Carrying the Torch: The role of the visual arts in communicating scientific lessons from fire ecology

by

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ABSTRACT

Disruption of historic fire regimes in Southeastern Michigan is associated with a host of negative ecological effects such as reduction of landscape diversity and loss of prairie and savannah ecosystems. The return of fire to the landscape is critical to maintenance of local ecosystems, however the use of fire has coupled social and ecological dimensions that commonly predicate its application on public awareness and willingness to support prescribed fire.

An interdisciplinary art-and-science exhibition about the fire ecology of Southeastern Michigan was designed and presented to a public audience in Ann Arbor, Michigan to evaluate art's potential to communicate actionable lessons from ecology. Exhibition visitors self-selected to complete surveys assessing changes to *understanding* of the ecological role of fire, *support* for the use of prescribed fire, and *concern* about the negative ecological effects of fire exclusion. Fire management professionals from local, regional, and state organizations visited the exhibition and completed surveys in which they ranked the exhibition's effectiveness as a tool for public engagement. Survey respondents identified exhibition features that were effective at informing educational or affective responses. Select follow-up interviews were conducted to further identify valuable dimensions of the exhibition that could inform recommendations for future art-science collaborations.

Survey results from 100 respondents indicated overall increases in ecological understanding, support, and concern. 64.18% of respondents without pre-existing advanced knowledge reported an increase in understanding. 74.41% reported an increase in support for prescribed fire. 85.25% reported an increase in concern about the ecological effects of fire exclusion. The majority of the 21 fire management professionals surveyed (52.38%) rated the exhibition "very effective" as a tool for public engagement. Survey and interview responses indicated that the inclusion of a narrative children's book and a diverse array of visual media were most effective at conveying information and affecting emotional engagement. Findings support the potential of the arts for effective communication of critical ecological and scientific information to a public audience.

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I would also like to thank those in the world of wildland fire whose leadership, guidance, and patience has shaped my career in fire management, providing the best possible supplementary research in the form of practical lessons from fire ecology. Many who are named and unnamed here are present in spirit in much of the artistic work produced as part of this thesis project. In particular: thanks to Cassandra Fleckenstein for facilitating my entry into the federal wildland firefighting workforce; Kristopher Green, for two seasons of mentorship on his phenomenal Forest Service engine; and Max Leidenfrost, who took an interest in my thesis during the 2021 fire season. His efforts at keeping me on track were appreciated (if unrewarded), as was his donation of retired USFS prevention signs which were utilized in artistic work featured in the exhibition.

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Finally, I am grateful for the natural areas in and around Ann Arbor and to those who steward them, past and present. It is a core belief underlying the work summarized here that a connection to the natural world is of fundamental importance for individual, community, and ecosystem health. Immersion in the forests, prairies, and savannas of southeastern Michigan were instrumental to my own sense of well-being throughout this work and my experiences there provided the motivation to work towards their continued protection and appreciation in my own small way with the creation, documentation, and evaluation of the *Carrying the Torch* exhibition.

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1. INTRODUCTION

Climate change, unprecedented losses in biodiversity, worsening natural disasters, and mounting friction between conservation and development interests are confronting societies at local and global scales. Insofar as effective action to mitigate present and future environmental crises hinges on widespread public awareness and support, this dependency raises questions about how salient environmental science research can be compellingly brought to public attention (Diaz et al. 2016, Curtis et al. 2012, Nadkarni 2004). The scientific community recognizes the necessity of communicating findings to a public audience, caching the enterprise as a fundamental responsibility (Greenwood et al. 2001, Lubchenco 1998). However, conventional outlets of knowledge dissemination through academic practices have been recognized as insufficient in their abilities to engage the public (Brewer 2001). Seminars, conferences, lectures, and journal publications have been criticized as "preaching to the choir"—namely, their audiences are self-selecting for those with a pre-existing interest in the topics presented and as such are limited in scope (Nadkarni 2004). The critical audience for environmental science to reach to inspire change at the level and scale required in the twenty first century is not the scientifically literate cognoscenti, but a majority of the public, many of whom self-report low levels of scientific awareness or extant interest in supporting and engaging in pro-environmental action (Miller 2004, Nadkarni 2004).

The preaching to the choir concern may also apply to coverage of scientific findings in the media, where readers of environmental science journalism are likely to be those who already possess a high level of interest in environmental topics (Nisbet et al. 2009). Scientific journalism presents the additional problem insofar as the researchers who best understand the content and significance of their findings are not those presenting them to the public. This division of knowledge generation and dissemination duties yields an imperfect "symbiotic-adversarial" relationship between the scientific and journalistic communities as mediation between the source of scientific content and its audience introduces potential for unintentional inaccuracies at best and unhelpful sensationalism at worst (Friedman et al. 1986).

It is therefore critically important that alternative methods of communicating about science to broader audiences are developed, evaluated, and expanded, not just by outsiders, but with the direct participation of the scientific community (Groffman et al. 2010). Historically, the arts have enjoyed considerable success in galvanizing public interest in social and political movements, highlighting their potential to be agents of informational dispersal to a lay audience. Within the scope of environmental initiative, there have been demonstrated instances of the arts influencing conservation outcomes (Belfiore et al. 2007, Saratsi et al. 2019). There is a sizable contemporary environmental art movement from which scientists have been proportionally absent, despite the fact that their research is often cited as the onus for the artwork produced (Galafassi et al. 2018, Chang 2015). These sorts of independent artistic enterprises share the same shortcomings of other forms of scientific outreach when the party communicating findings to the public bear little to no connection to the party conducting the research, leading to potential gaps and inaccuracies in the information conveyed. Moreover, evaluations of the actual effects of environmental art projects are few and far between, such that understanding of how and to what extent they impact audiences in ways that enact pro-environmental cognitive and behavioral changes is underexamined (Lesen et al. 2016).

While such collaborative work remains relatively rare, there are growing instances of collaborations between scientists and artists seeking to collectively communicate research through art—end-running the problems of preaching to the choir in traditional publication avenues and informational inaccuracy by involving scientists and artists jointly in the creative enterprise and evaluating the results of communication to further understanding about how such collaborations affect positive change. Findings from past collaborations suggest that environmental art has the capacity to reach broad audiences, synthesize complex ecological information in terms that are interesting and and accessible to public audiences, resonate with those who might be unswayed or uninterested by scientific presentation, and promote new ways of looking at issues, even among experts (Colavito et al. 2020, Trainor et al. 2013, Connelly et al. 2016, Curtis et al. 2012). Furthermore, the incorporation of the arts into conventional ecological discourse constructs opportunities for much-needed conversations between scientists, managers, and the public such that the value of the collaboration is not solely borne by the end viewer, but also shared by the collaborators themselves (Colavito et al. 2019).

As a continuation within this underserved vein of inquiry, this study investigates viewer responses to an ecologically informed art exhibition in Ann Arbor, Michigan: *Carrying the Torch: Rekindling Prescribed fire in Michigan's Prairie Peninsula*. The extent and the manner in which visitors' experience of the exhibition modified ecological *understanding*, level of *support* for science-based management practices, and *concern* for ecosystem health as it pertains to the specific ecological phenomenon of fire exclusion in southern Michigan was evaluated through visitor surveys and follow-up interviews. Visitors self-reported changes in each of the three categories of interest after viewing the exhibition. Visitors were also asked to identify and reflect upon components of the show that they felt to be responsible for increases in understanding, support, or concern so that questions of not only *whether* but *how* the exhibition shaped the changes they reported could be identified. The analysis of the exhibition's educational and affective properties constitutes an expansion upon past inquiry, allowing for a set of recommendations to be made for replication and refinement in future ecology-art collaborations focused on education and outreach.

2. BACKGROUND AND LITERATURE REVIEW

If the arts are to be called upon optimally as a means of scientific outreach, investigations of their applications are necessary to understand and validate their claims of communicative potential and to motivate and inform their expanded use. There is a relatively nascent but quickly growing body of scientific literature that takes as its focus precisely this investigation, evaluating interdisciplinary collaborations between the artistic and scientific communities using scientific methodologies. An overview of this literature, its background, and an analysis of its needs for expanded inquiry are given here for the purpose of informing and motivating the present study.

2.1 Disciplines divided: A background of art in science and science in art

Art has a long-standing presence in the origins of science—a relationship which is reciprocated by a prodigious history of science in art. Scientific illustration was once the exclusive means of visually capturing and conveying of scientific evidence in all fields prior to the advent of photography and later digital image generation technologies and is still relied upon to this day. Advances in science once were closely linked if not synonymous with advancements in art at the time in which polymaths like Fillippo Brunelleschi pioneered one-point perspective or Leonardo da Vinci conducted painstaking empirical research for his anatomical studies (Ackerman 1998). Within the bounds of the environmental sciences, botanical and zoological illustration played an essential role in the taxonomical determination of species (Curtis 2011, Clark et al. 2020). Both art and science rely on the keen observational skills of their practitioners, differing significantly in contemporary application but nonetheless stemming from remarkably similar historical origins in theory and practice (Halpern 2011, Clark et. al 2020).

Despite the inextricable roots of art and science, more recent trends indicate a growing apart of the disciplines as increased specialization reinforces academic silos (Connelly et al. 2016, Clark et al. 2020, Halpern 2011). In the editorial preface to *Nature's* 2005 issue *Artists on science: Scientists on Art*, guest editors Alison Abbott and Adam Rutherford reflected that "it is hard to find today a true artist–scientist like Leonardo da Vinci, as noted for his science and engineering skills as his *Mona Lisa* and *Last Supper*. There is just too much to know." (Abbott and Rutherford

2005). While increased specialization is an unavoidable byproduct of the prolific expansion in understanding and expertise accumulated since the time of Leonardo, the rift between disciplines has grown so broad that there is a risk of unintelligibility between them (Halpern 2011). The "great divide" between the arts and sciences was famously noted by scientist and novelist C.P. Snow in his Rede Lecture *The Two Cultures*, in which he describes a "gulf of mutual incomprehension—sometimes hostility and dislike, but most of all lack of understanding" between the sciences and the arts (Snow 1959).

Researchers have noted a reticence from both the scientific and artistic communities to cross disciplinary boundaries and engage in joint production of art initiatives (Halpern 2011, Connelly et al. 2016, Clark et al. 2020, Holm et al. 2012, Lau et al. 2022). In the social and scientific quagmire surrounding the large environmental problems of contemporary society, interdisciplinary work generates essential opportunities for the creation and dispersal of knowledge at the complexity and scale required to meet such multifaceted issues head-on (Bhaskar et al. 2010). There is a dire need for integrated, boundary-breaking research in the environmental arena specifically pertaining to public communication and engagement with environmental issues. Even with the cultural and intellectual divides between the arts and sciences being what they are, recognition of this need has spurred increasing collaborative initiatives which ground continued development and expansion within and between fields.

2.2 Contemporary interactions between environmental art and science

Art historian Martin Kemp summarized the differences between artistic and scientific enterprise by means of their ultimate communicative intentions:

> "A work of art always remains open for interpretation, drawing the spectator into the shape of the artist's visualization, but without being able to exert fixed control over the feelings it induces. There is always room for the beholder's share. Scientists may wish to engage the reader or spectator in a wonderful journey of imaginative visualization, but in the final analysis they wish to communicate an interpretation that embodies testable content in an unambiguous way." (Kemp 2005).

Within the realm of environmental inquiry and communication, there is a diverse array of capacities in which art and science interact—different combinations of and extents to which the ultimate intentions of each field are represented in applications which combine them. Some interactions between environmental art and science lean more heavily towards the arts' interpretive

end-product while others place greater weight on testable, unambiguous content anchored in science.

The landscape of art-science interactions can be understood in broad strokes as a continuum of disciplinary integration—from independent work conducted within the conventions of one field that borrows somewhat from the other without sacrifice of established methodologies or intentions of the native discipline, to complete departures from procedural precent in the novel synthesis of two fields. This distinction between working *within* a field and working *between* fields may be best articulated using categories of multi-disciplinarity, inter-disciplinarity, and trans-disciplinarity adapted from the work of Marilyn Stember and subsequent investigations concerned with boundary-spanning research and practical advancements in global change (Stember 1991, Holm et al. 2012, Clark et al. 2020, Saratsi et al. 2019).

An artist who incorporates environmental data into their practice engages in *multidisciplinary* activity: information from another discipline is incorporated into the procedures, practices, and acceptable work outputs of their own field (i.e. Meade 2008). Active collaboration between disciplines takes this integration a step further by combining procedural elements from both fields, though it is worth it is noting that it is not the combination of *people* but of *approaches* that is the hallmark of this sort of work. Examples might include artists learning from scientists to develop a scientifically-informed exhibition which is then evaluated through established scientific methods. Work in this category may be thought of as is *interdisciplinary*: practices and intentions from both art and science are included in a shared enterprise which ultimately preserves the respective artistic and scientific nature of its component parts (i.e. Colavito et al. 2020). Sometimes collaboration takes a form that completely transcends disciplinary precedent, and the result is something that cannot neatly be divided into scientific or artistic components. One such example might be the direct collaboration of artists and scientists to create an object, visualization, or other such work product that is simultaneously artistic and scientific in nature (i.e. Clark et al. 2020). Work in this vein is *transdisciplinary*: it obscures conventional boundaries and cannot be carved at the joints into discernable discipline-specific components. These categories of are not distinct—they overlap on a sliding scale which captures a great diversity of environmental art and science applications. Rough categorization along this axis has been included because it is useful in providing a general sense of the landscape of art-science interactions in the environmental arena and the placement of this study within it.

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Multidisciplinary work constitutes the lion's share of extant work at the nexus of art and environmental science. Within this category there is no shortage of multidisciplinary activity within the arts pertaining to environmental science, but there is a proportional deficiency of activity within the environmental sciences when it comes to art (Lesen et al. 2016). The environmental art movement furnishes a wealth of examples where artists utilize scientific data and conclusions to produce work within the disciplinary conventions of artistic practice (Jean 2019). Environmental art is still a relatively recent phenomenon with a complex landscape that is still being studied and mapped (Thornes 2008, Blandy et al. 1998). To the extent that analyses of the movement to date are available, they reveal a multidisciplinary identity insofar as the creative work at the art-science nexus is done predominantly by artists in the absence of scientists One such study demonstrated a much larger participation from those with art-based training than those with science-based training, with 95% of those engaged with what researchers identified as "environmental science-art" reporting an arts background, 45% reporting a combined arts-and-science background, and only 5% reporting a purely science background. These findings accord with others that indicate training in the arts to be an important predictor of involvement at the nexus of art and environmental science: those without a background in the arts are unlikely to participate (Chang 2015, Clark et al. 2020).

Thus there are fewer documented instances of scientists using art to independently create or communicate science, though multidisciplinary endeavors in the reverse to exist. Forest ecologist Nalini Nadkarni incorporates artistic methodologies such as "tree paintings" in her ecological research—markings made from tree branches' natural movement in the wind—to quantify tree movement and outreach to nonscientific audiences simultaneously (Nadkarni 2006). Others in environmental fields recognize and report deep aesthetic currents in their own scientific activities—a manifestation of a larger claim that the individual experience of conducting scientific research has fundamentally aesthetic if not artistic dimensions (Lau et al. 2020, Sullivan et al, 2002, Eisner et al. 2002).

While the multidisciplinary approaches heretofore considered are widely believed to be valuable, consensus remains that there is further benefit to be obtained from increasing disciplinary

integration such that both science and art are included where heretofore science has been conspicuously absent (Lau et al. 2022). Frequently this sort of barrier-breaking comes in the form of direct collaboration between practitioners of art and science in work that exhibits interdisciplinary or transdisciplinary characteristics. Unlike the promising growth of multidisciplinary initiatives within art, increasingly collaborative approaches are underrepresented given heightened demands for precisely such integration in response to complexity in building understanding and facilitating communication about environmental problems, and it is past applications of these approaches which best introduce the work conducted in the present study (Bhaskar et al. 2010).

2.3 The research landscape of environmental science and art collaboration

Inter- and transdisciplinary endeavors between environmental art and science exhibit remarkable variety and the research which concerns them is relatively nascent. As such, there is little established protocol for the form or evaluation of such collaborations in the scientific literature (Halpern 2011, Clark et al 2020, Connelly et al. 2016). To speak generally, research at the nexus of environmental science and art collaboration exhibits the following features: 1) It includes artistic methodologies, not instrumentally as an illustrative tool, but procedurally as an inherent feature of the research activity in question. This distinguishes the work in question from pure environmental science; 2) It includes an evaluative component that seeks to generate evidence and offer conclusions about the nature of the collaborative enterprise. This distinguishes the work in question from pure environmental art. In short, such research is the conjunction of the interpretive freedom and testable content outlined in the prior section (Kemp 2005).

These criteria are broad and blanket generalization about the focus and methodologies of studies which satisfy them is too vague to be illuminating: art and science are brought together and the nature of their interaction is scientifically examined. It is more informative to identify two broad areas within the literature. One area is concerned with the collaborative process itself—asking questions about how interactions between art and science during knowledge production might modify, expand, inform, or shape *participants*' views and conceptions of their respective disciplines. The other area is concerned with the communication of scientific content to an *external audience* through interdisciplinary interactions between science and the arts. This is to say that the first area of study examines processes of interaction between arts and science while the second

evaluates the products of such collaborative activities for communicative potential to a lay audience. Thus there is a vague directionality established in the literature in which studies of the first sort provide context and information about the activities which produce the communicative opportunities examined by studies of the second. The division between these areas of research is not a harsh one—there are studies that exhibit characteristics of both groups, investigating both the effect of the collaboration on the collaborators and the effects of its products on an audience. A visualization of these distinctions is provided in *Figure 1* to accompany the present discussion: A description of the available research in each category, an analysis of overarching trends in the literature overall, and a location and justification for the current study in light of past endeavors and demonstrated informational needs.

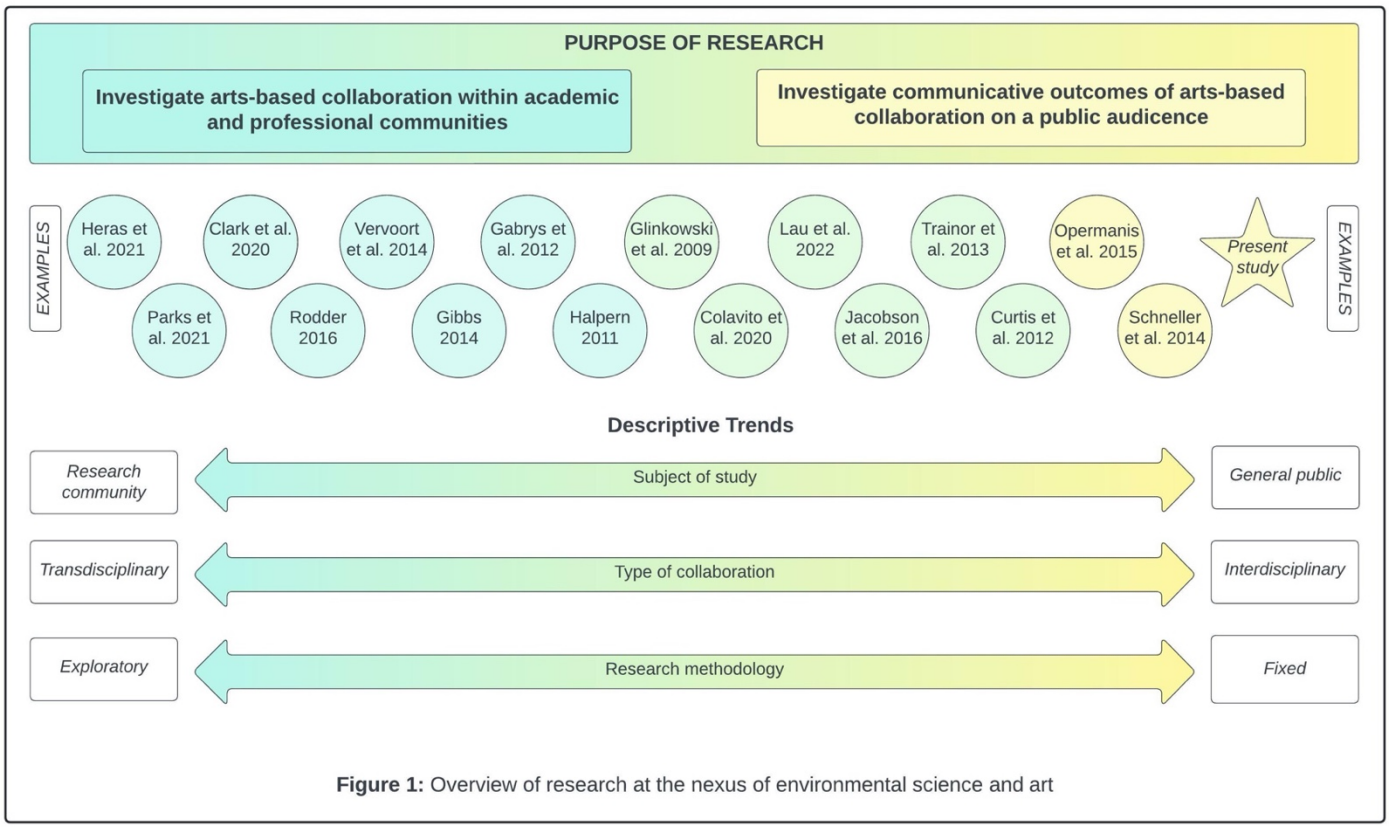

Figure 1: Overview of research at the nexus of environmental science and art

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It is widely acknowledged in the environmental and sustainability sciences that the methodologies of knowledge production itself will need to expand beyond the bounds of traditional scientific research to adequately address the complex and inherently cross-disciplinary problems of the twenty-first century (Heras et al. 2021, Propper 2017). Research in the first area identified above is concerned with these processes of expansion particularly as they occur through collaborative processes between artists and scientists through the incorporation of arts-based practices in processes of scientific research. Such research creates collaborative opportunities, documents ways in which collaboration occurred and, in the words of a representative study, conducts a "phenomenological exploration of participants' experiences with art in relationship to research, their perceptions of the aesthetic nature of research and scientific practice, their orientation toward the purpose of art in science communication contexts, and their own self-perceptions as artists" (Parks et al. 2021).

