people**.

1.2 The Geovisualization Itself

Geographers and landscape designers have been interested for decades in technological advances that allow people to create photo-realistic 3D renderings for better visualization and comprehension of spaces and places, arguing that more life-like communication tools can change behavior (Niepold, Herring, and McConville 2008; Meitner, Gandy, and Sheppard 2005; Sheppard 2005; Fisher and Unwin 2002). Today virtual reality (VR) is becoming more ubiquitous, yet I refer more to immersive media rather than VR because "immersion refers to the technological qualities of VR media" (Hruby et al. 2020, 156), and this includes even media like 360º videos that are not technically *virtual*, which is to say designed by computer graphics (see also Klippel et al. 2020). As Jeremy Bailenson explains, "For purists, VR requires motion tracking and digitally created environments that can be moved through" (2018, n.p. Introduction). This thesis includes a desktop-based immersive tour, or geovisualization, of pine barrens habitat restoration. The tour portrays phases of clear-cutting and documentation of a "live" prescribed burn, both of which are key landscape treatments for restoring pine barrens in areas where they once existed but are now heavily forested. These are integrated with scenes showcasing the eventual environmental shifts that occur as pine barrens develop, along with some of the signature wildlife and other scenic assets of pine barrens people may be unfamiliar with. I created the tour by using 360º videos to

document these scenes before integrating them with interactive narrative elements in a video game software (Unreal Engine) that allows for a user-guided, photo-realistic immersive desktop experience. Like Klippel et al.'s focus on nurturing a "*sense of place*" through immersive, place-based learning (2020, 449 emphasis in original), I aimed for my immersive tour to create a sense of "presence" or the subjective "sense of 'being there' in a mediated environment" (Li, Daugherty, and Biocca 2002, 44). Presence – particularly, spatial presence, in contrast with a corollary sensation also wrought through immersive, *peopled*, environments, "social presence" (Pimentel et al. 2021) – is one of the most researched explanatory factors for the persuasive powers of immersive media (Filter et al. 2020; Breves and Heber 2020; Fraustino et al. 2018; Aitamurto et al. 2018; Hruby et al. 2020; Klein 2003; Laarni et al. 2015; Skarbez, Brooks, Jr., and Whitton 2018; Lombard and Ditton 1997). Given that presence can make media presentations so impactful, I included a questionnaire to elicit people's experience of it in my between-subject user study on the impact of media interventions upon attitudes toward pine barrens restoration practices.

1.3 Research Question and Hypothesis

With this empirical and theoretical basis, the following research question guides the study:

> *To what extent does an immersive media tour of pine barrens affect attitudes toward clear-cutting and prescribed burning for pine barren restoration purposes – as well as pine barrens themselves – when compared to conventional, 2D media consisting of text and photographs?*

My hypothesis was:

> *An immersive tour using interactive 360° videos will enhance attitudes towards clearcutting, prescribed burning and landscape restoration of pine barrens more than conventional media due to higher "spatial presence."*

CHAPTER II

CONCEPTUAL BACKGROUND

This chapter introduces readers to the general problem of conveying the ecological rationale for restoring a rare and generally underappreciated habitat through intensive procedures such as clearcutting and prescribed burning. One confounding factor for landscape managers resuscitating imperiled habitats is the potential disruption to stakeholders' sense of place given their attachment to an existing – in this case, forested – landscape. These conditions help frame the case study at hand, which centers on pine barrens in northern Wisconsin. This chapter aims to inform readers of the ecological characteristics of pine barrens, the relation of stakeholder input to restoration projects, relevant research into public attitudes, and the persuasive capacity of immersive media. An important facet of managerial challenges regarding stakeholder engagement is the contradiction between the ecological value of pine barrens and their comparatively (perceived) un-scenic qualities when compared with people's attachments to a forested Northwoods aesthetic. Using immersive media to convey the means and ends of pine barrens restoration is an attempt to overcome this perceptive and evaluative gap, and potentially provides a basis for further use of this media technology for similar contexts.

2.1 Pine Barrens Natural History and Current Restoration Conditions

2.1.1 Pine barrens ecology

Pine barrens are a globally rare habitat type similar to savannas or prairies that have dwindled in the upper Midwest since 19th century European settlement and ensuing combinations of fire suppression and afforestation (Eckstein 1995; Gobster, Schneider, et al. 2021; Radeloff, Mladenoff, and Boyce 2000; Epstein 2015; Lampereur 2013). The

habitat's former extent across the Great Lakes region included not only Wisconsin but also parts of northern Michigan, Minnesota, New York, and southeast Manitoba and eastern Ontario in Canada (Pregitzer & Saunders 1999 as cited in Gobster, Schneider, et al. 2021, 2). Recent estimates of their range in Wisconsin paint a picture of drastic habitat loss. United States Forest Service (USFS) personnel wrote in 2013 that roughly 10,000 acres exist in scattered areas across the state (Lampereur 2013). Elsewhere, Wisconsin Department of Natural Resources (DNR) naturalist Eric Epstein (2015) estimated that the state retains only a few thousand acres of pine barrens habitat. Although Epstein noted that "several thousand more […] are potentially restorable," this sum still constitutes a mere 1% of their estimated historic footprint of 2,349,000 acres at the onset of Euro-American settlement in Wisconsin (Epstein 2015, 95; Eckstein 1995, 102). Pine barrens therefore rank high in terms of global and regional vulnerability according to the WDNR's Natural Heritage Inventory; they carry a global label of "G2" and a state label of "S2," both indicating imperilment or "high risk of extinction" due to scarcity, "steep declines, severe threats or other factors" (Wisconsin Department of Natural Resources n.d.). Against historic losses and recent pressures on the state's pine barrens (compare, for example, their threat designation in Eckstein 1995), conservation managers are attempting to collaborate across study areas to better understand efficient and viable applications of fire and best practices for increasing public interest in these habitats.

Pine barrens' fire regimes generated a unique diversity of grasses, sedges, and flowering plants and herbs that help distinguish their niche as a habitat for birds, mammals, pollinators, and insects alike. In short, the sun-fed, fire-adapted understory is a signature of barrens. In a 1959 study of plant Wisconsin plant communities, Curtis (1959)

noted that barrens have an "extraordinary development of shrubs" that far exceeds any other Wisconsin habitat, with redroot and huckleberry reaching "their maximum Wisconsin levels in this community" (cited in Eckstein 1995, 99). Blueberries, though, were most noteworthy in his account, and still today managers describe their prolific growth following application of fire. A thorough account of the biotic communities is given in Epstein (2015). Ecologists emphasize that restoring these habitats will provide important niche habitats for numerous native animal and plant species of concern (P. H. Gobster, Schneider, et al. 2021; Radeloff, Mladenoff, and Boyce 2000; Epstein 2015; Lampereur 2013). Wisconsin DNR identifies over 52 animal and more than 14 plant species of high conservation concern that rely on pine barrens habitats or are often associated with them (Wisconsin Department of Natural Resources 2021).

Pine barrens – and their counterparts in southern Wisconsin, oak barrens – are unique not only for their biological diversity, but also for their dynamic composition. Eckstein wrote that they are "difficult to describe and classify" for their shifting mosaic nature, which is reflected in a litany of descriptive labels by early surveyors: "pine-oak woodland," "pine brush," "level prairie," "brush prairie" to name a few (Eckstein 1995, 98). Although biologically diverse, pine barrens may be characterized as "open landscapes on sandy soils that are subject to frequent fires" with a scattering of trees dominated by a preponderance of grasses and shrubs (Lampereur 2013, 17). Still, Epstein (2015) emphasizes ecologically-relevant differences among "patch sizes and age classes," and that this heterogeneity is lost when managers tend "to manage individual stands as static entities in space and time" (98). For instance, tree groves can punctuate barrens habitats even as barrens are overwhelming considered an open-canopy landscape. Like

any landscape, these patterns in the land shift with time, especially given the semi-frequent fire return intervals ranging from six to 30 years prior to European settlement in northern Wisconsin (Guyette et al. 2016; Lampereur 2013).

Pine barrens' general lack of trees is described in archival accounts of early surveyors who recorded as few as four or five trees per acre[2] on lands that are now cloaked in forest.[3] Jack pines (*Pinus banksiana*) were the dominant trees in pine barrens, often growing in even-aged, sometimes dense, stands. Other trees commonly associated with the habitat are northern pin oak (*Quercus ellipsoidalis*) and red pine (*Pinus resinosa*) (Epstein 2015, 96). Due to a century of fire suppression, "the vast majority of barrens vegetation […] have succeeded to forest, typically with high canopy closure" (Epstein 2015, 98). Managers of this canopied landscape look to the social archive and the natural record to identify former stronghold areas where pine barrens restoration is appropriate (Lampereur 2013) (Figure 2.1). Approved projects rely on logging, prescribed burns, and sometimes herbicides to revert a century of forest growth and re-adapt its cycles to fire.

[2] For reference purposes, an acre is roughly the size of an American football field without the end-zones. A full American football field is roughly 1.32 acres.
[3] John Lampereur (USFS Chequamegon-Nicolet National Forest Lakewood District silviculturist), interview with author, April 23, 2021.

Figure 2.1 USFS personnel inspecting restoration site. Fire manager Tym Sauter (Left) and silviculturist John Lampereur (Right) walk through a densely stocked area of forest in the Lakewood District of the Chequamegon-Nicolet National Forest that once hosted highly frequent fire return intervals (as little as six years) and is a viable site for pine barrens restoration. Photo by author.

Figure 2.2 A snapshot of Dunbar Barrens. This view typifies the open landscape and grassy understory characteristics of pine barrens. Photo by author.

Wisconsin's historic pine barrens occurred most predominantly in the northwestern, central, west central, and northeastern regions where glaciers deposited massive amounts of sands and sandy loam. These soils typically lack water retention and are low in nutrients (Epstein 2015; Lampereur 2013; Eckstein 1995), yet host diverse drought- and fire-tolerant plant species that nourish a rich biome. Most remnant pine barrens, whether managed by state or federal agencies, are sprinkled across two particular ecological landscapes of northern Wisconsin, the Northwest Sands and the Northeast Sands (Figure 2.3). Today the most ecologically viable patches of Wisconsin's northwestern pine barrens occur at Moquah and Namekagon Barrens, although Radeloff (2000) also describes Crex Meadows and the Douglas County Wildlife Area as open areas managed with fire that demonstrate mixed characteristics of barrens. All of these are managed by state or county conservation officials except Moquah Barrens which is inside the Chequamegon-Nicolet National Forest (CNNF) and managed by the USFS. Moquah is the largest extent of barrens in the state. It has enough varied open habitat to suit the 10,000-acre needs of the sharp-tailed grouse, a species of high conservation concern (Radeloff, Mladenoff, and Boyce 2000).

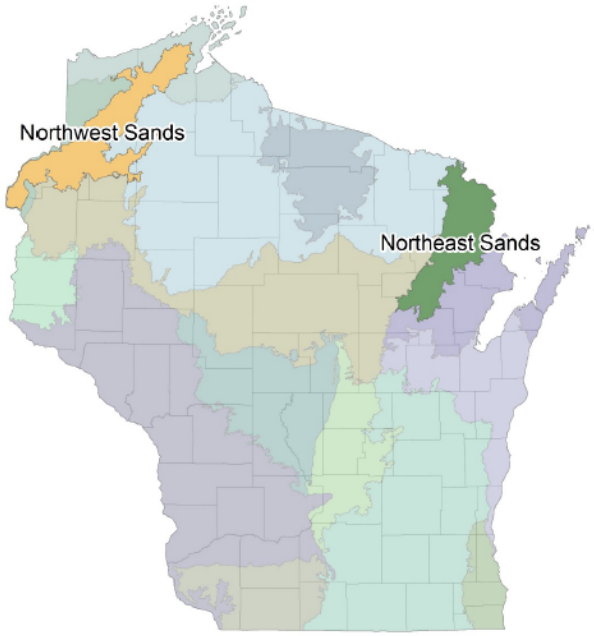

Figure 2.3 Northwest Sands and Northeast Sands Ecological Landscapes (Wisconsin Department of Natural Resources 2015 as cited in Sturtevant, Kern, and Donner 2016).

Notable areas of the Northeast Sands ecological landscape that contain a portion of barrens characteristics, albeit disrupted or incomplete, include state-managed Dunbar State Wildlife Area, Spread Eagle Barrens, and the more southerly Athelstane Barrens. In addition, the USFS recently set about restoring around over 800 acres of barrens habitat near Waubee Lake in the CNNF as part of the "Lakewood Southeast Project" (Lampereur 2013). Like Athelstane Barrens, the Lakewood Southeast Project is an area of utmost restoration value (five stars) within the Wisconsin DNR's Land Legacy project that catalogs the state's most significant sites for ecological and recreational potential (Wisconsin Department of Natural Resources 2006; Lampereur 2013, 17; Wisconsin Department of Natural Resources 2015, 43). Although pine barrens restoration is a notable part of the project, more acreage in the project is allotted to less intensive

treatments (ie. prescribed burns and mechanical thinning without clearcutting) to simply thin pine stands according to historic standards.

2.1.1.1 Pine Barrens in this Study

Since the visual elements of the communication stimuli in this thesis are designed to convey both the standard and noteworthy assets of pine barrens, fieldwork took place across most of the sites outlined above. Nevertheless, much of the work is both grounded in and informed by coordination with John Lampereur and USFS fire managers responsible for Waubee Barrens activities in the Lakewood Southeast Project of the CNNF. The following section explains the history of pine barrens elimination before describing current restoration practices.

2.1.2 Cultivating the Northwoods: Settlement and Afforestation

Reduction of pine barrens occurred gradually from a complex interplay of land settlement and ecological changes wrought through widespread "cut and run" logging, severe fires, newfound forestry policies to suppress fire, and state-sponsored tree planting (Lampereur 2013; Epstein 2015; Eckstein 1995; Radeloff, Mladenoff, and Boyce 2000; Stearns 1997). Wisconsin led the country in pine timber production in the later 19th century (Lampereur 2013; see also Stearns 1997), and "slash from the harvesting operations fueled extensive fires" (Radeloff et al. 1999, 1651). Northern Wisconsin was increasingly settled as farmers took to these cleared lands advertised by timber companies, even into the early 20th century when logging shifted to hardwoods (Stearns 1997, 11; Radeloff et al. 1999, 1651; Wilson 1982, 19). Fire intensity appears at this time to differ from historical patterns given the extent and intensity of industrial activities – beside the tinderboxes caused from logging slash, railroad operators used fire to clear

land for tracks, sparks from trains ignited fires, and railroad employees often burned discarded rail ties. The deadliest wildfire in US history, the Peshtigo Fire of 1871, began from such activities before incinerating 1.2 million acres in northeast Wisconsin and claiming over 1,200 lives (Hultquist n.d.).

Afforestation in the Northwoods began in the first decades of the 20th century and took firmer root by the 1930's. Wisconsin's first state forester E. M. Griffith (1903-1916) sought to expand Wisconsin's forests through fire suppression, protection of second-growth stands, and expansion of state forest reserves. Inspired by his time in Europe, Griffith also sought to increase forests for their recreational promise. His praise for northern Wisconsin as "one of the most wonderful lakes regions in the world" (Wilson 1982, 16) was a prescient take on the eventual cultivation of tourism in the Northwoods as an idyllic, forested getaway (see Shapiro 2013). Though slow at first, Griffith's fire-suppression agenda gained traction after 1910 with increased investments in fire lines, higher pay for fire wardens, lookout towers, and road and telephone infrastructure (Wilson 1982, 36–42). During Griffith's tenure, 183,000 acres of forest reserves were established, a template for tree nurseries and plantations was created, and the vision of counties establishing forest preserves from derelict timberlands was born (Wilson 1982; Wisconsin Conservation Hall of Fame Foundation, n.d.; Auer 2011).

Landownership in the Northwoods progressively shifted toward small-scale agriculture until widespread bankruptcy of the 1930's that placed tax-delinquent lands largely in the control of county or federal officials (Radeloff et al. 1999; Lampereur 2013; Stearns 1997; Wilson 1982). In 1933 the Chequamegon and Nicolet National Forests were established, covering over a 1.5 million acres across 12 counties in

northwestern and northeastern Wisconsin. Alongside Wisconsin state support of county-level zoning for forest preserves, the federal government oversaw mass tree planting campaigns in the national forests as part of the Civilian Conservation Corps' (CCC) activities (Stearns 1997; Lampereur 2013, 12).[4] The furrowed rows of tree planter efforts are still visible today even in Moquah Barrens and Waubee Barrens, the latter being the major site of field research for this study. In the area around Waubee Barrens in the Lakewood District of the CNNF, Lampereur notes that the CCC planted over 3 million trees across 3,200 acres while also fighting fires. "By all available evidence," according to Lampereur, "most of the forests in the [restoration] project area are now far more densely stocked than they have been in the past 160 years" (2013, 12).

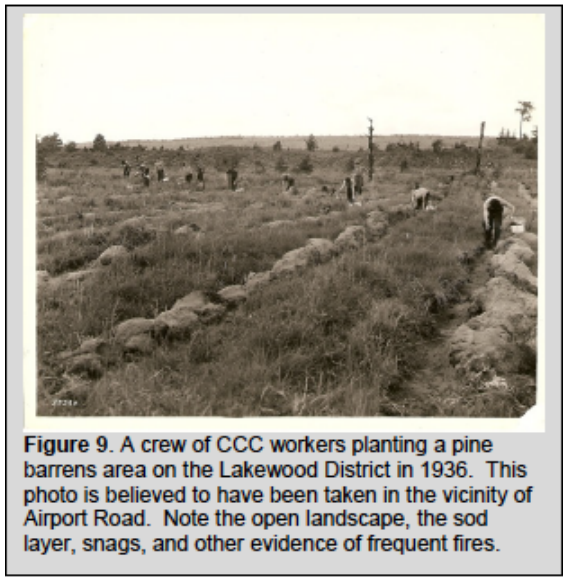

Figure 2.4 Archival photograph of tree planters in today's Lakewood District of the CNNF. Source: Lampereur 2013, 12.

[4] The Chequamegon and Nicolet national forests are spatially separate but have been managed as one since 1993.

2.1.3 Tools for Restoration

Restoring pine barrens relies upon practices that will, for all intents and purposes, rewind the past century of forest maturation and industrial habitat disturbance (Gobster, Schneider, et al. 2021; Gobster, Arnberger, et al. 2021).[5] The main tools used for these purposes include timber harvesting ("mechanical thinning"), re-applying fire ("prescribed burns"), and in some cases using herbicides to kill off particularly durable species like oaks that easily re-sprout. For new pine barren restoration sites, such as the Waubee Barrens in the CNNF's Lakewood District, mechanical thinning takes the form of clear-cutting in order to create a drastic opening in the landscape. Through these intensive treatments, managers practically cull the forest – and thereby the aesthetic "lure of the Northwoods" (Shapiro 2013) – and sustain the changes through applying something (fire) that was long deemed a threat to public forests.

Fire, though, is a strong environmental fuel for diverse plant communities. Ecologists recognize that numerous native forbs and grasses easily repopulate these habitats, yet are still trying to understand how to achieve the right regimen of fire application and frequency in order to keep specific balances of native grasses and shrubs. Some areas like Dunbar and Spread Eagle Barrens are dominated by non-native herbs and host more ferns than would be expected from archival accounts of barrens – technically portions of these habitats could be deemed more of a bracken grassland (Wisconsin Department of Natural Resources 2015, 17; Lapin 2019).[6]

---

[5] John Lampereur, USFS Chequamegon-Nicolet National Forest Lakewood District silviculturist, interview with author, February 2021. Brian Sturtevant, USFS research ecologist, interview with author, February 2021.

[6] Carly Lapin, [title with WDNR], personal communication Summer 2021.

Although fire is the primary treatment used by forest managers to sustain these landscapes, prescribed burns cannot take place until "mechanical thinning" or logging takes place. Managers explain that the combination allows for a balance of safety and productive forestry, whereby overly dense forests are milled and fuels are likewise reduced. USFS fire manager for the Lakewood Southeast Project Scott Lynn explained that fire is too hazardous and liable to escape control if applied to dense stands, but that fire bosses can better choreograph fire's spread when woody fuels are removed.[7]

Waubee Barrens managers in the Lakewood district of the CNNF chose to clear the "slash," or logging debris, after clear-cutting, but not all managers follow this procedure. The different management choices reflect considerations of aesthetics, the age of a restoration site, ongoing research on fire behavior, and seasonal restraints on the capacity of fire crews. Waubee managers attempted to account for any potential public disapproval of "messy" logging debris after consultations with the public and with similar open-habitat initiatives across the state.[8] During fieldwork, Lampereur and USFS fire manager Scott Lynn also explained that leaving the slash to burn could increase the fire intensity in ways that weren't productive or desired. These decisions were made partly to account for nearby stakeholder preferences and attitudes. Their considerations of the public further reflect the demographic differences they encounter relative to the even more sparsely populated areas further north where managers at Moquah Barrens follow different procedures. At Moquah, USFS research ecologist Brian Sturtevant explained that barrens managers do not "masticate" (mechanically dispose of) the slash, but instead

[7] Scott Lynn (USFS fire manager), interview with author April 23, 2021.
[8] John Lampereur, interview with author, April 2021.

burn it in the prescribed fire application. Some of the areas I witnessed in Moquah that were ready to burn didn't include the same appearance of logging debris as at Waubee barrens. The oaks were small, which makes sense since Moquah Barrens has been actively managed for decades – Waubee Barrens, being a newer restoration site, included larger debris piles due to relatively recent initial "first cuts" into the dense forest. The persistence of these oaks at Moquah partly explain why managers there are studying the effect of burning the slash, too. Sturtevant and others are interested in understanding the intensity of below-ground heat given more above-ground fuel, with the hope that oak roots will be more severely impacted and killed back through higher applied heat (Sturtevant, Kern, and Donner 2016). If roots are not killed then the burn results in a "top-kill" and the tree can grow back later in the year through their roots. Burning slash in the spring is an attempt to account for the fact that fire managers miss what is botanically a very impactful time to burn – that is, summer, when oaks are less resilient to fire – since fire crews are increasingly sent to the fight wildfires in the western US and thereby undermine prescribed burn capacity (and safety) in Wisconsin summers.[9] The seasonal limitations show some of the difference between current fire regimes and those year-round applications by Native stewards of the landscape (Guyette et al. 2016). One of the shortcomings to modern fire practices, according to some, could be that limited fire return intervals decrease the likelihood that restoration projects will match historic records.[10]

---

[9] Brian Sturtevant (USFS research ecologist), interview with author, June 2021. Tym Sauter (USFS fire manager), interview with author, July 2021.
[10] Carly Lapin (Wisconsin DNR biologist), interview with author, July 2021.

Given the peculiarities and dynamic patterns of the most healthy pine barrens, some researchers emphasize the need for large-scale landscape interventions to help connect barrens patches and allow for their more historically accurate mosaic patterns to emerge and shift over time (Epstein 2015; Radeloff et al. 1999; Wisconsin Department of Natural Resources 2016, 21). Barrens' complexity is underscored by these naturalists who also explain that the habitat's biodiversity and ecological viability is reduced when they're managed as static "islands." This landscape-scale priority reflects broader trends in ecosystem management nationwide congruent with the integrated processes of natural systems (Floress, Connolly, et al. 2018; Palmer et al. 2004). Similarly, the bid to expand the scope of these projects also invites public approval or criticism, especially in northern Wisconsin where private land adjoining national forests is increasingly parceled, fragmented, and developed (Wisconsin Department of Natural Resources 2015; Thompson 2018).

2.2 Multiple-Use Public Lands Management and Stakeholder Attitudes

2.2.1 Managing for expectations: stakeholder engagement

In the United States, environmental management is increasingly done at the landscape-scale in ways that require the collaboration and buy-in of multiple agencies and publics (Floress, Connolly, et al. 2018; Floress, Haines, et al. 2018b; Rickenbach et al. 2011). Management objectives in these contexts are shaped by historical and contextual prioritizations of commercial production, environmental preservation, and ecological restoration (Brunson et al. 1996; P. H. Gobster et al. 2007). In this vein, the USFS endorsed the more socially-conscious paradigm of "ecosystem management" in 1992 (Rogers 1996). This entails adherence to multiple-use guidelines meant to account

for diverse values and needs held by individuals and groups in society (Brunson 1996; Rogers 1996). Still, achieving legitimate multiple-use conditions is a challenge that compels researchers and managers alike to make sense of the variable, even contradictory, attitudes, values, and beliefs that make up and disrupt "social acceptability" of management plans (Brunson et al. 1996; Floress, Connolly, et al. 2018; Stankey and Shindler 2006). These aspects of landscape management and stakeholder engagement bear upon activities of managers responsible for promoting and overseeing pine barrens restoration.

Given the current paradigm of public accountability for forest management plans, this thesis uses the term "stakeholders" to focus more specifically on the non-managerial contingent of individuals who have interests in using, visiting, and enjoying public lands. Stakeholders in this case include both nearby residents of national forests – whether seasonal or permanent – and visitors.

2.2.2 Attitudes

Attitudes entail positive or negative evaluation of an object (Eagly and Chaiken 1993; Petty, Wegener, and Fabrigar 2006; Crano and Prislin 2006), and therefore provide an inlet to social acceptability that researchers, ecosystem managers, and landscape architects have used to assess public dis/approval on different forms and intensities of fire management (Absher, Vaske, and Shelby 2009; Loomis, Bair, and González-Cabán 2001), mechanical thinning (Tahvanainen et al. 2001), and landscape alteration (Cranmer et al. 2020). Attitudes are popularly seen as having affective (emotional) and cognitive (beliefs, knowledge) dimensions that, while dynamic, may mediate between general

value orientations and resulting behavior and decision-making (Whittaker, Vaske, and Manfredo 2006).

Social psychological research into attitudes is often associated with cognate research on persuasion and communication, even as the concept of attitudes has been deconstructed over the last two decades. For instance, the traditional arc of attitude research in the 20th century treated attitudes as "fixed 'things' [in memory] waiting to be pulled out, used, and put back in place" (Banaji and Heiphetz 2010, 357). A constructivist view of attitudes today realizes they instead may be partly implicit, and even "formed when needed, rather than enduring personal dispositions" (Schwarz, 2007, 639, as cited in Banaji and Heiphetz 2010, 357). In other words, "attitudes can be short-term or long-term" (Alice H. Eagly and Chaiken 2007, 585). More specifically they may be flexible, and open to persuasion through informed learning and experience. People also may hold one or more attitudes toward an object and their expression of these attitudes may change given different contexts (Ajzen 2001, 29). All of these characteristics inspire researchers to analyze both the latent components or antecedents of attitudinal strength (Visser, Bizer, and Krosnick 2006), and what communication methods can impact and enhance attitudinal responses (Crano and Prislin 2006). Unpacking the components of "strong attitudes" has long been guided by academic interest in the power of attitudes to influence "perception, cognition, and behavior" (Visser, Bizer, and Krosnick 2006, 2). Notwithstanding these developments, the priority of attitudinal research still focuses on an evaluative response to a given entity (or "attitude object"), which analysts may attribute to some combination of longer-term learning or experiential "residue," shorter-term contextual factors, and more overtly cognitive or emotional internal resources.

This thesis uses Eagly and Chaiken's definition of an attitude as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (Alice Hendrickson Eagly and Chaiken 1993, 1). Eagly and Chaiken use this definition to distinguish the expression – ie., a person's vocal statement or written response – from the inner, evaluative tendency. They explain that the evaluative response "reflects a whole range of influences in addition to those that emanate from the inner tendency," which itself is composed of "mental residues of past experience with the attitude object" (Alice H. Eagly and Chaiken 2007, 586–87).

2.2.3 Construal Theory

Construal Level Theory is useful in helping to explain the evaluative tendencies people bring to bear on an attitude object as a function of their familiarity with or sensed distance from that object (N Liberman, Trope, and Stephan 2007). Construal level theory explains that the more that people feel temporally, spatially, or socially distant from a target object or event, the more they mentally construe its features in the abstract and the less certainty it holds. Conversely, people who feel closer to an object through temporal, spatial, or social experience, the more they mentally construe its specific qualities and assume a higher level of certainty for events (Fujita et al. 2006; Nira Liberman and Trope 2008). Numerous studies, moreover, have found that the spatial, temporal, social, and hypothetical dimensions of psychological distance tend to be associated (Nira Liberman and Trope 2008; R. W. Hamilton and Thompson 2007; Spence, Poortinga, and Pidgeon 2012).

Although people rely on abstract and concrete construal in tandem, some research indicates that attitudes formed from direct experience are stronger, more enduring, and

more predictive of behavior (Fazio and Zanna 1981; Wu and Shaffer 1987). This thesis's focus on immersive media contributes to persuasive communication scholars' interest in the persuasive potential of surrogate first-hand experience through immersive media (Ahn 2021). Preceding recent breakthroughs in the field of VR, Rajecki (1982) and Hertwig et al. (2004) showed that direct experiences impact people's perception of risk and decision-making, as the personal experience becomes a more salient reference point. This effect on perception may be due to the fact that direct and indirect experiences are encoded in the mind in different ways (R. W. Hamilton and Thompson 2007). One example where this is borne out is in climate change risk, where researchers found that people who sensed a closer relationship to the issue of climate change indicated greater concern for its impacts (Spence, Poortinga, and Pidgeon 2012). Similar to the premise that closer psychological distance in message content is more likely to compel action (Zwickle and Wilson 2014), Spence et al. (2012, 13) argue that climate change risks must be communicated in ways that bridge psychological distance and impress upon people's lived experience. Advances in technology today make it more possible to build on early research suggesting that 3D, interactive landscape visualizations decrease the abstract qualities of message content (Sheppard 2005), whether this be climate change or even, in this case, pine barrens restoration plans.

Field research interviews in this thesis suggest that psychological distance undercuts efforts to communicate pine barrens restoration goals, rationale, and scope. Firstly they are already a very rare habitat that relatively few people may recognize, which may engender both social and spatial psychological distance. Secondly, their creation through long-term intensive management procedures is temporally distant since

the target flora may only germinate several seasons after restoration procedures begin. Moreover, following the research by Hamilton and Thompson (2007),[11] it is arguable that the USFS's means of communication – including mainly informational mail and in-person stakeholder meetings – are more likely to inspire people's abstract construal of the ends and means of pine barrens restoration. This reliance on abstract evaluation can lead to more uncertainty regarding the goals and outcomes of restoration since certainty is a dimension of psychological distance that is linked to the other spatial, temporal, and social dimensions (Nira Liberman and Trope 2008; R. W. Hamilton and Thompson 2007; Spence, Poortinga, and Pidgeon 2012). As immersive media scholar Sun Joo Ahn says, "when designing for persuasion, experiences that closely mimic first-hand events may be more effective than secondhand depictions" (2021, 165). USFS personnel responsible for pine barrens management echoed this sentiment, endorsing the idea of a 3D, interactive environment to showcase the outcomes of restoration and the many ecological assets of pine barrens.