The collaborative process most studied to date involves the co-production of a work of art—either in pairs or larger groups that include members from both disciplines—and utilizes a wide variety of artistic approaches, media, and processes in the creation of the final work (Halpern 2011, Clark et al. 2020, Heras et al. 2021, Gibbs 2014, Gabrys et al. 2012). Certain others acknowledge limitations posed by the co-production model and opted for a scheme of collaboration that was less time-intensive for participants, examining instead a residence-based model in which artists were placed in laboratories to conduct artistic research in parallel with scientific research without an explicit agenda for co-production. (Rodder et al 2016, Parks et al. 2021).

Through qualitative means of evaluation including participant surveys, interviews, and observational notes, broader trends emerge throughout this area of literature that indicate key benefits of collaboration to those involved and identify particular processes and tools that could be utilized in the implementation of further collaborative engagements such as the creation and use of "boundary objects"—physical entities that exist as both objects of art and objects of science (Halpern 2011). Findings indicated a host of interconnected benefits accrue as a result of collaborative arts-science initiatives. In many cases, the inclusion of art-based practices prompts expansion of procedural approaches in scientific research, allowing for new ways of investigating scientific questions that holistically augment existing research strategies and blur distinctions between individual roles as either practitioners of arts or science (Heras et al. 2021, Clark et al.

2020, Gibbs 2014). This methodological expansion correlates with reports of more nuanced understandings of creative and scientific work that augmented prior pathways of thought about participant's subjects of study. Increases in scope when conceiving research questions may also have contributed to creative advances to solutions-based thinking prompted by imagination of alternative futures through artistic modalities (Heras et al 2021, Gibbs 2014). Participants in collaborative activities between the arts and sciences also reported increased interest in continued collaborative activities and heightened senses of understanding of the processes and practices employed by peers in opposing disciplines (Gabrys et al. 2012). Increased interest in the potential for arts-based communication about science was also a common theme noted in participant reflections across multiple studies (Heras et al. 2021, Parks et al. 2021, Clark et al. 2020, Gibbs 2012, Halpern 2011). However, conjecture about the use of art, or the use of the collaborative processes incorporating the arts, as tools for public communicated was not directly corroborated in most studies which took as their primary aim the evaluation of collaborative process in science-based art.

The other area in the literatures takes as its object the communicative role of science-art collaborations to a lay audience, expanding upon pre-identified limitations of studies which did not include a public communication evaluation (Halpern 2011). These studies investigate the communicative impacts of art-science initiatives on the public, though many of the studies in this category also consider responses from collaborators to determine the effects of collaborations on participants and to gather their reflections on the communicative outcomes. Utilizing similar qualitative data collection methods as the research described in the prior category, there are three modes of investigation employed within this category that vary primarily on the basis of persons queried. The first seeks to evaluate public-oriented communicative outcomes of science-based art by assessing scientists' views on the communicative potential of the arts in question to a public audience. Additionally some such cases include responses from professionals in land management who are well versed in the scientific underpinnings of their ecosystem management activities and are likewise considered informed about scientific communication needs. Another combines scientist and professional opinion with direct evaluation of the general public's response, while the third focuses exclusively on the communicative effect on the public with no concomitant evaluation of scientist or manager views.

The second and third modes are the only methods that actively engage with the public to directly evaluate communicative impact on a lay audience. Research that employs the first methodology illuminates critical lessons about the scientific community's willingness to participate in or otherwise engage with arts-based communication measures and is an extension of much of the research that investigates specific interactions between artists and scientists within research domains (Curtis et al. 2012, Jacobson et al. 2016). However, in such cases the impact on the proposed audience is evaluated speculatively—scientists render opinions about what they perceive to be useful but the measurement of usefulness itself can be found more readily in studies that employ either a hybrid or an exclusively public-oriented focus as these directly address the effects on the public (and not the perceived or hypothesized effects as told by an intermediary).

Of the available studies investigating communicative dimensions of science through art which included a public evaluation component, public understanding of concepts from the environmental sciences was found to increase (Colavito et al. 2020, Colavito et al. 2019, Glinkowski et al. 2009,. Lau et al. 2022, Trainor et al. 2013, Opermanis et al. 2015). In recognition of the arts unique ability to interact with viewers in both cognitive and affective capacities, many studies included one or more evaluative components which sought to measure changes to viewer's emotions, attitudes, or affective beliefs in light of their experience of science-based art initiatives. Findings indicated that support for scientifically-informed ecosystem management and restoration increased, as did general indicators of concern in response to the evidence presented (Colavito et al 2020, Glinkowski et al. 2009, Opermanis et al 2015). Likelihood of pro-environmental behavior was also found to have increased following exposure to arts-based science communication. (Opernamis et al. 2015). Controls were established in some cases to determine how the inclusion of the arts in particular assisted in the transference of scientific knowledge or affective connection, and results indicated that the scope of audience reached increased by virtue of arts inclusion in comparison to modes of presentation that were purely scientific in nature (Opermanis et al. 2015).

* * *

Within the extant literature, the two areas of research have been distinguished by their ultimate ends—the investigation of collaborative activities between artists and scientists and the investigation of the practical communicative potential borne by such collaborations. There are

several overarching trends accompanying this rough grouping worth noting (see gradated arrows at bottom of Figure 1).

First, the choice of subject is not starkly delineated amongst the groups identified. In the case of research that evaluates collaborative processes, it follows directly that the collaborators are the ones studied. In the case of research that evaluates communicative features of environmental art and science collaborations, data is collected from members of the public audience but is often also collected from collaborative participants. Participant data is used not only as a secondary evaluation of the communicative performance but also to identify beneficial features of the collaborative process to the participants themselves. In this sense, some of the questions belonging to research in the second category cross over into the first.

A second feature of the differences between these areas is the extent to which disciplines are *intermixed* as opposed to *interposed*. In the exploratory, practice-based studies that document the nature of the collaboration itself, the arts and sciences often interact from the very start and are dissolved together through practices that transcend conventional activities of either discipline. In the communication-based studies, the arts and sciences each participate in the joint venture at different points in the cumulative project such that it bears identifiable features of both art and science. In this capacity they tend to be interdisciplinary without extending into the realm of transdisciplinarity.

A third dimension of difference between categories is the level of abstraction present in the research question and methodology itself. Transdisciplinary approaches which seek to document and understand the nature of collaborative integrations tend to have little to no pre-established hypotheses about the content of their findings. Data in all cases discussed is qualitative by virtue of the ultimate subject being changes in human cognition and social dynamics that are measured through means of surveys, interviews, observational studies, focus groups etc. (and not, for example, through neuroscientific monitoring). However, research in the second category tends to exhibit more concrete, testable hypotheses by virtue of taking as its subject the practical process of communication. Limited research that truly spans both these categories tends to be of a scale and complexity to admit the inclusion of both types of inquiry (Glinkowski et al. 2009).

* * *

The landscape of research is complex: varying by topic of inquiry, methodology, extent of collaborative integration, form of evaluation, and scope of public inclusion within and between the two general categories heretofore described. This literary overview serves to illustrate the following underexplored areas that the present study seeks to address.

2.3.1 Under-examination of communicative potentials and processes

The available literature is more heavily dedicated to understanding collaborative processes among practitioners of science and art (the first category of research heretofore identified), with many studies speculating about further utilization of such processes for communication of scientific concepts to a lay audience. However relatively few undertake a direct evaluation of that hypothesis, and almost none exhibit sole focus on public-oriented communicative potential of art-science collaboration. A past review of environmental science and art collaborations indicated that while there were many multidisciplinary examples in which the art were harnessed as communicative vehicles for science-inspired content, there were few evaluations of their effects. In contrast, 17% of projects at the nexus of art and environmental science investigated collaborative processes between scientific researchers and artists in academic contexts (Lesen et al. 2016).

Focus on understanding of arts-inclusive collaborative processes within the research community should not eclipse the recognized need for understanding the communication of such knowledge to the broader public. In some cases, neglect of the latter may be influenced by concerns about the instrumental use of art as an ‘emasculated’ translator of science (Connely et al, Parks et al. 2021). Others have gone further to imply that the supposedly exploitative role of art in communication bears comparatively little significance to the work of transdisciplinary collaboration among research practitioners (Gibbs et al., Rodder 2016).

While concerns about underestimating the value of the arts by ascribing to them only instrumental value as the domesticated communicators of science are legitimate (and indeed pervade much larger conversations about the arts beyond their interactions with environmental science), past precedent illustrates that art in its unconstrained and robust form can successfully communicate scientific content (Orrghen 2017, Lau et al. 2022). It is possible to recognize the communicative role the arts play in such circumstances without making the mistake of reducing them to that role, and researchers should not feel uncomfortable in acquiring further understanding

of clearly evident communicative capacities so long as value of art is not assumed as secondary to that of science (Parks 2021). Suppositions that art can only communicate science if it is neutered and compromised by forcing artists to "renegotiate the standards of their own practice" do a disservice to both fields by failing to recognize the legitimate communicative potential in one and denying the other services borne of that potential (quotation from Rodder 2016).

Furthermore, select findings from studies in the first category which have assumed priority over studies in the second indicate that the latter is necessary to reap the benefit identified in the former. Disciplinary-expanding enterprises combining art and science often prompted scientists to reflect on alternative art-based strategies for communicating their own work, evidencing a link between the collaborative process of research and the collaborative process of communication between the arts and sciences. However, even in cases where scientists reported reflection on other ways to communicate, many still showed a reticence to actually incorporate the arts into their own practices of presentation and communication, signaling a need for artists to be present, not just for high-level collaboration expanding processes of research, but for the practical enterprise of communicating research findings as well (Curtis et al. 2012, Lau et al. 2022). This study places itself in this under-examined category of communication-focused research, investigating the hypothesis that the arts are effective communicators of scientific information to a lay audience.

2.3.2 Need for more detailed understanding of communicative mechanisms

In the limited number of available studies which investigate scientific communication to the public through the arts, science-based art collaborative initiatives were found to bear communicative success. Further work in this area is warranted, not only to augment existing understandings about the potential for the arts to communicate scientific information generally speaking, but to expand knowledge of the *particular mechanisms* through which they do so in cases where communicative success is noted. In other words, investigation not only *whether*, but *how* the arts might communicate scientific lessons to a lay audience allows for broader analyses of the features and practices that have been particularly instrumental in the communicative mission, understanding of which provides a more complete picture of how to optimize such interactions. There is room within the scope of single studies to engage in this type of analysis, something that has received limited attention even in the few studies focusing on communicative

projects of this sort. Inclusion of such analysis is another dimension in which the present study occupies an acknowledged gap in current understanding.

2.3.3 Under-representation of transdisciplinarity in communication-oriented investigation

Studies which include an evaluation of the communicative effects of art-science collaboration tend to examine interdisciplinary work. That is to say that there are identifiable divisions of labor between artists and scientists which largely remain within the scope of conventional activities within each discipline. Scientists provide insight into their research to artists, educating and inspiring artists' work on the relevant scientific information. Artists then create the artistic work utilizing their own established protocols and methodologies, and the final evaluation of the work's public reception is conducted by scientists.

The division of labor in this manner has proven to be effective in generating and documenting communicative advances, but instances of more complete artistic-scientific integration bear further scrutiny. The difference in integration here is akin to the distinction between a solution and a suspension in chemistry. Opportunities for increased insight into both the artistic and scientific processes included may be possible: for example, with the inclusion of scientific practices into artistic ones in the creation of work, or through the input of artists in identifying evaluative criteria that comprehensively investigate the effects of public exposure to science-based art initiatives. Such integration has ample representation in studies focused on understanding collaborative processes between researchers but has yet to be adequately extended to research focused on the communicative role of the arts in environmental science. The present study seeks an evaluation of art-science transdisciplinarity explicitly aimed at communication of scientific lessons.

3. METHODS AND MATERIALS

An ecologically informed art exhibition about fire ecology in southeastern Michigan was designed and presented at the Duderstadt Gallery in Ann Arbor Michigan. The exhibition was open to the public from 12-6pm Monday through Friday from February 15 – 27, 2022. The exhibition exposed visitors to scientific information about fire ecology in Michigan ecosystems and included information about fire adaptation, historical fire regimes in Southern Michigan, ecological effects of prescribed burning, and repercussions of fire exclusion, among other topics summarized in detail below. Visitor surveys were conducted during the exhibition window. Follow-up interviews were conducted following the exhibition. Survey and interview data were coded and analyzed to determine changes in visitors' understanding of fire ecology, support for prescribed fire, and concern about the ecological effects of fire exclusion that occurred as a result of viewing the exhibition. Surveys and interviews also asked participants to identify components of their experience of the exhibition which served to generate changes in the prior categories, providing insight into the mechanisms through which ecological art exhibitions inform viewers' ecological understanding and affective attitudes about an ecological topic and its practical manifestations in natural resource management.

3.1 Study Site and Participants

The Duderstadt Gallery is a public gallery located in the James and Anne Duderstadt Center on the University of Michigan's North Campus. The gallery hosts a wide variety of exhibitions throughout the academic year and is a well-known feature of the Duderstadt Center, a multidisciplinary hub for creative collaboration that houses university resources such as the Art, Architecture, and Engineering Library, the Digital Media Commons, and a large array of media production resources available to university members across the University of Michigan's Ann Arbor campus. The gallery is centrally located along a well-trafficked walkway utilized by many members of the university community including undergraduate, graduate, and post-graduate students from many disciplines, university faculty and staff, university guests, and members of the general public.

Exhibition visitors self-selected to attend the show and participate in surveys. Unsolicited participation from public passers-by during the gallery's standard hours occurred throughout the exhibition's duration. The exhibition was additionally publicized to promote gallery attendance and participation in data collection strategies. Emails and digital fliers were circulated through mailing lists for students, faculty, and staff at the University of Michigan's Program in the Environment and School for Environment and Sustainability. Additional mailing lists for staff and volunteers at the city of Ann Arbor's Natural Areas Preservation department, the Michigan Prescribed Fire Council, and the Lake States Fire Science Consortium were used to reach members of the general public and fire management professionals. A listing for the exhibition was placed in the University Record. A digital flier was placed on the front page of the Duderstadt Center website and a dedicated exhibition webpage was created on the Duderstadt Gallery website. Printed fliers and promotional materials were posted around the Duderstadt Center and adjacent university buildings, as well as in the School for Environment and Sustainability's Dana Building, and other public sites in Ann Arbor (Appendix 1). A mixed graduate and undergraduate environmental humanities course from the University of Michigan School for Environment and Sustainability attended the exhibition on February 15, 2022 and received a guided tour. Local and regional fire management professionals from Matthaei Botanical Gardens, Ann Arbor Natural Areas Preservation, Michigan Prescribed Fire Council, Lake States Fire Science Consortium, and The Nature Conservancy attended throughout the exhibition window.

3.2 Topic Selection

Carrying the Torch: Rekindling Prescribed Fire in Michigan's Prairie Peninsula sought to communicate critical scientific information about the fire ecology of southeastern Michigan ecosystems to a lay audience. It explored the dynamic tension between ecologically beneficial and catastrophic fire, the role of fire in the creation and preservation of local fire-dependent ecosystem types like prairie, savanna, and open-canopy woodland through disturbance of vegetational succession, historic local fire regimes evidenced by dendrochronology and charcoal analyses, species-level adaptations to fire and fire-created habitats, and past and present cultural attitudes influencing human tolerance and application of fire on the landscape, among other related themes.

The choice of ecological topic for the exhibition *Carrying the Torch: Rekindling prescribed fire in Michigan's Prairie Peninsula* (hereafter referred to as *Carrying the Torch*) was

compound, hinging on a host of interrelated ecological, social, and individual considerations regarding the importance and practical potential of public outreach about ecology.

First, fire exclusion has profound, wide-reaching effects throughout fire adapted ecosystems like those of southeastern Michigan, making the return of fire to the landscape an ecological issue of considerable importance with a high degree of local salience (Chapman et al. 2008).

Second, the restoration of landscape fire in the service of ecosystem restoration and management targets can be dependent on the social and cultural attitudes of the local communities. Social attitudes and public tolerance for prescribed fire play a considerable role in determining feasibility of fire practices and restoration targets (Cheng 2003). Increased public awareness about the ecological benefits of prescribed fire have been demonstrated to constitute one of the factors most responsible for upticks in public support regarding the use of prescribed fire (McCaffrey 2006). There is therefore a demonstrated practical benefit to be derived from public outreach and education surrounding the use of prescribed fire manifesting as greater support for sustainable land management and restoration practices.

Third, the ecological information about fire ecology and prescribed fire is highly actionable at an individual level. Ann Arbor has a robust prescribed fire volunteer program, as do agencies working in the land management and restoration sectors at the regional level. Civic engagement with prescribed fire practice through community meetings, private contracting to burn and restore private lands, and advocacy for expanded use of restorative fire exist such that there is potential for interest acquired during the exhibition to prompt further pro-environmental behaviors.

Fourth and finally, the ecological history of the local area is one that is profoundly shaped by fire. Past research suggests that connection to place through deepened understanding of its history, ecology, and functioning can be critical in public adoption of pro-environmental attitudes and behaviors (Opermanis et al. 2015). As such, an understanding of the fire ecology of southeastern Michigan could contribute to building more holistic understandings of place and individual sense of belonging which in turn constitute reasons for subjective environmental valuation.

3.3 Research Questions

This study sought to evaluate the communicative effect the *Carrying the Torch* exhibition had on visitors, focusing on changes to visitors' ecological understanding, support for prescribed fire, and concern regarding the deleterious ecological effects of fire exclusion in southeastern Michigan. It also sought to identify particular features of visitors' experience that contributed to changes in the above categories. Finally, it sought to further determine the effectiveness of the exhibition as a tool for public engagement by evaluating feedback from fire management professionals and subject experts.

It is clear from past studies assessing the role of the arts that their capacities to convey information *and* affect the viewers on an emotional level are jointly fundamental to their unique communicative potential (Friedman 2013, Lesen 2016). Design of research which accurately and sufficiently evaluated the effect of an ecological art exhibition on viewers required a focus sensitive to both cognitive and affective changes. Expanding upon questions posed by prior research examining the effects of ecologically informed art initiatives on a public audience, three relevant dimensions of visitor experience were identified: understanding of the ecological topic, support for science-based management practices aimed at ecological restoration, and concern about the ecological phenomenon requiring mediation. Translated to the particular topic of the exhibition, surveys and interviews sought to answer the following questions about the nature of cognitive and affective changes bone of experiencing the *Carrying the Torch* exhibition:

1) Did the experience of the *Carrying the Torch* exhibition modify visitor's self-reported levels of ecological understanding about the role of fire in southeastern Michigan ecosystems?
2) Did the experience of the *Carrying the Torch* exhibition modify visitor's self-reported support for land management practices utilizing prescribed fire in southeastern Michigan ecosystems?
3) Did the experience of the *Carrying the Torch* exhibition modify visitor's self-reported concern regarding the ecological effects of fire exclusion in southeastern Michigan ecosystems?

Past studies have demonstrated limited analysis of why the environmental art-science collaborations on which they focused generated the results they did. An explanation of not only

whether but *why* such collaborations have been successful in the past is warranted to optimize future projects. A further aim of this research was to elucidate dimensions of visitors' experience of the exhibition which contributed to the cognitive and affective changes they reported. That is to say, what about the show modified their understanding, support, or concern, in the instances in which it did so. To that end, two questions were included on the survey: one which asked viewers to analyze which particular element(s) of their experience contributed to *understanding* (cognitive changes), and another which asked viewers to identify element(s) which contributed to generating thoughtfulness or engagement with the topic (*affective* changes).

4) What qualities, components, or features of *Carrying the Torch* exhibition did visitors feel were responsible for cognitive changes (i.e. increases in understanding), if such changes were reported?
5) What qualities, components, or features of the *Carrying the Torch* exhibition did visitors feel were responsible for affective changes (i.e. increases in concern), if such changes were reported?

Finally, past precedent indicates that the feedback of management professionals and subject-matter experts can be useful in evaluating arts-based public engagement (Colavito et al. 2020). The final question incorporated in the study asked:

6) Did fire ecologists and management professionals consider the *Carrying the Torch* exhibition effective as a tool for public engagement?

3.4 Exhibition Design and Production

Prior research investigating the effectiveness of scientific communication through the arts has predominantly focused on artistic work created by non-scientists (*see section 2.3*). There is very limited precedent in which artists and scientists have co-created work that underwent public-facing evaluation as a communicative device, and while there are few documented cases of researchers independently engaging in the creation of artistic work, there has been no documentation available regarding their communicative effects (Glinkowski et al. 2009, Halpern 2011, Meade 2008). Insofar as I assumed both roles of artist and researcher, this project represents an unusual consolidation of roles between disciplines.

I had extensive formal training in the visual arts prior to developing the present study and maintain an independent visual art practice outside the scope of this research. Prior to commencing

this study, I also accrued three years of professional experience in fire management and prescribed fire application, providing me additional access to invaluable practical knowledge about the ecological and social dimensions of the exhibition topic. These experiences, in combination with my graduate coursework at the School for Environment and Sustainability, provided insight into the creative, practical, and scientific disciplines combined in the development of *Carrying the Torch.*

Research and design of the exhibition began in January 2021 and continued until August 2021. Exhibition production began in August 2021 and continued until the exhibition installation in February 2022. The exhibition opened February 15, 2022 and was open to the public until February 27, 2022. Each phase of exhibition design, production, and presentation is discussed in turn.

3.4.1 Exhibition Design

Design of *Carrying the Torch* involved considerable merging of scientific and artistic sensibilities. The artistic objectives of an exhibition that had as its aim the communication of ecological information were twofold and echoed the questions raised by the study. The first artistic objective was to provide accessible scientific content to a public audience; the second to present the information compellingly through means that were artistically uncompromised. The tension between art's instrumental value as a communicator of scientific information and its less definable intrinsic values and internal standards of quality were among the many considerations present in the artistic and scientific design and production phases of *Carrying the Torch,* many of which are discussed further in Section 5.