2.3 Immersive Technology's Persuasive Presence

The goal of measuring the impact of immersive media experiences on individual attitudes toward pine barren restoration arises from diverse literature on the persuasive potential of new media technology for enhancing attitudes and learning outcomes in myriad contexts, including virtual tours. Immersive technology is generally characterized by media richness or life-likeness, and interactive opportunities rather than passive

[11] Their research shows that people who interact with a product form more concrete mental construals than those who learn about the same product through PowerPoint presentations (R. W. Hamilton and Thompson 2007).

transmission (Bailenson 2018; Breves and Heber 2020; Zhao et al. 2020; Hruby, Ressl, and de la Borbolla del Valle 2019). While interactive interfaces have a legacy of strategic use in persuasive communication and geovisualization (Coyle and Thorson 2001; Oh and Sundar 2015; Andrienko, Andrienko, and Gatalsky 2003), immersive technology pushes this envelope by inducing sensations of direct experience. In other words, the qualities of immersion lead to the subjective "sense of 'being there' in a mediated environment" (Li, Daugherty, and Biocca 2002, 44; Slater 1999; Hein, Mai, and Hußmann 2018), an effect often referred to as "spatial presence" (Hartmann et al. 2016; Lombard and Ditton 1997; "physical presence" in Lee 2004; "telepresence" in Draper, Kaber, and Usher 1998).

Short of providing an entirely virtual simulation of pine barrens, this study integrated 360º video (ie. omnidirectional video, see Rothe, Buschek, and Hußmann 2019) footage into a video game software for added interactivity. Diverse research using 360º videos on their own and in combination with interactive software have produced enhanced attitudes toward the content of disaster communication messages (Fraustino et al. 2018), attitudes and emotions toward wolf reintroduction (Filter et al. 2020), expectations surrounding planned wind farms (Cranmer et al. 2020), and learning outcomes for environmental education (Arvaniti and Fokides 2020; Ahmad, Mohamad Ali, and Mei Choo 2019; Ritter III, Stone, and Chambers 2019). Although immersion[12] increases when using head-mounted displays (HMDs, AKA "VR headsets") rather than desktop computers (Zhao et al. 2020; Klippel et al. 2020; Fonseca and Kraus 2016;

[12] Technology scholars identify "immersion" as a trait of the hardware or medium of communication, whereas the subjective sense of *being immersed* is denoted through the term "presence" and its iterations (eg. "social presence" is the feeling of being somewhere else with other people).

Breves and Heber 2020), Klippel et al. (2020) cite some instances where greater immersion diminished learning outcomes (Makransky et al. 2018; Oprean, Simpson, and Klippel 2018), suggesting that desktop experiences have credible application for certain learning scenarios.

The research product at hand necessarily had to compile sensory information on not only the outcomes of pine barrens, but also the processes that generate them. That is, any attitudinal research into stakeholder views on pine barrens must address both the ends and means of these restorative projects. Landscape managers are interested in better understanding and accounting for people's attitudes toward not only restoration outcomes but also the processes that compose them – in this case, clearcutting and prescribed burning. Scant research has taken place within this exact context, yet there is relevant literature inspecting both evaluations of landscape treatments and their outcome that also includes cognitive and emotional dimensions of experience. Although the following discussion of literature on public acceptance and perception encompasses more than attitudes per se, the literature helps frame the current study's intellectual merits.

2.4 Localized Context for Attitude Research

Two of the most significant dimensions that inform public perception – and thereby social acceptability – of landscape change are aesthetics and a sense of risk, or what is practically conveyed as trust in management agencies (Ford et al. 2014; Ribe 2013; Gobster et al. 2007; Gobster 1996; Daniel 2001; Estévez et al. 2015). People predominantly articulate their aesthetic notions through visual perception to discern a sense of scenic beauty that Daniel (2001) terms the "public-perception based approach" to visual landscape management. Since these perspectives are composed of latent,

culturally-informed assumptions of "naturalness" (Ford et al. 2014, 482; Gobster et al. 2007, 967), researchers associate them with people's emotional attachment to a "sense of place" (Tuan 1974) and the pleasure they derive from the surroundings (Gobster et al. 2007, 961; Buijs 2009, 2681). Indeed the visual evaluation method is central to recent stakeholder surveys indicating that pine barrens are "aesthetically challenged" and therefore less favorable as a management outcome for stakeholders (Gobster, Arnberger, et al. 2021). This is despite people's avowed approval of management decisions based on biodiversity outcomes. On the other hand, trust in management agencies is directly implicated in the sense of risk that non-expert stakeholders bring with them during public consultations. As Ford et al. (2014) explain, peoples' sense of trust can be analyzed in terms of "social trust" or the perceived similarity in values held by all stakeholders, and agency "competence" that includes the "consequences of management" (483). These aspects therefore not only often frame stakeholder dialogue, but also are integral to the case study at hand given the rarity of pine barrens, their drastic visual difference from over-stocked forests, and the relatively novel use of prescribed fire in northern Wisconsin (Shindler, Toman, and McCaffrey 2009, 162).

2.4.1 Fire Perceptions in Northwoods

The slow revision of fire suppression in the Northwoods means that many people are still wary of prescribed burning (Shindler, Toman, and McCaffrey 2009, 162) even as this treatment is often an effective means to reduce wildfire risk and increase biodiversity (Hmielowski et al. 2016, 1019). Shindler et al. (2009) found that relative to their neighbors in Minnesota, Wisconsin residents were more wary of prescribed burning and "may be more watchful as treatments are employed" (162). Moreover, both of these

groups appeared to have relatively less interaction with management agencies than their counterparts in other regional studies with a notable trend of "neutral" opinions regarding trust in the Forest Service (Shindler, Toman, and McCaffrey 2009, 162–63). The need to build cooperative trust and approval of prescribed fire across public-private ownership boundaries in northern Wisconsin is further highlighted by several socio-ecological features. These include the fact that northern Wisconsin already hosts the state's highest density of residents in the Wildland-Urban Interface (WUI) (E. Hamilton 2018; Radeloff et al. 2018) and that new development is increasingly fragmenting property parcels in areas adjoining national forests (Haight and Gobster 2009; Thompson 2018). Moreover, Hmielowski et al.'s (2016) priority analysis of prescribed fire in Wisconsin based on ecological factors and feasibility found that "the highest priority areas for applying prescribed fire occurred in the central, northwest, and northeast portion of the state" (Hmielowski et al. 2016, 1018). The importance of building private stakeholder trust and approval of prescribed fire in this landscape is reflected in these researchers' intention to use spatial analysis to strategically include private landowners in overall fire management plans and activities (1026).

The case study of Waubee Barrens indicates that vocal opponents of prescribed fire resisted management plans despite public outreach explaining how barrens restoration can aid the "Fire-Wise" program whose purpose is to lessen wildfire risk.[13] This is a possible reflection of the public wariness that Shindler et al. (2009) found in responses of Wisconsin residents toward prescribed fire. Although Forest Service staff

[13] John Lampereur, interview with author, April, 2021.

coordinated more outreach and stakeholder research after the public criticism, these communication strategies plus the initial letters sent to landowners all correlate with indirect experience of pine barrens education in light of the previous theoretical discussion. Beside attempting to build an immersive tour to communicate more specific construal of pine barrens, future research could target micro-contextual factors with residents at Waubee Barrens such as burn frequency, amount of acreage, or the exact location of the burns. I focused on the medium of the message, especially because USFS personnel indicated that people needed to experience barrens in order to appreciate them. Beyond this context, it appears that people may also benefit most from guided tours of prescribed burns, as Shindler et al. (2009) found that residents of Wisconsin, Minnesota, and Michigan responded most favorably to guided tours over any other informational material.

2.4.2 Overcoming Disapproval of Clear-Cuts and Barrens

People's trust in the competency of natural resource managers can also be informed by their aesthetic judgments of what is "natural." Research on social perceptions of "natural" and "healthy" habitats indicates that public ideas of environmental health often positively correlate with their scenic appraisals of forested and dramatic landscapes (Gobster et al. 2007; Ribe 2013). Yet many biologically diverse ecosystems contain dynamic processes and patterns that may be far from picture-perfect. Moreover, closer inspection of lush forests may reveal disease outbreaks, invasive species, and ahistorical conditions promoting fire danger. In this vein, landscape managers in upper Wisconsin face a communicative challenge when reconciling the primary rationale of pine barrens restoration – that is, biodiversity – with popular

conceptions of the Northwoods as lush, forested, and therefore *natural*. Popular demand for the lush environments of northern Wisconsin is built from a century of afforestation that grew in tandem with tourism marketing of the lake-filled, forest-blanketed Northwoods (Shapiro 2013). Upon first visual inspection, barrens don't match up to this socially-informed landscape ideal.

Paul Gobster has theorized the common gap between more wholistic comprehension of ecosystem processes and conventional visual judgments of naturalness and health. Gobster's use of the terms "ecological aesthetic" and "scenic aesthetic" (1996; 2007) – based on the work of Wisconsin's own Aldo Leopold – are helpful for distinguishing such differences in how people evaluate habitats or landscapes. Whereas the scenic aesthetic prioritizes both what is "dramatic and visual," immediately and affectively perceptible, the ecological aesthetic encompasses the "subtle, multimodal characteristics of a dynamic environment" and its natural processes. The ecological aesthetic, with its emphasis on biodiversity, an understanding of systems and how ecological components form a greater sum than their parts, stems from Leopold's "land aesthetic" that he developed in essays that culminated in *Sand County Almanac*. Flader and Callicott (1993) highlight the importance of this notion in their compilation of Leopold's writings:

> *By contrast [to the scenic aesthetic], in Leopold's revolutionary land esthetic all the senses, not just vision, are exercised by a refined taste in natural objects, and esthetic experience is as cerebral as it is perceptual. Most important, form follows function for Leopold as for his architectural contemporaries. For him, the esthetic appeal of the country, in other words, has little to do with its adventitious colors and shapes – and nothing at all to do with its scenic and picturesque qualities – but everything to do with the integrity of its evolutionary heritage and ecological processes* (9-10).

Just as paradigm shifts in ecology have highlighted the ecological importance of disturbances (especially fire), the "ecological aesthetic" promotes human interaction with environments to both actively regenerate them and understand their systems more deeply. It is worth noting that where Leopold's philosophy espouses deeper, experiential human engagement with and understanding of the environment, these characteristics are hallmarks of much longer cultural lifeways endemic to Native societies of this continent (Simpson 2017; Robin Wall Kimmerer 2020; Ray, Kolden, and Chapin III 2012; R.W. Kimmerer and Lake 2001; Molnár and Babai 2021). Indeed, the visual intake of North American scenery as an idyllic nature "untouched" and meant for preservation is built on Native dispossession and erasure of Native stewardship of bountiful, dynamic landscapes (Anderson 2005), Wisconsin included. These different perspectives on what the land provides is evident in the appraisals of pine barrens by Native nations and the Euro-American settlers who displaced them. On one hand, Ojibwe and Menominee societies "long used fire to maintain the open character of pine barrens as a preferred landscape condition for wildlife habitat, medicines, [and] materials for human subsistence" (Gobster, Schneider, et al. 2021, 2). Early European foresters, on the other hand, derided barrens as "monotonous brushwoods," "almost worthless," and as "burned out barrens" to connote a *barren landscape* (Roth 1898, 10, and Fletcher 1853, as cited in Gobster, Schneider, et al. 2021, 2).[14]

Interestingly today, although social research indicates people prefer closed canopy landscapes consistent with a Northwoods aesthetic, survey responses also suggest that

[14] John Lampereur, interview with author April 2021.

those already familiar with pine barrens are more willing to approve of "intensive types of pine barrens treatment designs retaining fewer trees" than those who have not visited pine barrens (Gobster, Arnberger, et al. 2021, 10). Gobster writes that this kind of correlation between familiarity and approval could be evidence of an ecological aesthetic held by some people. Beside this point, the aspect of familiarity also indicates the importance of direct experience in this population's formation of attitudes.

This study anticipated that people would feel more familiar with barrens through spatial presence in the immersive tour, and thereby indicate stronger attitudinal enhancement toward their restoration. The following chapter describes the methods used in this study.

CHAPTER III

METHODOLOGY

I analyzed the impact of a novel 3D geovisualization intervention through a between-group participant study with questionnaires measuring attitudes toward the goals and procedures of a habitat restoration project in northeastern Wisconsin. This chapter describes the procedures and elements of the user study.

3.1 Basis of the User Study

I presented 192 crowdsourced regional participants with a sociodemographic questionnaire at the start, followed by questionnaires measuring attitudes toward fire, clear-cutting, and the habitat of pine barrens. These questions were presented to participants twice: once before the randomized stimuli, and once afterward. I used quantitative analysis in R to measure for significant differences in each group's reported "pre-test" and "post-test" attitude scores for each category (fire, clear-cuts, and pine barrens). This methodology matches standard academic design that uses people's ordinal, closed responses (ie. a Likert scale of, for instance, five responses from "highly disagree" to "highly agree") to questions about an entity to measure the respondent's attitudes toward that entity (Banaji and Heiphetz 2010).

As for the informational stimulus, my study randomly assigned participants to learn about pine barrens restoration goals and practices either through 1) a desktop-based virtual tour, or 2) a website. In this study I built a desktop version of an immersive tour due to COVID restrictions and because immersive desktop experiences from 360º videos provide lower technological entry-point at both the producer and consumer ends in the event that a virtual tour as constructed here proves valuable in the future. The website

was created as a control representing a more conventional, but less interactive, media of textual explanation with photographic imagery. Both stimuli contained roughly the same message content to the degree that is feasible. Users then answered an exit questionnaire adopted from Hartmann et al. (2016) that measures subjective experience of "presence" or the feeling of immersion in a media presentation.

The following explains the rationale and procedures related to recruiting participants, designing materials, and running the user study.

3.1.1 Participants

I solicited 192 participants for the study from the recruitment website Prolific. Participants were able to take part in this online study if they indicated through their Prolific profile that they are at least 18 years old, fluent in English, and a resident of the state of Wisconsin or Minnesota. Each participant was paid $6.25 through Prolific for an average of 20-25 minutes of their time after they completed the study.

I prioritized geographic recruitment (to Prolific users in Wisconsin and Minnesota) since the study focuses on landscapes of northern Wisconsin; an open pool of respondents beyond this region may not have the same connotations of or attachments to the Northwoods as this group. Prolific allows researchers to filter through respondent profiles based on geography, and my final study's incentive structure was more robust than an initial attempt to recruit undergraduate responses through collegial networks at University of Wisconsin. Willing professors in Geography and related fields at UW were helpful in forwarding links and advertisements to the user study, but relying on voluntary interest in a random drawing for a 25$ Amazon gift card resulted in poor response rates.

Grant money from the University of Oregon's Center for Science Communication Research allowed me to re-distribute the user study and pay participants through Prolific.

Moving from distribution through collegial networks to a more dispersed delivery across a wider public also generated a greater sociodemographic variety of respondents, and potentially prevented more exposure bias associated with the academic interests of undergraduates enrolled in Geography or similar classes focused on natural resources.

3.2 Materials

3.2.1 Distributing the study through Prolific

Prolific is a crowdsourcing website that is useful for quantitative studies seeking larger recruitment numbers to legitimize generalizable results because it advertises research study participation to willing members of the public at large. Kraut et al. (2004) argue that sites like Prolific (or its competitor Mechanical Turks) ease the barriers to conducting social scientific research, making studies "less expensive and easier to conduct" because of automated recruitment (106). Psychological studies of visualization media benefit from the scalable features of crowdsourcing that reduce burdens of participation and diversify the pool of subjects (Heer and Bostock 2010). Users on Prolific are paid for their time by the research team, which further incentivizes participation. Paying for crowdsourcing is scalable since reimbursement is pegged to a relatively low amount per user due to the often simple nature of tasks that people are asked to do in these types of research studies.

3.2.2 Qualtrics and Informed Consent

The Prolific advertisement for this study redirected participants to Qualtrics, a survey making and taking website. Participants were directed to my study which included

the stimuli and questions for the user study. Upon visiting Qualtrics, users entered their Prolific ID to cross-reference with their Prolific profile information to receive compensation. The second page of the Qualtrics study provided the participants with the consent form (Appendix A). Participants needed to answer "yes" to indicate that they read the information about the study and consent to its terms in order to continue to the rest of the questions in the user study.

3.2.3 Socio-demographic data

Participants input basic socio-demographic and lifestyle information through an introductory questionnaire consisting of four questions. The first two ask for age and gender identity. The latter two are Likert style scales asking about people's familiarity with Wisconsin's Northwoods and if they or their family own/s property there (including for how long, if so).

3.2.4 Pre-test and Post-test Questionnaires

Items in the pre- and post-test questionnaires were designed to gather information for measuring people's attitudes toward prescribed fire, clearcutting, and pine barrens. The questions in the study balanced contextual specificity with broader generalizability in accordance with the study's focus on a loosely regional type of restoration project rather than a specific case with nearby landowners. For reference, Whittaker, Vask, and Manfredo (2006) argue that attitudinal questions framed around concrete circumstances are more meaningful than questions posed in the abstract. People's attitudes toward fire for instance, could vary based on where exactly the prescribed burn is being conducted or the frequency of said burns. Still, grounding questions in specifics like this is more feasible where participants are recruited from a limited area and more concrete

managerial parameters are under review (eg. Nelson, Monroe, and Johnson 2005). The inquiries were focused by asking respondents to consider the questions in the context of northern Wisconsin, and each was worded to reflect semi-specific concerns. Respondents were informed that there are no "correct" answers.

The questions for each attitude category (fire, clear-cuts, and pine barrens) are framed with different considerations in mind to help elicit a person's evaluation of whether the topic at hand is generally positive or negative, similar to other attitude studies (Alice Hendrickson Eagly and Chaiken 1993; Petty, Wegener, and Fabrigar 2006; Crano and Prislin 2006). The category of clear-cuts contains the fewest items (3) and the questions mainly focus on their utility as a restoration tool and people's general feelings about forest managers conducting them in Wisconsin's national forests. More questions are devoted to prescribed fire and pine barrens. These latter questions cover not only perceived utility or worth, but also how much people see them as naturally fitting into the Northwoods social and natural landscape. I designed these questions from my review of studies on stakeholder attitudes toward prescribed fire or forest thinning by Absher, Vaske, and Shelby (2009); Bell and Oliveras (2006); Bright, Newman, and Carroll (2007); and Beckwith et al. (2010). I used conventional closed-response questions on a Likert scale (Banaji and Heiphetz 2010) and included a few optional open-response questions across the set of questionnaires. Likert scales ranged from 1-5 indicating "highly disagree" to "highly agree" or the equivalent (see Appendix B), as described below.

3.2.4.1 Prescribed Fire and Clear-cutting Measurements

Items 1-5 measured attitudes toward fire (both prescribed and as a natural disturbance) with 5-point scales including (A) "Highly disagree" to "Highly agree"; (B) "Very inappropriate" to "Very appropriate"; (C) "It's a very bad problem[…]" to "Not a problem at all[…]";[15] or (D) "Very negative" to "Very positive." Questions are prefaced with a brief definition of prescribed burns as the "controlled application of fire to a landscape by a team of fire experts, often to manage landscapes." Respondents indicate their ranked answer to the following:

1. Fire is a natural part of Wisconsin's Northwoods. (A)
2. Certain habitats benefit from prescribed fire. (A)
3. Creating more open types of habitat with prescribed fire is ___ (B)
4. How do you consider the effect of smoke from prescribed fires? (C)
5. What are your general feelings about forest managers conducting prescribed burns in Wisconsin's national forests? (D)

The scale was reliable with an omega value of $\omega = 0.8$.

Items 6-8 measured attitudes toward clear-cuts with a 5-point scale and include the (A), (B), and (D) scales referenced above. The questions include:

6. Creating more open types of habitat through clear-cutting is ____ (B)
7. Clear-cuts can be an important habitat restoration tool. (A)
8. What are your general feelings about forest managers conducting clear-cuts in Wisconsin's national forests? (D)

The scale was highly reliable with an omega value of $\omega = 0.93$.

The fire scale contains more questions than clear-cuts since fire is more integral to the pine barrens restoration process in that it is repeated over time, and since its features extend tangibly and potentially beyond its "footprint" in the form of smoke or escaped

[15] The full text of these answers to the question on smoke were longer and can be found with all other questionnaire material in Appendix B.

flames, respectively. These latter aspects are some of the health and material risk factors publics may associate with fire. Additionally, prescribed burns are attempting to imitate a natural process, therefore it is fair to – as Gobster suggests (1996) – ask people to judge how much they associate it as a "natural" or appropriate element of the local landscape.

Following the Likert items, respondents were asked to share any thoughts or concerns they have about prescribed fire and clear-cuts if they were interested. Although I did not conduct a qualitative analysis, I included a few open responses in case they could help shed light on people's answers. All questions in the post-test remained the same except for a slight change in wording on the open-response items in the post-test where I asked for comments on any *changes* in a respondent's outlook toward prescribed fire or clear-cutting. Again, these open responses were optional.

3.2.4.2 Pine Barrens Measurement

All but one of items 9-15 were focused on measuring people's attitudes toward pine barrens. Item #9 asks for people's Likert-scaled agreement on whether "scenic beauty is a good measure of landscape health." I included this question based on the work of Gobster and others indicating that popular assumptions of habitat health often correlate strongly with people's culturally-informed affinities for more "beautiful" landscapes in the form of dramatic vistas, forested terrain, etc (Gobster et al. 2007; Williams and Cary 2001). The rest of the questions focused specifically on pine barrens and all of them used the "highly disagree" to "highly agree" scale.

I presented questions 10-15 within the northern Wisconsin context, and provided a brief description of pine barrens as an "open habitat" alongside a sample landscape photograph from Dunbar barrens for reference. The following questions were asked:

10. This habitat type does NOT belong in northern Wisconsin
11. This habitat/landscape is beautiful
12. This landscape suits my outdoor recreational activities. (You could see yourself visiting and enjoying the experience.)
13. Not many wildlife depend on this type of landscape.
14. "I accept conservation decisions to transform several hundred acres of forest into this kind of habitat."
15. Converting portions of forest into this landscape helps to reduce the threat of wildfires.

The scale was reliable with an omega value of $\omega = 0.78$.

These questions were the same in the post-test except in the latter I provided respondents the opportunity to give open comments at the end. I excluded this option from the pre-test to lessen study fatigue, and assumed that pre-test qualitative views on pine barrens might be reflected in any of the respondents' open comments after the informational stimulus.

During analysis I removed item #15 from the pine barrens scale because upon re-assessing I decided this question is more knowledge-based rather than an evaluative assessment as attitudinal questions should be.

3.2.5 Main Stimuli

I created the immersive tour and the website and hosted them through different web platforms. Since the immersive tour required the most work, I prioritized building that during and after fieldwork in Spring and Summer 2021. Much of the design revolved around writing compelling scripting or a narrative arc, which will be explained in section 3.2.5.1. Completing the immersive tour also informed how I would write and compile imagery for the website, since I wanted the message content of the website to largely match that of the immersive tour for comparison purposes. The website idea was borne from familiarity with the US Forest Service's explanatory mail that foresters like John

Lampereur use as one means of communicating with landowners during preparation for prescribed burns (see Appendix E). Unlike this mail, though, neither the immersive tour nor the website was framed from "the voice" of the Forest Service; they contained no USFS insignias or other visual cues, and any narrative "voice" was consistent with an "impartial" and unnamed 3rd party that only referenced Forest Service efforts while explaining pine barrens restoration. This made the material somewhat journalistic. Any resulting use of the technology by an agency like the USFS would likely be redesigned so that the narrating agency would have a more deliberate presence in the eyes of the audience.

During fieldwork in Spring and Summer 2021, I built the virtual tour by visiting and documenting pine barren habitats across northern Wisconsin, particularly in the Lakewood district of the Chequamegon-Nicolet National Forest where I coordinated mostly with USFS silviculturist John Lampereur. He brought me to over five different sites that reflect sequential stages of the pine barrens restoration process. These areas consisted of non-logged forest; recently logged areas with different degrees of slash removal before fire application; an active prescribed burn; and post-burn sites that were in varying stages of re-growth. Nicole Shutt, a master's student who has collaborated with the USFS for research on pollinators and blooming flowers, also directed me toward sites within the Lakewood area that contained prolific amounts of Milkweed since this plant benefits from barrens restoration. Extra evidence of barrens-associated flora and fauna came from video and audio footage captured at Dunbar, Spread Eagle, and Moquah Barrens, thanks to assistance from Brian Sturtevant and Carly Lapin of the USFS.

On these excursions I targeted small areas that are emblematic of restoration and set up a tripod with a 360º GoPro camera and omnidirectional microphone in order to create the main audio-visual components of the immersive tour. While in the field I also captured certain scenes with standard (ie. rectangular, not 360º) digital video recording equipment. Footage of signature barrens wildlife and wildflower blooms required recurrent trips (and a lot of good fortune) in order to document their seasonal or otherwise time-based presence (eg. a dawn bird chorus). The scene showcasing the mating dances of the sharp-tailed grouse (in Moquah Barrens) is a primary example. Time spent in the field also allowed for spontaneous documentation of more subtle wildlife like bees and snakes in formerly burned barrens. As the year 2021 experienced a drought that curtailed the fruiting behavior of blueberries in the barrens, I relied on less contextualized close-up shots of someone picking berries at a berry farm in central Wisconsin. I edited all of the footage in GoPro Fusion Studio and Adobe Premier Pro (and some in the advanced video editing software DaVinci Resolve) so that I could trim or select footage, alter audio, and add text overlays to each 360º "scene" according to a narrative blueprint I devised. The second half of computer work consisted of integrating these assets into a project in Unreal Engine, which is a 3D video game software.

I chose to use 360º video since it was more convenient than building a computer-based 3D simulation of pine barrens habitats, but still affords the viewer a vivid, immersive view of these spaces. Although computer graphics and data-based visualizations have greatly advanced in the last twenty years, research and practice for automating a workflow that accurately captures biologically diverse ecosystems is still only budding (Huang et al. 2020). In this light Wallgrun et al. (2021) emphasize 360º

cameras' capacities, affordability, and ease-of-use allow instructors to "create the content for virtual tours of real-world fieldwork or research sites themselves with much lower costs, efforts, and expertise required than before" (2).

3.2.5.1 Narrative

Based on the increasing attention placed on using stories in science communication (Zak 2014; Stewart 2011; Green and Brock 2000; Bilandzic, Kinnebrock, and Klingler 2020; Roth 2020; Bieniek-Tobasco et al. 2020), I built my virtual tour sequence with certain narrative elements in mind. Stories are known to cohere many disparate elements into a meaningful whole (Cohn 2013; Mocnik and Fairbairn 2018; Gershon and Page 2001), thus making something as complex as pine barrens restoration comprehensible to a general audience. I expected that such a structure would help ensure that the explanations were not only informative but the entire experience was engaging as well, even if the content is not easily recognizable as a "story" per se. This narrative explanation plays out via a series of video portals the user is invited to walk through. At each one a sphere envelops the user with the projection of 360º videos documenting and explaining the scope of pine barrens restoration. I highlighted and elaborated on certain elements through introducing interactive widgets at various moments, which users click on with their mouse in order to: a) learn more via a text pop-up, b) "move to here" whereby the 360º video changes to a projection of the view from the highlighted point (based on placing the tripod there during fieldwork), or c) to witness another, rectangular video pop-up meant to induce the sense of peering closer at some action that's taking place within the 360º sphere.

Figure 3.1 This is a screenshot from within the streaming video game level that is the immersive tour. These pink columns are where players walk in order to trigger the video spheres/scenes to spawn and begin playing the audio-visual scenes of the pine barrens tour.

One of the hallmark traits of narrative structure – both in the classic Three Act plotline and more granular analyses of its constituent pieces (Cohn 2013; Brewer and Lichtenstein 1982) – is a *complication* that both generates narrative tensions and invests readers in following the plot, or story, to learn outcomes and causality. Brewer and Lichtenstein (1982) explain that this feature hooks the audience either through surprise, suspense, or curiosity, all of which they equate to *affect* or psychoactive arousal. The complication often follows contextual scene-setting and characterization so that the audience is familiar with and (ideally) empathizing with protagonists or other characters who will be impacted by the complicating event (van Laer et al. 2014). In my case, I used compelling imagery and text to introduce the Northwoods in a way that simultaneously

set the scene with the intent of portraying this landscape as the main character for audience focus, even if subconsciously. I created a narrative hook, or complication, shortly after by cluing participants in on the fact that large swaths of the lush Northwoods did not always appear so forested but instead historically hosted open landscapes accustomed to fire. By providing pine barren imagery representative of these past conditions, I complicated the sense of place I'd just conjured through vivid imagery and captions describing people's place-attachment to the Northwoods. I did this to prime the reader's interest in learning the restoration practices used to bring these fire-dependent habitats (in this case pine barrens) back to life.

Figure 3.2 A screenshot of text inside the immersive tour's first 360º sphere, which plays footage (with more accompanying text) from a drone flying over a forested area near Dunbar Barrens.

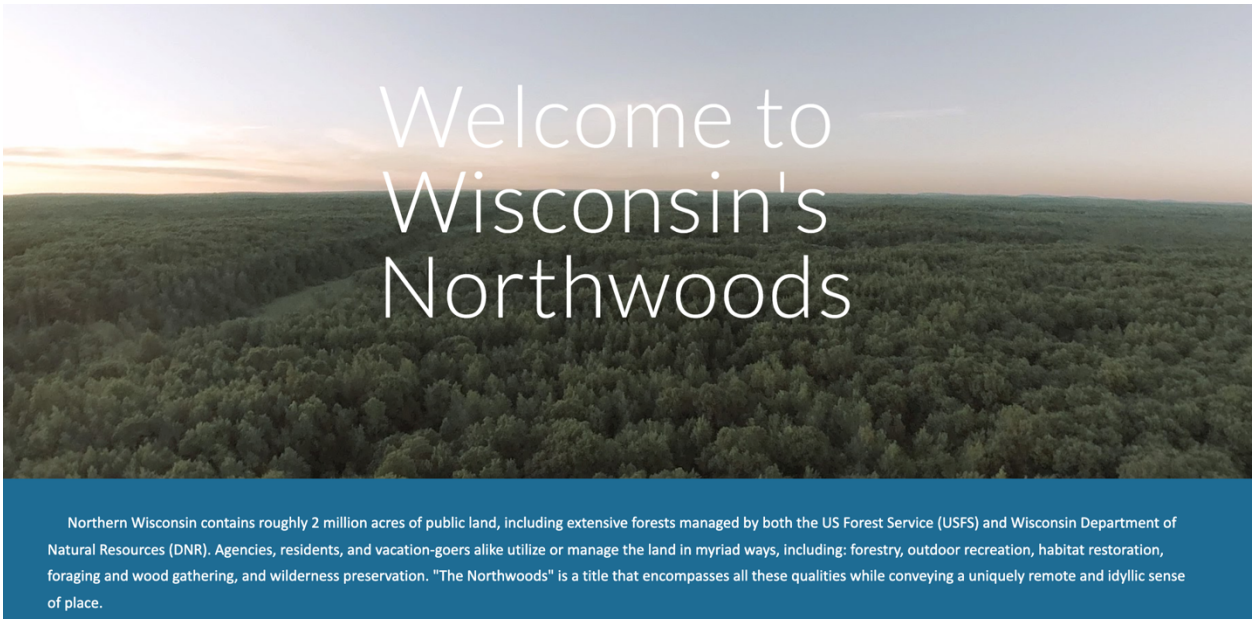

Figure 3.3 A screenshot of the first portion of the explanatory website. The text contains the same message as what is played in the immersive tour's first sphere, but the latter is more condensed (see Appendices C and D).

At this point in the immersive tour, the user is welcomed by prompts to explore onward and experience a representative example of pine barrens habitat. Prompts that welcome the user onward were placed after each video sphere, thereby investing the user in onward momentum that at once reinforces linearity and curious engagement.

Figure 3.4 This image is a screenshot from the end of the initial drone footage. Players see this small prompt-box after clicking a highlight button that appears near the end of the textual narration (part of which is still faintly visible in the sky: "…they have swallowed *open* habitats that existed in natural balance with fire until a century ago."

Linear momentum built on interactivity is not possible in the website document, but some momentum is naturally realized through the vertical scrolling mechanics and the simple nature of reading text (see for instance Roth 2020; Mocnik and Fairbairn 2018).

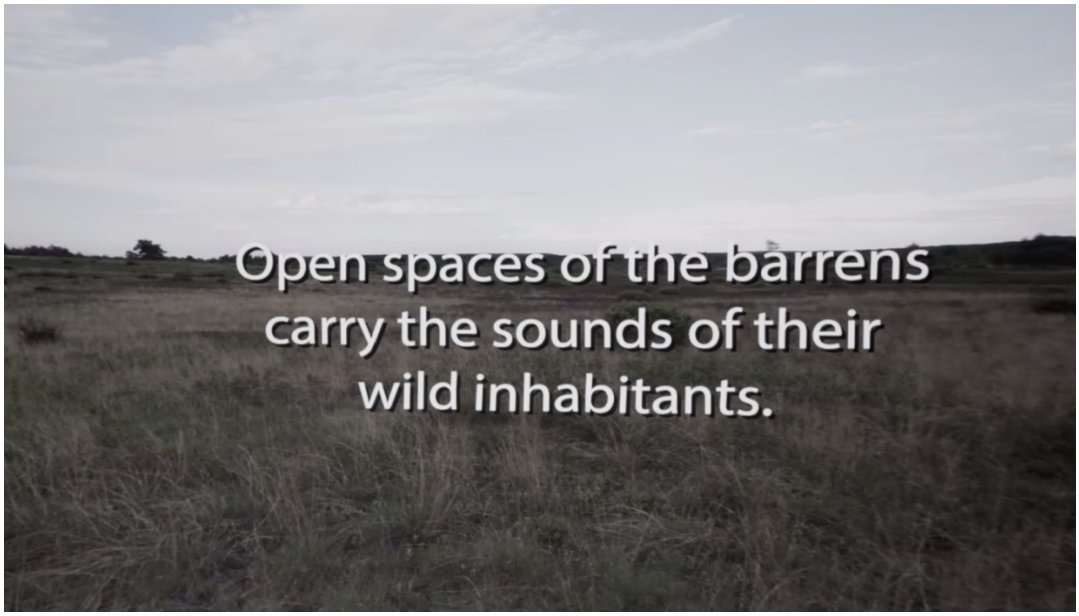

Figure 3.5 Upon clicking the prompt-box "to see an example of this restored habitat," participants are surrounded by open expanses of Dunbar Barrens and the diverse morning bird chorus (plus elk) that was recorded on site.

Figure 3.6 The equivalent narrative moment in the explanatory website, which portrays the surprisingly open barrens landscape indicative of a bygone mosaic that once covered vast expanses of northern Wisconsin.

Constructing and conveying the narrative tension – in the form of the “current” and “before” visuals of the Northwoods general landscape – provides a natural segue to follow-up sequences of the restoration process. Participants in the immersive tour walk through several stages of restoration, including: pre-activity site selection; post-logging with “slash” (woody debris) on the ground; post-logging and post-mastication (ie. slash cleanup); post-logging/mastication and into an active prescribed burn; a post-burn site two years after the fact; and finally two scenes replete with wildflower blooms, blueberry picking, and mating dances of the Sharp-tailed Grouse (a species of special conservation concern that relies on the largest pine barren habitats). The “plot” material in the middle is meant to expand user’s exposure to USFS personnel, some of the planning process, and the multiple rationales underpinning the medial phases of restoration including clear-cutting and fire application. Audience members encounter John Lampereur and USFS fire manager Tym Sauter inspecting a densely forested site that is prime for restoration, overhearing their conversation on expectations and plans for logging and prescribed fire. Later scenes envelop tour participants in scenes of slash and masticated sites ready for burning, partly in order to give audiences a spatial appreciation for the scene and scope of restoration activities. For instance, users are able to pan left and right around themselves to see where forest will still be standing as part of the restoration mosaic. Video editing technology allowed for vivid highlighting of oak shrubs that would endure and re-forest the area if fire were not applied. As mentioned, too, interactive widgets populate the screen at key points to further explain the activities and outcomes. The video technology combined with simplified, distilled "signposts” explaining the procedures help convey the

importance of applying fire in a straightforward, easily interpretable manner, compared to a fuller discussion couched in technical language of science and forestry.

Figure 3.7 A screenshot of the "prescribed burns" portion of the website. All the images inset in this section are freeze-frames from the 360º video of the prescribed burn.

The prescribed burn itself arguably constitutes the "peak" of the narrative experience, where players in the immersive tour witness more "live action" than at any other point in the tour. The rare opportunity to be on the front lines of an active prescribed fire will likely provide users with unique exposure to this practice, during which time they learn about safety protocols and witness low-intensity ignitions that gradually and safely consume the targeted area. Drone footage carries the viewer through the sky and over the burn for panoramic views that showcase how confined the smoke

column is, which drifts straight upward in accord with the plans of weather-savvy managers.

Tour participants proceed from the prescribed fire to see the ecological benefits afterward through a few scenes of barrens-associated flora and fauna. This could be equated to the narrative moment of "resolution" or "denouement" where the story is tied together and the climax is integrated into the overall plot. Although audience members got a taste of what a barrens habitat can hold at the beginning of the tour, by this point they are still unfamiliar with the flora and fauna that live in or frequent these spaces. Here, audiences hopefully feel they are given an opportunity to perceive barrens "deeper" than the image, or visual field, as it were – and so they are brought more fully into what it may feel like to experience barrens.

As mentioned earlier, capturing and representing the wildlife and botanical assets of pine barrens posed a challenge that required outsourcing recommendations on what other barrens sites across northern Wisconsin demonstrate these features (eg. wildflower blooms, blueberries, diverse avian populations). Most of the footage at the finale come from Dunbar and Moquah Barrens, although these aren't explicitly referenced in the tour. An allusion to them is made as audiences read a signpost widget that welcomes them to see what some of the state's larger expanses of Barrens provide.

Both the tour and the website end with a map illustrating the projected range of pine barrens in the mid-1800's before intensive and permanent European settlement with its ensuing culture of fire suppression, and the tiny residual areas where viable pine barrens exist today.

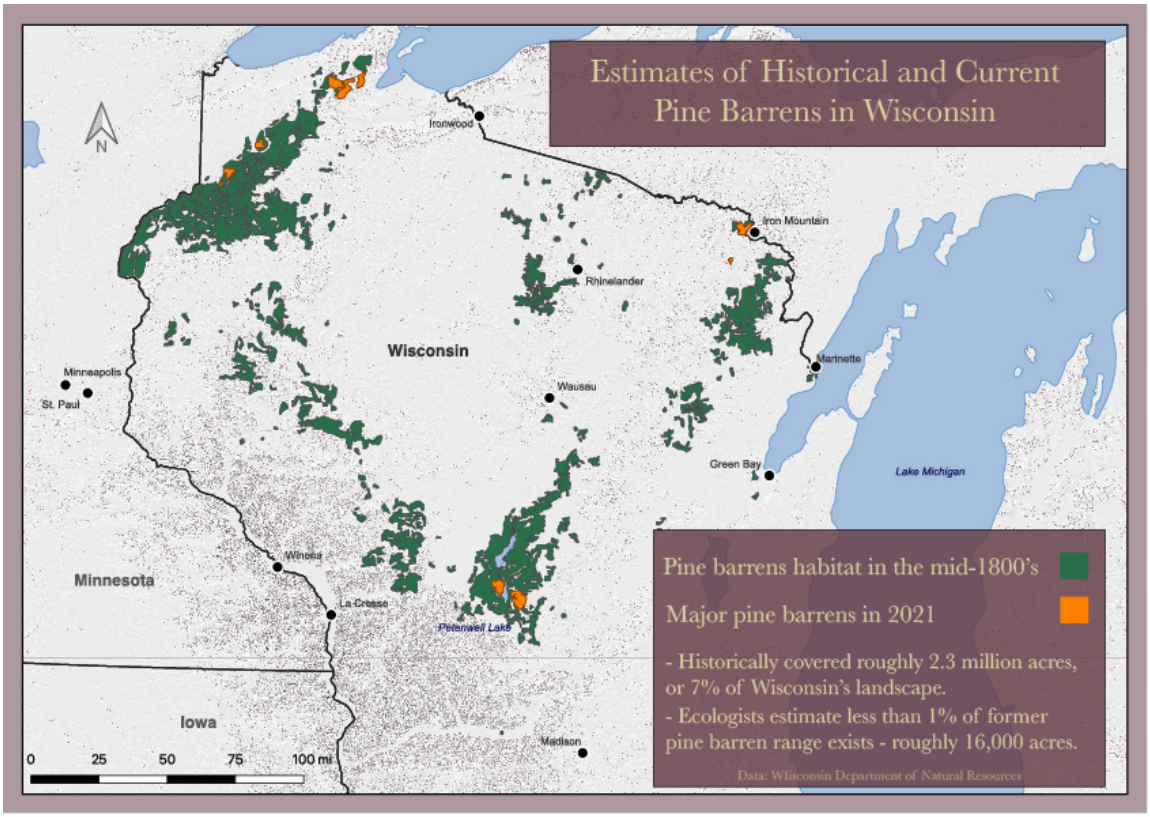

Figure 3.8 Map indicating estimated current spatial extent of pine barrens and their range in the mid-1800's before full European settlement. Map by: James Lamping and author.

3.2.6 Post-test Questionnaire

The post-test questionnaire was identical to the first across all categories, except for the open-response questions, as mentioned before. After the closed-response Likert style items related to fire and clearcutting, participants were asked to describe any changes in outlook they had toward these activities as a result of the learning material. After the close-response Likert items related to pine barrens, respondents in the post-test are able to write any comments they have on barrens habitats.

3.2.7 The Exit Questionnaire

Lastly, participants answer 8 questions of the Spatial Presence Experience Scale (SPES) used by Hartmann et al. (2016) to measure subjective experiences of spatial presence. Researchers studying presence tend to employ questionnaires rather than direct observation (Hein, Mai, and Hußmann 2018; Schwind et al. 2019), particularly because the construct of spatial presence is an internal, psychological experience and therefore mostly captured through self-report measures (Hartmann et al. 2016, 2; see also Hein, Mai, and Hußmann 2018, 7). I chose the SPES instrument because the designers created it as a refined version of one of the most theoretically comprehensive survey tools on presence, the Measure Effects Conditions-Spatial Presence Questionnaire (MEC-SPQ) created by Vorderer et al. (2004). Moreover, it is brief, has been tested for validity, and is applicable across different media types – this latter criterion was important in my case study because I wanted either the immersive tour group or the website group to be able to answer the same questions for comparison purposes. Two underlying dimensions of the SPES measure the degree to which a user's egocentric self-location is effectively transferred into the media environment, and the degree of actions the user interprets as possible through the media format. Each dimension informs one half of the questions, which are as follows:

1. I felt like I was actually there in the environment of the presentation
2. It seemed as though I actually took part in the action of the presentation
3. It was as though my true location had shifted into the environment of the presentation.
4. I felt as though I was physically present in the environment of the presentation.
5. The objects in the presentation gave me the feeling that I could do things with them.
6. I had the impression that I could be active in the environment of the presentation.

7. I felt like I could move around among the objects in the presentation.
8. It seemed to me that I could do whatever I wanted in the environment of the presentation.

3.3 Analysis

3.3.1 Comparative statistics

I used R (RStudio 1.2.5033) to run comparative analyses between the 3D immersive tour group and the 2D website group in order to assess differences among numerous dimensions of the data and questions involved in the study. Those who experienced the immersive tour will be referred to as either "3D" or "Tour" participants, and those who visited the website will be called the "2D" or "Text" participants. I first converted all Likert responses to a scale of -2 to 2. For example, respondents were asked to rank their level of disagreement or agreement with the statements such as the following:

11. *This habitat/landscape is beautiful*

In this case, the data was transformed from:

"Highly disagree" → -2
"Disagree" → -1
"Neutral" → 0
"Agree" → 1
"Highly agree" → 2

However, some questions were worded negatively, in which case the numeric scores were multiplied by -1 in order to reverse the numeric range while maintaining congruence with a positive/negative evaluation. The following item is one example:

1. *This habitat type does NOT belong in northern Wisconsin*

I used the same logic to transform all responses across categories in this study into numeric values to make it easier to compare responses across questions.

3.3.2 Calculating attitude scores

Each participant received an attitude score for a given set of questions, including those related to (prescribed) fire, clear-cutting, and pine barrens. For each participant and within each category of questions (eg. clear-cutting), I added the numeric values (ranging from -2 to 2) of each of their answers to provide a sum "attitude score." The scales for each attitude score reflect how many questions are in the scale, and are as follows:

Table 3.1 Number of questions and range of possible scores for each attitude scale.

	N questions	*Min possible score*	*Max possible score*
Fire	5	-10	10
Clear-cuts	3	-6	6
Pine barrens	5*	-10	10

Note: Question #15 was removed from the pine barrens attitude scale, resulting in a scale composed of five questions. This question was removed because it asks for dis/agreement on whether pine barren habitat characteristics mitigate the risk of wildfires, and therefore the question's character aligns more with a knowledge assessment rather than a value judgment. Moreover, discussion of barrens' potential to mitigate against wildfires was conveyed more directly in the web pamphlet than the tour, where in the latter respondents may have missed a text element within a 360º sphere.

To conduct comparative analysis of each media intervention's impact on attitudes across categories, I first tested for statistical significance of the impact of each media type in isolation across attitude categories by running the non-parametric Kruskal-Wallis test on the relevant pre- and post-test attitude scores. To test for statistically significant differences in outcomes between stimuli, I input both groups' post-test scores for the target attitude into the Kruskal-Wallis test. I also applied these same within-group and between-group methods to every individual question, including item #9 which was not integrated into any of the attitude scales.

To focus more closely on pine barrens and the impact that each stimulus had toward people with negative initial predispositions, I ran between-group Kruskal-Wallis

tests on subgroups of individuals who gave neutral or negative answers to the pre-test questions in the pine barrens portion of the study.

The final analyses consisted of combining people's stimulus treatment with their ensuing SPES score through a series of two-way ANOVA tests to see if differences in spatial presence brought about by 3D or 2D media impacted target attitudes or questions. Iterations of this analysis helped to answer the main hypothesis of the study which predicted that the immersive tour would have a stronger positive impact on people's attitudes toward pine barrens restoration *due to spatial presence*, or the feeling of being immersed in the media. I first used Kruskal-Wallis tests to see if the two media treatments differed significantly in terms of people's reported SPES scores, or spatial presence. I ran this test first as a measurement of the media's impact on the overall SPES score derived from the eight SPES questions, and also as a measurement of media impacts on both of the two sub-scales of SPES: "self-location" as measured by SPES items #1–4, and sense of interactivity (or "possible actions," Hartmann et al. 2016) as measured by SPES items #5–8. The creators of SPES encourage researchers to break up the scale for such analyses (Hartmann et al. 2016, 22). Results in the next chapter explain the differences found when changing these variables. Based on those differences I did not keep focusing on the interactivity component of SPES (#5–8) in my final analyses of interaction effects for specific questionnaire items (ie. all items asking about prescribed fire, clear-cuts, and pine barrens). Instead I ran two-way ANOVAs looking for interactions between stimulus type and either the total spatial presence score (SPES 1–8) or its self-location sub-component (SPES 1–4) when I analyzed each questionnaire item in isolation (in contrast to the aggregated attitude scores). I used Shapiro-Wilks tests to

test for normality and Levene's test to check for homogeneity of variance of the data before running two-way ANOVAs.

CHAPTER IV

RESULTS

4.1 User Study Participants

There were 192 people who participated in this study through Prolific, and Qualtrics evenly split participants to be exposed to either the 2D or 3D stimulus. Data from a few participants had to be removed immediately. According to the response field asking participants to enter their Prolific User ID, two users logged into the study twice. Therefore their latter responses were removed. Furthermore, two participants did not finish the study, so their entries were removed.

One of the premier criteria for filtering participants to select a viable pool for analysis was to check how long they spent engaged in the immersive tour, since preliminary trials indicate that the experience takes at least 15 minutes to complete if one reads the text and interacts with elements fully. To account for time spent on the tour, I entered a hidden timer on the Qualtrics landing page where participants click the link for the information stimulus (ie. 3D tour or 2D website of text and photographs). The timer counts the seconds until each user clicks “next” on the Qualtrics page, which roughly approximates how much time they spent away from this page engaged in a media presentation through a different tab in their browser. I found a wide range of values for the time spent in each media presentation, but particularly the tour (Table 4.1).

I calculated the average amount of time users spent in their respective media intervention, and included only those who spent the average amount of time or exceeded it. The relatively low means (3D M = 7 min. 34 sec., 2D M = 3 min. 32 sec.) of this time threshold drastically reduced the number of viable participants to for both the tour (N =

23) and, to a lesser degree, for the website ($N = 50$) (Table 4.1). Still, reducing the time threshold any more than this (in order to increase the Tour's N number, specifically) was not desirable since preliminary trials of the tour indicate that it takes fully engaged participants at least 15 minutes to maneuver through all of its features. The fact that so many participants spent such short amounts of time on the tour was a concerning outcome; however, testing for differences in results with study participants who didn't actually engage the media stimulus under review was more concerning than having a small pool of participants. I also felt confident running analyses on this amount of participants since it similar to, or larger than, the amounts of participants that researchers of comparable between-group studies used in their peer reviewed research (Breves and Heber 2020; Aitamurto et al. 2018; Filter et al. 2020). After reducing the study pool ($N = 73$), the statistics on time spent in the 3D media stimulus show a more realistic average amount of time for completion ($M = 16$ min. 10 sec.) (see Figure 4.2).

Both the gender and age proportions differed between groups, although the latter was nearly consistent across three of the five possible age range responses. Women were most represented in the overall sample ($N = 39$) as were people between the ages of 26-35 ($N = 26$) (Figures 4.3 and 4.4). Most participants were at least "fairly familiar" with the Northwoods ($N = 50$) across the 2D and 3D groups and most of these people indicated that they have visited the region ($N = 29$), though very few have lived there or consider themselves a frequent visitor ($N = 6$). Roughly 18% of respondents in both groups had never heard of the area ($N = 13$, Figure 4.5). Across groups, people reporting property ownership in the Northwoods ($N = 7$) were far outnumbered by those who reported lack of ownership ($N = 66$, Figure 4.6).

Since pre-test attitudes were not statistically significantly different across each attitude category, I continued my analyses without normalizing the data based on these factors.

Table 4.1. Initial summary statistics of time spent on each media stimulus ($N = 190$).

	N	*Mean*	*Std. Dev.*	*Min*	*Max*
3D Tour	93	7 min, 34 sec	6 min, 28 sec	7 sec	38 min, 28 sec
2D Text	97	3 min, 32 sec	1 min, 58 sec	9 sec	8 min, 53 sec

Table 4.2. Summary statistics for reduced sample ($N = 73$).

	N	*Mean*	*Std. Dev.*	*Min*	*Max*
3D Tour	23	16 min, 10 sec	7 min, 46 sec	8 min, 19 sec	38 min, 28 sec
2D Text	50	5 min, 8 sec	1 min, 4 sec	9 sec	8 min, 53 sec

Table 4.3. Breakdown of participants' reported gender identification by stimulus group ($N = 73$).

		2D Text		*3D Tour*	
		N	*%*	*N*	*%*
Gender	*Man*	23	46.0%	8	34.8%
	Woman	24	48.0%	15	65.2%
	Non-binary	2	4.0%	0	0.0%
	Trans man	1	2.0%	0	0.0%
	Trans woman	0	0.0%	0	0.0%

Table 4.4. Breakdown of participants' reported age by stimulus group ($N = 73$).

		2D Text		*3D Tour*	
		N	*%*	*N*	*%*
Age	*18-25*	7	14.0%	6	26.1%
	26-35	18	36.0%	8	34.8%
	36-45	11	22.0%	6	26.1%
	46-55	6	12.0%	3	13.0%
	56 or older	8	16.0%	0	0.0%

Table 4.5. Breakdown of participants' reported Northwoods familiarity by stimulus group ($N = 73$).

Familiarity	*2D Text*		*3D Tour*	
	N	*%*	*N*	*%*
Not at all – Have never heard of it	9	18.0%	4	17.4%
Not Very - I've heard it's rural	8	16.0%	2	8.7%
Fairly - I know of it because of popular culture or local media	10	20.0%	5	21.7%
Familiar - I have visited occasionally	19	38.0%	10	43.5%
Very - I visit there often or have lived there	4	8.0%	2	8.7%

Table 4.6. Breakdown of participants' personal or family ownership of Northwoods property ($N = 73$).

Property Ownership	*2D Text*		*3D Tour*	
	N	*%*	*N*	*%*
My family does not own property in the Northwoods	44	88.0%	22	95.7%
1–5 years	0	0.0%	1	4.3%
6–25 years	4	8.0%	0	0.0%
More than 25 years	2	4.0%	0	0.0%

4.2.1 Cross-group comparison for prescribed fire

Post-test attitudes toward prescribed fire were significantly different ($p < .05$) from pre-test prescribed fire attitudes for both the 2D ($H(1) = 28.259$ $p = 1.061e\text{-}07$, $\eta 2 = 0.278$) and the 3D participants ($H(1) = 11.501$ $p = .0007$, $\eta 2 = 0.239$). Both stimuli produced more positive attitudes toward prescribed fire for participants (Figure 4.1). Post-test attitudes toward prescribed fire were not statistically different between the two treatment groups ($H(1) = 0.7883$ $p = .3746$, $\eta 2 = 0.00298$). Neither was the relative difference between each group's pre-test and post-test scores ($H(1) = 0.069541$, $p = .792$, $\eta 2 = 0.0131$) (see Table 4.7). Post-test fire attitudes for 2D participants had a higher range and maximum than for 3D participants (Table 4.8).

Table 4.7 P-values of Kruskal-Wallis test run on fire attitudes within and between treatment groups.

	Chi-squared	*DF*	*P-value*
2D pre- and post-test attitude scores	28.259	1	**1.061e-07**
3D pre- and post-test attitude scores	11.501	1	**6.957e-4**
2D and 3D post-test attitude scores	0.7883	1	.3746
relative change in fire attitude scores	0.069541	1	.792

Table 4.8 Summary statistical comparison for prescribed fire-related attitude scores between treatment groups.

			Pre-				*Post-*				
	N	*Mean*	*Mdn*	*SD*	*Min*	*Max*	*Mean*	*Mdn*	*SD*	*Min*	*Max*
3D Tour	23	3.35	4	2.98	-4	8	6.43	7	2.64	1	9
2D Text	50	3.04	3	2.55	-2	8	6.08	6	2.35	0	10

Although the immersive tour results did not statistically differ from those of the Text participants, the Tour subjects did largely provide proportionally more positive Likert responses across all five questions. Both groups showcase a relatively similar pre-test disposition toward fire. Compared to the 2D group, 3D subjects tended to report higher positive responses (Figures 4.1 and 4.2). However, the highest score in the range of answers (10) was provided by two subjects in the Text group.

Since post-test attitudes were not significantly different, I also analyzed relative change in attitude across groups from pre-test to post-test. Here, too, there was no statistically significant difference (Table 4.7).

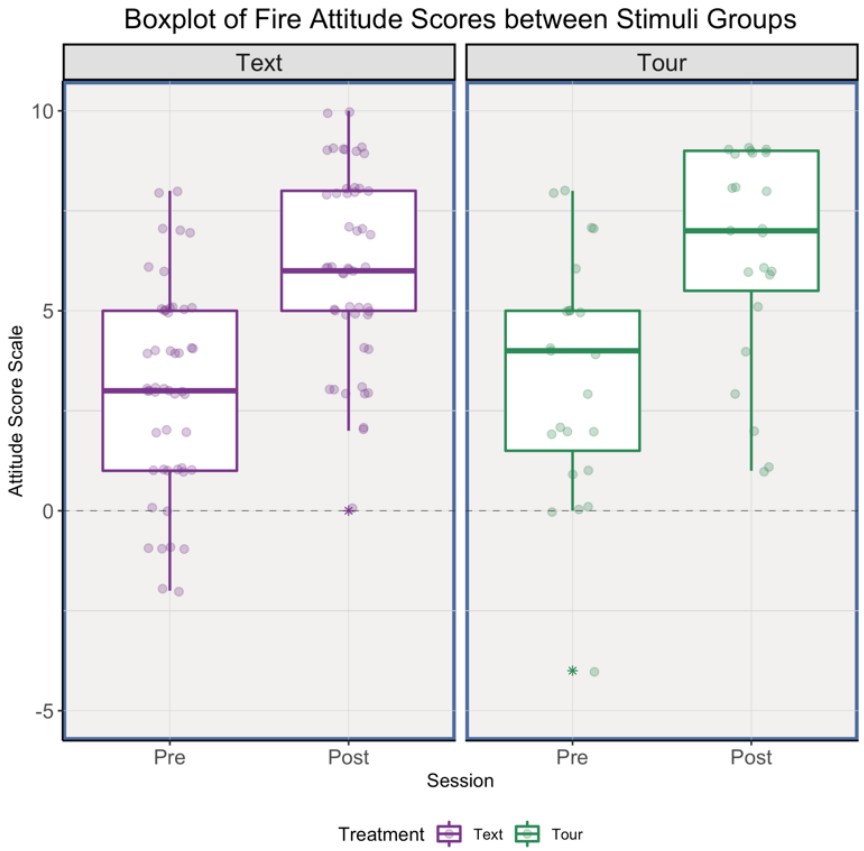

Figure 4.1 Box and scatter plots of prescribed fire-related attitude scores.

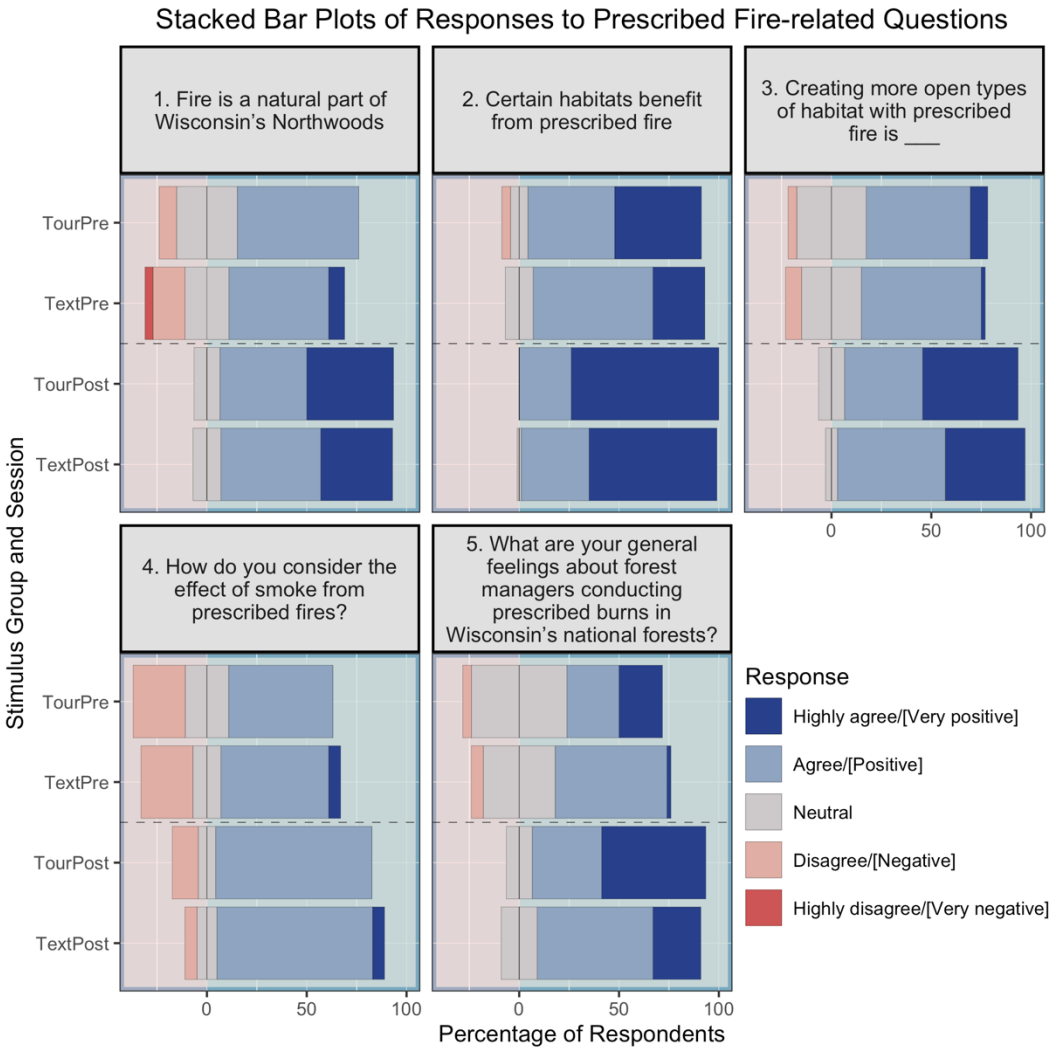

Figure 4.2 Diverging stacked bar charts of prescribed fire-related responses across treatment groups.