Research for the exhibition took multiple forms, integrating conventional and art-based methodologies. A literature survey of published research in fire ecology pertinent to the landscapes of southern Michigan was conducted. The findings from a wide variety of studies investigating dendrochronological and charcoal analyses of historical fire regimes, historic extents of fire-adapted prairie and savanna systems, indicators of anthropogenic fire application, accounts of past fires and cultural attitudes surrounding fire suppression, vegetative species composition with and without the presence of fire, habitat analyses for native species in fire-adapted systems, were reviewed, to name only a few. Findings from the literature survey were synthesized and written up in the text accompaniment to the visual artworks exhibited in *Carrying the Torch*. Research that informed the creation of particular art pieces were cited in the title cards accompanying the piece.

The full text accompaniment, artistic work and title card information, and concomitant citations are documented in the exhibition catalog, included as Appendix 2.

In addition to the broad-reaching survey of published fire-ecological research, the content and design of the exhibition was further informed by consultation with fire management professionals to acquire understanding of prescribed fire practices and to determine what informational gaps in public understanding might be well served by an ecologically-informed art exhibition. Exploratory interviews were conducted from January to April 2021 with two local land managers and prescribed fire practitioners: one from the Ann Arbor Natural Area Protection agency and the other from the Lake States Fire Science Consortium. Additional informal interviews were conducted with four agency employees of the U.S. Forest Service from May to July 2021. Interviews highlighted the importance of incorporating the human connection to fire and its historical application on landscapes, the ecological benefits of prescribed fire to plant and animal communities, and the sensory experience of landscape fire.

Prior to and during the design period, I assisted in numerous prescribed burns as an employee of the U.S. Forest Service and a local prescribed burn and restoration contractor, participating in the firing and holding processes associated with safe controlled burning in a variety of fuel types in Michigan and in the Western United States. Work in this vein conferred indispensable practical insight and experiential understanding that informed processes and content of artistic work generated for the *Carrying the Torch* exhibition.

Combining information from these three sources: review of published literature, expert consultation, and practical experience, the content of the exhibition was identified and developed into works of art. There were two parallel themes that were central to the exhibition's narrative: the ecological processes of fire and the cultural practices and attitudes associated with them. Ecologically, the core theme of the exhibition was the essential role of fire in the creation and maintenance of local ecosystems, many of which are rapidly disappearing in the face of fire exclusion. Culturally, the parallel motif was the role of humans in determining the fire environment: that humanity's activities of burning or suppressing fire that can profoundly impact ecosystems and that a critical facet of homo sapiens' historic role in southeastern Michigan was one of 'carriers of torches'—introducers of fire to the landscape.

The inclusion of the human role in local fire ecology had two rationales: first, it is a fundamental feature of fire regimes in southeastern Michigan that they were largely anthropogenic.

As such, human activities are inseparable from ecological functioning after many thousands if not millions of years of co-evolution (Guyette et al. 2002). Second, the included emphasis on past and present human activity—in particular the emphasis on human responsibility for environmental stewardship and active participation in ecological processes—accords the possibility of appealing to broader interest, heightened individual applicability, and the potential to build and connect with the localized environmental self-identity of viewers which has been shown to be an important indicator of pro-environmental behaviors and actions (Opermanis et al. 2015).

There is no stark delineation between "purely" ecological and "purely" social features of the fire environment in southern Michigan. The two are inexorable, and have been since humanity first began use of fire, becoming the "keystone species of the fire environment" (Pyne 1990). This inexorability is reflected in the intermingled social-ecological content in *Carrying the Torch*. In reference to the exhibition design objectives of accessible scientific content presented in a compelling manner, and the research questions geared towards evaluation of both cognitive and affective changes in visitors, it is nonetheless helpful to make the following distinctions in the choice of exhibition content so as to efficiently summarize the primary ecological lessons available to viewers in the *Carrying the Torch* exhibition. This characterization is accompanied by a hefty disclaimer that such an outline is a gross oversimplification and that there is significant crossover between scientific and social, cognitive and affective.

Broad educational, or otherwise informationally based objectives were established as follows. To counteract the public pre-conception that fire is a universally negative or destructive ecological agent, the exhibition sought to: a) Demonstrate and describe the ecological benefits of fire as documented in the scientific literature; b) Invoke the history of fire and comparisons to present norms to normalize the contemporary presence of fire in light of its historical presence; c) Describe the role of fire in the life histories of charismatic plant and animal species and the multi-layered connections between fire return and biodiversity preservation.

Social, cultural, or otherwise affective objectives were also identified. The exhibition sought to: a) Prompt reflection on cultural attitudes surrounding the use of fire; b) Inspire awareness, concern, or empathy for plants and animals threatened by fire exclusion; c) Inspire thoughtfulness about human responsibilities to steward their local environments, specifically through the use of fire; d) Prompt connection to local landscapes by cultivating appreciation of their unique ecological character informed by fire dynamics.

These objectives overlap significantly: for example increased knowledge may open the door to increased appreciation, or newfound emotional connection may inspire increased curiosity and learning. Education about the fire history in local ecosystems may interact with reflections on one's own role in stewarding those ecosystems.

3.4.2 Exhibition Production

Exhibition production included the curation and creation of artistic work, the creation of the text accompaniment and supporting information for art works such as labels, the installation of the exhibition in situ, and its photographic and videographic documentation in the gallery. While it is precisely art's open-ended ability to capture complexity that informs its communicative promise, it is also the same ineffable qualities of the arts that make them impossible to describe or fully capture in scientific reporting. This section describes the processes of creating the work included in *Carrying the Torch* in more detail, providing insight into some of my artistic intentions and processes of creation so that understanding of the nature of the exhibition can be as complete as possible and later discussions of exhibition efficacy and repeatability can be grounded.

* * *

The exhibition had six thematic sections designed to be viewed in order. Sections are labelled in the exhibition catalog so that interested parties may follow this discussion with its complete visual documentation.

The first section (I) brought to the fore concepts of destructive, catastrophic fire. Conversations with fire management professionals and members of the public indicated that a common public view of fire is that of a powerful destructive force in ecosystems. Accounts of catastrophic wildfires from around the world and in the Western United States underwrite contemporary societal concerns about fire's destructive capacities on the landscape. The artist intended this section of the exhibition to bring those perceptions into focus so that they might be confronted by later sections. This section consisted of a series of four paintings, one of which was loaned by guest artist and research ecologist Sara Adlerstein (Figure 2).

Figure 2: Section I of the *Carrying the Torch* exhibition featuring paintings which engage with ideas surrounding ecologically catastrophic fire.

The text accompaniment to this section read:

> "Fire has profoundly influenced ecosystems across the planet, predating the emergence of the human species by billions of years. It is a natural phenomenon borne of lightning, but it is also a cultural one when the kindling of the flame originates in human hands. As the singular species with the ability to harness fire, it has played a fundamental role in our own evolutionary history and that of the environments we inhabit. We have expanded the natural range of fire as we have expanded our own, introducing it to areas not commonly ignited by nature's lightning and in doing so co-authoring ancient evolutionary pressures that have kindled remarkable diversity in landscapes and ecosystems.
>
> Today, wildfire has been demonized in the public eye, fueled by accounts of catastrophic fires in western North America which perpetuate deep-seated assumptions about the destructive qualities of free-burning fire. The pieces on this wall draw into focus this contemporary cultural ethos, seeding questions about whether this unidimensional understanding of fire is sufficient to preserve the ecosystems we inhabit and our place in them."

A quotation from the ecological literature was also provided:

> "Models suggest that the future will have substantial increases in wildfire occurrence but prior to recent human-caused fire exclusion, fire-adapted pine forests of Western North America were among the most frequently burned in the world. Restoration of patterns of burning and fuels/forest structure that reasonably emulate historical conditions is consistent with reducing the susceptibility of these ecosystems to catastrophic loss" (Fulé 2008).

The second section (II) introduced concepts of fire's beneficial ecological role and the need for its reintroduction, even in fire-prone places. This section consisted of a large woodcut print hung a short distance from the gallery wall and backlit with red, yellow, and orange lighting (Figure 3). The print was entitled "That Which We Protect (Shelter)", and was an abstract piece which symbolized the use of prescribed fire to reduce fuel loading, restore fire-adapted communities, and reduce wildfire risk to protect lives, livelihoods and ecosystems. This piece served as a transition in which concepts of fire's necessary role in ecosystems and its relationship to human activity and management were introduced.

Selections from the text accompaniment read:

> "The ecological devastation caused by high severity fire in the western United States cannot be resolved by continuing to withhold fire in all but the most extreme cases where only in its most destructive form can it overcome fire suppression efforts. It is with more fire, not less, that fuel loads can be reduced and fire-starved landscapes restored to resiliency. The piece included in this segment of the exhibition

Figure 3: Section II of the exhibition featuring the woodcut print entitled *"That Which We Protect" (Shelter)*

illustrates metaphorically how returning low-severity fire to a landscape through prescribed fire can protect the treated area from devastation by high-severity conflagrations.

The consequences of removing fire from ecosystems adapted to its presence are not universal. In highly flammable landscapes like those of the American West, the repercussions of fire suppression are sensational: larger more destructive fires as forests grow thicker and flammable debris accumulates. In ecosystems like those of southern Michigan, the absence of fire manifests all but invisibly to the untrained eye: not as devastation by smoke and flame, but as an insidious disappearance of ecosystems, habitats, and species."

The third section (III) addressed landscape-level changes in southern Michigan through time before, during, and after widespread practices of fire exclusion were adopted. A series of three large mixed media paintings were created following careful study of GIS analyses, vegetative surveys, and natural observation to create a graphic, abstract representation of losses in landscape diversity (Figure 4). The series, entitled Succession I, II, and III, was created in part through the use of charcoal collected from burn sites and burn patterns generated from artistic experimentation in which paper was set on fire utilizing a drip torch—the device used by prescribed fire practitioners to light prescribed burns—and allowed to consume naturally, generating shapes incorporated in the final visual work (Figure 5).

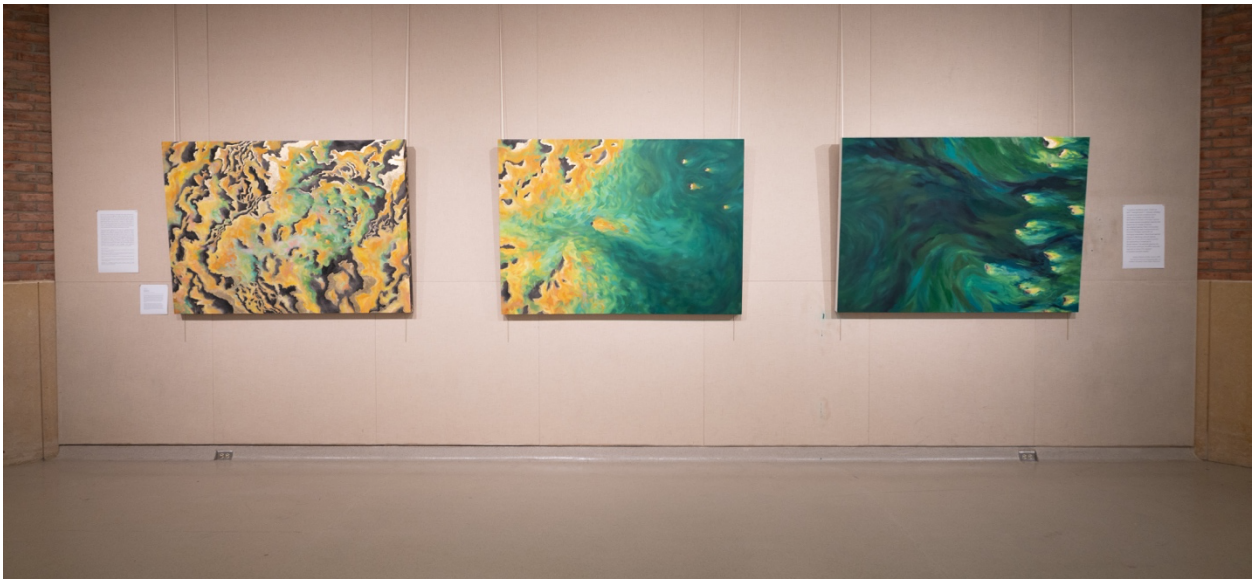


Figure 4: Section III of the exhibition illustrating successional dynamics in Southern Michigan ecosystems over time in light of fire exclusion. This section consisted of the three paintings shown here entitled *"Succession I, II, III" (Mesophistication).*

Selections from the text accompaniment read:

Figure 5: Process of creating *"Succession I"*

> The fires on southern Michigan's landscapes were largely anthropogenic and so too were its grasslands, prairies, and savannas. Fire scar dendrochronology (the study of environmental history using tree rings), and charcoal analysis in soils and lake sediments indicate a strong correlation between human populations and fire occurrence throughout eastern North America (Hart et al. 2011, Guyette et al. 2002). Waves of fire at levels above those expected from lightning corresponded to waves of human populations whose cultural attitudes embraced the use of fire on the landscape, shaping the plant and animal communities across particularities of time and place (Stambaugh et al. 2018).
>
> Following European settlement of the area, fire suppression became wide- spread and indigenous burning practices were forcibly halted. Mosaics of fire-maintained landscapes quickly converted to closed hardwood forests. Prairies and savannas are now some of the rarest communities in the Great Lakes region with less than 0.1% of the 2.23 million acres historically present in southern Michigan persisting to this day (Dickmann et al. 2004, Chapman et al. 2008). The series displayed here explores this narrative of conversion, from a diverse landscape shaped by fire to a homogenous one as successional stages progress unchecked by disturbance. Only recently with the dedicated efforts of prescribed fire practitioners, land managers, and indigneous communities is anthropogenic fire being restored to the landscape.

The "Succession" series was also accompanied by the following quotation from the ecological literature:

> "A positive feedback cycle—which we term "mesophication"— ensued, whereby microenvironmental conditions (cool, damp, and shaded conditions; less flammable fuel beds) continually improve for shade-tolerant mesophytic species and deteriorate for shade-intolerant, fire-adapted species. Plant communities are undergoing rapid compositional and structural changes, some with no ecological antecedent. Stand-level species richness is declining, and will decline further, as numerous fire-adapted plants are replaced by a limited set of shade-tolerant, fire-sensitive species. As this process continues, the effort and cost required to restore fire-adapted ecosystems escalate rapidly" (Nowacki et al. 2008).

The fourth section (IV) raised questions about the cultural attitudes surrounding fire on the landscape. It consisted of one large collage piece created from genuine fire prevention signs sourced from the U.S. Forest Service (Figure 6). The artist deconstructed and re-arranged the signs in ways that intentionally re-framed statements about fire prevention: for example, "Wildfire is good business for a healthy environment." The resulting image was a graphic juxtaposition of messages that invited viewers to make their own discoveries through closer examination.

Figure 6: Section IV of the exhibition featuring a large-format collage on wood panel created from re-purposed signage donated by the U.S. Forest Service.

The text accompaniment to this piece outlined a cultural shift from widespread indigenous practices of burning to one of universal fire suppression, highlighting the ecological effects of these practices:

> Why were cultures of burning which endured for thousands of years snuffed out, and why did a new epoch of fire intolerance replace them? Settlers imported forestry practices from Europe–practices upheld by a value system that regarded the natural world as a collection of resources to be exploited and consumed rather than as a natural system to be participated in and pre- served. In the northern half of Michigan, significant disruption by logging and the slash it created fueled some of the largest most lethal fires in the history of the United

> States, perpetuating a cycle in which the brutal consequences of one form of environmental mismanagement inspired gross mismanagement of another: universal fire suppression.
>
> In Southern Michigan, fire historically returned at average intervals of every 1-5 years in prairie sites and 5-20 years in dry, oak-dominated forests (Cohen et al. 2021, Dickmann et al. 2004). Fire suppression resulted in a profound reduction of fire on the landscape both spatially and temporally, placing southern Michigan in a severe fire deficit and producing unprecedented cascading ecological shifts in the region. Woody encroachment including that of opportunistic, invasive species quickly overtook open sites, decreasing vegetative species richness and threatening the species who rely on prairie and savanna communities for critical habitat (Ratajczak et al. 2012).

The following additional quotation from historic management literature was provided, exemplifying ecologically problematic philosophies that informed land management practices until relatively recently:

> "Prior to organized protection, the number of forest fires [in Michigan] averaged well over 3,000 a year, the annual burn over half a million acres, and the resulting damage to more than one and a half million dollars a year without taking into account the enormous economic loss resulting from millions of acres of unproductive land. Since 1930 the number of fires has been reduced by half, the area burned annually to less than two-tenths of one percent of the area protected...
>
> The record is one of which to be proud, but it does not mean that the fire problem has been licked or that further effort is unnecessary. The threat remains and only by eternal vigilance can forest fires be kept under control. ... Every fire is a menace and only by prompt and effective control can disastrous conflagrations be avoided" (Mitchell 1950).

The fifth section (V) utilized a combined approach of visual and narrative storytelling to communicate fire's role in maintaining critical habitat for native species and its potential to mitigate damage to ecosystem diversity from invasive species. In the Fall academic semester of 2020—prior to the conception of the *Carrying the* Torch exhibition—I wrote and illustrated a children's book intended for audiences of all ages as part of a graduate-level course at the University of Michigan School for Environment and Sustainability (EAS 501-119, Restoration Ecology). The short illustrated narrative tells the story of an eastern massasauga rattlesnake and her friend, an ancient oak tree, as both of their lives are imperiled by a lack of fire through habitat

loss and out competition by invasive species (Figure 7). The individual pages from this book were installed sequentially in the gallery and were supplemented for the purposes of the exhibition with additional information that provided further information about the biology of the species discussed, definitions of key terms, and guidance to further resources within the primary and secondary ecological literature. The full version of the illustrated narrative and accompanying annotation is provided in Appendix 3.

Figure 7: 1-3: Selections from children's book "Mandy's Prairie Home" and 4: Installation in gallery

The sixth section (VI) consisted of a sculptural installation accompanied by a multimedia display of audio and video media. A large sculpture entitled "Carrying the Torch" was created by the artist that featured a large branch of oak (*Quercus spp.*) cantilevered over a black platform on which were suspended drip torches (Figure 8). The main sculpture was surrounded on one side with cut stalks of invasive honeysuckle (*Lonicera mackii*) and opportunistic, late-successional Red Maple (*Acer rubrum*). On the other side, smaller black medallions of irregular shapes were arranged on the floor under and amongst other drip torches, which visitors were invited to handle.

Figure 8: Section VI of the exhibition including “Carrying the Torch” sculpture and video installation.

Figure 9: Still capture from the video footage featured in “Carrying the Torch” installation.

Behind the sculpture I installed three hanging screens on which were projected curated video footage of a prescribed burn conducted November 2021 in Nichols Arboretum by Matthaei Botanical Gardens staff and students as part of the Fall 2021 EAS 501-119 Restoration Ecology course for which I served as a Graduate Student Instructor (Figure 9). An audio track was produced with audio footage from the same prescribed burn which played on loop during the gallery's opening hours. The track consisted of a minute of cracking, popping noises of fire followed by eight minutes of silence.

The sculpture and installation provided visitors with a narrative of restoration and with insight into fire adaptation mechanisms borne by native tree species. Selections from the text accompaniment to the sculpture and multimedia installation read:

> Narrating a story of restoration, Carrying the Torch places drip torches, devices used by contemporary practitioners for carrying fire, in the arms of an oak. The arrangement of invasive and shade-tolerant species behind the oak represent the dense woody growth that arises in the absence of fire, shading out prairie species and oak seedlings. While the literal representation of oaks as "carriers of fire" is tongue-in-cheek, ecologically, they are profoundly fire-adapted species with evolutionary mechanisms to survive and perpetuate it through the flammability of their foliage.
>
> Restoration of an overgrown, fire-excluded landscape often begins with the manual removal of woody accumulation. The honeysuckle and maple in this piece were manually cut by the artist and by employees of the Ann Arbor Natural Area Preservation agency as part of local restoration initiatives. Once the bulk of woody debris has been cut, fire can more readily burn and has a better chance of disrupting the dense stand of woody plants, especially if repeated across multiple years. It takes care, significant labor, and sustained stewardship to re- store a prairie, oak savanna, or open woodland that has not experienced fire for many years.
>
> Visitors are encouraged to lift and examine torch- es standing on circular bases extending from the main installation (take care, they may be dirty!). The torches used in this installation are genuine, passing through many hands and across many landscapes before being retired from the working cache of the U.S. Forest Service in 2021.

The installation was further accompanied by the following quotation from the primary literature:

> "Evidence indicates that periodic understory fire was an important ecological factor in the development of oak forests. ... Mixed-mesophytic and later successional hardwood species, such as red maple, sugar maple, black birch, beech, black gum, and black cherry, are aggressively replacing oak. The leaf litter of these replacement species is less flammable and more rapidly mineralized than that of the upland oaks, reinforcing the lack of fire. The trend toward increases in non-oak tree species will continue in fire-suppressed forests, rendering them less combustible for forest managers who wish to restore natural fire regimes" (Abrams 2005).

* * *

An intentional consideration throughout the creation of the exhibition was the inclusion of many different types of artistic work in addition to the text-based accompaniment. Two-dimensional pieces in a wide range of media, sizes, levels of abstraction, and communicative strategies were all present, as were video, audio, and sculptural components. Rather than present an entire exhibition of one type of art, I chose to diversify modes of artistic production and presentation, both in response to artistic sensibilities about the presentation of certain ideas and to allow for visitor exposure to a variety of artwork types.

3.5 Study design

3.5.1 Surveys

Visitor surveys were developed to assess the identified research questions. A copy of the survey is available in Appendix 4. Surveys asked visitors to identify whether they were a fire management professional. Those who answered in the affirmative were asked to skip to question 8. Those who answered in the negative were asked to indicate their educational or professional background and to complete a series of six questions. The first and second questions asked visitors to rate their level of understanding about the ecological role of fire in Michigan ecosystems prior to attending the exhibition, and after attending the exhibition. The third and fourth questions asked visitors to rate their level of support for the use of prescribed fire as a management tool prior to attending the exhibition, and after attending the exhibition. The fifth and sixth questions asked visitors to rate their level of concern regarding the exclusion of fire in Michigan ecosystem prior to attending the exhibition, and after attending the exhibition.