Regarding proportional frequencies of Likert responses, Tour participants provided higher percentages of the highest possible positive response for all fire-related questions except for #4 that asks about the effects of smoke (Figure 4.2; "neutral" responses straddle the 0-axis, which splits the diverging proportions of negative and positive responses). Both stimuli dramatically cut down the proportion of "neutral" responses, indicating more decisive judgments by all participants – often for a more positive outlook toward each question.

4.2.3 Comparisons for clear-cutting

Similar to the results for the fire-related questions, both stimuli significantly impacted people's attitudes toward clear-cutting and the relative performance of both media was practically matched in terms of enhancing people's attitudes (Tables 4.9 and 4.10). The immersive tour results were not statistically significant from those of the Text group (H(1), p = .4834, η2 = 0.00717).

Table 4.9 Results of Kruskal-Wallis run on clear-cutting attitudes within and between treatment groups.

	Chi-squared	*DF*	*P-value*	*η2*
2D pre- and post-test attitude scores	29.503	1	**5.582e-08**	0.29
3D pre- and post-test attitude scores	15.569	1	**7.954e-05**	0.331
2D and 3D post-test attitude scores	0.007204	1	.9324	0.014
relative change in clear-cut attitude scores	0.49116	1	.4834	0.00717

Table 4.10 Summary statistical comparison for clear-cutting-related attitude scores between treatment groups.

		Pre-					*Post-*				
	N	*Mean*	*Med.*	*SD*	*Min*	*Max*	*Mean*	*Med.*	*SD*	*Min*	*Max*
3D Tour	23	-0.957	-1	2.80	-6	4	2.65	3	2.76	-6	6
2D Text	50	-0.24	0	2.62	-6	4	2.82	3	2.17	-3	6

Both groups showcased instances of highly negative attitudes toward clear-cutting before-hand based on several instances of the minimum score and since both means and medians were equal to or less than 0 (Table 4.10, Figure 4.3). Neither the results of the box and scatter plots, nor the diverging bar charts, show the concentrated positivity for Tour participants that was reflected in the prescribed fire responses where the upper quartiles occupied the upper range of post-test scores (Figures 4.3 and 4.4). Two people in both groups showed negative post-test attitude scores, but only the 3D group's overall

minimum remained constant, due to one respondent not changing their views from pre-test to post-test (Table 4.10, Figure 4.3). These two scores at the lower extreme, however, represent outliers given that most Tour respondents' attitudes toward clear-cuts enhanced in the post-test. The Tour group's post-test persistence of highly negative answers can be attributed to this extremely negative outlier, whereas no one in the Text group provided the most negative possible response to any question in the post-test (Figure 4.4). Text respondents reported higher percentages of the highest possible positive response on questions #1 and #3, but their Tour counterparts were more likely to give this kind of response to question #2 (Figure 4.4).

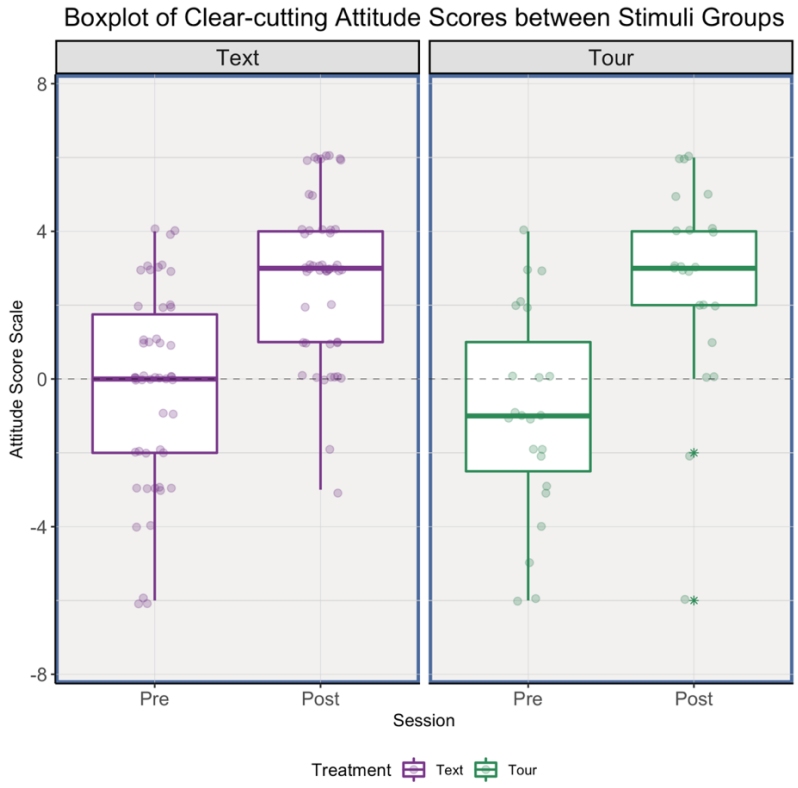

Figure 4.3 Box and scatter plots of clear-cutting attitude scores.

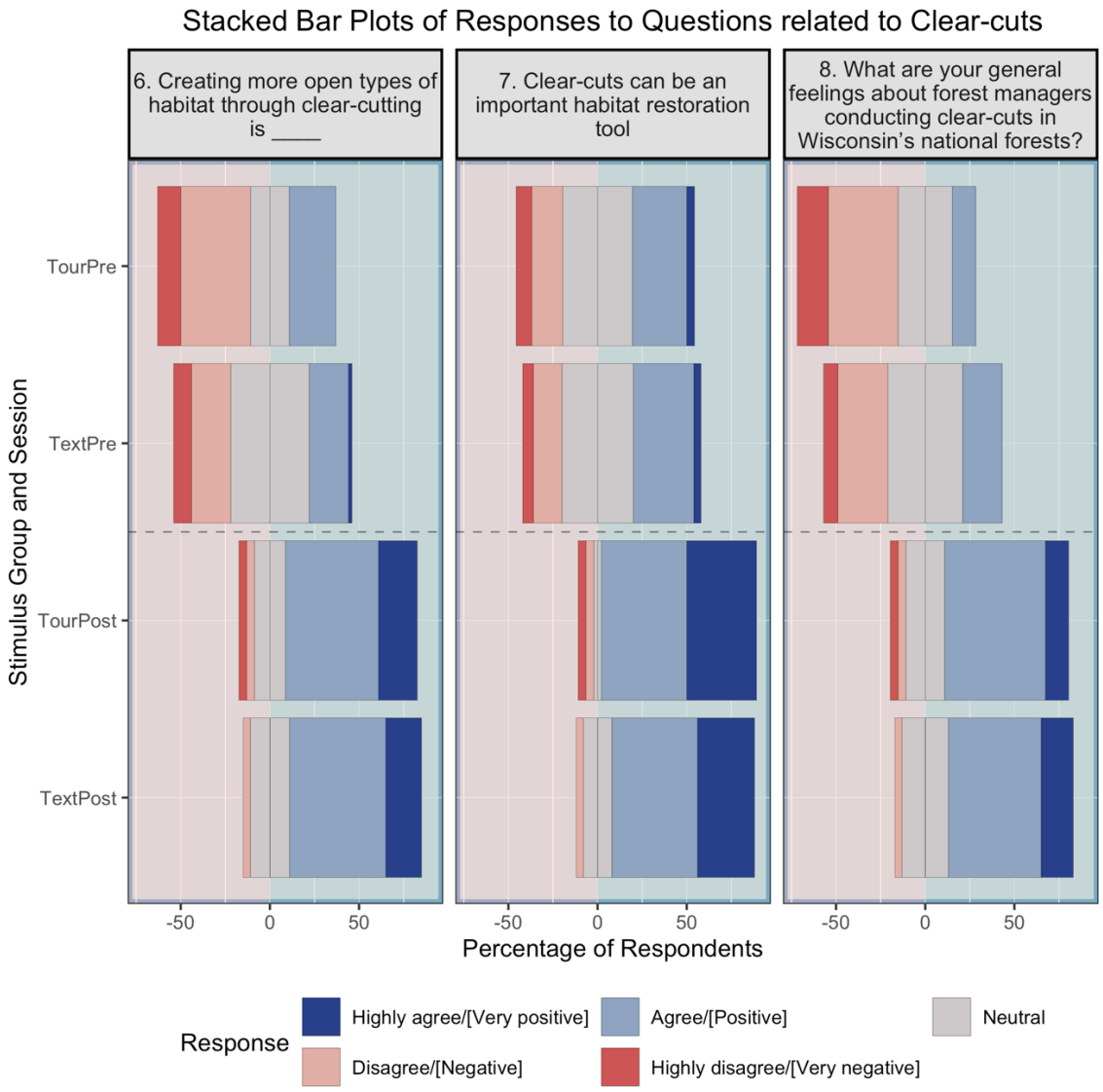

Figure 4.4 Diverging stacked bar charts of responses to clear-cut questions across treatment groups.

4.2.4 Comparisons for Pine Barrens

Tour and Text respondents both showcased significantly enhanced attitudes toward pine barrens, in line with the effects of both these media formats for previous attitude measurements and interventions (Sections 4.2.2 and 4.2.3). Again, however, the immersive tour's total impact did not prove to be statistically significant from that of the conventional website overall (Table 4.11). It did prove statistically more significant, though, for participants who indicated a negative or neutral pine barrens attitude score in the pre-test (Table 4.12).

Table 4.11 Results of Kruskal-Wallis run on pine barrens attitudes within and between treatment groups.

	Chi-squared	*DF*	*P-value*	*η2*
2D pre- and post-test pine barrens scores	34.421	1	**4.44e-09**	.341
3D pre- and post-test pine barrens scores	14.939	1	**.0001111**	.317
2D and 3D post-test pine barrens scores	2.1887	1	.139	.0167
Relative change in pine barrens attitude scores	0.15647	1	.6924	.0119
2D and 3D post-test pine barrens attitudes for those with pre-test attitude score < 1	3.9248	1	**.04758**	.0943

Table 4.12 Summary statistics for pine barrens attitude questions between treatment groups.

		Pre-					*Post-*				
	N	*Mean*	*Med.*	*SD*	*Min*	*Max*	*Mean*	*Med.*	*SD*	*Min*	*Max*
3D Tour	23	1.39	1	3.45	-5	8	5.48	6	2.52	0	10
2D Text	50	.5	0	2.82	-5	7	4.4	5	2.65	-3	9

Compared to results of the fire attitude scale, which also had an absolute range of -10–10, both treatment groups showcased a wider range of pre-test and post-test pine barren responses, except for the Tour group's post-test range of responses (Table 4.12). Overall, each treatment group tended to respond less favorably to pine barrens than they did to

prescribed fire, based on both pre- and post-test means, medians, and minimums across both categories (Tables 4.12 and 4.8, Figures 4.5 and 4.1).

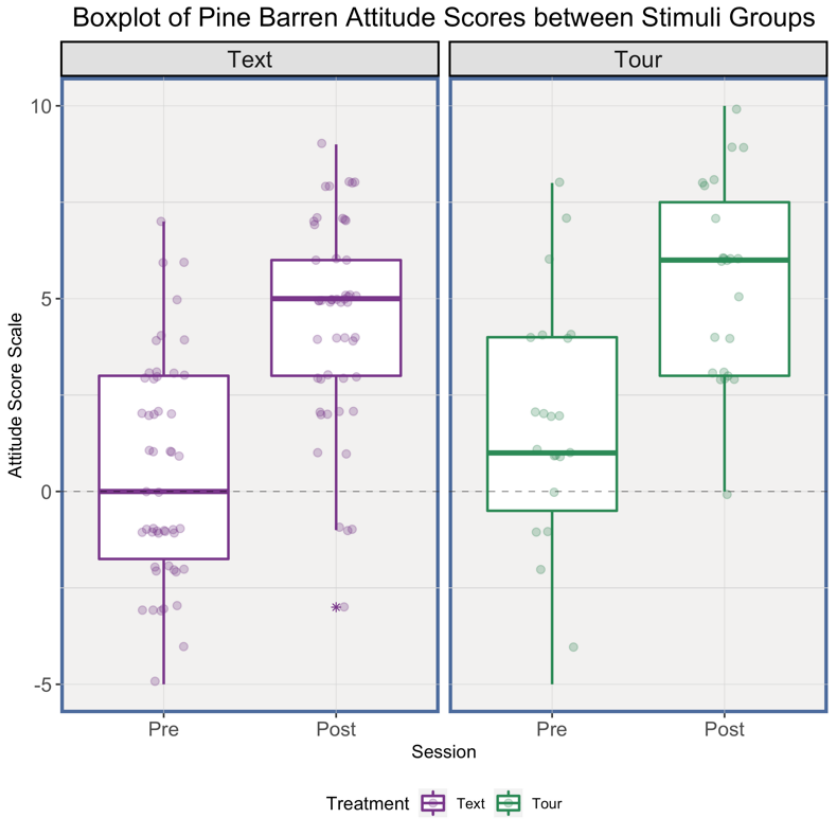

Figure 4.5 Box and scatter plots of pine barrens attitude scores.

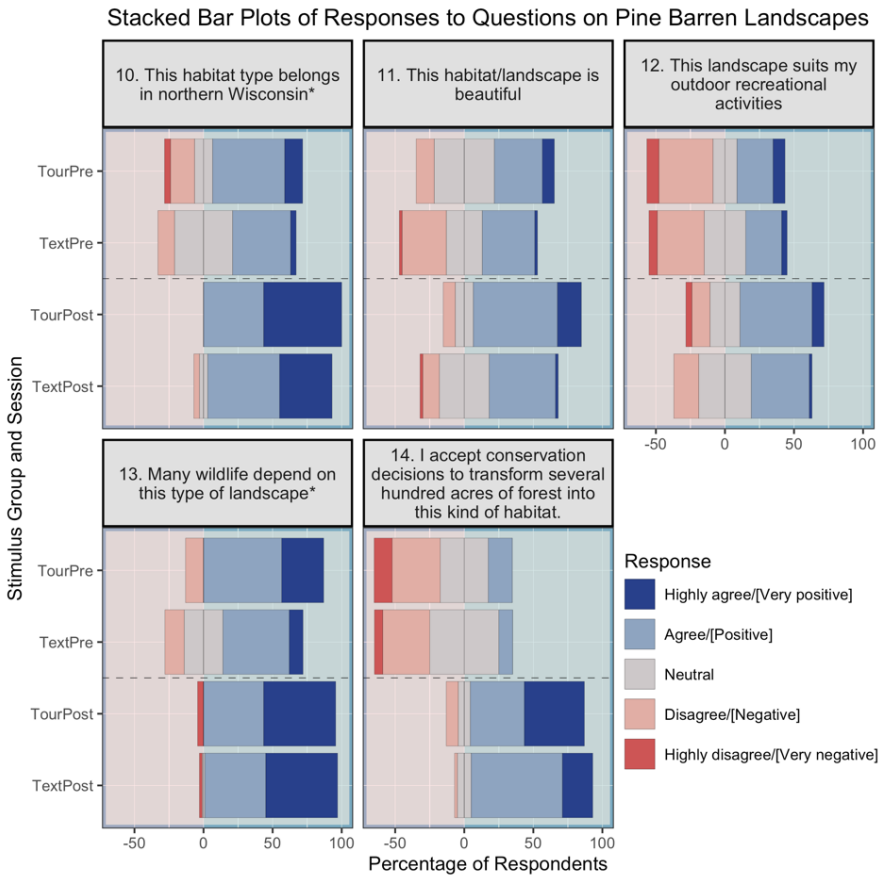

Figure 4.6 Diverging stacked bar charts of pine barrens-related responses across treatment groups.

Note: Questions 10 and 13 were initially framed in the negative, but have been re-worded in positive here for the sake of comparative visual representation. Question #10 in the study says "This habitat type does NOT belong in northern Wisconsin" and #13 says "Not many wildlife depend on this type of landscape."

The 3D group provided larger percentages than the 2D group of the highest possible positive responses for all post-test pine barrens questions (even for Question #13: 52.2% vs. 50.0%, respectively, Figure 4.6). The tour had a noticeably large impact on item #10's question about perceived naturalness of pine barrens in northern Wisconsin: initially over 21% of respondents answered negatively or very negatively, and 13% answered "neutral," which is over one third of the respondent pool. After the intervention, all 3D participants answered positively that pine barrens belong in the Northwoods. Question

#11 also illustrates interesting statistics, where over 77% of 3D participants answered that pine barrens are beautiful, with 13% remaining neutral and 8.7% disagreeing. By contrast, only 2% of the Text group highly agreed, 40% agreed, 36% remained neutral, and 14% disagreed or highly disagreed.

A dramatically large shift in responses is showcased in Question #14 as well, which on its own provides the singularly most direct inquiry into acceptance of pine barrens restoration out of all the questions. Both treatment groups overwhelmingly accepted forest manager decisions to transform several hundred acres of forest into pine barrens. Approximately 92.5% of 3D subjects either agreed or highly agreed with the statement, as did 88.0% of 2D respondents. The Tour group, though, contained 43.5% "Highly agree" responses compared to 22.0% of the Text group. Roughly 8–10% of participants of both groups remained neutral, while proportionally a few more of the Tour group still disagreed compared with those of the Text group (8.7% vs 2.0%).

Between-group Kruskal-Wallis tests on individual questions only indicate significant media differences for post-test responses to Item #11's question of whether pine barrens are beautiful or not ($H(1) = 6.5644$, $p = .0104$, $\eta 2 = .0784$) (Table 4.13).

Table 4.13 Kruskal-Wallis between-group post-test results for items #10–14.

Item	*Chi-squared*	*DF*	*Between group p-value*	*η2*
#10	3.0637	1	.08006	.0291
#11	6.5644	1	**.0104**	**.** 0784
#12	1.3754	1	.2409	.00529
#13	4.5497e-05	1	.9946	.0141
#14	1.1641	1	.2806	.00231

There were significant differences between the two stimuli when comparing respondents who initially answered neutral and/or negatively to specific pine barrens

questions in the pre-test. The tour had a statistically significantly higher impact on post-test attitude scores for respondents who: 1) were uncertain about or thought that pine barrens do not belong (ie. item #10 < 1) in Norther Wisconsin; 2) were neutral or thought that pine barrens were ugly (item #11 < 1); 3) disagreed that the landscape suited their recreational pursuits (#12 < 0). Also, there was significant difference between each media's relative impact on post-test attitudes for those who said they had highly negative feelings about forest managers transforming portions of forest into pine barrens (item #14 = -2) (Table 4.14).

Table 4.14 Results of between-group Kruskal-Wallis analysis on post-test attitude scores after selecting subjects who gave neutral and negative responses to specific pine barrens questions.

	P-value	*Post-test pine barren attitude measure*	η2
Item #10 < 1	**.02465**	Absolute	.123
#11 < 1	**.0439**	Absolute	.0746
#12 < 0	**. 03641**	Absolute	.116
#14 = -2	**.04953**	Delta	.0564

4.2.5 Comparisons of item #9 on correlation between habitat health and beauty

Beside the categorical attitude questionnaires that people answered, respondents also answered a stand-alone question that was meant to unpack their assumptions of landscape health being correlated to beauty or appearance. Question #9 asked for people's Likert-scaled agreement on whether "scenic beauty is a good measure of landscape health." Kruskal-Wallis results indicate within-group significant differences only for the Text group and no significant between-group differences in terms of how people answered this question pre- and post-test. When analyzing results for those who

initially were neutral or in agreement, the Tour did show a significant within-group difference in responses, as did the Text (Table 4.15).

Table 4.15 Kruskal-Wallis results targeting question #9 specifically.

	Condition	*P-value*	η2
2D pre- and post-test response	All	**.03068**	.0375
3D pre- and post-test response	All	.0896	.0428
2D and 3D post-test response	All	.08534	.0276
2D pre- and post-test response	> -1	**.01355**	.0593
3D pre- and post-test response	> -1	**.01364**	.169
2D and 3D post-test response	> -1	.3657	.00313

4.2.6 Spatial Presence Experience Scale Results

There was a statistical difference between Text and Tour treatment groups with regard to one sub-dimension of the scores on the Spatial Presence Experience Scale (SPES) once two blank spaces to two questions were changed to 0 ("neutral"). As a measure of spatial presence, the SPES combines an equal number of questions devoted to a user's sense of: 1) building an ego-centric location (AKA "self-location") within a spatial model afforded by the media content, and 2) the range of "possible actions" they may deploy in the space. As the creators of the scale explain for researchers using their model:

> "Depending on the interest of the researcher, the intensity of the spatial presence experience can be assessed by the total scores of SPES, or in a more differentiated way by examining the two sub-dimensions of SPES: self-location and possible actions" (Hartmann et al. 2016, 22).

Between-group analysis indicated that the 2D and 3D media had significantly different impacts on SPES depending on what SPES questions were included in the Kruskal-Wallis tests (Table 4.16), though the Tour generally outperformed the Text across all measures of SPES (Table 4.17 and Figure 4.7). The Tour provided users significantly

more spatial presence when considering only the sub-scale of self-location as measured by SPES items #1–4 (Table 4.16).

Table 4.16 Kruskal-Wallis results analyzing effect of media stimulus on SPES scores.

	T-test p-value	η2
SPES Ego-location (Q#1-4)	**.03688**	.0473
SPES Interactivity (Q#5-8)	.111	.0217
SPES Score total	.06758	.0330

Table 4.17 Summary statistics of SPES scores across treatment groups.

		SPES 1-4				*SPES 5-6*				*SPES Total*			
	N	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*	*Min*	*Max*
3D	23	1.26	4.15	-8	8	0.174	3.74	-8	8	1.44	7.27	-12	16
2D	50	-0.86	3.84	-8	7	-1.3	3.57	-8	5	-2.16	7.02	-16	11

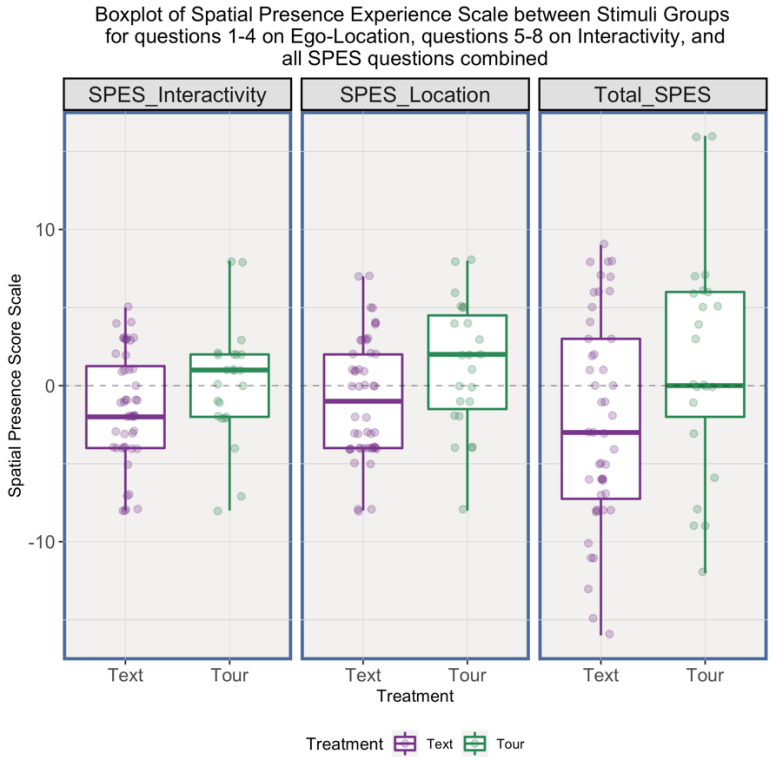

Figure 4.7. Box and scatter plots of SPES scores across groups.

Across media treatments, all participants reported lower SPES values for the sub-scale of interactivity[16] vs the sub-scale of self-location (Figure 4.7). Therefore, in the last analysis (section 4.3.2) I stopped analyzing SPES items #5–8 on their own.

4.3 Two-Way ANOVA tests for SPES Interactions

4.3.1 SPES and stimulus interactions on pine barrens attitudes

Data on SPES scores was normal according to my Shapiro-Wilk tests, and showed homogeneity of variance based on Levene's test (Table 4.18). SPES scores for self-location also showed homogeneity of variance but violated the normality assumption for two-way ANOVAs. I still ran two-way ANOVAs using this factor for the sake of exploratory analysis mainly due to the fact that stimulus impact on self-location showed statistical significance (Table 4.16).

Table 4.18 Shapiro-Wilk normality and Levene's Homogeneity of Variance results for SPES data (bold indicates normality and homogeneity of variance).

	Shapiro-Wilk	*Levene's Test*
	P-value	*P-value*
SPES Ego-location (Q#1-4)	.01756	.988
SPES Interactivity (Q#5-8)	.06571	.667
SPES Score total	0.3227	.795

The results of two-way ANOVAs targeting post-test pine barrens attitude scores showed no statistically significant interaction effect between media stimulus and spatial

[16] The SPES sub-scale of "possible actions" is also referred to as the "interactivity" dimension in this thesis, since "possible actions" is a measure of people's sense of being able to touch, manipulate, and essentially interact with objects in a media presentation (see Hartmann et al. 2016).

presence, neither for the entire SPES score, nor for the sub-dimensions of ego-location nor interactivity (Table 4.19).

Table 4.19 Two-way ANOVA for interaction of media stimulus type and SPES scores on pine barrens attitude scores.

	P-value
SPES Ego-location (Q#1-4)	.16
SPES Interactivity (Q#5-8)	.588
SPES Score total	.284

4.3.2 SPES and stimulus interaction on all individual questions

Two-way ANOVAs were run on all questions in combination with media stimulus and SPES (total, and self-location, separately) as independent variables. The results of these two-way ANOVAs show that there was a significant interaction effect between media stimulus and level of sensed spatial presence for people's responses to questions #3, 5, 13, and 14 (Table 4.20). Details of the main effect analysis for the two-way ANOVAs show that the degree of people's spatial presence score helped determine the 3D tour's significant impact on for people in terms of their: sense that creating more open habitats with prescribed fire is appropriate (#3); feelings about forest managers conducting prescribed burns in Wisconsin's national forests (#5); and their acceptance of forest managers transforming several hundred acres of forest into pine barrens (#14). Conversely, the main factor analysis shows the 2D stimulus significantly impacted people's perceptions of pine barrens' wildlife carrying capacity as a function of their reported spatial presence (#13).

Table 4.20 P-values of two-way ANOVA tests for SPES scores and stimulus variable applied to each question.

	Questionnaire item	*SPES 1–4*	*SPES 1–8*
1	*Fire is a natural part of Wisconsin's Northwoods.*	.218	.167
2	*Certain habitats benefit from prescribed fire.*	.740	.386
3	*Creating more open types of habitat with prescribed fire is ___*	**.017**	**.043**
4	*How do you consider the effect of smoke from prescribed fires?*	.324	.374
5	*What are your general feelings about forest managers. conducting prescribed burns in Wisconsin's national forests?*	**.021**	**.030**
6	*Creating more open types of habitat through clear-cutting is ___*	.577	.353
7	*Clear-cuts can be an important habitat restoration tool.*	.388	.532
8	*What are your general feelings about forest managers conducting clear-cuts in Wisconsin's national forests?*	.352	.312
9	*Scenic beauty is a good measure of landscape health.*	.876	.587
10	*This habitat type does NOT belong in northern Wisconsin.*	.072	.151
11	*This habitat/landscape is beautiful.*	.172	.082
12	*This landscape suits my outdoor recreational activities.*	.529	.950
13	*Not many wildlife depend on this type of landscape.*	**.003**	.053
14	*I accept conservation decisions to transform several hundred acres of forest into this kind of habitat.*	**.018**	.060

On item #3, I ran Levene's test to check for homogeneity of variance, and $p = 0.244$, so this assumption still stands for the 2-way ANOVA; however, the p-value of the Shapiro-Wilks is $p < 0.05$, so the assumption of normality is violated. On item #5, the Levene's p-value = 0.199, so this assumption held; with a Shapiro-Wilk p-value < 0.05, normality could not be assumed. Item #13 also broke the normality assumption, yet showed homogeneity of variance ($p = 0.806$). Item #14 violated both assumptions. Likert scales responses are, as a standard, not normal (Norman 2010), yet there is no no-parametric alternative to a two-way ANOVA.

CHAPTER V

DISCUSSION

This research sought to explore the differential impact that an immersive geovisualization of pine barrens could have on people's attitudes toward this novel landscape and the restoration treatments of prescribed fire and clear-cutting that are integral to creating pine barrens. Although the 3D immersive tour's overall impact on pine barren attitudes was not significantly different from the 2D website stimulus, the tour did significantly outperform the latter when enhancing attitudes for those subjects *who initially held neutral or negatively-scored attitudes toward pine barrens* (ie. based on overall pre-test attitude score). The tour similarly significantly enhanced pine barrens attitudes for participant subgroups who reported neutral or negative responses *to specific questions* in the pine barren questionnaire (ie. based on individual pre-test items in the pine barrens scale before their aggregation).

Notwithstanding the study's focus on the benefits of immersive media, it is also noteworthy that both media stimulus groups significantly shifted their attitudes across all three target attitudes (fire, clear-cutting, pine barrens). This finding indicates that conventional media may suffice for meeting certain thresholds of attitude change for scientific communicators interested in strategic engagement with the public.

Section 5.1 discusses results of changes in attitudes to pine barrens; section 5.2 discusses the results of the changes in attitudes toward landscape treatments of prescribed fire and clear-cutting; section 5.3 discusses the results on spatial presence; and section 5.4 contains concluding thoughts.

5.1 Differential attitude changes toward Pine Barrens

This study advances the potential promise of using immersive media in stakeholder engagement when considering the fact that the 3D tour did induce significantly more positive pine barren attitudes than the 2D stimulus for those people who initially were neutral or held a negative attitudes toward pine barrens. These findings contribute to the strategic toolkit for landscape managers working on improving social acceptability of management decisions since persuasive objectives often revolve around modifying the perspective of people who are neutral or opposed to projects.

It is noteworthy that not only this shift occurred, but also that each media stimulus on its own had a globally significantly positive impact on pine barrens attitudes, because similar studies with informational interventions about pine barrens have not resulted in a change in landscape preference (Gobster, Arnberger, et al. 2021). Although this study did not directly include comparative assessments of people's preferences for multiple habitat types like that of Gobster et al. (2021), the questions were framed within the context of the Northwoods and even included specific items querying for people's approval of transforming "several hundred acres of forest" into pine barrens (item #14).

The study also contributes to Gobster's work on encouraging a greater "ecological aesthetic" in members of the public since the contradiction between aesthetic values and ecological values undermines acceptance of this relatively un-scenic landscape (Gobster 1996; Gobster, Arnberger, et al. 2021). This contradiction in aesthetic vs. ecological values was seen quite clearly in a few of the open responses by participants:

> *"I see their importance now after reading the article... though I do, at the same time, love the woods as they are."[Text group]*

> *"I think they are more important than they look - especially after reading the article." [Text group]*

While these Text respondents indicated a more integrative understanding of pine barrens, the between-group analysis on specific questions of the pine barrens attitude scale revealed that the 3D tour significantly enhanced people's agreement that the pine barrens landscape is beautiful. Study participants answered each pine barrens question while looking at a static photograph of an example of pine barrens, and the significant difference in responses indicates that 3D tour participants "brought the experience with them" so to speak. They were able to effectively see past the image more readily and conceive of beauty through more experiential mental schema. As stated by Gobster's team after consulting local landowners,

> "*Visiting pine barrens allows for exploration, multisensory immersion, and an intimate connection with the landscape and its non-human inhabitants – ways of interactive learning that may be important in landscapes such as pine barrens that lack the spectacular qualities commonly regarded as scenically beautiful"* (Gobster, Arnberger, et al. 2021, 12)

Gobster has explained that informing notions of aesthetics with the experiential evaluation and enjoyment of landscapes can produce a more complex, multi-sensory "ecological aesthetic" (Gobster 1996). He adds that managers and researchers may begin to unpack the ecological aesthetic through investigating people's perceptions of "appropriateness" with regard to habitat alterations. Attending to notions of what is "appropriate" helps to merge aesthetics and biodiversity "within a single problem focus" (Gobster 1996, 85). He argues that engaging people over what appropriately belongs to a place is an "integrative" approach to the problem of ecological values contradicting aesthetic values. As such, the notion of "appropriate" is closely linked to people's conception of what "naturally" belongs to a place (Gobster 1996).

Since most people in the study were familiar with the Northwoods, it is significant that those who deemed pine barrens as not naturally belonging to the region (item #10) were more likely to later give a higher attitude toward pine barrens after experiencing the tour. While all participants scores show a dramatic positive shift to endorse the contextual naturalness of pine barrens, nearly half of the 3D group responded very positively to this question: in item #10 over half of the 3D group firmly endorsed the idea of pine barrens' naturalness in the overall Northwoods landscape (Figure 4.6). Shifting people's notions of appropriateness expands their own place-attachments by enhancing a contextual understanding of the environment. As one participant from the 3D group said,

> *"I simply had no idea that this type of field and open area was part of the original landscape of Northern and NW Wisconsin."*

The motivation to expand people's contextual understanding of appropriateness is that by doing so, they may be more open to seeing historical conditions restored. The previously quoted subject brings this fact to light as their entire pine barrens attitude score shifted from -5 pre-test to 6 afterward. Some open responses by 3D participants highlight how new contextual understandings supersede their prior aesthetic values and ecological assumptions of pine barrens. For instance:

> *"I think they're beautiful in their own way. They are certainly less romantic (to me) than forests, but their beauty comes from the habitat that they create, the wildlife and plants they support, and their ability to decrease the chance of devastating fires. I will keep a lookout for them when next in the Northwoods!"*

> *"They're not my favorite looking landscapes, but definitely necessary I think for the conservation of the greater environment."*

Meanwhile, participants who at first thought that scenic beauty was a good indicator of landscape health (item #9) significantly changed their outlook on this question through engagement with both the Tour and the Text. Moreover, Tour participants on average

were in greater disagreement with the question in the post-test than those of the Text group, indicating that a higher percentage of Tour respondents modified their assumptions about habitat health being directly linked to perceptive beauty alone.

While partly addressing notions of appropriateness, question #10 ("This landscape is NOT natural to northern Wisconsin") also was an approximate index to gauge people's familiarity with pine barrens. Since those 3D participants who answered neutral or deemed it unnatural[17] showed significantly higher positive attitudes toward pine barrens than their counterparts in the Text group, this category of the public could benefit most from an immersive experience. Other studies of stakeholder engagement through immersive virtual environments have found similar results showing that the greatest shift in attitudes through immersive reality was for people unfamiliar with the context under study (Cranmer et al. 2020).

The impact of the immersive media is also visible on recreational activities (item #12), where the tour significantly enhanced people's overall pine barren attitudes who initially judged the landscape as unsuitable for their recreational activities (Table 4.14). For those in the Tour group, extra analysis showed that recreation scores were highly correlated with beauty scores, while for the Text group this facet (ie. item #12) was highly correlated with the perception of pine barrens' biodiversity (item #13) (see Appendix G). Immersive tour scenes of blueberry picking and encountering wildlife or summertime wildflower blooms could help explain this, while also helping to realize the goal of USFS personnel to convey these "assets" to stakeholders. Questions in future

[17] That is, they provided a number of "1" or "2" in the study, which was then later multiplied by -1 to make all data comparable across questions, regardless of their positive or negative framing.

research could ask about people's recreational activities – this question was eliminated for the sake of reducing people's time on the survey instrument.

Importantly, the Tour created a higher relative degree of attitude change toward pine barrens for those participants who were most opposed to the item that explicitly asked about transforming forests into pine barrens (item #14) (Table 4.14). Extrapolating from this finding, I suggest that "moving the needle" for people who are so intently opposed to a concrete proposal of a restoration objective would be very important. Accounting for and possibly softening such intense views is part and parcel to stakeholder engagement models where collaborative learning is involved for the sake of striking some common ground, even if full consensus as a goal is left aside (Blatner et al. 2001).

5.2 Prescribed Fire and Clear-cuts

Whereas the immersive tour holds promise for improving people's discrete attitudes toward pine barrens, the advantages of immersive media are not as straightforward regarding the forest management practices that generate pine barrens: prescribed fire and clear-cutting. Firstly, both types of media showed significant impact on pre-test and post-test attitudes for the respective habitat procedures. Across groups, there were generally lower final attitude scores toward clear-cuts than prescribed fire, though (see Appendix F for comparative scale).

5.2.1 Prescribed Fire

The text was as effective as the immersive tour in enhancing people's attitudes toward prescribed fire. This is important given that prescribed fire is the main treatment for ensuring longevity of pine barrens, and because of the unique qualities of fire that

increase its perceived sense of risk in the eyes of the public, particularly for a region that is socially less accustomed to fire such as that of the Northwoods (Shindler, Toman, and McCaffrey 2009, 162). Inspecting the individual item responses, though, does show that 3D participants did give proportionally higher "highly positive" answers to the Likert items.

One of the most basic, yet still noteworthy, aspects of the shift in Likert responses toward fire for both groups is the reduction of "neutral" responses between pre-test and post-test assessments. The initial "neutral" responses represent a practical point of leverage for public education and direction of otherwise ambivalent attitudes – importantly, in forming more decisive attitudes, people could develop a more negative or positive evaluation of prescribed fire depending on what they learn and how they experience its effects. In their research, Floress, Gobster, and colleagues emphasized that results of their survey of landowner landscape treatment preferences near the Lakewood Southeast Project indicated a large degree of unformed opinions toward prescribed fire (Floress, Haines, et al. 2018a). Their main discussion for future opportunities of engagement focused on the opportunity to shape these neutral responses into more positive opinions. A cluster of motivating factors for approval of prescribed fire that they found in their research includes effectiveness, trust in agency personnel, and assuredness that the outcome will result in the planned objective (ie. pine barrens) (Floress, Haines, et al. 2018b, 20–22). Although this study does not address motivations driving people's decisions as they respond to the questionnaires, there are still items in the questionnaire that associate fire with conservation agency personnel and with open habitats.

In this light, the last question of this attitude scale provides some of the clearest direct evidence for approval of forest managers using prescribed fire. When asked for their feelings about forest managers conducting prescribed burns in Wisconsin's national forests, over 52% of 3D participants answered "Very positive," and all but the remaining 13% answered "positive." This was a much higher "very positive" ranking than the Text group's 24%, although 58% of these participants did answer "positive."

Also the Tour subjects were more likely to view fire as a natural component of the Northwoods, though this group in the pre-test was admittedly less likely to be decisively skeptical on this item compared to the Text respondents. Both groups appeared generally open to the idea that "certain habitats benefit from prescribed fire" initially, but higher percentages of Tour respondents affirmed this more strongly afterward (score of "2") – they similarly were more likely to endorse creating "open habitats" with prescribed fire as "very appropriate" based on item #3.

The question of this series that retained the most negative responses was that of item #4 regarding the effects of smoke, although both groups lessened their apprehension of smoke in the post-test. The fact that item #4 rejects the trend of the Tour group's more positive responses is interesting considering the immersive experience of a "live" prescribed burn in the tour. Whereas the text explicitly stated that smoke dissipates after a day or so, the tour was less explicit and relied on impressing people with this fact through a drone fly-over of the prescribed burn where a smoke column ascends vertically into otherwise clear skies. As this occurred later in the tour experience, some people's attention may have waned by this point. Both stimuli described fire managers planning around safe and favorable weather conditions.

The partial feedback through open responses illustrates that people feel more comfortable after learning of the procedures and seeing the outcomes of prescribed burns for both the Text and Tour groups. One comment from the Tour group, though, showcases the ability of audiovisual media to collapse the temporal distance between habitat treatments and outcomes and convey the vividness of ecological restoration:

> *"I mostly have the same views since I already knew a little about the subject, but it was nice to learn more about how the habitat benefits and it was interesting to see videos of the actual wildlife that is able to thrive after the conservation efforts."*

People largely reported becoming more informed about the rationale of the practices, but also referenced the summary of ecological history and how fire suppression over time has drastically changed the landscape, suggesting that both the Tour and Text directly improved knowledge on the contextual appropriateness of prescribed fire.

5.2.2 Clear-cuts

People in both groups were more cautious of accepting clear-cuts, based on overall attitudes. Scalar adjustments (see Appendix F) indicate that when matched with prescribed fire attitudes, people of both groups responded relatively unfavorably to clear-cuts. This can signal a persistent aversion to see complete transformations of portions of forest in the Northwoods landscape. According to Ribe (1990), whose work has informed that of Gobster, a multitude of specific variables – including spatial tree density, species, age and size, plus the regional context – inform people's visual assessment of perceived beauty in forests. Ribe's early research (Ribe 1990; 1991) accounts for these factors in northern forests including portions of Wisconsin and indicates that clear-cuts occupy the lower extreme of perceived beauty (Ribe 1991, 39) in best-fit regression models. His research shows that thinning forests is preferable to clear-cutting, although certain

characteristics of re-growth may result in a rebound of scenic preference afterward. Research from other regional forests mirrors this public preference for less intensive thinning activity compared to larger harvests (Vodak et al. 1985; Shelby et al. 2005). Notably for the Northwoods, Ribe's early models developed in Wisconsin suggest that the "viewer's aversion to forest damage" is one of the strongest determinants of average scenic beauty perceptions. Ribe found a reinforcing effect between "visually present dead trees, tall slash, and bare ground" (1990, 96) that induce a sense of forest death. These connotations may be socially reproduced with regard to clear-cuts in a state like Wisconsin whose populations, despite benefitting from an active wood products industry, also largely value the intrinsic qualities of their forests. Indeed some of the responses from participants illustrate such perceptions:

> *"I did not consider the importance of pine barrens due to lack of knowledge. I still feel opposed to clear-cuts on a personal nature, but can understand their need in the realm of forest management."* [Text]
>
> *"Prescribed fires appear to be beneficial regarding habitat restoration and preservation; however, I need more information regarding clear-cuts because I believe that they can cause devastating harm to the soil."* [Tour]
>
> *"If clear cutting was used for this purpose in the video that I feel quite a bit better about it and would support it, I still have mixed emotions though due to woods I grew up in being clear cut and the forestry units doing worse because of it. This also reassured me about how good controlled burns are."* [Tour]

The significant change in attitudes within groups, however, does indicate that informed decisions can result in more acceptance for these relatively intensive treatments. Moreover, the shift in attitudes also matches later research from Ribe showing that people's "informed acceptability perceptions (as opposed to uninformed scenic beauty) were not significantly affected by high down wood levels" (Ribe 2013, 31). Both stimuli

of this study appear to strengthen the "informed" nature of people's perceptions with regard to the acceptability of using clear-cuts to produce open habitats.

5.3 Spatial Presence Effects

Measuring people's spatial presence in this study was a major component that could help explain any significant impact of the immersive tour on attitudes. When measuring overall spatial presence through the SPES scale, however, results show that there was not a significant difference in people's reported spatial presence between media treatment groups. There was a significant difference, however, for reports on the "self-location" dimension of spatial presence. The discrepancies between people's self-location versus their sense of "possible actions" (the second dimension of the SPES questionnaire) makes sense given certain aspects of the 3D tour. The effect of moving an avatar through the virtual space with its series of 360º videos containing rich, extensive imagery, likely is a key component of the positive self-location scores. Any suspension of disbelief that the experience is being mediated, though, seems to run aground with respect to people's sense of possible actions, perhaps when they find there are no objects to handle and that stepping deeper into a 360º image isn't possible. Positive SPES scores for the Text group may indicate response bias, since the title of the study included mention of a virtual tour, in which case respondents may have held onto this idea that they were supposed to feel immersed in the website, despite my attempts in the voluntary consent form to inform them of the study design and that there are no "wrong" answers. Alternatively, people may have been accurately reporting a certain degree of "narrative transportation" (Green and Brock 2000; Green, Brock, and Kaufman 2004) since the 2D stimulus's message

content was designed to conform with that of the 3D tour, which itself was scripted with certain narrative elements in mind (Chapter 3).

Two-way ANOVAs indicated that, for four questionnaire items, the media treatments had significant difference to the degree they incurred spatial presence for participants. In three of the four cases, the 3D tour and the SPES scores showed a significant interaction effect, which may be explained by the immersive quality of the tour; more analysis would need to be done to understand the interaction effect between SPES scores and Text for item #13 about wildlife. Notably, questions #5 and #14 are two of the most direct questions in the entire study to ask about people's feelings toward land managers using fire and transforming forest into pine barrens, and in both cases the interaction between spatial presence and 3D media had more impact on people's responses toward these questions that the interaction of spatial presence scores and 2D media.

As others have recognized (Klippel et al. 2020), immersive experiences can amplify audience enjoyment and engagement with media content, which is supported by some of the open responses for Tour participants who had high SPES scores. In the most dramatic instance, one participant said, "It was incredible, by far one of the best things I've ever done." This individual gave the highest responses to both the SPES questionnaire and the questions on pine barrens (16 and 10, respectively). Another Tour participant who reported full spatial presence remarked, "Really informational and I actually had a lot of fun with it!" And one woman with a SPES score of 7 and pine barrens attitude of 9 said, "Beautiful experience! Makes me miss museums, and the outdoors. Also makes me want to do more for the environment." It appears that these

people will take the experience with them, which may lead to more readily retained positive attitudes that are accessible through having virtually experienced something first-hand (Schöne, Wessels, and Gruber 2019). Furthermore, these people may represent individuals who have a personal "need for affect" that has been shown to influence "media enjoyment, persuasive communication, and narrative experiences" (Breves and Heber 2020, 6), and for whom *affective* communication through immersive experiences could be especially useful.

It is clear, though, that not everyone felt so engrossed by the content based on approximate times people spent engaged in the immersive tour. Hence, alternative methods of deploying and facilitating people's participation in the study would be beneficial and potentially incur higher spatial presence scores for the 3D media. This 3D tour was streamed through a somewhat unique consumer-grade streaming platform that is vulnerable to glitches and technical issues that can remind people they are interfacing with a type of media, thereby breaking the illusion of "being there" in the displayed environment. Conducting studies remotely always limits the ability of researchers to control for environmental conditions of subjects – during COVID there is an increased likelihood that people are negotiating more distractions when at home where they may very well be logging into their Prolific site for study participation. Furthermore, using in-person methods for a study like this one can allow the researcher to conduct focus groups and semi-structured interviews that give space for participants to reflect more deliberately and extensively on their experience. In a different study of this type, researchers could also re-assess attitudes or preferences at a later date, and see changes from immersive

media are more long-lasting despite their initial failure to show statistically significant differences from other media.

Conclusion

Overall, the immersive tour did not outperform the 2D descriptions with vivid imagery and clean design whose message content matched the tour. Instead, both media significantly improved peoples' attitudes about prescribed fire, clear-cuts, and pine barrens restoration, illustrating that the additional costs and time associated with creating a VR experience may not be necessary for gaining public support for pine barrens restoration.

However, the tour significantly enhanced pine barrens attitudes for those subgroups who were neutral or negative about restoration goals to begin with based on their initial pine barrens attitude scores. Similarly, the tour did significantly improve pine barrens attitudes for those who were most intensely opposed to the idea of conservation efforts to transform several hundred acres into barrens, and those who were neutral or in disagreement with the naturalness, beauty, and recreational potential of barrens. These details – on an important demographic of potential stakeholders – do support hypothesis #1 that an immersive tour will lead to higher attitudes than a conventional text explanation. Moreover, the study opens opportunities to further consider how new tools of stakeholder engagement can help foster an experiential sense of beauty that is part of building people's ecological aesthetic and notions of what is environmentally appropriate.

Finally, although each media did significantly shift people's views of clear-cuts, it appears that participants' initial attitudes toward this habitat treatment are more enduring

than their respective attitudes toward prescribed fire and pine barrens. This wariness was present in the responses despite people agreeing with items that describe transforming parts of the forest for pine barrens restoration. This result partly indicates the strength of people's place-attachments or broader popular conceptions of logging and landscape health, which are valid. Implications of this research are that strategic communication with stakeholders may improve acceptance of pine barrens habitats and their sustenance over time, but that reclaiming their place in an already forested landscape is more challenging.

APPENDIX A

INFORMED CONSENT

Participants of my user study encountered the following consent form at the beginning of the user study:

Informed Consent for Research Participation

You are being asked to participate in a research study. The text below highlights key information for you to consider when making a decision whether or not to participate.

Carefully consider this information and please ask questions about anything you do not understand before you decide whether to participate.

This research requires a keyboard and is not mobile compatible. If you are on a phone you may revisit the survey from your computer through Prolific.

Key Information to Consider

Voluntary Consent: It is up to you whether you choose to participate or not in this research study. There will be no penalty or loss of benefits to which you are otherwise entitled if you choose not to participate or discontinue participation.

Purpose: To understand the learning and perceptual outcomes from virtual tours of landscape restoration projects. About 200 people will take part in this research.

Duration: Your participation is expected to last 20-30 minutes.

Procedures and Activities: You will be asked basic demographic information and answer questions regarding your outlook on the following: Wisconsin's North Woods, Pine Barrens, Prescribed Fire, and Clear-cuts. You will be presented with an informational presentation either by text or interactive video that describes specific landscape restoration procedures in northern Wisconsin, and you will be asked questions about your experience.

Once you have finished all questions you will indicate your completion so that you can be reimbursed. You may skip any questions you feel uncomfortable with or end participation at any time.

Risk: There are no foreseeable risks in participating.

Benefits: Beside being paid $6.25 for participation, you have the opportunity to learn about rare landscape restoration practices. This research has applications for better science communication and stakeholder engagement in habitat restoration contexts.

Alternatives: The only alternative is to not participate.

What happens to the information collected for this research?
Information from this research will be used to answer a set of research questions. The goal is to understand how different media and immersive geovisualization influence people's attitudes toward habitat restoration. The results will be published in an academic journal article.

How will my privacy and data confidentiality be protected?
We will not collect any personally identifying information in the questionnaire - your Prolific ID is meant only to ensure compensation. All data collected in the questionnaire will be stored on a password protected laptop or password protected server.

Will I be paid for participating in this research?
You will be paid $6.25.

Who can answer my questions about this research?

Stuart Steidle
(213)503-3921
ssteidle@uoregon.edu

An Institutional Review Board ("IRB") is overseeing this research. An IRB is a group of people who perform independent review of research studies to ensure the rights and welfare of participants are protected. UO Research Compliance Services is the office that supports the IRB. If you have questions about your rights or wish to speak with someone other than the research team, you may contact:

Research Compliance Services
5237 University of Oregon
Eugene, OR 97403-5237
(541) 346-2510
ResearchCompliance@uoregon.edu

APPENDIX B

QUESTIONNAIRES

Participants in my user study encountered the following questionnaires after the informed consent form.

DEMOGRAPHIC INFORMATION

Please check the box that best characterizes you or your experience for the following questions.

What is your Prolific ID? _____

1. How old are you?
   - ◊ 18-25 □
   - ◊ 26-35 □
   - ◊ 36-45 □
   - ◊ 46-55 □
   - ◊ 56 or older □
2. How do you identify?
   - ◊ Woman □
   - ◊ Trans woman □
   - ◊ Trans man □
   - ◊ Man □
   - ◊ Non-binary □
   - ◊ A gender not listed here (Please specify if you wish) _____
   - ◊ Prefer not to say □
3. How familiar are you with Wisconsin's Northwoods?
   - ◊ Not at all - Have never heard of it
   - ◊ Not Very - I've heard it's rural
   - ◊ Fairly - I know of it because of popular culture or local media
   - ◊ Familiar - I have visited occasionally
   - ◊ Very - I visit there often or have lived there
4. Do you or your family own property in the Northwoods? If so, for how long?
   - ◊ My family does not own property in the Northwoods
   - ◊ Less than one year
   - ◊ 1-5 years
   - ◊ 6-25 years
   - ◊ More than 25 years

Please consider the following questions or statements in the context of northern Wisconsin to the extent you are able, and mark one answer that best reflects your views currently. There are no "correct" answers and an optional, free-response box follows these questions.

"Prescribed fire/burning" refers to the controlled application of fire to a landscape by a team of fire experts, often to manage landscapes.

1. Fire is a natural part of Wisconsin's Northwoods.
    - ◊ Highly disagree
    - ◊ Disagree
    - ◊ Neutral
    - ◊ Agree
    - ◊ Highly agree
2. Certain habitats benefit from prescribed fire.
    - ◊ Highly disagree
    - ◊ Disagree
    - ◊ Neutral
    - ◊ Agree
    - ◊ Highly agree
3. Creating more open types of habitat with prescribed fire is ____.
    - ◊ Highly disagree
    - ◊ Disagree
    - ◊ Neutral
    - ◊ Agree
    - ◊ Highly agree
4. How do you consider the effect of smoke from prescribed fires?
    - ◊ It's a very bad problem and should be avoided at all costs.
    - ◊ It's often an issue and should be minimized.
    - ◊ Neutral
    - ◊ At times an issue, but not much as long as the burn is well coordinated.
    - ◊ Not a problem at all.
5. What are your general feelings about forest managers conducting prescribed burns in Wisconsin's national forests?
    - ◊ Very negative
    - ◊ Negative
    - ◊ Neutral
    - ◊ Positive
    - ◊ Very positive

A "clear-cut" refers to cutting down nearly all the trees within a designated space to meet a management objective such as timber harvest, reducing fuel for prescribed fire, etc.

6. Creating more open types of habitat through clear-cutting is ____.
    - ◊ Very inappropriate
    - ◊ Inappropriate
    - ◊ Neutral
    - ◊ Appropriate
    - ◊ Very appropriate
7. Clear-cuts can be an important habitat restoration tool.
    - ◊ Highly disagree
    - ◊ Disagree
    - ◊ Neutral
    - ◊ Agree
    - ◊ Highly agree
8. What are your general feelings about forest managers conducting clear-cuts in Wisconsin's national forests?
    - ◊ Very negative
    - ◊ Negative
    - ◊ Neutral
    - ◊ Positive
    - ◊ Very positive

Feel free to share any comments on prescribed fire and/or clear-cuts:

---

9. Scenic beauty is a good indicator of landscape health.
    - ◊ Highly disagree
    - ◊ Disagree
    - ◊ Neutral
    - ◊ Agree
    - ◊ Highly agree

Please consider the following questions or statements in the context of northern Wisconsin as much as you are able, and mark one answer that best reflects your views currently. There are no "correct" answers.

These questions ask about an open habitat type known as **pine barrens**, with a photograph of one such landscape included below for reference.

	Highly disagree	Disagree	Neutral	Agree	Highly agree
This habit type does NOT belong in the Northwoods.	○	○	○	○	○
This habitat/landscape is beautiful.	○	○	○	○	○
This habitat/landscape suits my outdoor recreational activities. (You could see yourself visiting and enjoying the experience.)	○	○	○	○	○
Not many wildlife depend on this type of habitat.	○	○	○	○	○
"I accept conservation decisions to transform several hundred acres of forest into this kind of habitat."	○	○	○	○	○
Converting portions of forest into this landscape helps to reduce the threat of wildfires.	○	○	○	○	○

[*Randomized exposure to either a) or b) below*]

a) Tour

Please visit the virtual tour to learn about the use of logging and prescribed fire to restore rare pine barrens habitats. This portion takes between 15-20 minutes and is interactive. It works best in Chrome and Safari browsers.

- The link will present you with an instructional video on how to move through the tour.
    - (The video will repeat until you click "skip video" at which point the tour begins)
- The interactive tour also begins with a signboard of slightly expanded instructions.
- Move your character through the portals in sequence to learn about restoration procedures.
- If you run into a technical issue you may restart the tour.

Upon completing the tour and map interaction **please return to this survey and finish the questions.**

Thank you

b) Webpage

Please read this web pamphlet to learn about the use of logging and prescribed fire to restore rare pine barrens habitats. This portion takes roughly 5-7 minutes.

Once you are finished, **please return to this survey to finish answering questions**.

Thank you

Please consider the following questions or statements in the context of northern Wisconsin to the extent you are able, and mark one answer that best reflects your views currently. There are no "correct" answers and an optional, free-response box follows these questions.

"Prescribed fire/burning" refers to the controlled application of fire to a landscape by a team of fire experts, often to manage landscapes.

1. Fire is a natural part of Wisconsin's Northwoods.
    - ◊ Highly disagree
    - ◊ Disagree
    - ◊ Neutral
    - ◊ Agree
    - ◊ Highly agree
2. Certain habitats benefit from prescribed fire.
    - ◊ Highly disagree
    - ◊ Disagree
    - ◊ Neutral
    - ◊ Agree
    - ◊ Highly agree
3. Creating more open types of habitat with prescribed fire is ____.
    - ◊ Highly disagree
    - ◊ Disagree
    - ◊ Neutral
    - ◊ Agree
    - ◊ Highly agree
4. How do you consider the effect of smoke from prescribed fires?
    - ◊ It's a very bad problem and should be avoided at all costs.
    - ◊ It's often an issue and should be minimized.
    - ◊ Neutral
    - ◊ At times an issue, but not much as long as the burn is well coordinated.
    - ◊ Not a problem at all.
5. What are your general feelings about forest managers conducting prescribed burns in Wisconsin's national forests?
    - ◊ Very negative
    - ◊ Negative
    - ◊ Neutral
    - ◊ Positive
    - ◊ Very positive

A "clear-cut" refers to cutting down nearly all the trees within a designated space to meet a management objective such as timber harvest, reducing fuel for prescribed fire, etc.

6. Creating more open types of habitat through clear-cutting is ____.
    - ◊ Very inappropriate
    - ◊ Inappropriate
    - ◊ Neutral
    - ◊ Appropriate
    - ◊ Very appropriate
7. Clear-cuts can be an important habitat restoration tool.
    - ◊ Highly disagree
    - ◊ Disagree
    - ◊ Neutral
    - ◊ Agree
    - ◊ Highly agree
8. What are your general feelings about forest managers conducting clear-cuts in Wisconsin's national forests?
    - ◊ Very negative
    - ◊ Negative
    - ◊ Neutral
    - ◊ Positive
    - ◊ Very positive

Feel free to share any comments on how your views may have changed toward prescribed fire and/or clear-cuts:

_____

9. Scenic beauty is a good indicator of landscape health.
    - ◊ Highly disagree
    - ◊ Disagree
    - ◊ Neutral
    - ◊ Agree
    - ◊ Highly agree

Please consider the following questions or statements in the context of northern Wisconsin as much as you are able, and mark one answer that best reflects your views currently. There are no "correct" answers.

These questions ask about an open habitat type known as **pine barrens**, with a photograph of one such landscape included below for reference.

	Highly disagree	Disagree	Neutral	Agree	Highly agree
This habit type does NOT belong in the Northwoods.	○	○	○	○	○
This habitat/landscape is beautiful.	○	○	○	○	○
This habitat/landscape suits my outdoor recreational activities. (You could see yourself visiting and enjoying the experience.)	○	○	○	○	○
Not many wildlife depend on this type of habitat.	○	○	○	○	○
"I accept conservation decisions to transform several hundred acres of forest into this kind of habitat."	○	○	○	○	○
Converting portions of forest into this landscape helps to reduce the threat of wildfires.	○	○	○	○	○

Feel free to share any comments on pine barrens:

Lastly, considering the informational experience you took part in during this survey, please rate your agreement with the following statements.

	Highly disagree	Disagree	Neutral	Agree	Highly agree
I felt like I was actually there in the environment of the presentation.	○	○	○	○	○
It seemed as though I actually took part in the action of the presentation.	○	○	○	○	○
It was as if my true location had shifted to the environment in the presentation.	○	○	○	○	○
I felt like I was physically present in the environment of the presentation.	○	○	○	○	○
The objects in the presentation gave me the sense I could do things with them.	○	○	○	○	○
I had the impression that I could act in the environment of the presentation.	○	○	○	○	○
I felt like I could move around among the objects in the presentation.	○	○	○	○	○
It seemed to me that I could do whatever I wanted in the environment of the presentation.	○	○	○	○	○

Anything that you would like to share about your experience? _____

Thank you for taking part in this survey. Please click the following re-direct link to be brought back to Prolific and have your participation confirmed:

https://app.prolific.co/submissions/complete?cc=1B0D347D

Your response has been recorded.