All respondents were asked to identify element(s) of the exhibition they considered most effective at conveying ecological information, and element(s) of the exhibition they considered

most engaging or thought-provoking. A list of the art works included in the exhibition was provided underneath each question to facilitate identification. A field for additional open-ended comments was also provided. Survey comments from both members of the public and fire management professionals are included in Appendix 5. Respondents who identified as fire management professionals were provided an additional question asking them to rate the effectiveness of the exhibition as a tool for public engagement. All participants were asked to indicate whether they would be willing to participate in a short follow-up interview and to provide necessary contact information if they answered in the affirmative.

3.5.2 Survey Collection and Analysis

An orientation blurb was placed at the entry to the gallery which introduced viewers to the show and contextualized the gallery exhibition within the study and informed them about survey procedures (Figure 10). Additional signs informing viewers of the importance of survey participation to the research were placed throughout the gallery. Paper surveys and pens were available to visitors at podiums dispersed throughout the space and visitors who volunteered to fill out a survey were asked to place completed papers in a drop box by the gallery exit. The drop box was emptied nightly and the paper surveys were scanned and numbered.

Figure 10: Orientation blub at the exhibition entrance including information about survey procedures.

Due to the relatively small sample size and the use of convenience sampling, survey results were analyzed to generate descriptive statistics, but at the scale of this study, no inferential statistical conclusions were drawn. This method of inquiry mirrors the methodologies of past studies investigating the role of art in communicating scientific information, and the limitations of this approach and suggestions for expansion in future research are tendered in Section 5 of this report.

At the conclusion of the exhibition window, survey responses were coded into a spreadsheet. Responses from members of the public and fire management professionals,

differentiated by responses to question 1, were evaluated separately for all but questions 8 and 9 which asked respondents to identify elements of the exhibition deemed subjectively most effective at conveying information or affecting emotional engagement.

Responses from questions 2-7 which asked members of the public to rate levels of ecological understanding, support for prescribed fire, and concern about the ecological effects of fire exclusion were assigned numerical values from 1 to 5 corresponding to the five ranked categories on the survey. Sums of like responses were calculated for each criterion of understanding, support and concern, providing insight into the distribution of responses before and after viewing the exhibition. The manner in which understanding, support, and concern were affected by exhibition visitation was shown by determining the number of participants who reported an *increase* in understanding, support, or concern from their reported level prior to viewing the exhibition. Increases of one, two, three or four categories as defined by the survey were recorded and reported so that a basic understanding of the magnitude of change experienced by individuals could be outlined. Averages were calculated to determine the mean levels of understanding, support, and concern before and after exhibition visitation. Comparison of averaged allowed for insight into the degree of change reported and for comparisons to be made within and across categories of exhibition effectiveness. Fire management professionals' evaluation were reported by category of ranked effectiveness. The exhibition elements identified as promoting ecological understanding or facilitating affective changes were analyzed for frequency of occurrence.

3.5.3 Interviews

Opt-in semi-structured interviews expanded upon visitor responses collected in surveys. Interviews expanded upon survey data to provide further descriptive insight into individual responses that inform recommendations for future art-science collaborations aimed at scientific education. 49 survey participants volunteered to be contacted for follow-up interview. An e-mail list was generated from contact information provided in surveys. Emails were sent individually to each respondent requesting an interview. Potential interviewees who responded in the affirmative were scheduled for interviews over zoom and provided with a copy of their completed survey and the exhibition documentation including the exhibition catalog and a short video summary for their

reference before and during the interview. Interviews lasted approximately 25 minutes and were recorded with the subjects' permission, which was granted on all occasions.

Eight interviews were conducted. Six were conducted with members of the public who did not have a professional background in fire ecology. Two were conducted with fire management professionals. Sample interview guides for both groups are provided in Appendix 6. Interviews with members of the public asked participants to reflect on their relationship to fire prior to the exhibition, their perceptions of fire on the landscape before viewing the exhibition and how their perceptions may have changed after experiencing the exhibition. They were then asked to reflect upon their survey responses regarding changes to their understanding of fire ecology, support for prescribed fire, and concern about fire exclusion. In instances where changes occurred, interviewees were asked to recall features of the show that may have shaped those changes and to reflect on how those features may have influenced them. Interviews concluded with broader questions which asked participants to comment upon their perceptions of the arts as communicators of scientific information, and to analyze how their visit to *Carrying the Torch* may have informed those perceptions. An opportunity to add any additional comments was provided prior to concluding each interview.

Interviews with fire management professionals asked them first about their general impressions of the exhibition, prompting them to characterize their subjective experience and to reflect on whether or how it may have impacted them. Interviewees were then asked to evaluate the effectiveness of the exhibition as a public outreach tool in more detail. They were asked to evaluate the accuracy and completeness of the scientific information presented in the exhibition and to identify any information important for public understanding that was not included. Interviews concluded with broader questions about the use of art to communicate to the public about ecological topics salient to land management. As with interviews of the general public, fire management professionals were provided an opportunity at the end of the interview to add additional comments as they saw fit.

Interviews were transcribed using web-based transcription software and transcriptions were reviewed against recordings for accuracy. Interviewee responses were coded and categorized thematically loosely according to the structure of the interview guides. Responses were reported in established analyzed categories, quoting subjects directly where appropriate.

4. RESULTS

4.1 Survey Results

4.1.1 Participant Background

100 surveys were collected over the course of the two-week exhibition. Survey participants reported a diverse array of professional and educational background (Figure 11). The background most reported was STEM (24% of survey participants), followed by fire management (21%), and environmental sciences (14%). Participants with a background in the sciences (70%) were more common than those with a background in the arts or humanities (19%). Fire management professionals (21%) and members of the general public (79%) were both well-represented in the surveys, allowing for direct and indirect evaluation of the exhibition's communicative properties through means of public inquiry and solicitation of expert opinion.

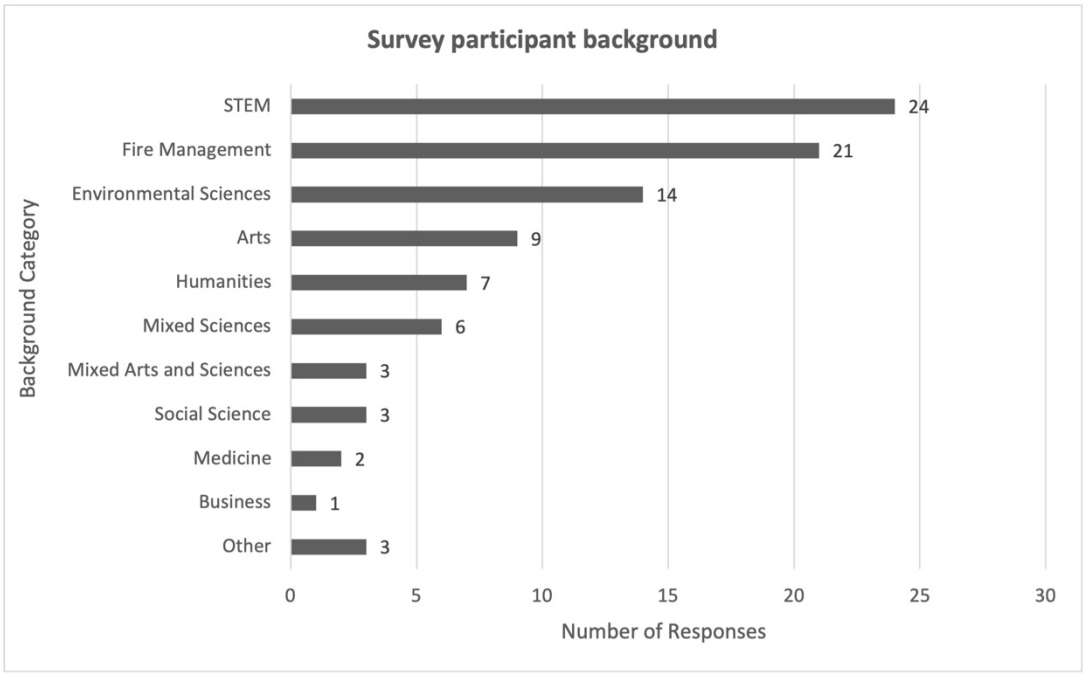


Figure 11: *Survey participants by background category (n = 100). The 'mixed sciences' category represents respondents who indicated more than one of: STEM, Environmental sciences, and Social science. The 'mixed arts and sciences' category represents any respondents who indicated a background in one of the above science categories in addition to an arts or humanities background.*

4.1.2 Understanding of ecological role of fire

Self-reported understanding among the general public prior to viewing the exhibition was well-distributed. (Figure 12A). Of the 79 survey participants who did not identify as fire management professionals, 17.7% (n=14) of respondents reported no prior understanding, 20.25% (n=16) reported poor understanding, 18.9% (n=15) reported basic understanding, 27.8% (n=22) reported moderate understanding, and 15.2% (n=12) reported advanced understanding. When converted to a numerical scale from 1 to 5, with "none" corresponding to 1, "poor" to 2, "basic" to 3, "moderate" to 4, and "advanced" to 5, the average level of understanding prior to viewing the *Carrying the Torch* exhibition was 3.02, corresponding to basic understanding as defined by the survey parameters. After the exhibition, 0% of respondents reported having no understanding of fire's ecological effects in local ecosystems. 3.79% (n=3) of respondents reported poor understanding, 22.78% (n=18) reported basic understanding, 49.37% (n=39) of respondents reported moderate understanding, and 22.78% (n=18) reported advanced understanding after visiting the exhibition.

Self-reported levels of ecological understanding exhibited an overall increase after exhibition visitation (Figure 12B). Figure 12C represents percentage of respondents by magnitude of change in reported understanding. The 15.2% of participants who reported advanced understanding prior to viewing the exhibition could exhibit no change in their level of understanding as recorded in their survey response after viewing and are not included in Figure 12C. Of the 67 respondents eligible to experience an increase in their reported levels of ecological understanding, 64.18% (n=43) reported an increase of one or more categories of understanding. 31.34% (n=21) reported an increase of one category of understanding, 25.37% (n=17) reported an increase of two categories, and 7.46% (n=5) reported an increase of three categories of understanding as characterized by the survey. 35.82% (n=24) reported no change in understanding. The average level of understanding after the exhibition was 3.92, corresponding to a 'moderate' level of understanding on the scale established by the survey (Figure 15).

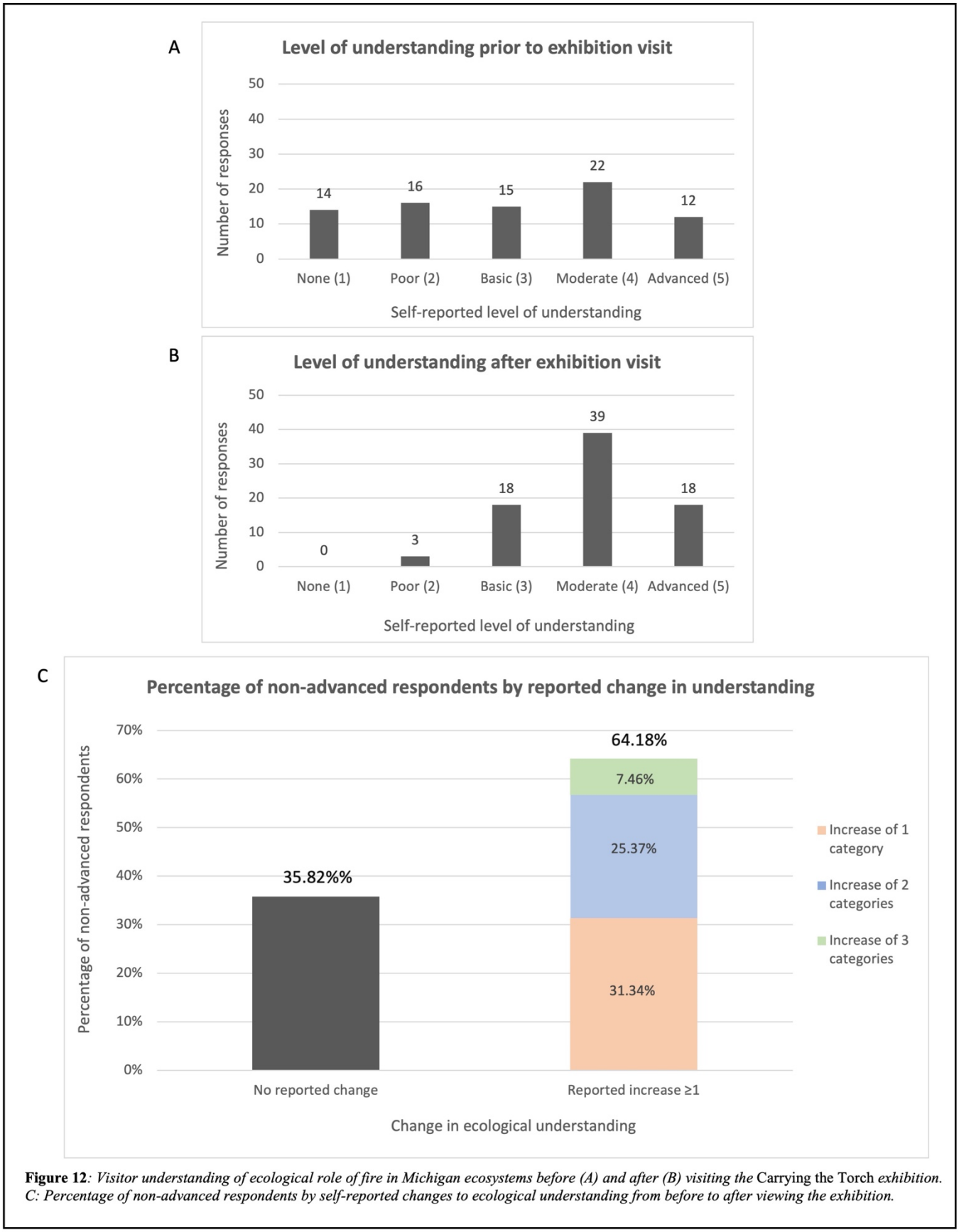


Figure 12*: Visitor understanding of ecological role of fire in Michigan ecosystems before (A) and after (B) visiting the* Carrying the Torch *exhibition. C: Percentage of non-advanced respondents by self-reported changes to ecological understanding from before to after viewing the exhibition.*

4.1.3 Support for the use of prescribed fire

Baseline levels of support for the use of prescribed fire were higher than understanding of its ecological role among participant members of the public prior to viewing the exhibition with an average pre-exhibition level of support of 3.87 corresponding to a level of 'moderate' as established by the survey. (Figure 13A, Figure 15). 78 survey participants responded to survey questions regarding support for prescribed fire. Prior to the exhibition, 3.80% (n=3) reported being unsupportive of the use of prescribed fire as a land management strategy, 13.92% (n=11) reported low prior support for the use of prescribed fire, 17.72% (n=14) reported neutral prior support, 20.25% (n=16) reported moderate prior support, 44.30% (n=35) reported high support prior to viewing the exhibition. Levels of support for prescribed fire after viewing the exhibition were higher than their antecedent values with an average level of support of 4.44 corresponding to 'moderate support as defined by the survey (Figure 13B). 0% (n=0) of respondents reported no support, 6.41% (n=5) reported low support, 7.69% (n=6) reported neutral support, 21.79% (n=17) reported moderate support, and 64.10% (n=50) reported a high level of support for prescribed fire subsequent to viewing the exhibition.

Overall changes in support over the course of the exhibition were less pronounced than changes in understanding due to higher proportions of pre-existing support for prescribed fire prior to exhibition visitation. However, greater increases were reported among respondents who did not report a high level of antecedent support than were reported for changes in ecological understanding. Figure 13C represents changes in support among survey participants who did not report a high level of antecedent support for the use of prescribed fire as a land management strategy. Of the 43 respondents without prior advanced support, 74.41% (n=32) reported an increase in self-perceived support of one or more categories established by the survey. 48.84% (n=21) of eligible respondents reported a one-category increase, 18.60% (n=8) reported a two-category increase, and 6.98% (n=3) reported an increase of three categories of support. 20.93% (n=9) reported no change in level of support for the use of prescribed fire. 4.65% (n=2) of respondents who were not antecedently highly supportive reported a decrease in support of one category (in both cases from a level of "moderate" to a level of "neutral").

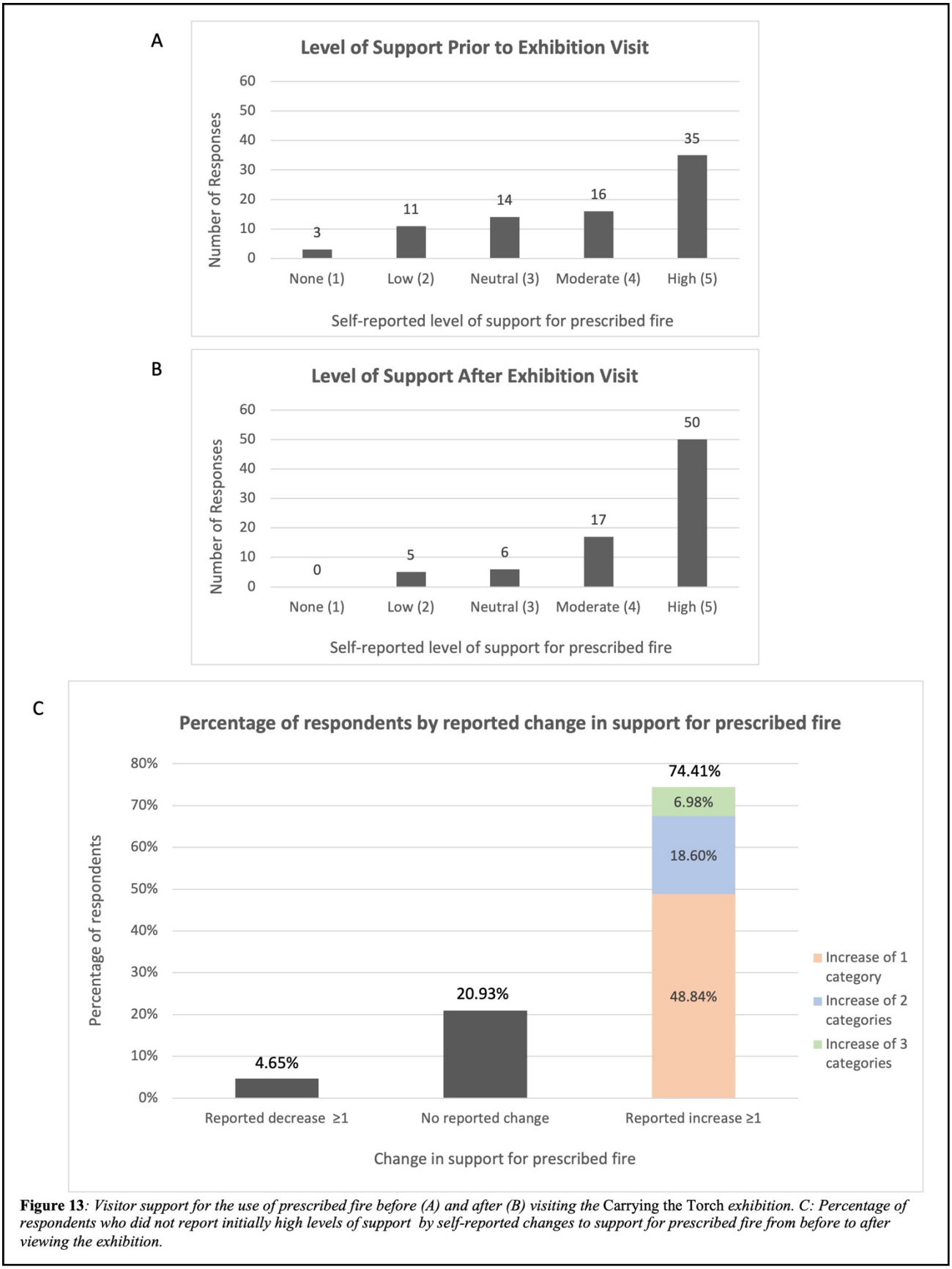


Figure 13: *Visitor support for the use of prescribed fire before (A) and after (B) visiting the* Carrying the Torch *exhibition. C: Percentage of respondents who did not report initially high levels of support by self-reported changes to support for prescribed fire from before to after viewing the exhibition.*

4.1.4 Concern about ecological effects of fire exclusion

The average pre-exhibition level of concern about the ecologically detrimental effects of fire exclusion was 3.14 corresponding to "neutral" on the survey's scale. 78 survey participants responded to questions regarding ecological concern before and after their experience of the *Carrying the Torch* exhibition. Prior to the exhibition, 15.19% (n=12) of respondents reported no pre-existing concern, 16.67% (=13) reported a low level of concern, 25.64% (n=20) reported a neutral level of concern, 20.51% (n=16) reported a moderate level concern, and 22.37% (n=17) reported a high level of concern (Figure 14A). After viewing the exhibition, the average level of concern was 4.33 corresponding to a survey category of "moderate." As described in Figure 14B, 0% (n=0) of participants reported no ecological concern after viewing the exhibition. 3.85% (n=3) reported a low level of concern, 7.89% (n=6) reported a neutral level of concern, 39.74% (n=31) reported a moderate level of concern, and 48.72% reported a high level of ecological concern after their experience of the exhibition.

Changes in concern experienced by respondents who did not already possess a high level of concern about the ecological effects of fire exclusion were higher than in categories of understanding or support (Figure 14C). Of the 61 respondents who reported less-than-maximal levels of concern prior to viewing the exhibition, 85.25% (n=52) indicated an increase in concern of at least one category after their experience of *Carrying the Torch*. 49.18% (n=30) indicated an increase in concern of one category of concern, 11.47% (n=7) indicated an increase of 2 categories, 21.31% (n=13) indicated an increase of 3 categories, and 3.28% (n=2) reported an increase of 4 categories of concern about the ecological effects of fire exclusion. 14.75% (n=9) of respondents eligible to exhibit an increase in concern reported no change.