APPENDIX C

VISUAL STIMULI OF 3D TOUR

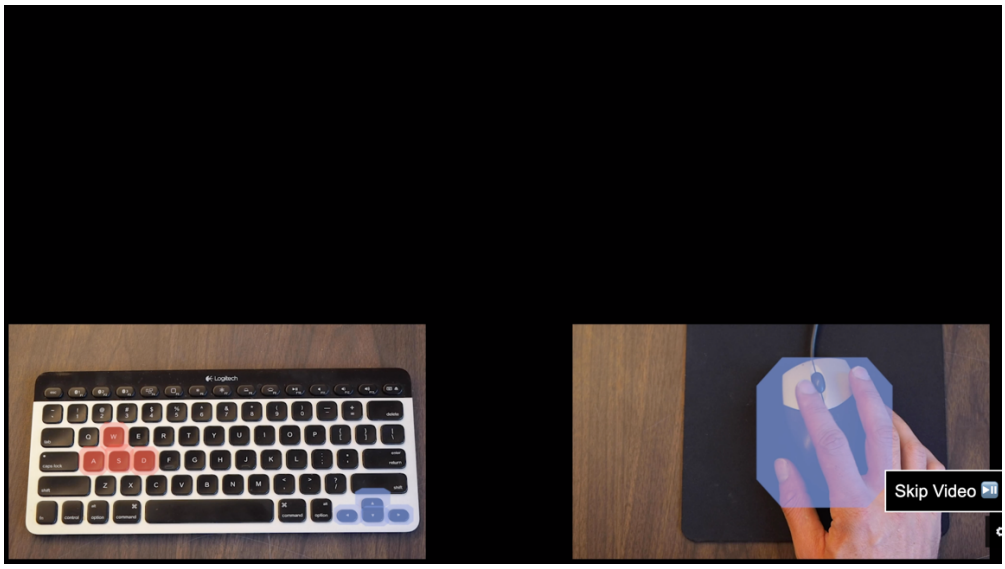

Figure C.1 Screenshot of the opening instructional video that 3D participants view when they first click the link to the immersive tour. Audio narration and navigation demonstration instruct participants on how to move through the tour.

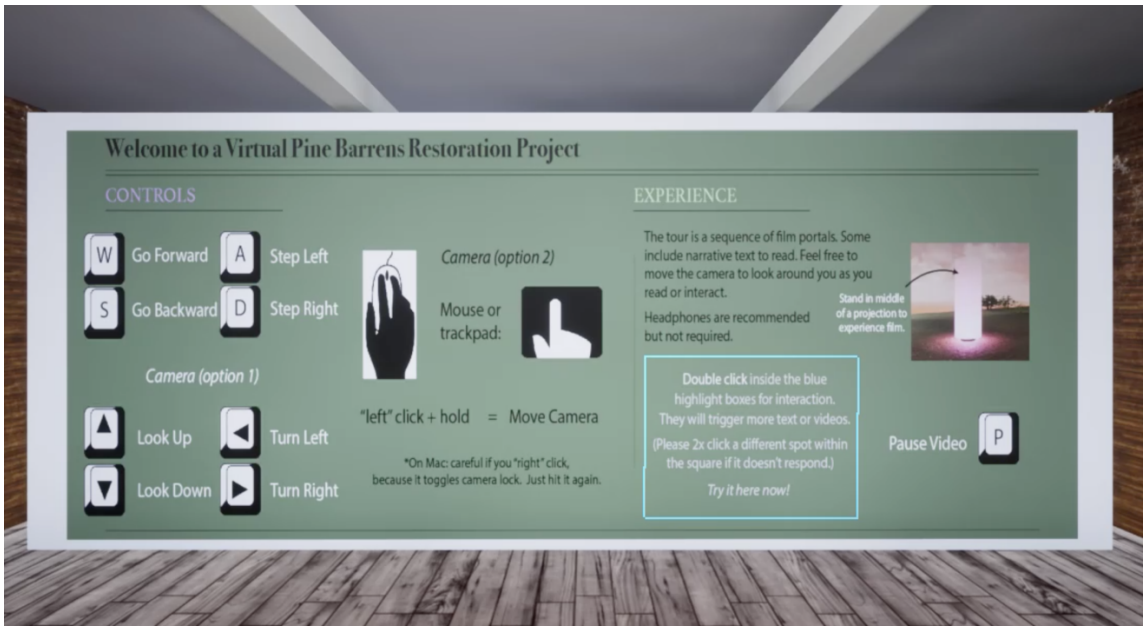

Figure C.2 Screenshot of the first thing participants see from within the tour. This illustrates an instructional sign spanning a wall inside a building where participants begin the experience before moving outside to enter the video portals.

Figure C.3 A screenshot of some of the video portals participants walk into to trigger fully panoramic and omnidirectional 360º video scenes.

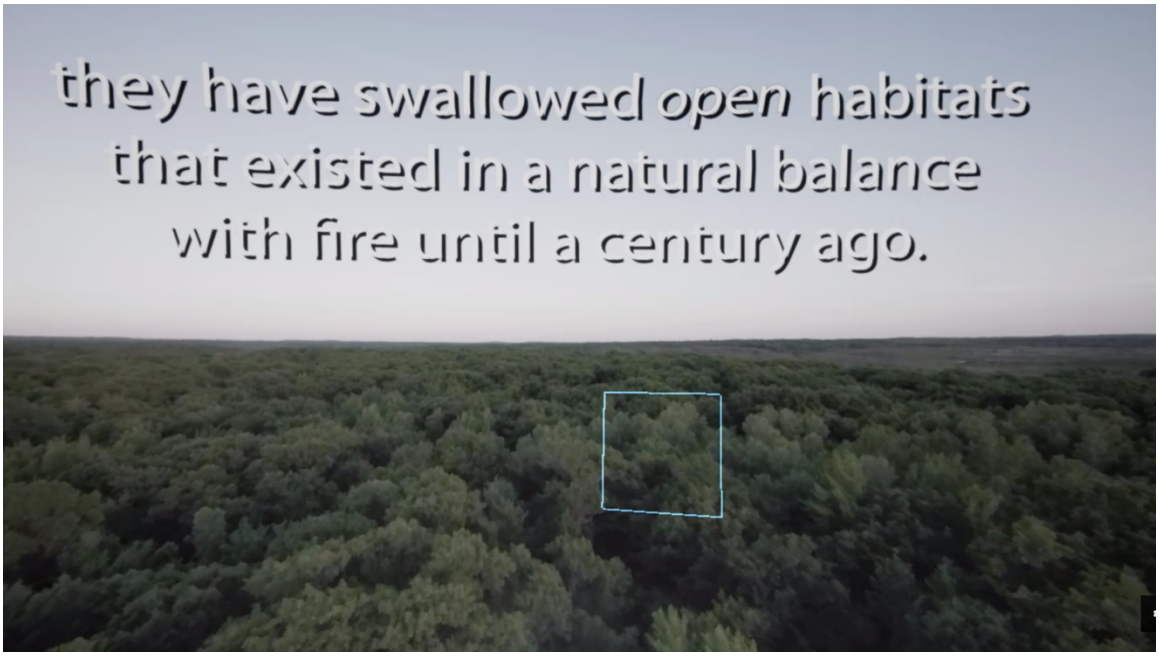

Figure C.4 Part of the opening text in the first 360º scene, which introduces people to the Northwoods. The blue box is a clickable widget that triggers more text to appear.

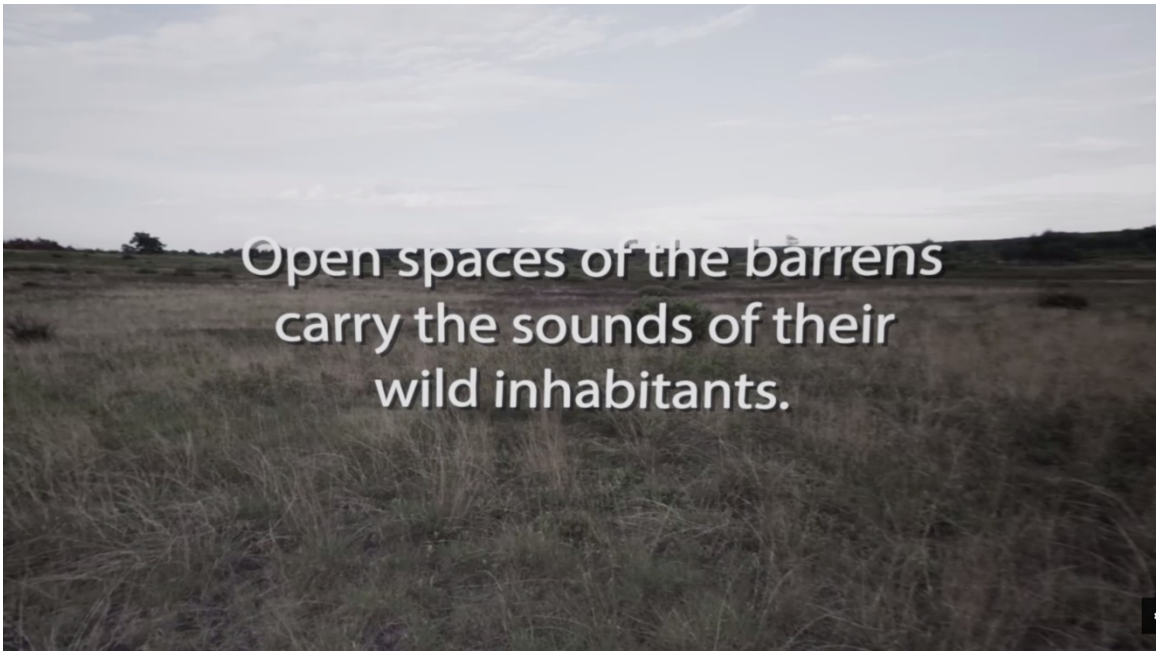

Figure C.5 Screenshot of first example of pine barrens habitat.

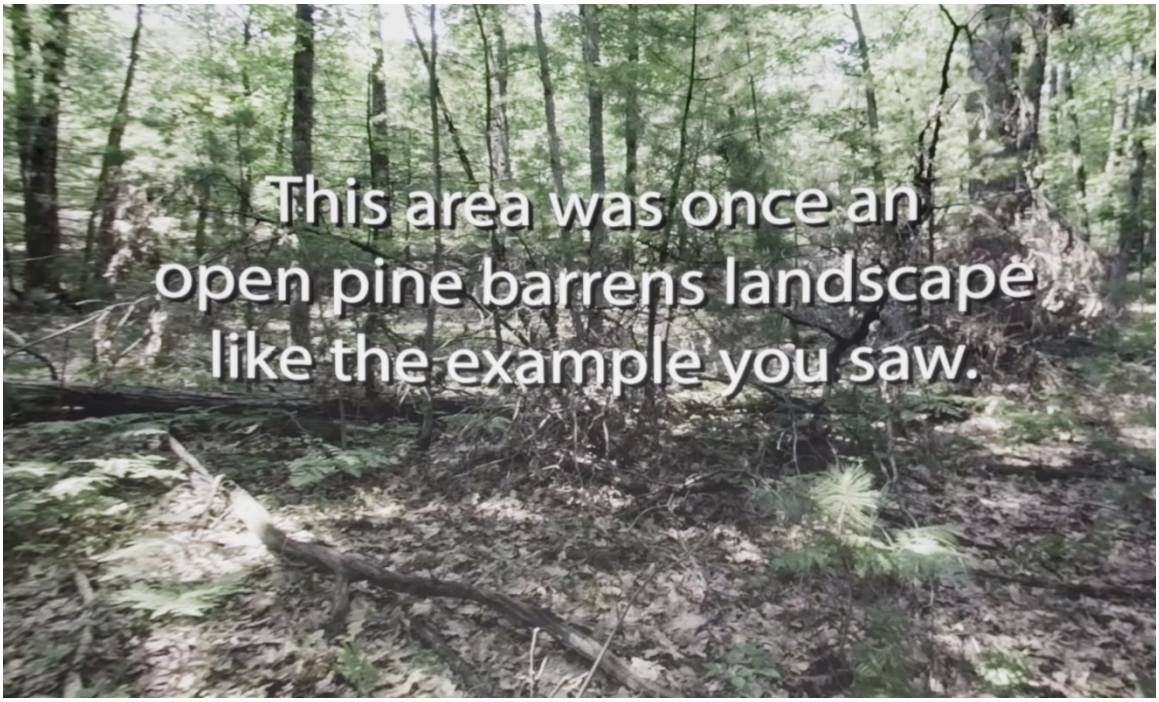

Figure C.6 Part of the text narration of the second immersive sphere where participants "meet" foresters identifying viable restoration sites.

Figure C.7 Continuation of the scene with foresters identifying restoration sites.

Figure C.8 USFS personnel John Lampereur and Tym Sauter walking in dense forest discussing restoration plans. Floating text moves through the sphere as the personnel walk, and is used to reinforce key points of what they said in the scene.

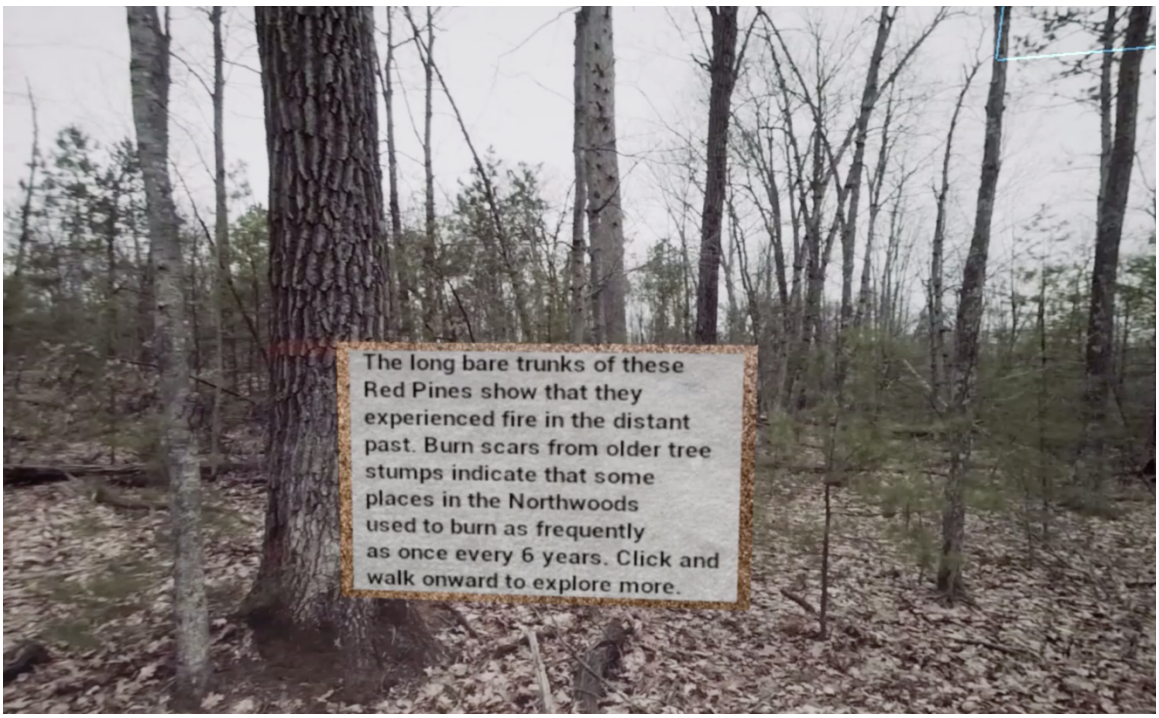

Figure C.9 An example of a text-element pop-up after a participant clicked on one of the few remaining red pines visible in this forest scene.

Figure C.10 Example of a text-element pop-up in a scene from a recently logged restoration site.

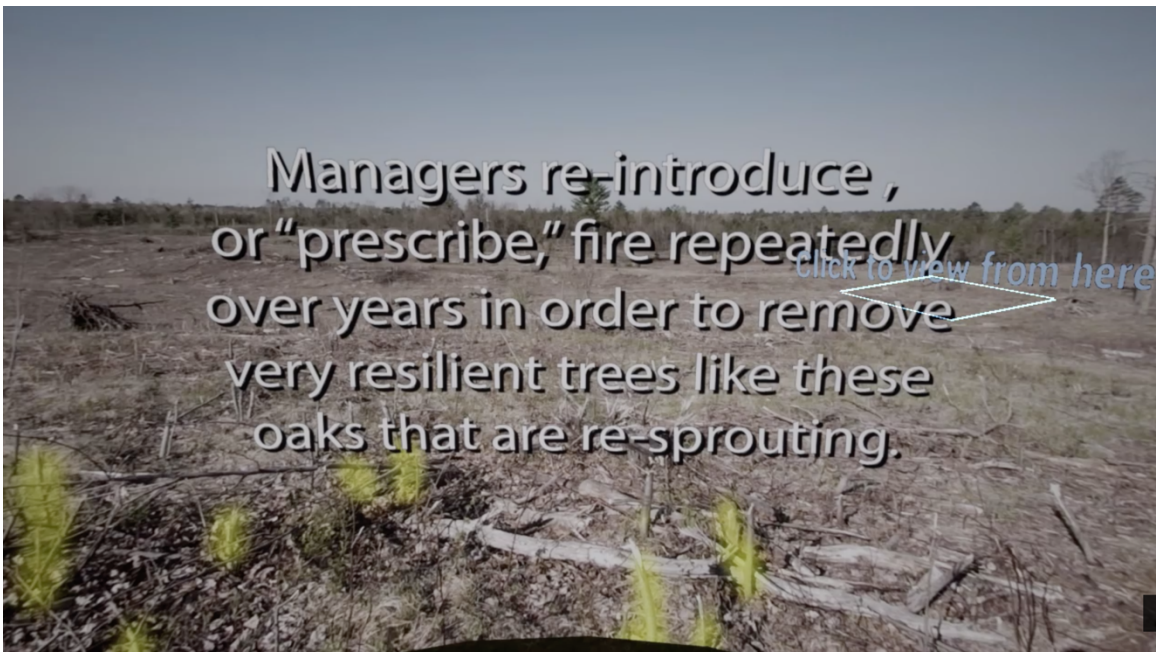

Figure C.11 Screenshot from a space that has been clear-cut and where slash was removed, but still requires fire. The "Click to view from here" would not be visible simultaneously as the white text describing land managers prescribing fire, but would arise after the latter text fades away. When users click the "click to view from here" square, the scenery changes to show what the 360º camera documented from that space.

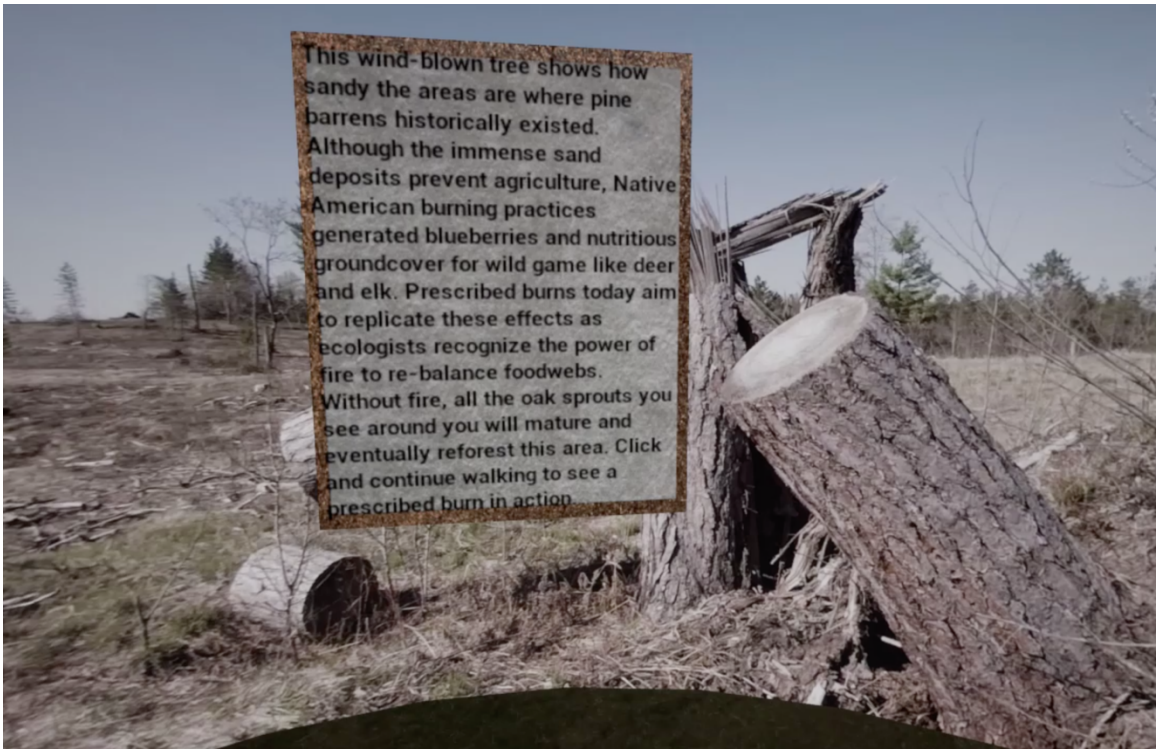

Figure C.12 Example of another text widget in the tour.

Figure C.13 Screenshot from footage in the 360º sphere that depicts the stages of a prescribed burn. At this point participants are exposed to the burn crews.

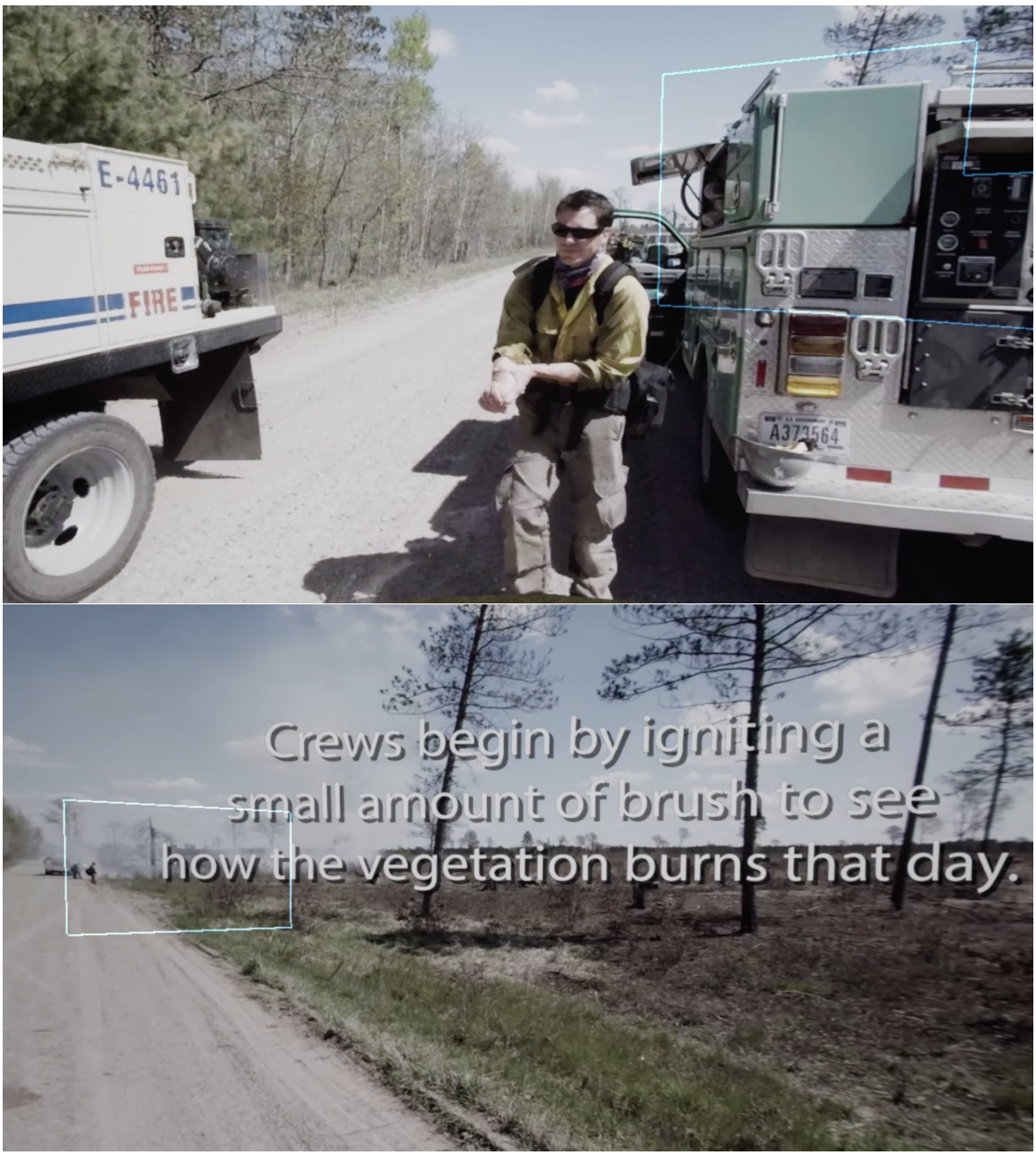

Figure C.14 More footage from the prescribed burn, including interactable widgets that trigger more pop-up text.

Figure C.15 Screenshot of the multi-layered footage of crews applying fire. The video inset is triggered by participants clicking on a blue square (see second portion of Figure C.14), and is meant to induce a sense of "zooming in" to get a closer look at activities in the field.

Figure C.16 Screenshot of the prescribed fire scene as smoke builds and dissipates in the wind.

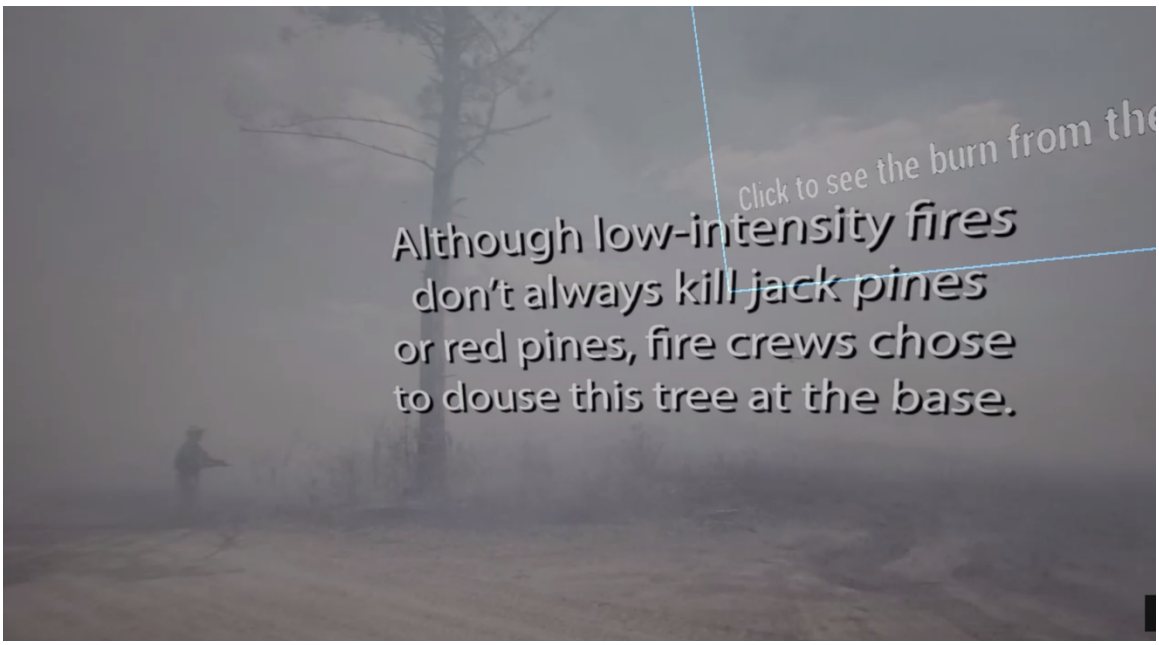

Figure C.17 Screenshot of prescribed fire scene. (The blue box widget overlapping the text is an artifact of pausing video while gathering screenshots, and usually wouldn't appear until this specific smoke scene fades).

Figure C.18 Screenshot of prescribed fire scene at the burn perimeter. The semi-truck passes by in the scene and the text explains that traffic is "still passing safely."

Figure C.19 Screenshots of 360º drone footage above the prescribed burn.

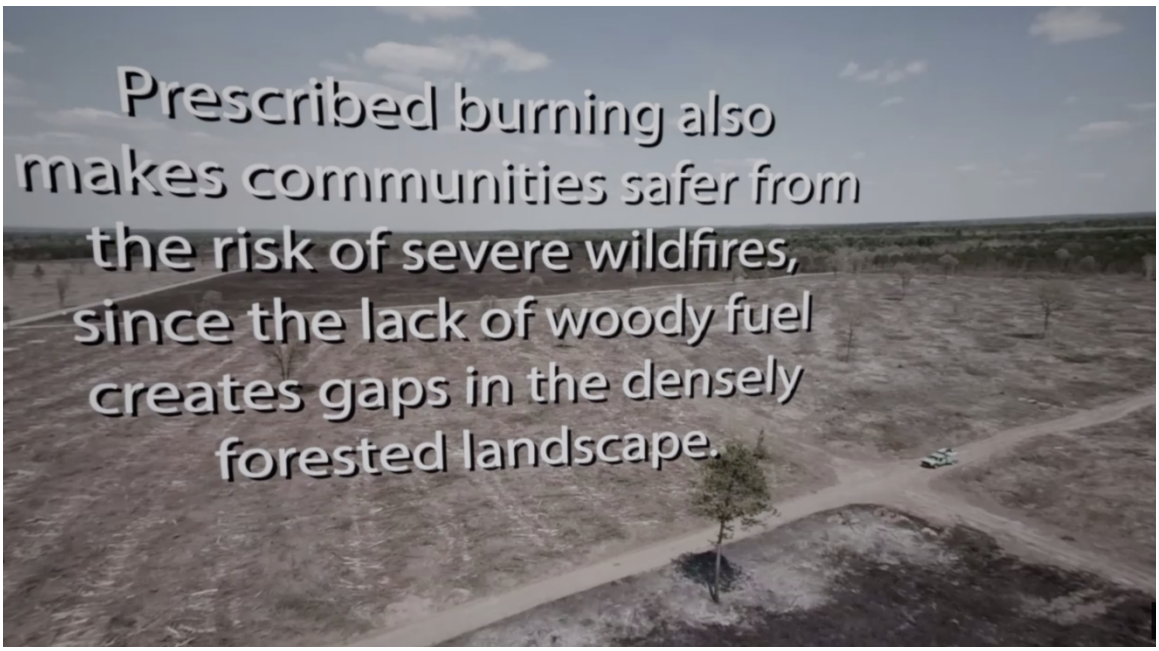

Figure C.21 Screenshot of extra explanation of benefits of prescribed burns/open habitats.