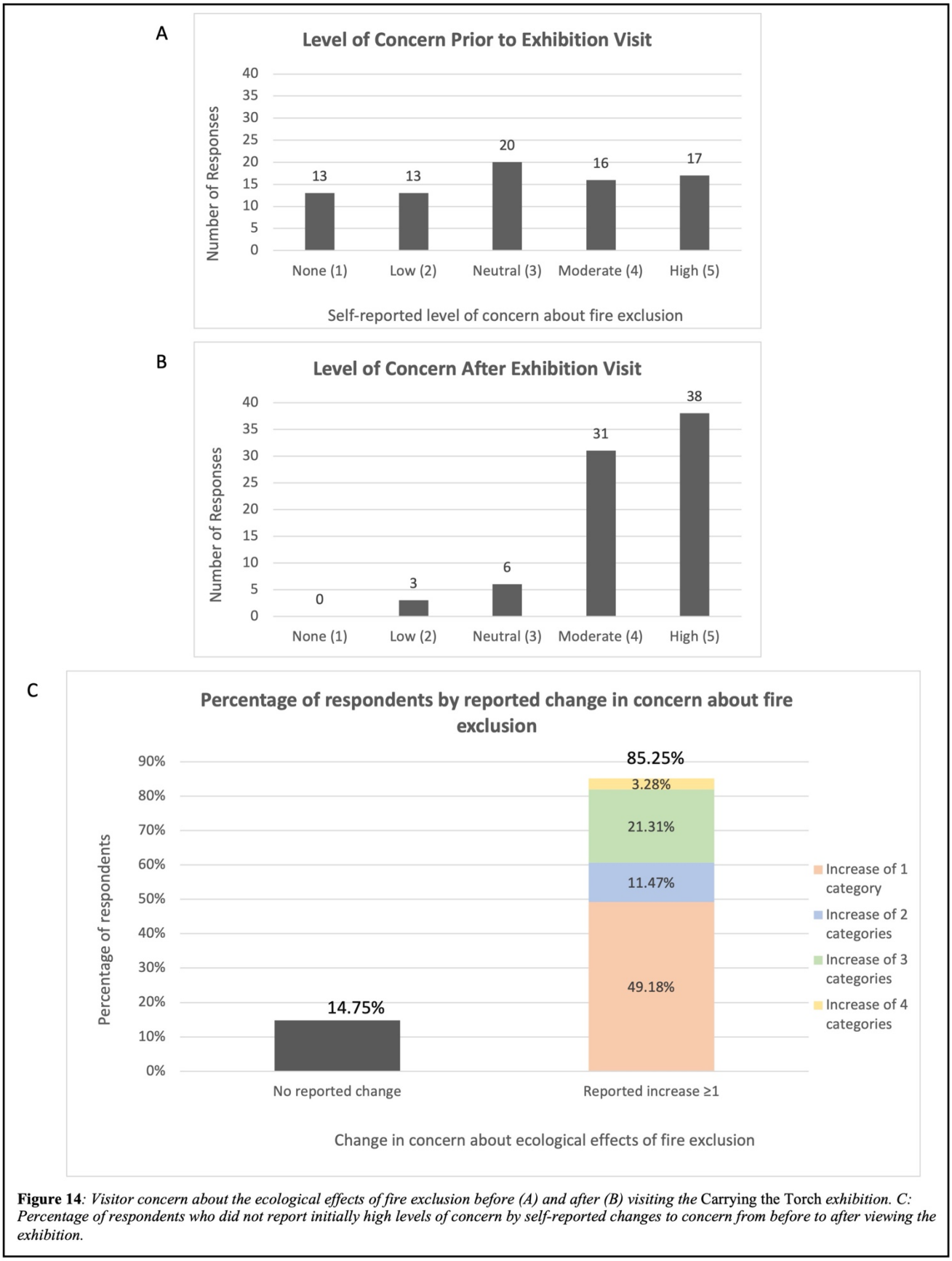
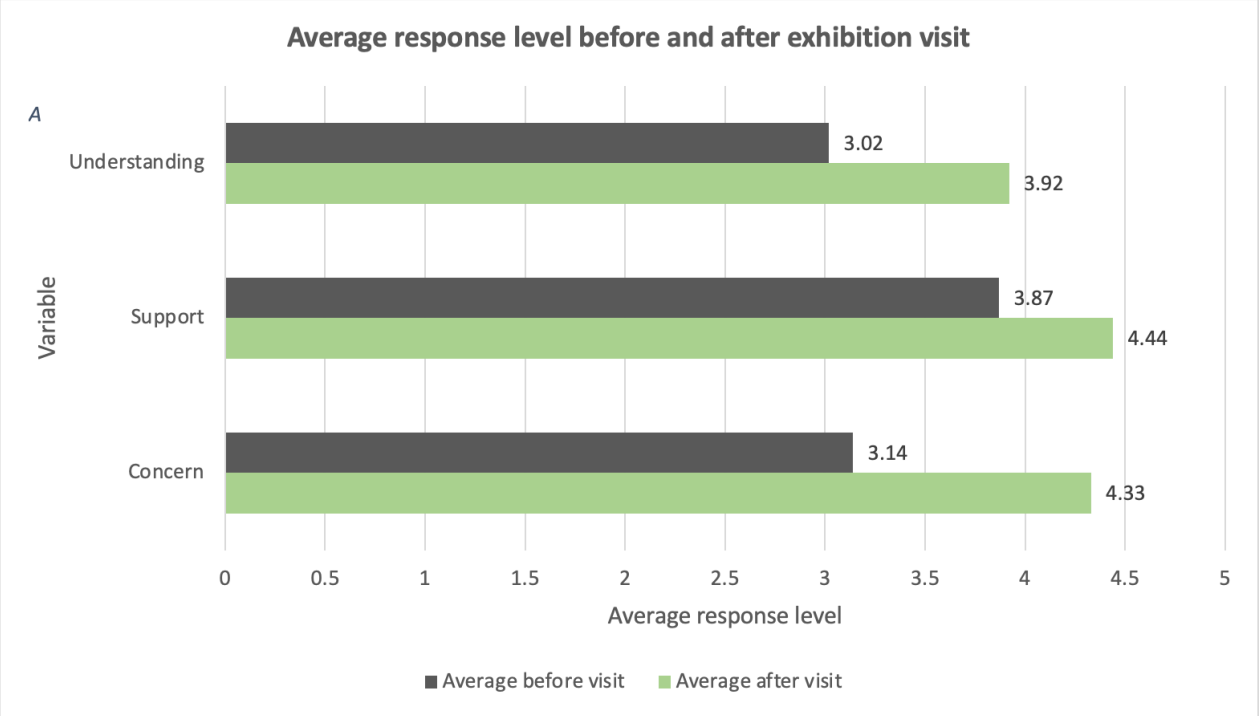


Figure 14: *Visitor concern about the ecological effects of fire exclusion before (A) and after (B) visiting the* Carrying the Torch *exhibition. C: Percentage of respondents who did not report initially high levels of concern by self-reported changes to concern from before to after viewing the exhibition.*

4.1.5 Understanding, support, and concern in overview

Average levels of response for each of the three variables of understanding, support, and concern before and after exhibition visitation provide insight into the nature of the changes reported by visitors (Figure 15A). Concern was the variable for which the greatest increases were reported, followed by understanding of the ecological topic and support for prescribed fire respectively (Figure 15B). Support for prescribed fire was the variable with the highest pre-exhibition response level and was also the variable which exhibited the least change.

A



B

VARIABLE	AVERAGE DIFFERENCE IN RESPONSE LEVEL
UNDERSTANDING	0.9
SUPPORT	0.57
CONCERN	1.19

Figure 15*: A: Average response level on a scale of 1 to 5 for each criterion: understanding, support, and concern before and after visit to the Carrying the Torch exhibition. B: Average difference in response level between before and after viewing the Carrying the Torch exhibition.*

4.1.6 Exhibition effectiveness as evaluated by fire management professionals

All survey participants who self-identified as fire management professionals rated the exhibition as effective as a tool for public engagement in some capacity (Figure 16). Of the 21 fire managers who responded, 11 (52.38%) rated the exhibition as very effective, 8 (38.10%) rated it as moderately effective, and the remaining 2 (9.52%) rated the exhibition as somewhat effective. Subsequent interviews with select fire management professionals provide additional qualitative insight into the qualities of the exhibition which were most effective as a tool for public engagement.

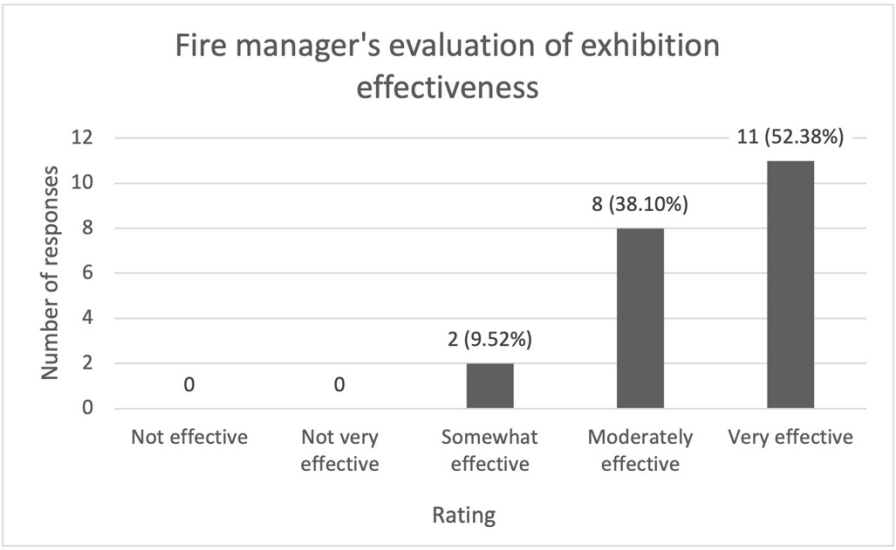


Figure 16*: Evaluation of exhibition effectiveness by fire management professionals based on responses to survey question 10*

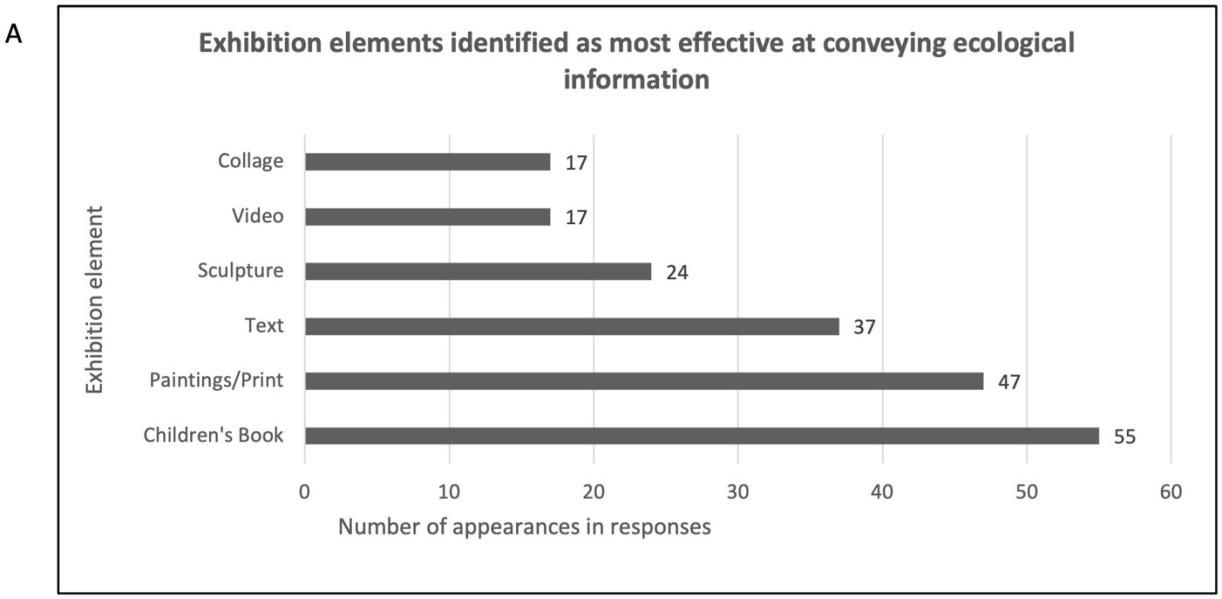
4.1.7 Exhibition elements identified as most effective

While interviews provided further insight into analysis of exhibition components and characteristics which were most effective at prompting increases in the identified cognitive and affective dimensions, survey responses illuminated basic features of the *Carrying the Torch* exhibition which contributed to the responses reported in the prior sections (Figure 17). Two questions on the survey asked visitors to identify particular elements of the exhibition most effective at conveying ecological information (question 7) or elements which were most thought-provoking or engaging (question 8). The majority of responses (55%) indicated that the children's book was effective at conveying ecological information. The paintings and print, and the text

accompaniment were also commonly indicated as effective communicators of ecological information, appearing in responses of 47% and 37% of surveys respectively. The exhibition element most commonly identified as being thought provoking or engaging was the paintings and print, which appeared in 63% of survey responses. The children's book and the sculpture appeared respectively in 37% and 29% of responses identifying thought-provoking or engaging exhibition elements.

The diversity of artistic approaches to communicate ecological information and prompt affective responses were reflected in the array of responses on the surveys. While the paintings and print, children's book, text accompaniment, and sculptural installation appeared most frequently in visitor responses, even the exhibition elements which appeared least frequently—the collage and video components—still populated sufficient quantities of responses to indicate that they played a role in communicating information or inspiring affective changes for at least a portion of participants. When asked about exhibition elements that conveyed ecological information, 17% of respondents indicated that the collage and video played a role, while 20% and 19% indicated that the collage and video were thought provoking or engaging, respectively.

Such findings begin to provide guidelines for future art-science collaborations. The inclusion of visual-narrative storytelling through the children's book was particularly well-received, as was the series of highly visual paintings and print. Furthermore, the inclusion of an array of visual and auditory modes of presentation may have captured the attention of a greater number of visitors than a single mode of presentation, based on the appearance of all exhibition elements in the array of responses provided to questions 8 and 9 on the survey. The effectiveness of a diversity of artistic approaches in communicating ecological information and prompting affective responses was echoed in survey comments. For example, one visitor commented "I think it was the combination of all exhibition [elements] that conveys it! I especially loved the sound effects thrown in." Another visitor noted: "I like the combination. They all reinforce each other"; while another wrote: "All elements form a cohesive whole."



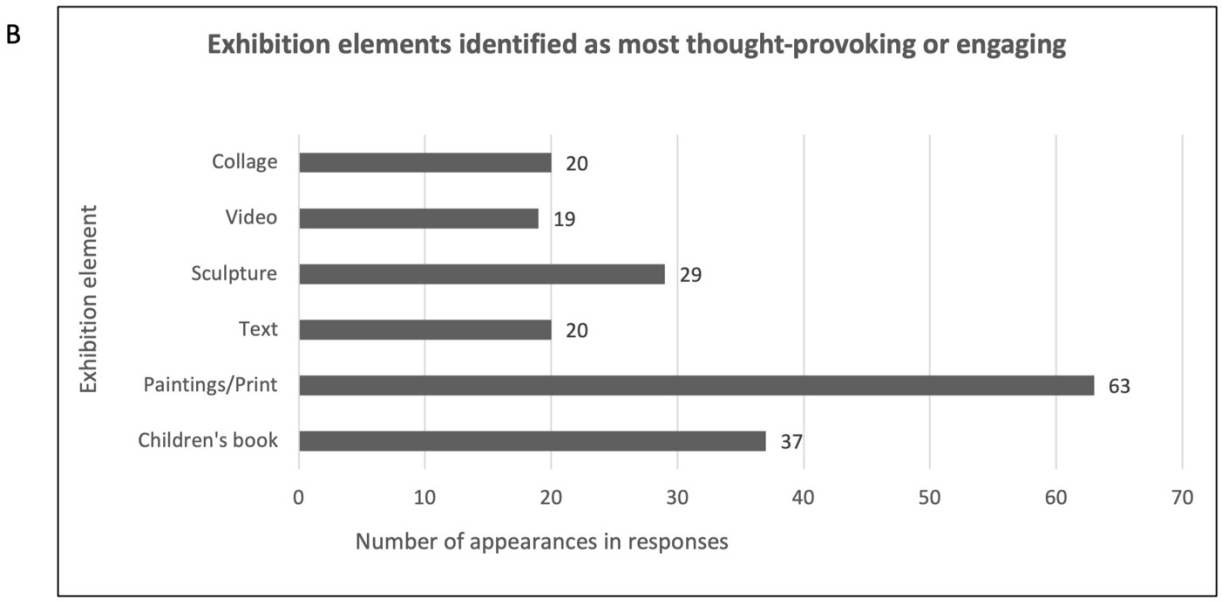


Figure 17*: A: Exhibition elements identified as most ecologically informative (A) or thought-provoking B) by survey respondents.*

4.2 Interview Results

Interviews elucidated individual visitors' responses to the *Carrying the Torch* exhibition. Insight into pre-existing perceptions of fire on the landscape, feedback about particular elements of the show that were effective communicative devices, and reflections on the value of art-science interactions were among the themes identified within interviews. While not exhaustive, the

interview process and the results described here provide supporting evidence to the results from visitor surveys and represent a qualitative extension of past inquiry. Interview results are thematically organized in the following sections.

4.2.1 Interviewee Backgrounds

Eight interviewees from diverse backgrounds participated in interviews from April 1 to April 15, 2022. Six members of the public and two fire management professionals agreed to be interviewed. Of the members of the public, two had an exclusive background in the arts. One participant was a music and music history professor at the University of Michigan. Another was a professional artist focused on climate and water issues who collaborates with scientists to communicate through art. One participant had a background of mixed arts and sciences, reporting an undergraduate degree in art and art history, a master's degree in landscape architecture, and a current administrative career in the University's Engineering department. This participant also reported past experience as a volunteer on local prescribed burns. Another participant—a current law student at the University of Illinois—had a background in the humanities and studied political science in undergraduate before pursuing a law degree. Two participants reported backgrounds in STEM—one was a graduate student at the University of Michigan School for Environment and Sustainability studying conservation science who also reported past experience on a prescribed burn crew, and the other was an undergraduate student in the University's Engineering department.

Levels of baseline ecological understanding, support for prescribed fire, and concern about fire exclusion also varied between interviewees. Two interview participants reported advanced pre-existing levels of understanding, two reported moderate levels, one reported a basic, and one reported no pre-existing level of understanding. Baseline support was relatively high among interviewees, with four reporting high levels of pre-existing support for prescribed fire, one reporting a moderate, and one reporting a neutral level of support. Pre-existing concern about the ecological effects of fire exclusion varied, with two interview participants reporting a high level of concern, one reporting a moderate level, one reporting a neutral level, and one reporting no pre-existing concern.

The two fire management professionals interviewed were both associated with the City of Ann Arbor Natural Area Preservation (NAP). One was the Parks and Recreation Services Deputy Manager of Natural Areas who oversaw and led the NAP prescribed burn program for 28 years in

addition to running a private restoration company specializing in prescribed fire throughout the Midwest. The other professional interviewed was the Volunteer and Outreach coordinator for NAP who coordinates volunteers for their prescribed fire program and handles NAP's public education about fire in local public settings.

4.2.2 Relationship with fire prior to viewing the exhibition

Interviewee reflections on their relationships to fire, particularly "wildfire" and "fire on the landscape" prior to viewing the exhibition illuminated a range of individual perspectives that, in many cases, underscored a negative view of fire despite pre-existing knowledge of its beneficial ecological effects in some cases. One interviewee who had past ecological training and prior experience participating in prescribed burns responded positively, saying:

> "I've always just been really fascinated by the science of it, but also really moved by the visceral experience of it."

Others responded more neutrally, citing a recognition of fire's ecologically regenerative properties that coincided with an acknowledgement of its potentially destructive power.

> "I guess I'd say I have a deep appreciation for the power of fire. For good or for ill. I don't think of it as a malevolent thing, but I don't think of it as something I put in my firepit in my backyard either."

> "I grew up going to Boy Scouts, so at times was even a little obsessive with fire and how it's fun. It had this element of danger, which was definitely a little, I don't know, edgy. … Before the exhibition I guess I was conflicted. Hearing all the news in, I think it was the summer of 2020, when there were these huge fires and they were really destructive. But it was like a couple of seasons beforehand when I was on a [prescribed burn] team and it was really helpful."

Other participants described associations with fire on the landscape that were predominantly negative. Each of these subjects cited past experience involving fire that had inspired feelings of fear or unease.

> "I have always been interested in fire, but not in a positive light. I'm in the first wall of the exhibit of seeing it as a big bad monster. When I was four I had a phobia of fire that was very impactful in my life. … It actually lasted quite a long time in my life, so I've always been very hesitant to learn or engage with any conversations about fire. And because of the wildfires in the west dominating the news cycle, it forced me to confront that more than I think I otherwise would have in my adult life. … I really thought of fire as a bad thing and an unnatural force happening as a result of drought and mismanagement. I did not really know about the history of people utilizing the land and taking care of it using fire. So before [seeing the exhibition], I was definitely in the category of fire is bad, there's too much of it, we need less of it and it's a threat."

> "In my experience, fire has always been kind of hostile. Like my only face to face experience with fire was when I was visiting the ocean when I was in China. We were deep in the mountains driving a car by this river, and then suddenly we just saw the air getting misty and there was a forest fire. We could see the smoke for miles around. And obviously we couldn't do anything because we're not firefighters. We just drove away. So that was kind of the only time I actually experienced fire, and it was scary seeing the smoke and flames engulfing the forest. … So generally, I truly felt fire as more of a danger to humans."

> "When I was a junior—early junior high school—I was fascinated with fire. … And I and my friends started a fire in a field by their horse barn, and the fire got out of control. And so the fire department had to come and put it out before it burned down a neighborhood. And so I was put on probation and I had to visit the fire department once a month in Glenview Illinois, and I learned about the destructive possibilities of fire and got to go to fires with the fire department. So I learned that it's a very dangerous, potentially dangerous, commodity around wooden houses."

Echoing the themes encountered in interviews with members of the public, fire management professionals reflected on negative views of fire on the landscape that they have experienced when interacting with members of the public while performing their duties. The Parks and Recreation Services Deputy Manager of Natural Areas commented:

> "I just think with Smokey [Bear], there's such a long history of his message of 'all fire is bad.' And I find that I often need to counter that directly and that it can't be a subtle sort of thing. It has to be very, very direct, deliberate statement that this is not an accurate message. And a quick anecdote on that: during a [prescribed] burn one time. … It was right near the road, Warren and Sheldon Roads, and we had signs up on the roads and the park people had signs up along the sidewalk. And I was walking through with my drip torch and I hear somebody talking on the phone and it sounds like he's calling 911. And I kind of walk out of the brush and he said, "Oh, yeah, he's here now." I said, "What are you doing?" He said, "I called 911." I said, "Why?" He said, "fire." And he looked down and pointed and was

> such a knee jerk reaction. Fire 911 And so I just think we have to very directly and deliberately try to counter the message from Smokey."

4.2.3 Changes in perception of fire after viewing the exhibition

These responses from members of the public and professional community underscore the need for educational intervention in counteracting a recognized bias against fire on the landscape that has been promoted by decades of anti-fire messaging from public entities like Smokey Bear (Pyne 1990, McCaffrey 2006). The increases in understanding, support, and concern apparent in the survey results were echoed in many of the individual responses of interview subjects when asked about how their visit to the exhibition affected these dimensions of their relationship to fire on the landscape.

Some subjects—especially those with less-than-advanced prior ecological understanding—emphasized the acquisition of ecological knowledge in the course of their visit.

> "I didn't know how fires could apply to the prairie ecosystem. … I didn't really think of fire as more of a widespread beneficial thing. So that obviously changed after I went to the exhibition."

> "I think going from nothing to something felt like a big jump just in terms of progress. I felt like the text of the exhibition … bumped it from what probably would otherwise have been basic to what I did feel was moderate. I think the progression was very easy to follow and I was retaining the information as opposed to just hearing it. I could talk about it after. I think it was there were details as opposed to just general concepts, thanks to the kind of multimedia educational experience."

The same subject later cited an increase in understanding as influencing an increase in concern about the ecological effects of fire exclusion:

> "I was smacked with my own lack of understanding early. … And so I guess my concern with fire exclusion was influenced by the fact that I was informed of how uninformed I was. I'm like 'oh my god, I don't even know what this is. How bad is this? I need to learn more.' Like I said, I felt like I had an understanding, but you hope to continue after that experience, learning about fire exclusion.

One participant who had prior experience on a burn crew and a moderate level of ecological understanding from coursework at the School for Environment and Sustainability commented, “I feel like it increased my understanding, but also I guess my desire to understand.” The same participant had reported high levels of support for prescribed fire before and after viewing the exhibition. He elaborated in the interview, noting that “I think if any part of my support increased, it was a little bit of urgency and I guess a little bit of realizing that others may not share the support and that my support can play a role in spreading that.” He connected that sense of urgency to an increase in concern, which increased from “moderate” to “high” on his survey response. “Before, I kind of thought it was common, I kind of thought people were on board. And after the exhibition I realized how there’s new growth every year and every year that fire is left out it takes more in one direction.”

Responses like these, even from those with high baselines levels of understanding, support, and concern illuminate added dimensions of value gained from their experience of the exhibition that were fine-grained enough to escape detection in survey responses. One subject who reported maximum levels across all three categories prior to the exhibition reflected about how her experience of the show inspired the potential for further pro-ecological action:

> “It reminded me of the beauty that comes out of controlled burns and makes me actually want to do a controlled burn on my property… It reminded me that we have this long, really symbiotic relationship with fire. Probably one of the earliest technologies humans have used.”

Only one interview participant described a perception of fire as a destructive force that was maintained even after the viewing of the exhibition.

> “The exhibition put in my mind the terrible fires that happened in 1871 in northern Wisconsin, that's the year of the Chicago fire, that loggers left a lot of slash where they just left all the things that they didn’t want from those trees and they took the stumps along or the logs. Those winds that made those devastating fires in northern Wisconsin also caused the Chicago fire to spread throughout the wooden city. So all of your demonstrations about fire put me in mind of those things.”

This perception of fire as a destructive force was not evidenced in the subject's survey response which reported a moderate understanding of the ecological effects of fire in Michigan landscapes both before and after viewing the exhibition, a high level of support for the use of prescribed fire before and after, and an increase in concern from neutral to moderate after attending the exhibition. The reaction was not due to a lack of understanding of the show's ecological messages, but rather a deep-seated attitude about fire that was confronted but not overturned by the evidence presented in the exhibition which was recapitulated in the subject's response but ultimately rejected:

> "There seems to be a point of view [in the exhibition] that says that this area, Southern Michigan, was doing it right when we did a lot of controlled burns. … My sense is that I'd rather have oak, hickory, or maple forest than a meadow. And your point of view seems to be that it's better to have controlled burns than to maintain these wonderful cool rich forests."

While this subject was an outlier among the relatively small sample of interviewees, responses of this kind serve to illustrate the limitations of a scientifically-informed art exhibition like *Carrying the Torch* in affect changes in understanding, support, or concern for all visitors. Disagreement with the scientific evidence and its presentation remains durable in some cases. Further research could fine-tune methodologies for investigating precisely how and why these outlying responses are generated and maintained.

4.2.4 Identification of successful exhibition components

Interviewee's reflections on elements of the exhibition they found most effective corresponded with the general findings from the surveys which identified the children's book and the paintings as informing ecological understanding and provoking affective responses. Many interviewees specifically mentioned the children's book in particular:

> "How effectively your children's book teaches about the use of fire and really frames it in a way that I don't think kids often think of fire. And I thought that was very successful and powerful and important."

> "I really like the little book that you drew. I grew up loving similar children's stories, so I thought that really resonated with me."

Fire management professionals also highlighted the children's book as an element of the exhibition deemed most effective at engaging and educating a public audience about the use of prescribed fire in local ecosystems.

> "I think overall the part I liked the best was the whole kid's story. Because though I didn't learn anything new there, I thought I love to see those kind of scientific principles put in a format that I think are accessible for kids. So I thought that was wonderful."

The effectiveness of the exhibition's multimedia presentation was evidenced indirectly in survey responses wherein every exhibition element appeared in responses identifying effective exhibition elements with even the least effective elements appearing in 17% of survey responses. Interviewees spoke more directly about the multimedia character and its role in overall exhibition effectiveness. Responses such as these indicate the importance of including a diversity of works and ways to engage in future science-art collaborations:

> "I really liked the variety of ways to connect. You know, it wasn't just paintings, it wasn't just the children's book, it wasn't just installations. I think all of those things sort of gave people different ways to connect with material…. It was very comprehensive in some way. As I said, it came at it from all these different angles. I think it it had been any one element of those different sort of installations… any one of them wouldn't have worked as well. So I felt that the impact of coming at it in all these different ways was really helpful."

> "The mix of media to have illustrative stuff, paintings, found objects, and video is just a nice multi-modal experience, which, you know, a lot of shows focus on just one medium. And so I like the groundedness of that."

Fire management professionals also identified multi-media presentation as a keystone element of the exhibition's perceived effectiveness as a tool for public education and communication about prescribed fire.

> "One of the things that I like best about it, especially looking back on it now through that little catalog that you said just reminded me of, was you did such a good job of covering a wide range of things from kids books to actual big physical objects there, and videos and

> art, and text. So I felt like you and I, as a formal former environmental educator myself, have had just a little bit of education theory and recognize the importance of giving things to people in a wide range of formats so they can kind of pick and choose. And I'm sure that as you talk to different people who went there, different things resonated with different folks. And so you did a good job of presenting a wide range of options for people so they could find what was most connected to them the best."

> "I loved how diverse it was. You know, there were there was video. There was kind of more abstract art. There were some very—sorry, I'm not an artist, I don't know the right word, but like—realistic art, you know, like looks like people doing things, or fire, you know. And then the book was just so adorable and appropriate for kids. There were the sounds of crackling fire throughout. And I loved how that appealed to both so many different senses. And it seemed to me like it would appeal to such a wide variety [of people], right? If someone prefers one medium over another, or is a different age or a different mental capacity or something? There was something there for everybody. It appealed to me. I really was impressed at how diverse it was. You know, sometimes you go to an art show and it's all kind of the same type of art over and over and again. And it was just so impressively diverse."

One subject highlighted the design and arrangement of the exhibition overall, drawing attention to the potential importance of curation and narrative sequencing in the presentation of science-art exhibitions:

> "I think that how you set is up, it really helped me engage, particularly with the intro of 'this is what we think of fire first' with the colors and the destruction, because I felt [I was] understood going into it. … It met me where I was at and was at a pace in terms of the movement of the pieces."

4.2.5 Suggestions for improvement

Subjects were also asked to reflect on dimensions in which the exhibition could be produced more effectively to better communicate, educate, and engage with a public audience. The primary response in this vein of inquiry recommended changing the location of the exhibition from a University-based gallery to a community-oriented space to better access a visitor base outside of the university community. One subject suggested that "having it at some place like the Ann Arbor District Library. … You'd get a very different audience experiencing it."

Fire management professionals also suggested changing or expanding the location of the exhibition and its publicization within the broader community to increase viewership. The Volunteer and Outreach Coordinator at NAP reflected:

> "Had I not had a relationship, if you didn't have the relationship you had with NAP, I wouldn't have heard about it. And, you know, this is something we see in all kinds of areas, right? There's all kinds of cool stuff happening on campus that the community doesn't really know about. And so in there, if you were to do this again or give advice to someone doing something similar, maybe we can find more ways of promoting something that's happening on campus to the wider community, because I think there is a value to everybody in Michigan, to the work that you were doing in the exhibit that you showed."

Other suggestions included the incorporation of a live speaker to interact with visitors—a feature of past successful ecologically-oriented science-art exhibitions in the past (Trainor et al. 2013, Opermanis et al. 2015, Colavito et al. 2019); and the incorporation of even more senses beyond sight and sound such as smell and touch.

Fire management professionals were additionally asked targeted questions drawing upon their scientific and practical expertise to evaluate the accuracy and scope of the scientific content presented in the exhibition. The accuracy of the scientific information included was well-received by both subjects from the professional community:

> "I think it was spot on. I think sometimes we tend to get to in the weeds with like stats and research and I thought it had depth without being too scientific and dry. I thought it was it was really accessible for someone without a scientific background."

> "I didn't see anything there that was wrong. Sometimes I'll read displays like that, exhibits and things and say, 'Oh, that's not quite right.' But no, I didn't see anything like that at all. I think you had it all right. And I think it was very effective at communicating."

One of the subjects suggested an extension of the exhibition content to include more information about issues of safety surrounding the application of prescribed fire.

> "There was information about current fire practices, but maybe there could have been more—I don't know, safety—like how many acres are burned without there being out of control fires, because I think people still have fear that the fire that we're putting on the ground is going to get out of control. And it does happen from time to time, but I don't think happens as much as people think it does. I know there's still kind of this fear of fire, even if it is done by professionals"

4.2.6 Reflections on the value of art-science collaborations

Past investigations into responses to art-science collaborations have reported increases not only in understanding of and interest in the given scientific topic, but a heightened awareness of and appreciation for the collaborative enterprise itself (Lau et al. 2022, Colavito et al. 2019, Trainor et al. 2013, Curtis et al. 2012). Similar results were noted in interview responses in this study and many participants affirmed the value of incorporating the arts into public-facing scientific communication within the context of the *Carrying the Torch* exhibition and in general. One participant emphasized the educational properties of the art in the exhibition.

> "It's a reflection on the medium itself that I learned so much and was so moved by the art. I felt like it was an approachable and engaging way to learn. I don't have a scientific background and I think I didn't have any sort of 'this is over my head so I'll just smile and nod' moment. I felt like I could actually engage with and continue to engage with it and talk to my friends after because it felt so accessible."

Others reflected on the potential for the arts to invoke affective responses in addition to conveying science-based information.

> "All the data has existed for years and often we have a lot that we need. But there's an element of direct action that we need to take. And that's inspired by things that really reach our hearts, which is art and things like that."

> "I think it's a way of bridging domains. I work in engineering. It's very rational. It's very data driven. And that's really, really important. And I think your show actually provided a lot of that that people who come from that mindset could respond to, like the language in the textual descriptions. And then the other things are more visceral. I think the arts can be a way of building a bridge between maybe disparate communities. To me its essential that they be connected and paired, but I don't think that's really a common view.
>
> It was very moving to me to see. I was like, 'oh my gosh, this is something I've yearned for, in some way, to see this come into reality in our world.' Your show gave me a lot of hope for the future. … The scientific understanding was deep and it was communicated really well. Sometimes people might do environmental work and its wonderful, but they don't sort of bring that depth to it. They may have that knowledge, but they aren't putting it out on show. And I think it was really great to see it so clearly articulated."

One participant who has an extensive background in combining art and science within her own career as a science-based artist expanded on some of the artistic challenges faced in interdisciplinary work like that presented in *Carrying the Torch*, and affirmed the role of the arts as necessary agents in accessing emotional and behavioral modification:

> "It's complicated to take a concept like that and weave a visual show using a bunch of different media to tie one concept together. And I thought you were pretty successful at that. … As an artist who makes work about communicating science all the time, it's very much in my brain about how do we take ideas that are complicated and that people have a lot of emotional reactions to that don't necessarily align with the science and do something useful with that artistically? And that sci-art spot is a weird place because we're not illustrators, but at the same time you're trying to convey more information than just, 'oh, it's a pretty painting', right? I believe very strongly that we don't change people's behavior just through data. … So you have to hit people emotionally in some way so that it resonates."

The Parks and Recreation Services Deputy Manager of Natural Areas reflected on his own reasons for his work in ecological restoration, particularly with the use of fire, and found a connection with art as a common ground for a connection with the natural world:

> "I don't do the work I do just because I've checked the data and the data says I should do this. It's all about my personal, personal connection. I grew up on a farm in Illinois and connected with nature out in the woods, and I think we connect to nature through non-scientific sorts of ways, even people that are scientific researchers or something. There's something about that experience out there. And for us working with fire, yes, I can see the good things that happen, but it is such a visceral thing to be out there and be part of it. So I think art really is how we connect with nature.

Additionally, the two fire management professionals interviewed both reflected on the value of arts-based communication and the role that their experience of *Carrying the Torch* played in generating inspiration for future arts-based communication strategies in their professional fields. Though the limited number of interview participants and self-selected participation in data collection strategies does not allow for extrapolation beyond the reporting done here, these responses accord with past investigations in which management professionals who were exposed to, and participated in, art-science collaborations in their given fields, reported increased likelihood if participating in and supporting future such initiatives.

“I was thrilled that you did this. I see the real value, the real value of it. I wouldn't have known how to do it. You know, I've got lots of experience as a fire practitioner, but if someone said, “you know about fire, why don't you do an exhibit like this?” I wouldn't have known how to go about doing it. And so I was intrigued by it.”

“I thought it was so much more moving and tangible to kind of be in the space with all of that going on. And it just got me thinking about what how we can communicate with the public differently and how we can educate the community in a different way other than just a black and white postcard and a PowerPoint presentation. And I haven't yet figured out what I can do, but I was just really inspired and want to put everybody into that exhibit so that they can experience the things that I did.

I have no artistic background at all. I have very—I'm going to say—little appreciation for art because it's just not a world that I ever explore. Not to say that I don't appreciate what you do, but I just don't go into that world very often. So I've never really thought of how to use art to communicate the things that I think are important to communicate. And I have started exploring it a tiny bit. … It really has inspired me to think about all of the different ways we could be using art and all of these other mediums to really resonate with people, because we need to touch them in their hearts. And so much of what we talk about is up here in the brain. This is what it was like before and this is what it's like now. And the data and these are the numbers and this is like a map. But I think once we start talking about the emotions and really touching people in their soul, they're going to feel it and understand it better. It's going to resonate more, it's going to stick with them more. And I think that is the power of art is to touch people in their soul.”

5. DISCUSSION

5.1 Role of the arts in shaping understanding, support, and concern for an ecological topic

The results from the surveys and follow-up interviews conducted in this study expand upon a growing body of evidence suggesting that the arts in interdisciplinary conjunction with the sciences can be meaningful agents of scientific communication to a public audience (*i.e.* Jacobson et al. 2016, Schneller et al. 2014, Trainor et al. 2013, Curtis et al. 2012). This study demonstrates the advantages that can be capitalized upon through the incorporation of arts-based modalities in scientific communication, particularly in a setting where public awareness and support can play a significant role in influencing real-world outcomes such as is the case with ecological restoration. Other studies have linked increases in understanding, support, and concern to increased likelihoods of pro-environmental behavior, making it the case that the harnessing of art to affect the changes in viewers demonstrated in this study has the potential to positively influence conservation outcomes (Opermanis et al. 2015).

5.2 Response of professionals

Increased incorporation of arts-based communication strategies into land and resource management, conservation, and restoration public education initiatives has promise to improve understanding and emotional connection to the topic at hand through increasing understanding, support and concern about an ecological topic (Kollmus 2002, McCaffrey 2006). The responses from fire management professionals in surveys and interviews indicate a high degree of confidence in the potential for exhibitions like *Carrying the Torch* to serve as valuable tools for public engagement about land management and restoration in the context of prescribed fire. Past studies with similar purposes of inquiry have also found that members of the professional and scientific community who attended or participated in an interdisciplinary event incorporating both arts and sciences reported increased likelihood of utilizing arts-based programming in the future (Curtis 2012, Colavito et al. 2019). While the surveys in this study did not inquire into likeliness of future utilization of arts in this manner by fire management professionals, interview responses from management professionals, in particular from the Volunteer and Outreach Coordinator the City of

\Ann Arbor Natural Area Preservation indicated a strong desire to incorporate art into more conventional public communication strategies.

5.3 Recommendations for future science art collaborations

Effective qualities of the *Carrying the Torch* exhibition were identified in surveys and expanded upon in interviews. Future science-art collaborations aimed at the communication of scientific information to a public audience could utilize these lessons as a jumping-off-point for fine-tuning communicative success. The exhibition's incorporation of a diversity of media appeared in survey responses, visitor comments, and in interviews. Future exhibitions could endeavor to expand further upon the range of sensory experiences and modalities of interaction presented in this case to possibly greater avail. The inclusion of narrative storytelling through the text and picture-based children's book was also identified as particularly effective at communicating ecological information and generating emotional resonance. The use of narrative storytelling in future exhibitions could therefore have the potential to improve communicative and engagement outcomes.

As greater numbers of studies are conducted at the nexus of art and science, methodologies of effective collaborative communication can be further honed. The nature of the arts is such that artworks even of the same medium can vary dramatically in their ability to convey and the manner in which they are received by an audience. In the absence of rigorous artistic standardization (which would limit their effectiveness), a much greater body of research will be required to identify and develop hyper-specific recommendations on communicative impacts across mediums and topics. This study seeks to modestly ascertain in general terms the mechanisms behind the success it reported in increasing understanding, support, and concern. Insodoing it expands upon past inquiry, adding nuance to the analysis of this case and potential for future actionability.

5.4 Limitations and recommendations for future research

5.4.1 Audience

The location of *Carrying the Torch* in the Duderstadt Gallery promoted exhibition attendance by members of the university community but may have inhibited participation from the broader community given its setting within a university building. Most survey participants and all interview participants who were not management professionals were affiliated with the university

either as students, staff, or faculty. Although the presentation of multiple shows in multiple locations, or the use of a large public space outside of the university, exceeded the scope of this study's capabilities, it is a limitation of this research that a broader cross-section of the local community was not reached. Future research with the scope to conduct multiple exhibitions or place them more publicly could expand upon the results reported in this case.

5.4.2 Sampling methodology

The singular nature of the *Carrying the* Torch event, the relatively small audience size and university-based demographic, and the self-selecting nature of exhibition visitation and survey participation did not allow for inferential statistics to be conducted extrapolating results to the broader population. These limitations are shared by many of the past studies that investigated the communicative effects of science-art collaborations, and while they do not undercut the value of the findings as evidence of the productive incorporation of the arts in science communication, future research with broader reaching scope and more rigorous sampling capabilities would allow for increased scope of applicability to audiences more generally. In any such case it will likely be difficult to end-run problems of self-selection—namely, subjects who choose to participate are those who have some pre-existing interest in art or science or both such that they desire to attend an arts-based event. However, future work investigating multiple exhibitions with multiple highly diverse audiences could expand upon this study.

5.4.3 Choice of variables: Understanding, Support, and Concern

The choice of the variables understanding, support, and concern followed in the vein of past research in which ecological understanding coupled with an emotional investment in the topic at hand were demonstrated benefits of public participation in art-science collaborations (Colavito et al. 2019, Opernamis et al. 2015, Curtis wet al. 2012). The choice of ecological understanding as a relevant variable was therefore relatively straightforward. Concern was chosen as an appropriate dimension through which to examine emotional effects of exhibition visitation, as it not only encompasses a relatively broad array of emotional responses but has been shown to be an important predictor of further pro-environmental attitudes and behavior (Kollmuss and Agyeman 2002). Support for prescribed fire constituted a third variable linking changes in understanding and emotional connection to issues surrounding fire ecology

The selection of these three experimental dimensions were likely not exhaustive of all relevant visitor responses or changes in response to *Carrying the* Torch. In narrowing the focus of the study to understanding, support, and concern, nuanced responses sufficiently fine-grained to escape detection by these three categories could go unrecorded. Namely, there may be a response that sits outside these three established categories that is nonetheless an important dimension of visitor experience. Telescoping back to underlying goals, if the goal of arts-based communication is to inspire action (beyond simply communicating scientific information in an educationally accessible and emotionally engaging manner), future research is warranted to elucidate this connection and identify potential other variables to include in future inquiry. This study investigated communication specifically—and not, for example, the actions taken because of it—so while dimensions beyond ecological understanding had to be incorporated to access the unique benefits promised by the arts (namely their emotional, affective capacities), this study did not delve into all possible effects on visitors such as the influence of further pro-environmental behaviors, though research does indicate a connection between changes in cognition, emotional investment, and action (Opermanis 2015, Kollmuss and Agyeman 2002).