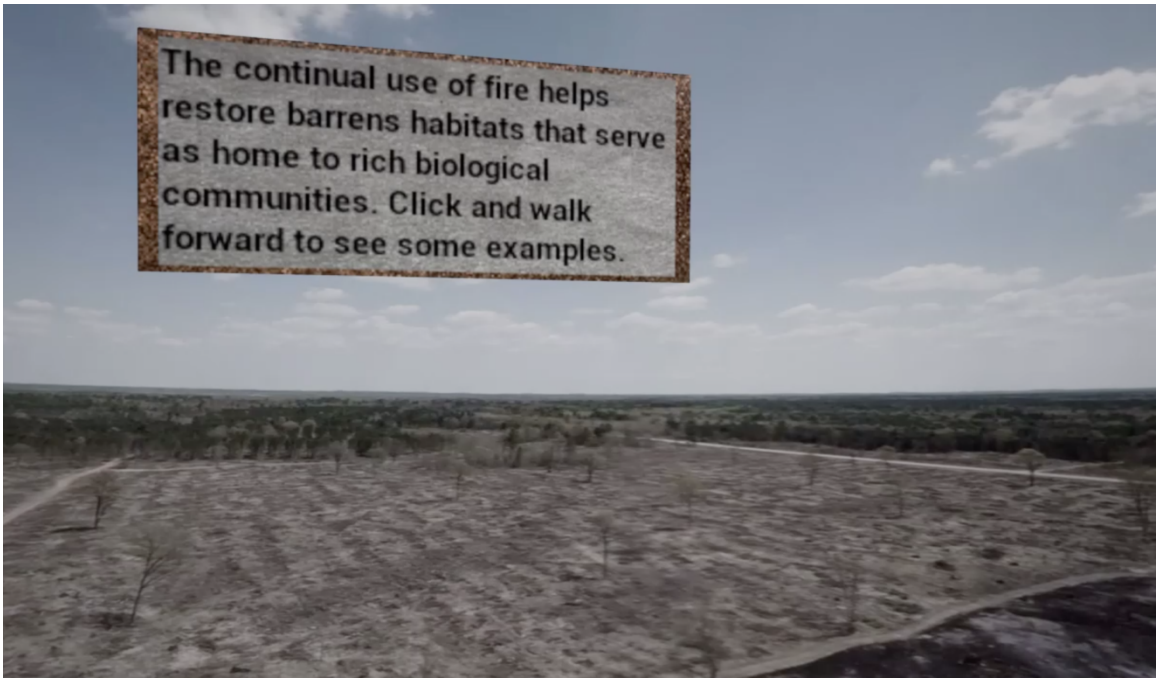

Figure C.22 Screenshot of the signage that invites participants to leave the prescribed fire video sphere.

Figure C.23 Imagery from a video sphere that evolves through several different scenes of wildlife assets. It begins with an invitation to click and view a pop-up video of a snake in the barrens.

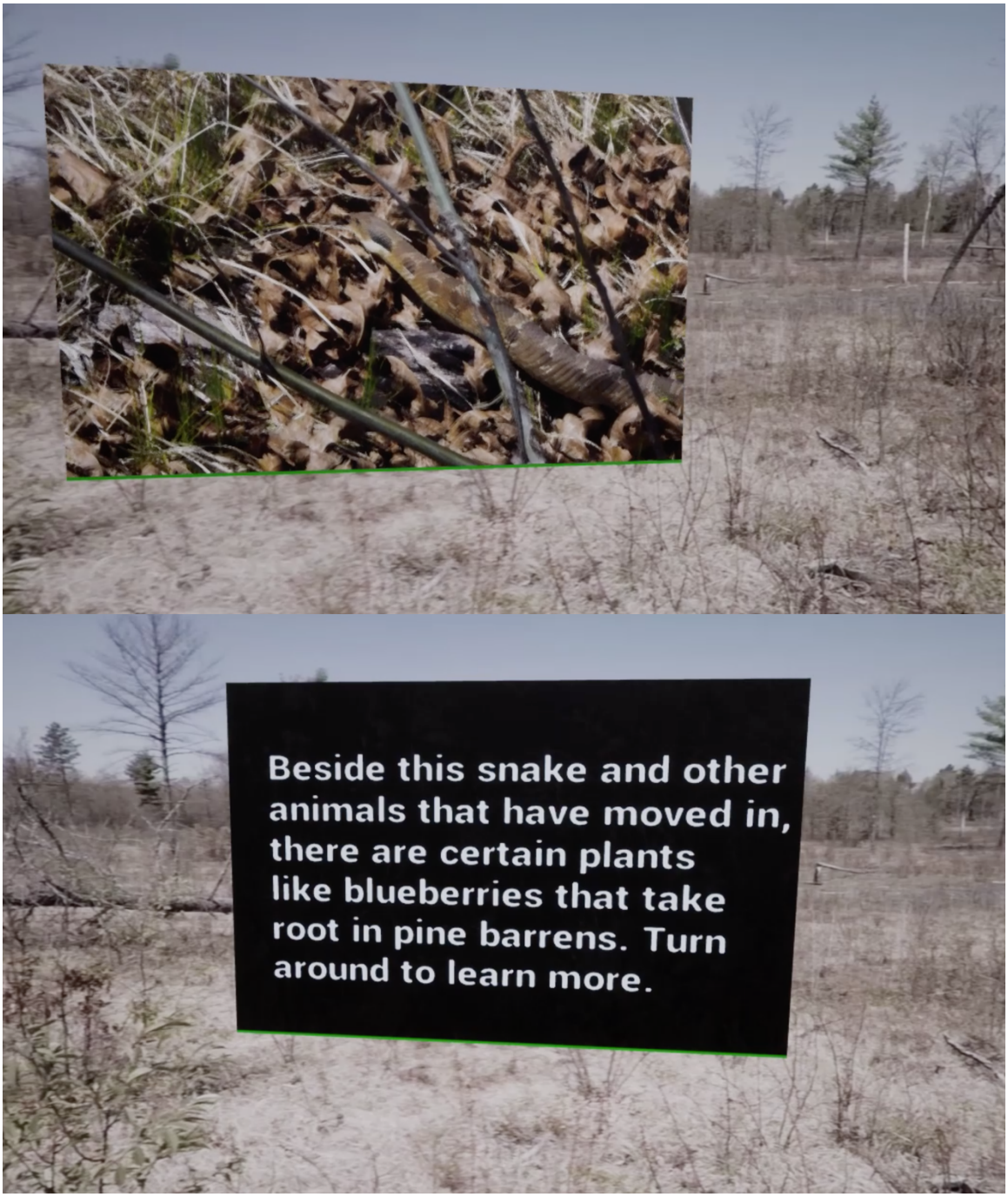

Figure C.24 Additional screenshots of the footage from this vantage in the barrens.

Figure C.25 Screenshot of the video transitioning to talk about the preponderance of blueberries in pine barrens and the pollinators they attract.

Figure C.26 Screenshots of the next sequence of imagery showing wildflower blooms that occur in pine barrens. The flowers in both the sphere and the inset video are lupine, which participants learn is the sole food source for the endangered Karner Blue Butterfly.

Figure C.27 Screenshots from within a field of milkweed where viewers observe monarch butterflies in different life phases. The text in the second section continues to explain the Monarch's recent candidacy for endangered species status. Milkweed, the main food of the Monarch, is adapted to disturbances and open habitats, and therefore associated with pine barrens.

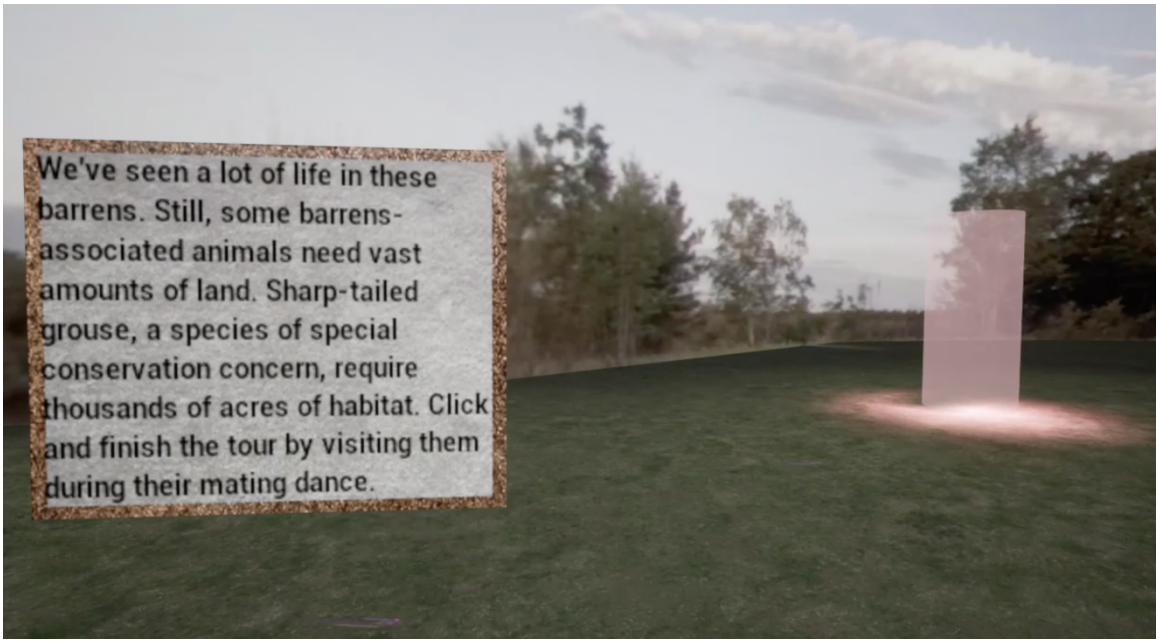

Figure C.28 Screenshot of the text that invites viewers to visit the last video portal.

Figure C.29 Screenshot of the opening view of the sharp-tailed grouse bird blind.

Figure C.30 Screenshots of action within the bird blind, intended to help viewers feel they are there. Text on the screen moves toward the camera held by this observer, which guides the audience's eye into the field where sharp-tailed grouse are dancing during mating displays.

Figure C.31 Screenshot of the inset video seen from within the bird blind that shows sharp-tailed grouse dancing during mating season.

Figure C.32 Screenshot of the last guided experience in the tour.

Figure C.33 Screenshot of the interactive map that toggles between historic and current expanses of pine barrens. When participants click the map an automatic message appears that thanks them for their time and reminds them to return to the user study when they're finished.

APPENDIX D

VISUAL STIMULI OF 2D WEBPAGE

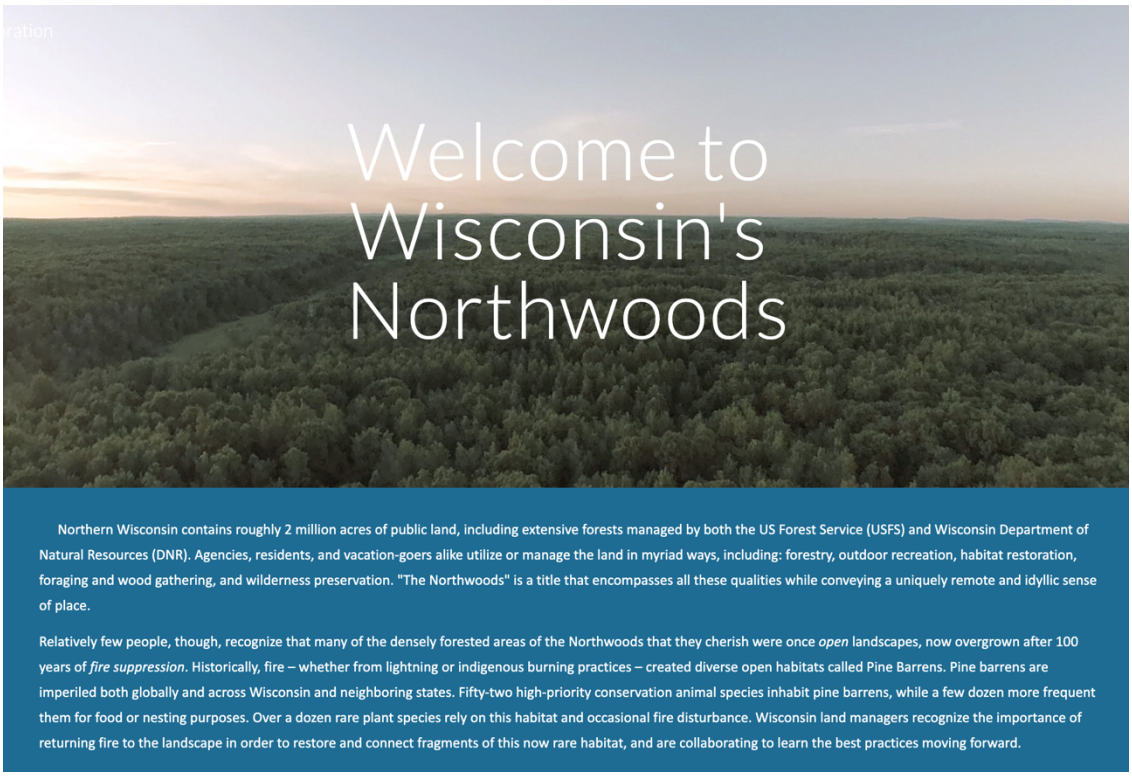

Figure D.1 Screenshot of the uppermost portion of the webpage.

Figure D.2 Imagery of pine barrens that participants see as they scroll down the page.

The Restoration Process

Thanks to historical documentation of early explorers, settlers, and land surveyors, today's land managers have a window into where pine barrens existed in the past. In the Chequamegon-Nicolet National Forest's Lakewood District, personnel use these notes to help inform where to restore pine barren habitat. The forested space in the following photographs was described in one archival account as having only around four or five trees *per acre* (roughly the size of a football field).

Figure D.3 A subheading break in the webpage.

USFS fire manager Tym Sauter and silviculturalist John Lampereur assess an area thick with restoration potential that was once pine barrens.

Sparse Red Pines familiar with fire are still scattered amongst newer forest. This pine's bare trunk was "fire pruned" in the distant past.

Figure D.4 Examples of images in a 'carousel' that viewers can click where they learn more about some of the natural history and current conditions near Waubee Barrens.

Safe re-introduction of fire

After a century of permissive regrowth, northern forests are too dense with fuel to immediately introduce fire safely. Managers therefore rely on Wisconsin's still robust timber industry to first log most of the broadleaf trees from target areas. Clearcutting parcels reduces fuels and allows prescribed fires to burn at a manageable, low intensity. The process also shortens the restoration timeline by many years. Clear of trees and their shade, the newly sunlit ground begins to host once dormant native grasses, shrubs, and flowering plants that will re-establish with fire as well.

Trees from this site are sent to mills, and often managers return to dispose of the "slash" or logging debris with machinery that chews up or "masticates" it. Mastication often appeals to nearby landowner aesthetic preferences, and further reduces fuels for low-intensity burns.

After mastication, fire is still necessary in order to prevent resilient oaks from reforesting the area. The woody stubs in this image are oaks re-sprouting from their roots, which quickly out-compete the scattered pines for sunshine.

Some animals that benefit from barrens restoration:

- Red-headed woodpecker
- Black-headed woodpecker
- Whip-poor will
- Brown thrasher
- Black-billed cuckoo
- Vesper sparrow
- Grasshopper sparrow
- Lark sparrow
- Winter wren
- Golden-winged warbler
- Blue-winged warbler
- Connecticut warbler
- Prairie warbler
- Common nighthawk
- Easter towhee
- Brewer's blackbird
- Upland sandpiper
- Wild turkey
- American woodcock
- Sharp-tailed grous
- Spruce grouse
- Franklin's ground squirrel
- Prairie vole
- Red foxe
- Coyote
- Fisher
- Wolf
- Black bear
- White-tailed deer
- American badger
- Eastern red bat
- Boreal chorus frog
- Karner blue butterfly
- Monarch butterfly
- Blanding's turtle

Figure D.5 Screenshot of the webpage that begins to describe more of the restoration process and the animals that benefit from access to pine barren habitat.

Prescribed burns

When the landscape begins to dry out in the spring, experienced fire managers select ideal weather conditions to coordinate their burns. They may spend weeks waiting for the ideal mix of conditions (such as temperature, winds, and dryness), in order to prevent disorderly spread of flames and reduce the hazards of smoke for nearby populations. A small amount of vegetation is lit as a "test ignition" to indicate the burn behavior of the material and if the fire should proceed.

Well-planned fires account for wind and nearby communities so that smoke is non-obtrusive. In most cases the smoke drifts skyward and dissipates that same day or the next day.

Prescribed burns are done by trained firefighters who can manage the flames when conditions change. On this burn they cautiously put out flames creeping up a pine at the perimeter of the burn unit.

The 50 acres of this burn sits near areas that still have slash and also areas that remain as forest. The openness of these burn footprints - and the resulting barrens - also helps reduce the risk to communities of severe wildfires at the wildland-urban interface.

Figure D.6 Imagery and text explaining prescribed burns.

The Post-Fire Landscape

Dramatic changes occur after fires and are noticeable within only a few seasons. Blueberries are a signature crop of post-burn barrens, providing families and individuals with an exciting summer activity. Past naturalists also described huckleberry thickets denser than in any other kind of landscape in Wisconsin. Wildflowers bloom throughout the spring and in different waves all summer long, attracting rare butterflies like monarchs and the karner blue, plus myriad buzzing pollinators.

Lupine is one of myriad wildflowers that bloom through summer. Caterpillars of the endangered Karner blue butterfly feed on it exclusively.

Figure D.7 Screenshot of information on the post-fire flora and fauna that often establish in pine barrens through consistent application of prescribed fire.

This is a baby monarch caterpillar, which feeds entirely on the milkweed plant. Milkweed grow in sunny, disturbed areas like barrens.

A hazy future

Ecologists along with natural resource managers of the USFS and Wisconsin DNR are still researching the complexities of fire and what intervals are needed for restoring viable pine barrens habitat.

Restoration priorities also include expanding the few and fragmented barrens that still exist. The necessity is highlighted by the territorial needs of certain animals like the sharp-tailed grouse, whose sparse populations require a few thousand acres of open habitat. The reclusive birds draw nature lovers from across the country for their eclectic and loud mating dances each spring. Nevertheless, Wisconsin DNR officials worry if the populations will survive in the coming decades.

For more information you may contact or browse resources from the USFS and Wisconsin DNR. We hope that you are able to learn more about the unique opportunity that Wisconsin has to restore this dwindling habitat.

Figure D.8 Screenshot showing more examples of flora and fauna that thrive in fire-adapted habitats like barrens, plus brief explanation of the large territorial needs of sharp-tailed grouse and the appeal of their mating dances for recreational birders.

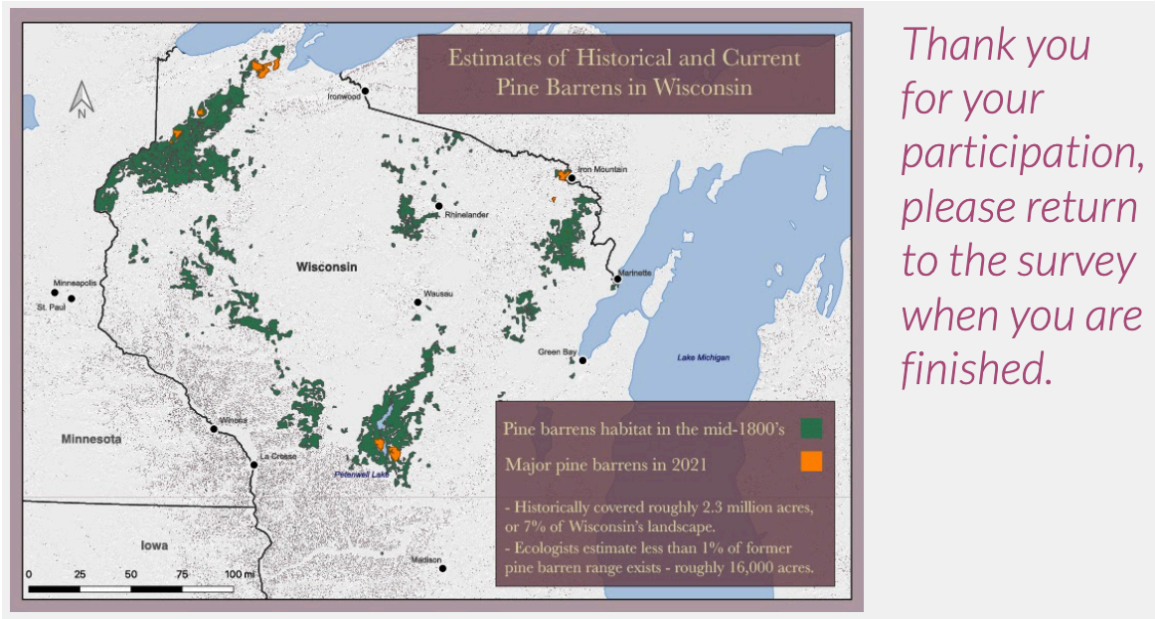

Figure D.9 Screenshot of the comparative map that participants see as the last element of the webpage.

APPENDIX E

USFS LETTER TO NEIGHBORS ABOUT LAKEWOOD SOUTHEAST PROJECT

United States Department of Agriculture

Forest Service
Chequamegon-Nicolet National Forest

Lakewood-Laona Ranger District

Lakewood Office	Laona Office
15085 State Road 32	4978 Highway 8 West
Lakewood, WI 54138	Laona, WI 54541
715-276-6333	715-674-4481
715-276-3594 FAX	715-674-2545 FAX

TTY: 711 (National Relay System)

File Code: 2430
Date: September 22, 2014

Dear Forest Neighbor,

Lately, you may have noticed some activity taking place on the national forest lands near your property. Some of our people have been preparing timber sales and gathering information needed to implement and monitor our activities. I've received a few inquiries about this and thought it would be helpful to give you an update and explain what's happening out there.

Several years ago, you may remember receiving a letter requesting comments on the Lakewood Southeast Project. The Lakewood Southeast Project includes a suite of management activities on a 37,000 acre area of the national forest that includes your area. The project includes timber harvests, prescribed burning, road work, and other management activities designed to move the forest toward desired conditions.

What are "Barrens"?

- **Barrens** are savanna plant communities that occur on sandy soils. They are dominated by grasses, low shrubs, small trees, and scattered large trees. They are often associated with similar habitats known as Savannas and Woodlands.
- **Savannas** contain scattered trees in a grass-dominated setting.
- **Woodlands** are characterized by open park-like forests of varying density.

A key component of the project is the restoration of pine barrens, savannas, and woodlands in an 800 acre area to the north of Old Highway 64 and, generally, to the east of Airport Road. This will be a big change from the existing condition so I want to explain what we're doing and why.

The Airport Road Area lies on a large area of glacial sand outwash. Your property and the surrounding national forest is located in a drought-prone landscape that supports dry forest types that are adapted to wildfire. We know that, for hundreds of years, fires burned through the area and maintained a much more open and grassy landscape than we see today. Beginning in the 1930's, reforestation and fire suppression efforts began to radically change this landscape. As time passed, the landscape became more closed and the predominant fuels changed from grasses to multiple layers of trees. This would greatly change the behavior of wildfires. Instead of low-intensity grass fires that can be easily

In the 1930's most of the project area was tractor furrowed and planted with jack pine. The above photo shows a CCC crew planting the present-day project area. Note the thick sod layer, barrens landscape, and fire-scarred snags

attacked with engines and hand crews, the closed forests with "ladder fuels" can produce high intensity crown fires that cannot be fought directly with these resources. This puts firefighters and lives and properties in the Wildland Urban Interface at risk.

Some species that would benefit from barrens restoration

- Red-headed woodpeckers
- Black-backed woodpeckers
- Whip-poor wills
- Brown thrashers
- Bluebirds
- Black-billed cuckoos
- Vesper sparrows
- Grasshopper sparrows
- Lark sparrows
- Dickcissels
- Winter wrens
- Golden-winged warblers
- Blue-winged warblers
- Connecticut warblers
- Prairie warblers
- Loggerhead shrikes
- Common nighthawks
- Eastern towhees
- Brewer's blackbirds
- Upland sandpiper
- Wild turkeys
- American woodcocks
- Franklin's ground squirrels
- Western harvest mice
- Prairie voles
- Woodland voles
- Least shrews
- White-tail jackrabbits
- Grey and Red foxes
- Coyotes
- Fishers
- Black bears
- White-tailed deer
- American badgers
- Northern long-eared bats
- Eastern red bats
- Boreal chorus frogs
- Henry elfin butterflies
- Chryxus artic butterflies

Open pine barrens and savannas have become far less common habitats. Prior to European settlement, Wisconsin was estimated to have had 2.3 million acres of pine barrens and 1.8 million acres of oak barrens on its landscapes (12% of the state's land area). Since the early 1800's, Wisconsin pine and oak barrens were almost completely destroyed by development, logging, and fire exclusion. Today, we have an estimated 26 thousand acres (.08% of the state's land area) of scattered pine and oak barrens statewide. This has resulted in pine barrens being designated as "very rare" and oak barrens as "globally imperiled" by the Natural Heritage Inventory. There are 17 species of birds, 12 species of mammals, and 1 amphibian associated with this habitat that are considered "Species of Greatest Conservation Need" in Wisconsin.

While planning the Lakewood Southeast Project, my staff recognized that the Airport Road Area could support either closed pine forests or open barrens and savannas. However, they saw an opportunity to manage this landscape to reduce the fire hazard to private properties while restoring very rare habitat conditions for a host of wildlife which thrive in grassland communities.

In designing this project, my staff visited with other natural resource managers and toured a number of properties where similar efforts have taken place. They've made every effort to design the treatments with the lessons learned at these other sites.

Restored savanna/woodland. US Fish and Wildlife Service. Necedah National Wildlife Refuge, Necedah, Wisconsin.

To implement barrens and savanna restoration we will use a variety of timber harvests and follow them with prescribed fire. The harvest treatments range from heavy cuts that resemble clearcuts - to moderate cuts that create an open, park-like condition - to thinnings that will maintain a closed forest. The timber harvests will remove the trees and most of the associated slash. In order to accommodate the logging traffic, subsequent management activities, and future ATV traffic, the main access roads will be upgraded with gravel beds. At the same time, fuel breaks will be created along the perimeter of the area to improve fire protection in the Wildland Urban Interface.

Airport Road Area prior to planting, 1936. This photo illustrates open barrens (foreground), pine savanna (left background), and woodlands (right background).

Following the harvests, we will make careful use of prescribed fire to reduce residual slash and encourage the establishment of barrens plant species. We anticipate a dramatic response from native grasses, wildflowers, and forbs such as blueberries.

As noted above, there are many wildlife species of grave concern that we expect to benefit from this project. In addition, other species would also benefit from the restoration of this habitat. Some examples include white-tailed deer, black bears, badgers, foxes, turkeys, and woodcocks.

Included with this letter is a map that illustrates the planned actions in the Airport Road Area. Timber sale marking is planned to begin this fall/winter and should be completed by the spring/summer of 2015. We plan to award the sales sometime in 2015 or 2016. Harvest activities would likely begin shortly thereafter. Prescribed burns would take place after the timber sales are completed.

Thank you for taking the time to read about this project. If you have additional questions or concerns, please give me a call at (715) 276-6333 or e-mail me at jseefeldt@fs.fed.us.

Sincerely,

Jeff Seefeldt
District Ranger

Pine barrens restored by the Wisconsin Department of Natural Resources.
Spread Eagle Barrens State Natural Area, Florence, Wisconsin.

APPENDIX F

SCALAR CALIBRATION OF ATTITUDE SCALES

The table below provides attitude scores of both media treatment groups for each attitude scale (fire, clear-cuts, pine barrens) when adjusted to the least common multiple. Initially both the fire and pine barrens scales had a range of -10–10, whereas clear-cutting had a scale of -6–6, therefore the two were matched by a possible scale of -30–30 for simple comparison purposes.

Table F.1 Mean and median attitude scores compared on relative scale.

		Mean		*Median*	
		Pre-test	*Post-test*	*Pre-test*	*Post-test*
Fire	*Tour*	10.05	19.29	12	21
	Text	9.12	18.24	9	18
Clear-cuts	*Tour*	-4.785	13.25	-5	15
	Text	-1.2	14.1	0	15
Pine barrens	*Tour*	4.17	16.44	3	18
	Text	1.5	13.2	0	15

APPENDIX G

POST-TEST CORRELATION TABLES

Table G.1 Correlation scores for questions in the pine barrens post-test question set. Bold entries indicate highest correlation relationship.

Tour	*Q1 [Belongs]*	*Q2 [Beautiful]*	*Q3 [Recreation]*	*Q4 [Wildlife]*	*Q5 [Restoration feelings]*	*Attitude Score*
Q1	1.00	0.08	0.07	0.49	**0.65**	0.67
Q2	0.08	1.00	**0.53**	0.07	-0.15	0.52
Q3	0.07	**0.53**	1.00	0.04	-0.14	0.54
Q4	0.49	0.07	0.04	1.00	0.62	**0.72**
Q5	**0.65**	-0.15	-0.14	**0.62**	1.00	0.62
Attitude Score	0.67	0.52	0.54	0.72	0.62	1.00
Text						
Q1	1.00	0.33	0.44	0.44	**0.61**	**0.78**
Q2	0.33	1.00	0.39	0.14	0.38	0.64
Q3	0.44	**0.39**	1.00	**0.56**	0.32	0.77
Q4	0.44	0.14	**0.56**	1.00	0.32	0.69
Q5	**0.61**	0.38	0.32	0.32	1.00	0.71
Attitude Score	0.78	0.64	0.77	0.69	0.71	1.00

BIBLIOGRAPHY

Absher, James D., Jerry J. Vaske, and Lori B. Shelby. 2009. "Residents' Responses to Wildland Fire Programs: A Review of Cognitive and Behavioral Studies." PSW-GTR-223. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. https://doi.org/10.2737/PSW-GTR-223.

Ahn, Sun Joo. 2021. "Designing for Persuasion through Embodied Experiences in Virtual Reality." In *Persuasive Gaming in Context*, edited by Teresa de la Hera, Jeroen Jansz, Joost Raessens, and Ben Schouten. Nieuwe Prinsengracht 891018 VR Amsterdam, Nederland: Amsterdam University Press. https://doi.org/10.5117/9789463728805.

Aitamurto, Tanja, Shuo Zhou, Sukolsak Sakshuwong, Jorge Saldivar, Yasamin Sadeghi, and Amy Tran. 2018. "Sense of Presence, Attitude Change, Perspective-Taking and Usability in First-Person Split-Sphere 360° Video." In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–12. Montreal QC Canada: ACM. https://doi.org/10.1145/3173574.3174119.