Alongside an acknowledgment of narrowness, there must also be an acknowledgment of breadth. The categories 'understanding', support' and 'concern' are broad, introducing opportunities for more detailed analysis which future research could provide. In this study, participants self-reported their self-perceived levels of understanding, support, can concern before and after viewing the exhibition. While this data provides insight into public response, this survey strategy allows for mis-reporting (i.e. over- or under-estimating one's ecological understanding). In future work, more rigorous survey methods may be possible. For example, a series of questions testing ecological understanding before and after the exhibition could be given in place of asking visitors to self-rate their knowledge. Similarly, support for prescribed fire could be accessed through more fine-grained survey questions about likelihood of participation in local prescribed fire meetings or trainings etcetera. In such a case case, a pool of participants would have to be selected in advance of exhibition visitation and incentivized to participate in a more rigorous survey process.

Survey strategies like those described above exceeded the logistical capabilities of this study, but it is also worth noting that attempts to formalize subject selection and evaluation may compromise the degree to which participant experience accurately reflects the experience of the

average visitor to an art-science event like *Carrying the Torch*. If potential subjects treat a visit to an art-science event more like a test than an open-ended 'fun' experience, their responses might not be indicative of a non-subject's experience of the same phenomenon.

5.5 Transdisciplinarity and artistic valuation

In designing the research, certain assumptions about what the arts are capable of doing to people and, of that set of things, which are important, had to be made. Understanding, support, and concern were chosen on the basis of similar prior investigations, and they intentionally blur lines that are often drawn between supposed intrinsic and instrumental values of the arts. Can art be intrinsically emotive but instrumentally educational without the converse being true? It is worth noting that deeper questions about *how* the arts affect people have been asked since antiquity and continue to be asked within philosophy and social discourse (Belfiore et al. 2007, Anderson et al. 2012). While remarked upon in passing in explanation for research design, this study and research like it does not engage with these debates. I acknowledge that the data collected and described herein is an incomplete picture of the value of the arts, an incomplete picture even of how this particular instantiation may have affected or be valued by those who viewed it. It is a limited inquiry into one *facet* of what the arts do to people, which has been argued to this point, to nevertheless be an *important* facet to the extent that environmental sciences and associated conservation outcomes could benefit from its increased application.

In past research that queried artists and audience members involved with art-science collaborations, there were commonly voiced beliefs that art of high quality didn't communicate very well and, conversely, that art which communicated clearly did so by virtue of sacrificing nuance and artistic interest independent from the concepts it tries to communicate. An audience member surveyed in Meade's investigation of environmental art in Australia captured one half of this dichotomy in their comment about a particular show: *"It's compelling but I don't know that the pieces were direct enough in their impact. I think that probably makes them better, though."* The converse was highlighted by an artist involved in the same study: "*Unfortunately, to be effective it needs to effect on a mass scale and so has to be fairly confronting and direct – this lowers its ability to be sophisticated."* (Meade 2008). An artist in another study further bucked perceived pressures to "look for the science in the art," stating that contemporary art had to be ''*unwieldy and unapproachable as much as possible''* to be of artistic quality (Rodder 2016).

Artistically, the creative work in *Carrying the Torch* sought to challenge the notion that artistic work cannot both be of quality and simultaneously communicate scientific concepts, and conversely, that scientific information cannot be conveyed through art whose terms have not been renegotiated and whose integrity has not been compromised by the communicative enterprise. While questions of artistic quality were not addressed in this study, the uncompromised workflow of artwork creation and truth to an independent artistic practice and standards evidence the claim that the art included in *Carrying the Torch* was of similar character and quality to work made for other purposes which did not include a direct communicative evaluation. The evidence presented here is supportive of the notion that the arts and the sciences can interact symbiotically without detriment or loss of rigor incurred by either.

6. CONCLUSION

The development of effective, broad-reaching, and engaging modalities of scientific communication is critical to increase awareness and support for environmental issues embroiled within both ecological and social contexts. This study, as an extension of others like it, suggests that the arts can play a role in increasing public understanding of an ecological topic, support for practical implementation of ecosystem restoration initiatives, and concern about ecological well-being. Results indicate that an inclusion of a diverse array of art-based media, in particular the deployment of narrative storytelling, can be particularly effective at generating increases in ecological knowledge and emotional engagement with an ecological topic. Management professionals were supportive of the arts-based strategy implemented in the *Carrying the Torch* exhibition created through this study and may be more likely to look to arts-inclusive communication in the future. Future research into the application and effects of art-science collaboration as a form of public communication about science can expand upon these results and further investigate critical mechanisms of scientific engagement needed to address major environmental concerns worldwide.

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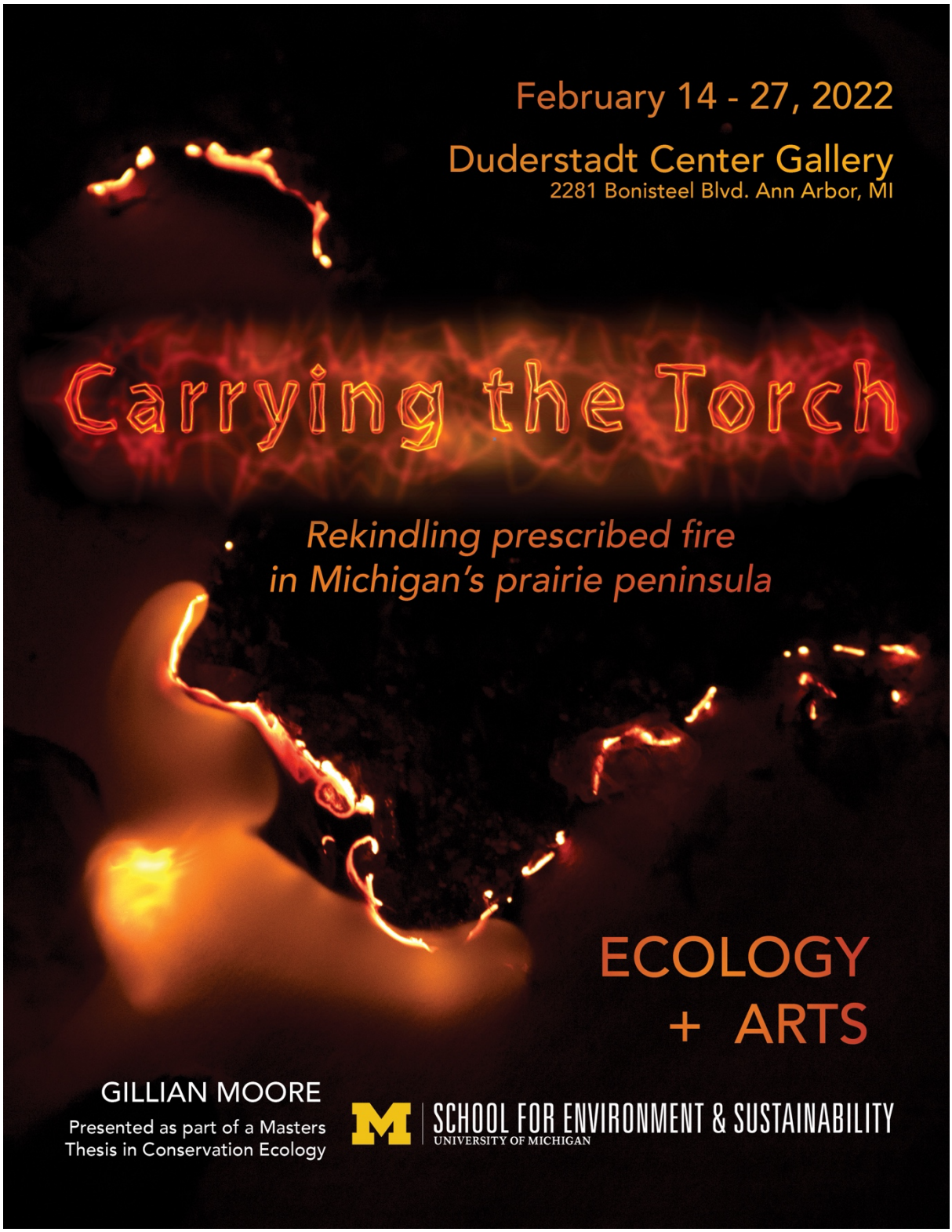
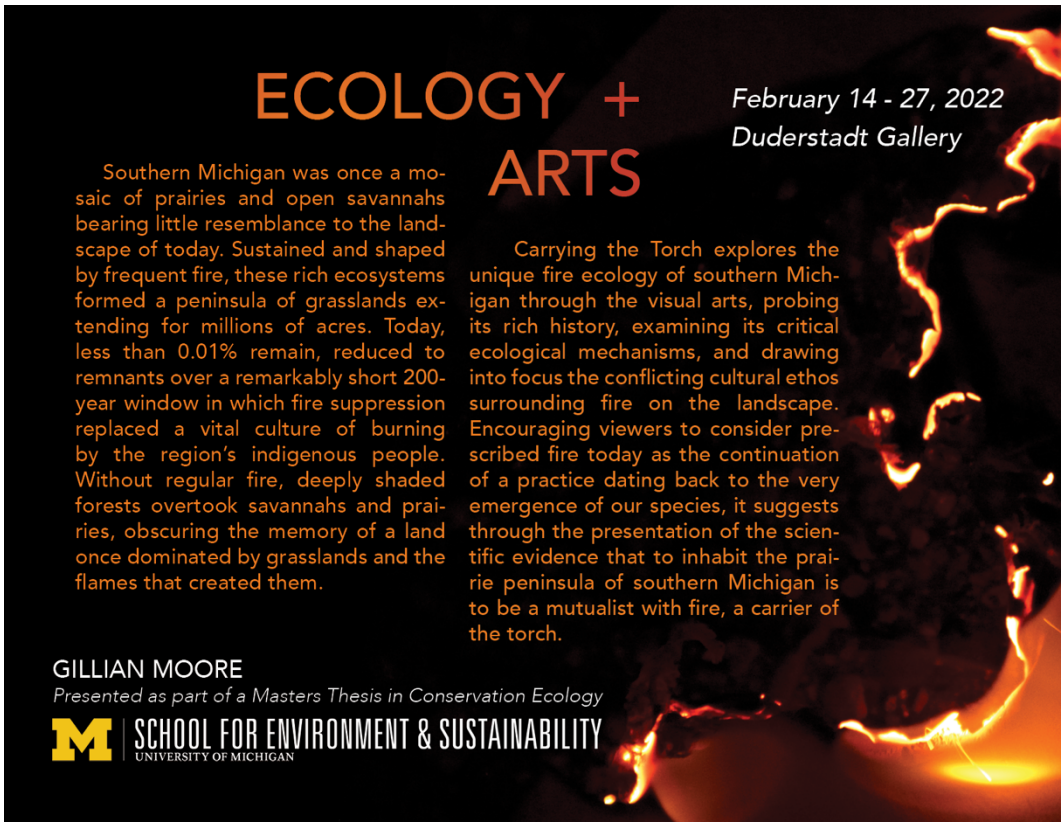
APPENDIX 1: EXHIBITION PROMOTIONAL MATERIALS

A. Exhibition Flier



B. Exhibition Postcard (front and back)



APPENDIX 2: EXHIBITION CATALOG

Please see following pages

CARRYING THE TORCH

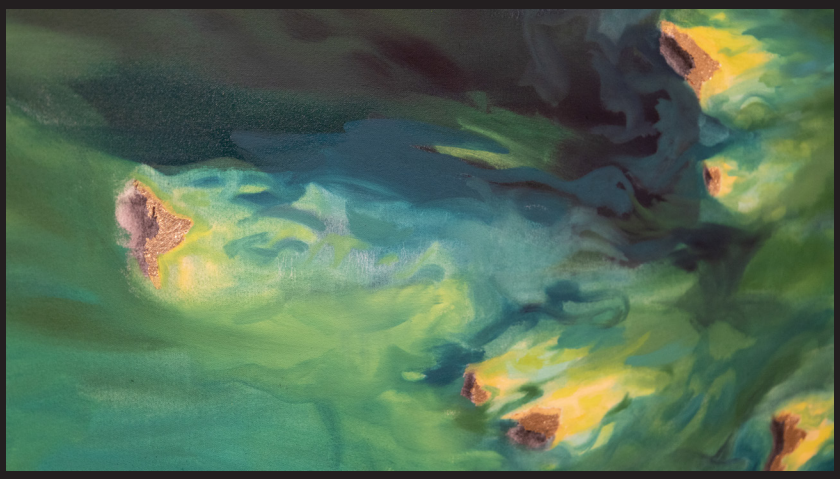
Rekindling prescribed fire in Michigan's prairie peninsula

Duderstadt Center Gallery
2281 Bonisteel Blvd. Ann Arbor, MI
February 14 – 27, 2022

GILLIAN MOORE

Presented as part of a Masters Thesis in Conservation Ecology

SCHOOL FOR ENVIRONMENT & SUSTAINABILITY
UNIVERSITY OF MICHIGAN



Acknowledgements

I would like to acknowledge the Keepers of The Three Fires: The Ojibwe, Ottawa, and Potawatomi peoples whose traditional burning practices shaped this landscape and are responsible for the unique fire ecology of Michigan's prairie peninsula.

I would like to thank the following individuals who generously gave their advice, expertise, and assistance, and without whom this exhibition would not have happened:

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University of Michigan School for Environment and Sustainability

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University of Michigan School for Environment and Sustainability

Dr. Julia Wondolleck
University of Michigan School for Environment and Sustainability

Dr. Scott Herron
Ferris State University

Kathi Reister
University of Michigan Duderstadt Gallery

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Lake States Fire Science Consortium

David Borneman and Colleagues
Ann Arbor Natural Area Preservation

Celia Faux

For her insight on the children's book Mandy's Prairie Home included in the exhibition.

Cassandra Fleckenstein

For her championship of women in the wildland fire workforce, which sparked my passion for fire.

Jonathon Heitzman

For his tireless production assistance and countless hours of labor.

Artist and Curator's Note

It has been a pleasure and an honor to present *Carrying the Torch: Rekindling Prescribed Fire in Michigan's Prairie Peninsula.* This exhibition was created as part of my Masters thesis in Conservation Ecology at the University of Michigan School for Environment and Sustainability—an unconventional ecology thesis to be sure, but one which I hope contributes a small piece to a nascent but quickly growing niche in the literature investigatingthe potential of the arts to communicate scientific lessons from ecology to the public.

The inspiration for this project came from many fronts: personal, professional, and academic. I arrived at the University of Michigan after two seasons as a wildland firefighter in the Western United states and returned in between the two years of my degree for a third season. I found my studies as a Masters student to be deeply satisfying and wonderfully challenging in a very different way than the time I put in on the fire line. But I left the Forest Service in Oregon to begin my Masters program only days before the Labor Day Fires of 2020 which burned over 1.2 million acres in the state, destroying thousands of structures, taking nine lives, and constituting the most destructive Oregon fire season on record. In leaving, I felt like I had walked away from work that was acutely necessary in favor of the relative quiet and comfort of my studies whose ultimate significance was more nuanced and indeterminate—its propensity to help anyone other than myself less certain. I felt the same sense of frustrated restlessness in the face of the 2018 fire season while I was completing my undergraduate degrees in Visual Art and Philosophy in Chicago, and it was this need to expand my activity beyond the academic research and artistic practice that had up to that point consumed my attention that prompted me to begin my career with the Forest Service. Once again in the Midwest, I felt caught between two worlds, yearning for a way to meaningfully connect my research with the experience and sense of purpose that I brought from my work in the wildland.

While turning over this debate in my mind, I came across a small number of unusual studies published in ecology journals. These papers detailed collaborations between scientists and artists who had taken the initiative to create exhibitions aimed at furthering public understanding of ecological topics where understanding was critically lacking. I had come to Michigan in large part as an artist seeking to inform my work by expanding my scientific background—so while I had long been exploring the processes of making art about science, I had not considered the possibility of conducting a scientific study about art. Here was a precedent that sparked my interest: a translational enterprise that sought to be impactful through public education about actionable science—merging research with communication and theory with practice—all while self-critically examining the value of the endeavor through the scientific process so that success, if it were to be had, could be measured, shared, and replicated. My thesis advisor, Dr. Sara Adlerstein, is herself a celebrated ecologist and visual artist, and just as much as the discovery of research precedent in the literature lit the fuse for the design of this study, her paintings steeped in ecological expertise provided ample creative inspiration for artistic work profoundly informed by science. With her generous support, the exhibition Carrying the Torch and the research which encompasses it became possible.

There was no question in my mind that the exhibition would be about fire ecology, but the final content and message of the exhibition did not become clear to me until very late in the timeline of its creation. It was one thing to contemplate the research and translation of extant scientific evidence into paintings, sculptures, and collages, but another entirely to put it together in a way that would connect with viewers on a deeper level, communicating not just the facts but their significance in a compelling way. I knew I would have to draw upon the emotional content of my own experiences to have any hope at credibility in the artistic production. I had seen firsthand the destructive capabilities of fire just as I had seen ample evidence of its restorative properties on the landscapes in the west. I lived and breathed the function of flames in the fire-adapted ecosystems where I worked, watching in real time as fire reasserted itself after centuries of fire exclusion to often disastrous effect. Back in Michigan I sifted through my journals, notes, and photographs created over the course of my fire seasons and found I was unable to easily reconcile the profuse anger and sadness scattered across those pages with my love for the work, my fascination with fire, and the repeated insistence upon its urgent return to the ecosystems that rely on it. I realized my own ambivalence was characteristic of a much deeper cultural motif apposite in different modalities to almost every society and extending over millennia of human interaction with our environment—one in which aversion to fire's disturbance paradoxically coexists with a reliance upon its effects—not only within the small confines of the hearth fire but across ecosystems and landscapes. Throughout our evolutionary history we have feared fire and collaborated with it, changing forever our own evolutionary trajectories alongside those of the species around us. Only recently has war been declared upon its manifestations on the landscape with organized protection and prevention institutions intent upon fire eradication replacing past cultural attitudes, denying and forgetting basic truths about the fiery origins of our species, our long-standing collaboration with fire, and the environments we co-create. The renowned fire historian Stephen Pyne is oft-quoted by scientists and fire managers alike: "Earth is a uniquely fire planet, and humanity a uniquely fire creature, and the ecology of their interactions is both ancient and profound."

I was researching voraciously—thumbing through books and journal articles in the back of the engine during work and trawling databases to create stacks of notes and concept maps upon my return to university. Though most of my personal experience with fire lay west of the Mississippi, I quickly became attuned to the unmistakable, if sometimes subtle, signature of fire in ecosystems all over the world through my graduate coursework and independent research. I became fascinated with the fire history of southeast Michigan, coming to discover from GIS syntheses, dendrochronology studies, soil analyses, cultural records, and historical accounts the truly profound influence that fire had in creating the place that had become my new home. Unlike the fire-prone forests and rangelands of the Western U.S, there are few natural ignitions in Michigan that could produce the extent and frequency of past fires detailed in these studies. A long history of cultural burning by indigenous peoples had supplemented nature's limited firing operations in the area, creating an incredibly diverse and unusual mosaic of woodlands, prairies, and savannas across the southern portion of the state for thousands of years. Perhaps the most gripping realization I had throughout the research I did was that, unlike the conspicuous conflagrations in the west which announce the ecological dysfunction of fire exclusion in a manner impossible to ignore, the disappearance of fire from Michigan's landscapes is all but ignored and ignorable by the public. The presentation of the problem is less apparent than millions of acres of charred forest to unstudied eyes, but the magnitude of departure from ecological baselines is not dissimilar. Furthermore, fire adapted ecosystems in Michigan endure the further insult that many people like and might positively prefer the current ecologically im-

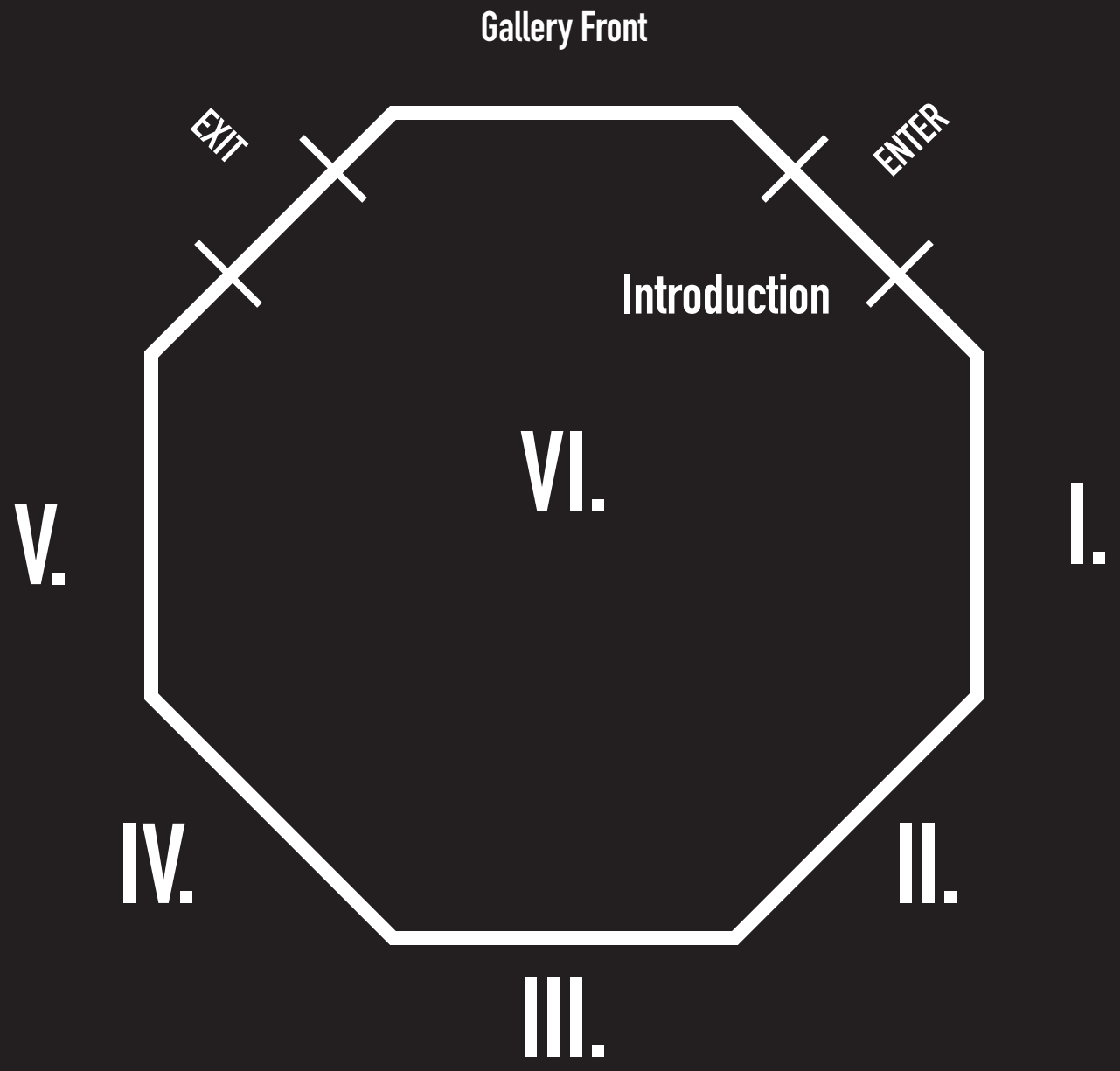
poverished state—viewing the limited vegetative communities in the lush forests that have overtaken the prairies and savannas as nothing more than the desirable status quo. Thus, an exhibition about fire in Michigan was a golden opportunity to engage with the larger conversations about fire management, ecology, and public involvement with fire's return to the landscape. Prescribed fire is an indispensable tool in restoration across a huge diversity of ecosystem types. Its implementation is vital to reduce fire risk in highly flammable places, but even where the threat of catastrophic wildfire looms large, practitioners experience significant public pushback when trying to get fire on the ground. In places like Michigan, the benefits of burning are largely enjoyed by oaks, massasauga rattlesnakes, wildflowers, prairie grasses, insects, and birds and the costs are borne by communities whose tax dollars and tolerance for unsightly smoke are not compensated by a reduction in risk. Knowledge about the needs of the ecosystem accompanied by care and affection for the species which comprise it are absolutely essential to motivate appropriate stewardship.