Ajzen, Icek. 2001. "Nature and Operation of Attitudes." *Annual Review of Psychology* 52 (1): 27–58. https://doi.org/10.1146/annurev.psych.52.1.27.

Anderson, Kat. 2005. *Tending the Wild: Native American Knowledge and the Management of California's Natural Resources*. Berkeley, Calif. London: University of California Press.

Auer, Jeremiah J. 2011. "A Century of Tree Planting: Wisconsin's Forest Nursery System." *Tree Planters' Notes* 54 (2): 7.

Bailenson, Jeremy. 2018. *Experience on Demand: What Virtual Reality Is, How It Works, and What It Can Do*. First edition. New York: W. W. Norton & Company, Inc.

Banaji, M.R., and L. Heiphetz. 2010. "Attitudes." In *Handbook of Social Psychology*, edited by S.T. Fiske, D. T. Gilbert, and G. Lindzey, 353–93. John Wiley & Sons. https://psycnet-apa-org.libproxy.uoregon.edu/record/2010-03505-010.

Beckwith, J.A., S.A. Moore, S.E. Clement, B.D. Curnow, and R. Admiraal. 2010. "The Impact of Forest Thinning on Perceptions of Recreational Value and Forest Health." Technical Report. Perth: Beckwith Environmental Planning and Murdoch University.

Bell, Tina, and Immaculada Oliveras. 2006. "Perceptions of Prescribed Burning in a Local Forest Community in Victoria, Australia." *Environmental Management* 38 (5): 867–78. https://doi.org/10.1007/s00267-005-0290-3.

Bieniek-Tobasco, Ashley, Rajiv N Rimal, Sabrina McCormick, and Cherise B Harrington. 2020. "The Power of Being Transported: Efficacy Beliefs, Risk Perceptions, and Political Affiliation in the Context of Climate Change." *Science Communication*, 1075547020951794. https://doi.org/10.1177/1075547020951794.

Bilandzic, Helena, Susanne Kinnebrock, and Magdalena Klingler. 2020. "The Emotional Effects of Science Narratives: A Theoretical Framework." *Media and Communication* 8 (1): 151–63. https://doi.org/10.17645/mac.v8i1.2602.

Blatner, Keith A, Matthew S Carroll, Steven E Daniels, and Gregg B Walker. 2001. "Evaluating the Application of Collaborative Learning to the Wenatchee Fire Recovery Planning Effort." *Environmental Impact Assessment Review* 21 (3): 241–70. https://doi.org/10.1016/S0195-9255(00)00080-9.

Breves, Priska, and Vivien Heber. 2020. "Into the Wild: The Effects of 360° Immersive Nature Videos on Feelings of Commitment to the Environment." *Environmental Communication* 14 (3): 332–46. https://doi.org/g3sm.

Brewer, William F, and Edward H Lichtenstein. 1982. "Stories Are to Entertain: A Structural-Affect Theory of Stories." *Center for the Study of Reading Technical Report*, no. 265: 14.

Bright, Alan D., Peter Newman, and Joshua Carroll. 2007. "Context, Beliefs, and Attitudes toward Wildland Fire Management: An Examination of Residents of the Wildland-Urban Interface." *Human Ecology Review* 14 (2): 212–22.

Buijs, Arjen E. 2009. "Public Support for River Restoration. A Mixed-Method Study into Local Residents' Support for and Framing of River Management and Ecological Restoration in the Dutch Floodplains." *Journal of Environmental Management* 90 (8): 2680–89. https://doi.org/10.1016/j.jenvman.2009.02.006.

Cohn, Neil. 2013. "Visual Narrative Structure." *Cognitive Science* 37 (3): 413–52. https://doi.org/10.1111/cogs.12016.

Cranmer, Alexana, Jonathan D. Ericson, Anna Ebers Broughel, Benjamin Bernard, Erryca Robicheaux, and Maxim Podolski. 2020. "Worth a Thousand Words: Presenting Wind Turbines in Virtual Reality Reveals New Opportunities for Social Acceptance and Visualization Research." *Energy Research & Social Science* 67 (September): 101507. https://doi.org/10.1016/j.erss.2020.101507.

Crano, William D., and Radmila Prislin. 2006. "Attitudes and Persuasion." *Annual Review of Psychology* 57 (1): 345–74. https://doi.org/10.1146/annurev.psych.57.102904.190034.

Curtis, John T. 1959. *The Vegetation of Wisconsin: An Ordination of Plant Communities*. Madison: University of Wisconsin Press.

Daniel, Terry C. 2001. "Whither Scenic Beauty? Visual Landscape Quality Assessment in the 21st Century." *Landscape and Urban Planning* 54 (1–4): 267–81. https://doi.org/10.1016/S0169-2046(01)00141-4.

Eagly, Alice H., and Shelly Chaiken. 2007. "The Advantages of an Inclusive Definition of Attitude." *Social Cognition* 25 (5): 582–602. https://doi.org/10.1521/soco.2007.25.5.582.

Eagly, Alice Hendrickson, and Shelly Chaiken. 1993. *The Psychology of Attitudes*. Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

Eckstein, Ronald. 1995. "Oak and Pine Barrens Communities." In *Wisconsin's Biodiversity as a Management Issue*, 98–114. Madison, WI: Wisconsin Department of Natural Resources.

Epstein, E.E. 2015. "Natural Communities, Aquatic Features, and Selected Habitats of Wisconsin." In *The Ecological Landscapes of Wisconsin: An Assessment of Ecological Resources and a Guide to Planning Sustainable Management*, 95–99. Madison, WI: Wisconsin Department of Natural Resources. https://p.widencdn.net/exmng9/1805Ch7.

Estévez, Rodrigo A., Christopher B. Anderson, J. Cristobal Pizarro, and Mark A. Burgman. 2015. "Clarifying Values, Risk Perceptions, and Attitudes to Resolve or Avoid Social Conflicts in Invasive Species Management: Confronting Invasive Species Conflicts." *Conservation Biology* 29 (1): 19–30. https://doi.org/10.1111/cobi.12359.

Fazio, Russell H., and Mark P. Zanna. 1981. "Direct Experience And Attitude-Behavior Consistency." In *Advances in Experimental Social Psychology*, 14:161–202. Elsevier. https://doi.org/10.1016/S0065-2601(08)60372-X.

Filter, Elin, Alexander Eckes, Florian Fiebelkorn, and Alexander Georg Büssing. 2020. "Virtual Reality Nature Experiences Involving Wolves on YouTube: Presence, Emotions, and Attitudes in Immersive and Nonimmersive Settings." *Sustainability* 12 (9): 3823. https://doi.org/10.3390/su12093823.

Fisher, Peter F., and D. Unwin, eds. 2002. *Virtual Reality in Geography*. London ; New York: Taylor & Francis.

Floress, Kristin, Stephanie Connolly, Kathleen E. Halvorsen, Amanda Egan, Thomas Schuler, Amy Hill, Philip DeSenze, Scott Fenimore, and Kent Karriker. 2018. "Implementing Landscape Scale Conservation across Organizational Boundaries: Lessons from the Central Appalachian Region, United States." *Environmental Management* 62 (5): 845–57. https://doi.org/10.1007/s00267-018-1081-y.

Floress, Kristin, Anna L. Haines, Emily Usher, Paul H. Gobster, and Mike Dockry. 2018a. "Landowner Attitudes toward Prescribed Fire on the Chequamegon-Nicolet National Forest (CNNF)." Webinar, December 12. http://lakestatesfiresci.net/docs/LSFSCDec2018Webinar-LandownerAttitudes-Floress.pdf.

Floress, Kristin, Kristin Haines, Emily Usher, Paul H. Gobster, and Mike Dockry. 2018b. "Landowner and Visitor Response to Forest Landscape Restoration: The Chequamegon-Nicolet National Forest Lakewood Southeast Project." Stevens Point, WI: Center for Land Use Education, University of Wisconsin - Stevens Point.

Ford, Rebecca M., Kathryn J. H. Williams, Eric L. Smith, and Ian D. Bishop. 2014. "Beauty, Belief, and Trust: Toward a Model of Psychological Processes in Public Acceptance of Forest Management." *Environment and Behavior* 46 (4): 476–506. https://doi.org/10.1177/0013916512456023.

Fraustino, Julia Daisy, Ji Young Lee, Sang Yeal Lee, and Hongmin Ahn. 2018. "Effects of 360° Video on Attitudes toward Disaster Communication: Mediating and Moderating Roles of Spatial Presence and Prior Disaster Media Involvement." *Public Relations Review* 44 (3): 331–41. https://doi.org/10.1016/j.pubrev.2018.02.003.

Fujita, Kentaro, Marlone D. Henderson, Juliana Eng, Yaacov Trope, and Nira Liberman. 2006. "Spatial Distance and Mental Construal of Social Events." *Psychological Science* 17 (4): 278–82. https://doi.org/10.1111/j.1467-9280.2006.01698.x.

Gershon, Nahum, and Ward Page. 2001. "What Storytelling Can Do for Information Visualization." *Communications of the ACM* 44 (8): 31–37. https://doi.org/10.1145/381641.381653.

Gobster, Paul H. 1996. "Forest Aesthetics, Biodiversity, and the Perceived Appropriateness of Ecosystem Management Practices." In *Defining Social Acceptability in Ecosystem Management: A Workshop Proceedings*, 77–97. 1992 June 23-25; Kelso, WA. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Gobster, Paul H., Arne Arnberger, Ingrid E. Schneider, Kristin M. Floress, Anna L. Haines, Michael J. Dockry, and Claire Benton. 2021. "Restoring a 'Scenically Challenged' Landscape: Landowner Preferences for Pine Barrens Treatment Practices." *Landscape and Urban Planning* 211 (July): 104104. https://doi.org/10.1016/j.landurbplan.2021.104104.

Gobster, Paul H., Joan I. Nassauer, Terry C. Daniel, and Gary Fry. 2007. "The Shared Landscape: What Does Aesthetics Have to Do with Ecology?" *Landscape Ecology* 22 (7): 959–72. https://doi.org/10.1007/s10980-007-9110-x.

Gobster, Paul H., Ingrid E. Schneider, Kristin M. Floress, Anna L. Haines, Arne Arnberger, Michael J. Dockry, and Claire Benton. 2021. "Understanding the Key Characteristics and Challenges of Pine Barrens Restoration: Insights from a Delphi Survey of Forest Land Managers and Researchers." *Restoration Ecology* 29 (1). https://doi.org/10.1111/rec.13273.

Green, Melanie C., and Timothy C. Brock. 2000. "The Role of Transportation in the Persuasiveness of Public Narratives." *Journal of Personality and Social Psychology* 79 (5): 701–21. https://doi.org/10.1037/0022-3514.79.5.701.

Green, Melanie C., Timothy C. Brock, and Geoff F. Kaufman. 2004. "Understanding Media Enjoyment: The Role of Transportation Into Narrative Worlds." *Communication Theory* 14 (4): 311–27. https://doi.org/10.1111/j.1468-2885.2004.tb00317.x.

Guyette, Richard, Michael Stambaugh, Daniel Dey, Joseph Marschall, Jay Saunders, and John Lampereur. 2016. "350 Years of Fire-Climate-Human Interactions in a Great Lakes Sandy Outwash Plain." *Forests* 7 (12): 189. https://doi.org/10.3390/f7090189.

Haight, Robert G., and Paul H. Gobster. 2009. "Chapter 5, Social and Economic Considerations for Planning Wildlife Conservation in Large Landscapes." In *Models for Planning Wildlife Conservation in Large Landscapes*, by Joshua J. Millspaugh and Frank R. Thompson III. Amsterdam: Elsevier. https://doi.org/10.1016/B978-0-12-373631-4.X0001-9.

Hamilton, Eric. 2018. "More Homes Built near Wild Lands Leading to Greater Wildfire Risk, Says Study Led by Volker Radeloff." *UW-Madison CALS News*, March 16, 2018. https://news.cals.wisc.edu/2018/03/16/more-homes-built-near-wild-lands-leading-to-greater-wildfire-risk/.

Hamilton, Rebecca W., and Debora Viana Thompson. 2007. "Is There a Substitute for Direct Experience? Comparing Consumers' Preferences after Direct and Indirect Product Experiences." *Journal of Consumer Research* 34 (4): 546–55. https://doi.org/10.1086/520073.

Hartmann, Tilo, Werner Wirth, Holger Schramm, Christoph Klimmt, Peter Vorderer, André Gysbers, Saskia Böcking, et al. 2016. "The Spatial Presence Experience Scale: A Short Self-Report Measure for Diverse Media Settings." *Journal of Media Psychology* 28 (1): 1–15. https://doi.org/10.1027/1864-1105/a000137.

Heer, Jeffrey, and Michael Bostock. 2010. "Crowdsourcing Graphical Perception: Using Mechanical Turk to Assess Visualization Design," 10.

Hertwig, Ralph, Greg Barron, Elke U. Weber, and Ido Erev. 2004. "Decisions from Experience and the Effect of Rare Events in Risky Choice." *Psychological Science* 15 (8): 534–39. https://doi.org/10.1111/j.0956-7976.2004.00715.x.

Hmielowski, Tracy L., Sarah K. Carter, Hannah Spaul, David Helmers, Volker C. Radeloff, and Paul Zedler. 2016. “Prioritizing Land Management Efforts at a Landscape Scale: A Case Study Using Prescribed Fire in Wisconsin.” *Ecological Applications* 26 (4): 1018–29. https://doi.org/10.1890/15-0509.

Hruby, Florian, León F. Álvarez Sánchez, Rainer Ressl, and Elva G. Escobar-Briones. 2020. “An Empirical Study on Spatial Presence in Immersive Geo-Environments.” *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science* 88 (2): 155–63. https://doi.org/10.1007/s41064-020-00107-y.

Huang, Jiawei, Melissa S. Lucash, Robert M. Scheller, and Alexander Klippel. 2020. “Walking through the Forests of the Future: Using Data-Driven Virtual Reality to Visualize Forests under Climate Change.” *International Journal of Geographical Information Science* 0 (0): 1–24. https://doi.org/10.1080/13658816.2020.1830997.

Hultquist, Tom. n.d. “The Great Midwest Wildfires of 1871.” National Weather Service. n.d. https://www.weather.gov/grb/peshtigofire2.

Kimmerer, Robin Wall. 2020. *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants*. Penguin Ecology. London: Penguin Books.

Kimmerer, R.W., and F.K. Lake. 2001. “The Role of Indigenous Burning in Land Management.” *Journal of Forestry* 99 (11): 36–41. https://doi.org/10.1093/jof/99.11.36.

Klein, Lisa R. 2003. “Creating Virtual Product Experiences: The Role of Telepresence.” *Journal of Interactive Marketing* 17 (1): 41–55. https://doi.org/10.1002/dir.10046.

Klippel, Alexander, Jiayan Zhao, Pejman Sajjadi, Jan Oliver Wallgrun, Mahda M. Bagher, and Danielle Oprean. 2020. “Immersive Place-Based Learning – An Extended Research Framework.” In *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, 449–54. Atlanta, GA, USA: IEEE. https://doi.org/10.1109/VRW50115.2020.00095.

Kraut, Robert, Judith Olson, Mahzarin Banaji, Amy Bruckman, Jeffrey Cohen, and Mick Couper. 2004. “Psychological Research Online: Report of Board of Scientific Affairs’ Advisory Group on the Conduct of Research on the Internet.” *American Psychologist* 59 (2): 105–17. https://doi.org/10.1037/0003-066X.59.2.105.

Laarni, Jari, Niklas Ravaja, Timo Saari, Saskia Böcking, Tilo Hartmann, and Holger Schramm. 2015. “Ways to Measure Spatial Presence: Review and Future Directions.” In *Immersed in Media: Telepresence Theory, Measurement & Technology*, edited by Matthew Lombard, Frank Biocca, Jonathan Freeman, Wijnand IJsselsteijn, and Rachel J. Schaevitz, 139–85. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-10190-3_8.

Laer, Tom van, Ko de Ruyter, Luca M. Visconti, and Martin Wetzels. 2014. "The Extended Transportation-Imagery Model: A Meta-Analysis of the Antecedents and Consequences of Consumers' Narrative Transportation." *Journal of Consumer Research* 40 (5): 797–817. https://doi.org/10.1086/673383.

Lampereur, John. 2013. "Forest Vegetation Resource Report for the Lakewood Southeast Project: Chequamegon-Nicolet National Forest." USDA, USFS.

Lapin, Carly. 2019. "Annual Property Implementation Plan February 2020 — June 2021: Spread Eagle Barrens State Natural Area." Draft. Wisconsin Department of Natural Resources. https://dnr.wi.gov/topic/lands/documents/APIP/SEBSNAExpandedAPIP21.pdf.

Leopold, Aldo, Susan L Flader, and J. Baird Callicott. 1993. *River of the Mother of God and Other Essays*. Madison, Wis.: Univ. Wisconsin P. https://archive.org/details/riverofmotherofg00leop.

Li, Hairong, Terry Daugherty, and Frank Biocca. 2002. "Impact of 3-D Advertising on Product Knowledge, Brand Attitude, and Purchase Intention: The Mediating Role of Presence." *Journal of Advertising* 31 (3): 43–57. https://doi.org/10.1080/00913367.2002.10673675.

Liberman, N, Y Trope, and E Stephan. 2007. "Social Psychology: Handbook of Basic Principles." *Psychol. Distance* 2: 353–83.

Liberman, Nira, and Yaacov Trope. 2008. "The Psychology of Transcending the Here and Now." *Science* 322 (5905): 1201–5. https://doi.org/10.1126/science.1161958.

Lombard, Matthew, and Theresa Ditton. 1997. "At the Heart of It All: The Concept of Presence." *Journal of Computer-Mediated Communication* 3 (2). https://doi.org/10.1111/j.1083-6101.1997.tb00072.x.

Meitner, M. J., R. Gandy, and S. R. J. Sheppard. 2005. "Reviewing the Role of Visualization in Communicating and Understanding Forest Complexity." In *Ninth International Conference on Information Visualisation (IV'05)*, 121–28. https://doi.org/10.1109/IV.2005.110.

Mocnik, Franz-Benjamin, and David Fairbairn. 2018. "Maps Telling Stories?" *The Cartographic Journal* 55 (1): 36–57. https://doi.org/10.1080/00087041.2017.1304498.

Molnár, Zs., and D. Babai. 2021. "Inviting Ecologists to Delve Deeper into Traditional Ecological Knowledge." *Trends in Ecology & Evolution* 36 (8): 679–90. https://doi.org/10.1016/j.tree.2021.04.006.

Nelson, Kristen C., Martha C. Monroe, and Jayne Fingerman Johnson. 2005. "The Look of the Land: Homeowner Landscape Management and Wildfire Preparedness in Minnesota and Florida." *Society & Natural Resources* 18 (4): 321–36. https://doi.org/10.1080/08941920590915233.

Niepold, Frank, David Herring, and David McConville. 2008. "The Role of Narrative and Geospatial Visualization in Fostering Climate Literate Citizens." *Physical Geography* 29 (6): 529–44. https://doi.org/10.2747/0272-3646.29.6.529.

Norman, Geoff. 2010. "Likert Scales, Levels of Measurement and the 'Laws' of Statistics." *Advances in Health Sciences Education* 15 (5): 625–32. https://doi.org/10.1007/s10459-010-9222-y.

Palmer, Margaret, Emily Bernhardt, Elizabeth Chornesky, Scott Collins, Andrew Dobson, Clifford Duke, Barry Gold, et al. 2004. "Ecology for a Crowded Planet." *Science* 304 (5675): 1251–52. https://doi.org/10.1126/science.1095780.

Petty, Richard E, Duane T Wegener, and Leandre R Fabrigar. 2006. "Attitudes and Attitude Change," 40.

Pimentel, Daniel, Sri Kalyanaraman, Yu-Hao Lee, and Shiva Halan. 2021. "Voices of the Unsung: The Role of Social Presence and Interactivity in Building Empathy in 360 Video." *New Media & Society* 23 (8): 2230–54. https://doi.org/10.1177/1461444821993124.

Pukis, Rick. 1997. "From Scenic to Ecological Aesthetics: Testing the Effect of Interpretative Messages and the Video Medium on Aesthetic Perceptions of Ecosystem Management Practices." MS Thesis, University of Montana.

Radeloff, Volker C., David P. Helmers, H. Anu Kramer, Miranda H. Mockrin, Patricia M. Alexandre, Avi Bar-Massada, Van Butsic, et al. 2018. "Rapid Growth of the US Wildland-Urban Interface Raises Wildfire Risk." *Proceedings of the National Academy of Sciences* 115 (13): 3314–19. https://doi.org/10.1073/pnas.1718850115.

Radeloff, Volker C., David J. Mladenoff, and Mark S. Boyce. 2000. "A Historical Perspective and Future Outlook on Landscape Scale Restoration in the Northwest Wisconsin Pine Barrens." *Restoration Ecology* 8 (2): 119–26. https://doi.org/10.1046/j.1526-100x.2000.80018.x.

Radeloff, Volker C, David J Mladenoff, Hong S He, and Mark S Boyce. 1999. "Forest Landscape Change in the Northwestern Wisconsin Pine Barrens from Pre-European Settlement to the Present." *Canadian Journal of Forest Research* 29 (11): 1649–59. https://doi.org/10.1139/x99-089.

Rajecki, D. W. 1982. *Attitudes, Themes and Advances*. 1st ed. Sunderland, Mass: Sinauer Associates.

Ray, Lily A., Crystal A. Kolden, and F. Stuart Chapin III. 2012. “A Case for Developing Place-Based Fire Management Strategies from Traditional Ecological Knowledge.” *Ecology and Society* 17 (3): art37. https://doi.org/10.5751/ES-05070-170337.

Ribe, Robert. 1990. “A General Model for Understanding the Perception of Scenic Beauty in Northern Hardwood Forests.” *Landscape Journal* 9 (2): 86–101. https://doi.org/10.3368/lj.9.2.86.

———. 1991. “The Scenic Impact of Key Forest Attributes and Long-Term Management Alternatives for Hardwood Forests.” General Technical Report NE-148. Proceedings, 8th Central Hardwood Forest Conference. Radnor, PA: USDA Forest Service, Northeastern Forest Experiment Station.

———. 2013. “Public Perceptions of West-Side Forests: Improving Visual Impact Assessments and Designing Thinnings and Harvests for Scenic Integrity.” General Technical Report. Density Management in the 21st Century: West Side Story. Portland, OR: USDA Forest Service, PNW Research Station. https://www.fs.usda.gov/treesearch/pubs/44815.

Rickenbach, M., L. A. Schulte, D. B. Kittredge, W. G. Labich, and D. J. Shinneman. 2011. “Cross-Boundary Cooperation: A Mechanism for Sustaining Ecosystem Services from Private Lands.” *Journal of Soil and Water Conservation* 66 (4): 91A-96A. https://doi.org/10.2489/jswc.66.4.91A.

Roth, Robert E. 2020. “Cartographic Design as Visual Storytelling: Synthesis and Review of Map-Based Narratives, Genres, and Tropes.” *The Cartographic Journal*, September, 1–32. https://doi.org/10.1080/00087041.2019.1633103.

Schöne, Benjamin, Marlene Wessels, and Thomas Gruber. 2019. “Experiences in Virtual Reality: A Window to Autobiographical Memory.” *Current Psychology* 38 (3): 715–19. https://doi.org/10.1007/s12144-017-9648-y.

Shapiro, Aaron. 2013. *Lure of the North Woods*. Minneapolis: University of Minnesota Press.

Shelby, Bo, Jonathan R. Thompson, Mark Brunson, and Rebecca Johnson. 2005. “A Decade of Recreation Ratings for Six Silviculture Treatments in Western Oregon.” *Journal of Environmental Management* 75 (3): 239–46. https://doi.org/10.1016/j.jenvman.2004.12.004.

Sheppard, Stephen R. J. 2005. “Landscape Visualisation and Climate Change: The Potential for Influencing Perceptions and Behaviour.” *Environmental Science & Policy*, Mitigation and Adaptation Strategies for Climate Change, 8 (6): 637–54. https://doi.org/10.1016/j.envsci.2005.08.002.

Shindler, Bruce A., Eric Toman, and Sarah M. McCaffrey. 2009. “Public Perspectives of Fire, Fuels and the Forest Service in the Great Lakes Region: A Survey of Citizen - Agency Communication and Trust.” *International Journal of Wildland Fire* 18 (2): 157. https://doi.org/10.1071/WF07135.

Simpson, Leanne Betasamosake. 2017. *As We Have Always Done: Indigenous Freedom through Radical Resistance*. Indigenous Americas. Minneapolis: University of Minnesota Press.

Skarbez, Richard, Frederick P. Brooks, Jr., and Mary C. Whitton. 2018. “A Survey of Presence and Related Concepts.” *ACM Computing Surveys* 50 (6): 1–39. https://doi.org/10.1145/3134301.

Spence, Alexa, Wouter Poortinga, and Nick Pidgeon. 2012. “The Psychological Distance of Climate Change: Psychological Distance of Climate Change.” *Risk Analysis* 32 (6): 957–72. https://doi.org/10.1111/j.1539-6924.2011.01695.x.

Stearns, Forest W. 1997. “History of the Lake States Forests: Natural and Human Impacts.” In *Lake States Regional Forest Resources Assessment: Technical Papers*, 8–29. USDA Forest Service General Technical Report, NC-189. USDA Forest Service.

Stewart, Iain. 2011. “Earth: A Three Act Structure.” University of Oxford, January 28. http://podcasts.ox.ac.uk/earth-three-act-structure.

Sturtevant, Brian, Christel Kern, and Deahn Donner. 2016. “Restoration of Fire-Dependent Pine Barren Ecosystems in Northern Wisconsin – Bridging the Gap between Research and Management Practices.” Webinar, Lake States Fire Science Consortium.

Thompson, Aaron. 2018. “A Socio-Ecological Framework for Strategic Forest Conservation Planning.” University of Wisconsin-Stevens Point.

Tuan, Yi-fu. 1974. *Topophilia: A Study of Environmental Perception, Attitudes, and Values*. Englewood Cliffs: Prentice Hall.

Visser, Penny S., George Y. Bizer, and Jon A. Krosnick. 2006. “Exploring the Latent Structure of Strength-related Attitude Attributes.” In *Advances in Experimental Social Psychology*, 38:1–67. Elsevier. https://doi.org/10.1016/S0065-2601(06)38001-X.

Vodak, M.C., P. L. Roberts, J. D. Wellman, and G. J. Buhyoff. 1985. “Scenic Impacts of Eastern Hardwood Management.” *Forest Science* 31 (2): 289–301.

Vorderer, Peter, Werner Wirth, Feliz Ribeiro Gouveia, Frank Biocca, Timo Saari, Lutz Jäncke, Saskia Böcking, et al. 2004. "MEC Spatial Presence Questionnaire (MEC-SPQ): Short Documentation and Instructions for Application." Report to the European Community, Project Presence: MEC (IST-2001-37661). Online. https://academic.csuohio.edu/kneuendorf/frames/MECFull.pdf.

Wallgrun, Jan Oliver, Eric Knapp, Alan Taylor, Alexander Klippel, Jiayan Zhao, and Pejman Sajjadi. 2021. "Place-Based Learning Through a Proxy - Variations in the Perceived Benefits of a Virtual Tour." In *2021 7th International Conference of the Immersive Learning Research Network (ILRN)*, 1–8. Eureka, CA, USA: IEEE. https://doi.org/10.23919/iLRN52045.2021.9459380.

Whittaker, Doug, Jerry J. Vaske, and Michael J. Manfredo. 2006. "Specificity and the Cognitive Hierarchy: Value Orientations and the Acceptability of Urban Wildlife Management Actions." *Society & Natural Resources* 19 (6): 515–30. https://doi.org/10.1080/08941920600663912.

Williams, Kathryn, and John Cary. 2001. "Perception of Native Grassland in Southeastern Australia." *Ecological Management and Restoration* 2 (2): 139–44. https://doi.org/10.1046/j.1442-8903.2001.00077.x.

Wilson, F. G. 1982. *E. M. Griffith and the Early Story of Wisconsin Forestry (1903-1915)*. Madison, WI: Wisconsin Department of Natural Resources.

Wisconsin Conservation Hall of Fame Foundation. n.d. "Edward Merriam (E. M.) Griffith." *Wisconsin Conservation Hall of Fame* (blog). https://wchf.org/edward-merriam-griffith/.

Wisconsin Department of Natural Resources. 2006. *Wisconsin Land Legacy Report: An Inventory of Places to Meet Conservation and Recreation Needs*. PUB-LF-040-2006. Madison, WI: Wisconsin Department of Natural Resources. https://www.wistatedocuments.org/digital/collection/p267601coll4/id/11073.

———. 2015. "Chapter 13, Northeast Sands Ecological Landscape." In *The Ecological Landscapes of Wisconsin: An Assessment of Ecological Resources and a Guide to Planning Sustainable Management*. PUB-SS-11310. Madison, WI: Wisconsin Department of Natural Resources.

———. 2016. "Regional and Property Analysis of Northwest Barrens Properties: Burnett, Douglas, & Washburn Co, Wisconsin." DNR Pub-LF-090. Madison, WI: Wisconsin Department of Natural Resources.

———. 2021. "Pine Barrens." 2021. https://dnr.wi.gov/topic/EndangeredResources/Communities.asp?mode=detail&Code=ctsav006wi#:~:text=This%20savanna%20community%20is%20typically,northern%20pin%20and%20bur%20oaks.

———. n.d. “Natural Heritage Inventory Portal Reports.” Wisconsin Department of Natural Resources. n.d. https://dnr.wisconsin.gov/topic/NHI/calypso/EOReport.html.

Wu, Chenghuan, and David R. Shaffer. 1987. “Susceptibility to Persuasive Appeals as a Function of Source Credibility and Prior Experience with the Attitude Object.” *Journal of Personality and Social Psychology* 52 (4): 677–88. https://doi.org/10.1037/0022-3514.52.4.677.

Zak, Paul J. 2014. “Why Your Brain Loves Good Storytelling.” *Harvard Business Review*, October 28, 2014. https://hbr.org/2014/10/why-your-brain-loves-good-storytelling.

Zwickle, Adam, and Robyn S. Wilson. 2014. “Construing Risk: Implications for Risk Communication.” In *Effective Risk Communication*, edited by Joseph Arvai and Louie Rivers. Earthscan Risk in Society Series. London: Routledge, Taylor & Francis Group.