Carrying the Torch aims for synthesis of these many lessons. The organization of the exhibition follows loosely the narrative I have tried to capture here. Beginning with the view of fire as a destructive force that has weighted the perceptions of almost all who have engaged in some capacity with contemporary fire seasons, it contrasts the villain we have come to know with the ecological benefits of prescribed fire, with the rich and varied fire history in Michigan, with critiques of cultural attitudes promoting fire exclusion, with narrative storytelling about species whose existence is reliant on its return, and with practical illustrations of fire's functioning within local ecosystems. It hopes to inform and inspire questions—not only about particular ecological details of the Michigan landscape—but about the fundamental ecological relationship that humanity bears to fire. It endeavors to highlight not only the ways in which our activities are responsible for disrupting natural systems and communities, but the ways in which they have been responsible for creating and shaping them for millennia. We are neglecting the role that we established for ourselves within nature long ago—the role of the fire species, the carriers of torches. More broadly, the exhibition shares as its mission that of many environmental outreach initiatives which have come before it: to inform people about the places in which they live, inspiring through knowledge a love and sense of responsibility for the land and the living things upon it including each other. Aldo Leopold wrote in the Sand County Almanac that "When we see land as a community to which we belong, we may begin to treat it with love and respect." While this truth extends to many dimensions of the human interaction with our environment, there is no question that we belong to fire, it to us, and all of us to the land.

Gillian Moore
Ann Arbor Michigan, 2022

CONTENTS

GALLERY MAP



INTRODUCTION

Southern Michigan was once a dynamic mosaic of prairies and open savannahs bearing little resemblance to the landscape of today. Sustained and shaped by frequent fire, these rich ecosystems formed a peninsula of grasslands extending millions of acres across the southern half of the state. Today, less than 0.01% of these fire-dependent ecosystems remain, reduced to remnants over a remarkably short 200-year window during which time fire suppression replaced a vital culture of burning by the region's indigenous people. Without regular fire, deeply shaded forests overtook savannahs and prairies, obscuring the memory of a land once dominated by grasslands and the flames that created them. As diverse communities of fire-adapted species decline and are replaced by others whose evolutionary mechanisms perpetuate pyric aversion, fire itself is less and less capable of re-entering the landscape the longer it is absent. The window for action grows smaller each passing year.

Carrying the Torch explores the unique fire ecology of southern Michigan through the visual arts, probing its rich history, examining its critical ecology, and drawing into focus the cultural ethos surrounding fire on the landscape. Encouraging viewers to consider prescribed fire today as the continuation of a practice dating back to the very emergence of our species, it suggests through the presentation of the scientific evidence that to inhabit the prairie peninsula of southern Michigan is to be a mutualist with fire, a carrier of the torch.

"Anthropological science finds evidences of the fire art in the ancient traces of man where relics of his arts have not been disturbed. Such an unbroken line running through thousands of years admits of a study of the development of an art so intimately connected with man's progress... which mark the beginning and accompany the development of our connection with nature...

One fact stands clearly forth, namely, that no remains of man's arts show him without fire as an ally."

Walter Hough
Fire as an agent in human culture, 1926

I.

Fire has profoundly influenced ecosystems across the planet, predating the emergence of the human species by billions of years. It is a natural phenomenon borne of lightning, but it is also a cultural one when the kindling of the flame originates in human hands. As the singular species with the ability to harness fire, it has played a fundamental role in our own evolutionary history and that of the environments we inhabit. We have expanded the natural range of fire as we have expanded our own, introducing it to areas not commonly ignited by nature's lightning and in doing so co-authoring ancient evolutionary pressures that have kindled remarkable diversity in landscapes and ecosystems.

Today, wildfire has been demonized in the public eye, fueled by accounts of catastrophic fires in western North America which perpetuate deep-seated assumptions about the destructive qualities of free-burning fire. The pieces on this wall draw into focus this contemporary cultural ethos, seeding questions about whether this unidimensional understanding of fire is sufficient to preserve the ecosystems we inhabit and our place in them.

Gillian Moore

Cranston I (Inferno)

Oil on canvas

Inspired by the 2018 fire season in California, Cranston I responds to the brutal physicality of wildfire: its intensity, color, and power. Painted prior to the artist's first season as a wildland firefighter, it invokes fire at its archetypal height of destruction.

Sara Ana Adlerstein Gonzalez

From Cell to Hell: Restoration on the footsteps of the Ritual Fire Dance

Oil on Masonite

Gillian Moore

Cold Trail

Oil, charcoal, and white ash on charred panel

Gillian Moore

Cranston II (Aftermath)

Oil on canvas

"Models suggest the future will have substantial increases in wildfire occurrence but prior to recent human-caused fire exclusion, fire-adapted pine forests of Western North America were among the most frequently burned in the world. Restoration of patterns of burning and fuels/forest structure that reasonable emulate historical conditions is consistent with reducing the susceptibility of these ecosystems to catastrophic loss."

Peter Fulé, Restoration Ecology, 2008

II.

Gillian Moore

That Which We Protect (Shelter)

Woodblock print on polyester interfacing

In fire-prone places, the risk of high severity fire cannot be fully snuffed out. That which we protect, we do so with prescribed fire, or with means that emulate its results. Throughout the American West, prescribed burns are conducted to reduce fuel loading and restore fire-adapted forests to historical norms mitigating the severity of later fires that reburn the treated area.

There are lives at stake in these protective measures. The piece makes a second reference to a fire shelter--a fir fighter's last resort means of weathering a flaming front should all other options for escape disappear. In both senses, the heat can be mitigated but not avoided, But in both cases, the chances of ecosystem or individual survival increase dramatically with proactive protective measures.

The ecological devastation caused by high severity fire in the western United States cannot be resolved by continuing to withhold fire in all but the most extreme cases where only in its most destructive form can it overcome fire suppression efforts. It is with more fire, not less, that fuel loads can be reduced and fire-starved landscapes restored to resiliency. The piece included in this segment of the exhibition illustrates metaphorically how returning low-severity fire to a landscape through prescribed fire can protect the treated area from devastation by high-severity conflagrations.

The consequences of removing fire from ecosystems adapted to its presence are not universal. In highly flammable landscapes like those of the American West, the repercussions of fire suppression are sensational: larger more destructive fires as forests grow thicker and flammable debris accumulates. In ecosystems like those of southern Michigan, the absence of fire manifests all but invisibly to the untrained eye: not as devastation by smoke and flame, but as an insidious disappearance of ecosystems, habitats, and species.

III.

The fires on southern Michigan's landscapes were largely anthropogenic and so too were its grasslands, prairies, and savannas. Fire scar dendrochronology (the study of environmental history using tree rings), and charcoal analysis in soils and lake sediments indicate a strong correlation between human populations and fire occurrence throughout eastern North America (Hart et al. 2011, Guyette et al. 2002). Waves of fire at levels above those expected from lightning corresponded to waves of human populations whose cultural attitudes embraced the use of fire on the landscape, shaping the plant and animal communities across particularities of time and place (Stambaugh et al. 2018).

Following European settlement of the area, fire suppression became widespread and indigenous burning practices were forcibly halted. Mosaics of fire-maintained landscapes quickly converted to closed hardwood forests.

Prairies and savannas are now some of the rarest communities in the Great Lakes region with less than 0.1% of the 2.23 million acres historically present in southern Michigan persisting to this day (Dickmann et al. 2004, Chapman et al. 2008). The series displayed here explores this narrative of conversion, from a diverse landscape shaped by fire to a homogenous one as successional stages progress unchecked by disturbance. Only recently with the dedicated efforts of prescribed fire practitioners, land managers, and indigneous communities is anthropogenic fire being restored to the landscape.

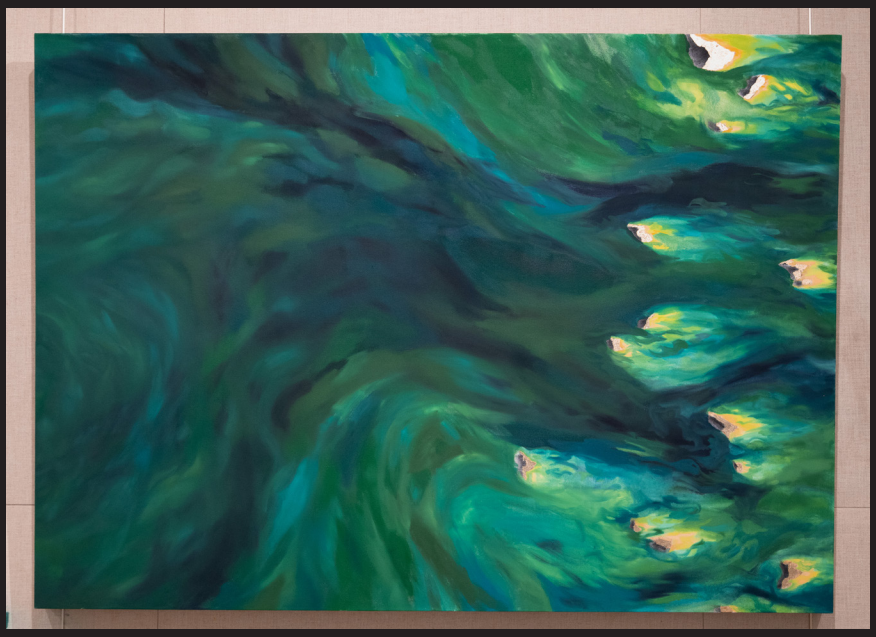
Gillian Moore

Succession I, II, III (Mesophistication)

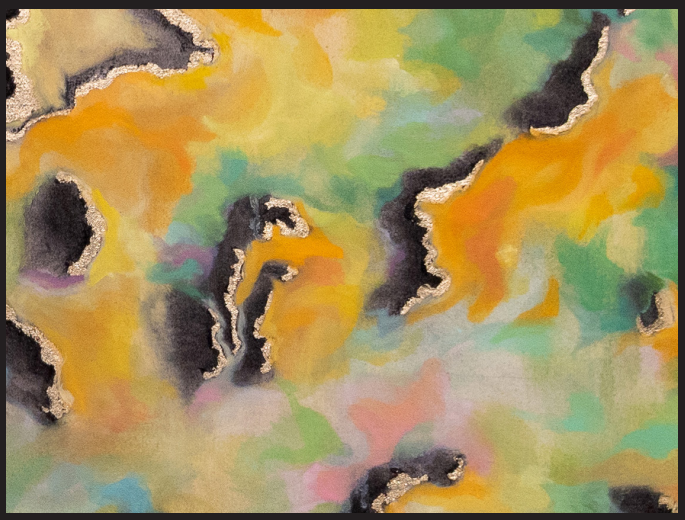
Oil, charcoal, and gold leaf on canvas panel

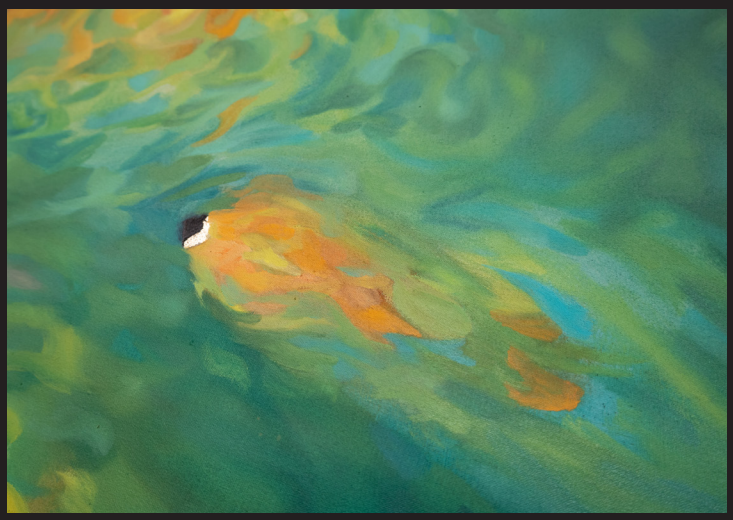
The Succession series is at once a historical narrative and diagram of successional phases. Southern Michigan was once dominated by open ecosystems. Prairies and oak savannas—grasslands dotted with widely-spaced trees—dominated the area. These grassland ecosystems were created and maintained through the regular application of fire by the Anishinaabe peoples whose regular practices of broadcast burning created a diverse mosaic of prairies, savannas, and woodlands. Evidence from tree ring analysis and charcoal sampling estimates a fire return interval of 3-10 years. Following European settlement of the are in the 19th Century, fire on the landscape all but ceased entirely under a new cultural ethos of complete fire suppression.

Grasslands rely on frequent fire to persist. Without it, woody plants quickly encroach, growing rapidly with the lack of disturbance and transforming the landscape into a dense, green



forest. The species who thrive under these conditions have evolved to suppress fire with dense, flat-lying leaf litter that holds moisture and extinguishes flame on the rare occasion it does re-appear on the landscape—a process known to ecologists as mesophistication. While the lush, green forests of today are what we may have come to expect, their complete conversion of the natural areas that remain represents amazing losses in landscape diversity, habitat variety, and biodiversity.





"A positive feedback cycle—which we term "mesophication"— ensued, whereby microenvironmental conditions (cool, damp, and shaded conditions; less flammable fuel beds) continually improve for shade-tolerant mesophytic species and deteriorate for shade-intolerant, fire-adapted species. Plant communities are undergoing rapid compositional and structural changes, some with no ecological antecedent. Stand-level species richness is declining, and will decline further, as numerous fire-adapted plants are replaced by a limited set of shade-tolerant, fire-sensitive species. As this process continues, the effort and cost required to restore fire-adapted ecosystems escalate rapidly."

Gregory Nowacki and Marc Abrams, 2008.
The Demise of Fire and "Mesophistication" of forests in the eastern United States. Bioscience.

IV.

Why were cultures of burning which endured for thousands of years snuffed out, and why did a new epoch of fire intolerance replace them? Settlers imported forestry practices from Europe–practices upheld by a value system that regarded the natural world as a collection of resources to be exploited and consumed rather than as a natural system to be participated in and preserved. In the northern half of Michigan, significant disruption by logging and the slash it created fueled some of the largest most lethal fires in the history of the United States, perpetuating a cycle in which the brutal consequences of one form of environmental mismanagement inspired gross mismanagement of another: universal fire suppression.

In Southern Michigan, fire historically returned at average intervals of every 1-5 years in prairie sites and 5-20 years in dry, oak-dominated forests (Cohen et al. 2021, Dickmann et al. 2004). Fire suppression resulted in a profound reduction of fire on the landscape both spatially and temporally, placing southern Michigan in a severe fire deficit and producing unprecedented cascading ecological shifts in the region. Woody encroachment including that of

opportunistic, invasive species quickly overtook open sites, decreasing vegetative species richness and threatening the species who rely on prairie and savanna communities for critical habitat (Ratajczak et al. 2012).

Gillian Moore

It's Your Choice?

Found-object collage: Vinyl signs on wood support

Across the nation, prevention signs identical to these are stapled to wooden panels in forests and campsites. Placing a playful spin on this practice using identical materials, this collage inspires viewers to creatively retro-engineer more appropriate messages than the fire-intolerance of Smokey Bear's iconic assurance "Only You can Prevent Forest Fires."

The defining character of one of the most successful public outreach campaigns in history, Smokey Bear has spearheaded a cultural shift towards fire intolerance. But if he's right that only we can prevent wildfire, only we can re-instate it, and if it really is our choice… I hope we choose wisely!

"Prior to organized protection, the number of forest fires [in Michigan] averaged well over 3,000 a year, the annual burn over half a million acres, and the resulting damage to more than one and a half million dollars a year without taking into account the enormous economic loss resulting from millions of acres of unproductive land. Since 1930 the number of fires has been reduced by half, the area burned annually to less than two-tenths of one percent of the area protected. . .
The record is one of which to be proud, but it does not mean that the fire problem has been licked or that further effort is unnecessary. The threat remains and only by eternal vigilance can forest fires be kept under control. . . . Every fire is a menace and only by prompt and effective control can disastrous conflagrations be avoided."

John A. Mitchell, 1950
Michigan Department of Conservation
Forest Fires and Forest Fire Control in Michigan

V.

Gillian Moore

Mandy's Prairie Home

Watercolor and ink paintings on board

Mandy's Prairie Home was originally conceived as part of coursework for a graduate-level Restoration Ecology course at the University of Michigan. Written and illustrated as a children's book for all audiences, it tells the story of an Eastern Massasauga Rattlesnake named Mandy and her friend, the Wise Old Oak as they grapple with the loss of their prairie home in the face of fire exclusion and invasive species. Highlighting the importance of habitat restoration and conservation, the story demonstrates the reliance on fire that characterizes ecosystems in the region.

Accompanying the original illustrations is information about the biology, ecology, and history of the species and places throughout the story. Visitors are encouraged to learn more from the resources compiled below and on the final page accompanying the narrative.

See a digital version of the book here

"On the one hand stretched bur-oak plains, spread with a verdant carpet, variegated with dazzling wild flowers, without an obstacle to intercept the view for miles, save the somber trunks of the low oaks, sparsely spreading their shadows across the lawn; on the other hand arose the undulations of the white oak openings, with picturesque outlines of swells and slopes, gracefully sweeping and sharply defined in the distance. Then, there lay the majestic prairie, grand in expansive solitude, its fringe of timber, as seen in the distance. . ."

S.C. Coffinberry, 1880

As excerpted in Chapman, K.A., R. Brewer (2008) Prairie and savanna in southern lower Michigan: History, classification, ecology. The Michigan Botanist 47 1–48.

VI.

Gillian Moore

Carrying the Torch

Multimedia installation
(Oak, Maple, Honeysuckle, and drip torches on wood base surrounded by video collages)

Narrating a story of restoration, Carrying the Torch places drip torches, the devices used by contemporary practitioners for carrying fire, in the the arms of an oak (Quercus). The arrangement of invasive honesysuckle (Lonicera mackii) and shade-tolerant maple (Acer rubrum) behind the oak represent the dense woody growth that arises in the absence of fire, shading out prairie species and oak seedlings. While the literal representation of oaks as "carriers of fire" is tongue-in-cheek, ecologically, they are profoundly fire-adapted species with evolutionary mechanisms to survive and perpetuate it through the flammability of their foliage.

Restoration of an overgrown, fire-excluded landscape often begins with the manual removal of woody accumulation. The honeysuckle and maple in this piece were manually cut by the artist and by employees of the Ann Arbor Natural Area Protection agency as part of local restoration initiatives.

Once the bulk of woody debris has been cut, fire can more readily burn and has a better chance of disrupting the dense stand of woody plants, especially if repeated across multiple years. It takes care, significant labor, and sustained stewardship to restore a prairie, oak savanna, or open woodland that has not experienced fire for many years.

Visitors are encouraged to lift and examine torches standing on circular bases extending from the main installation (take care, they may be dirty!). The torches used in this installation are genuine, passing through many hands and across many landscapes before being retired from the working cache of the U.S. Forest Service in 2021.

“Evidence indicates that periodic understory fire was an important ecological factor in the development of oak forests. . . . Mixed-mesophytic and later successional hardwood species, such as red maple, sugar maple, black birch, beech, black gum, and black cherry, are aggressively replacing oak. The leaf litter of these replacement species is less flammable and more rapidly mineralized than that of the upland oaks, reinforcing the lack of fire.

The trend toward increases in non-oak tree species will continue in fire-suppressed forests, rendering them less combustible for forest managers who wish to restore natural fire regimes.”

Marc D. Abrams, 2005. Prescribing fire in eastern oak forests: Is time running out? National Journal of American Forests, Volume 22(3).


EXIT

Gillian Moore

Untitled

Oil and gold leaf on canvas

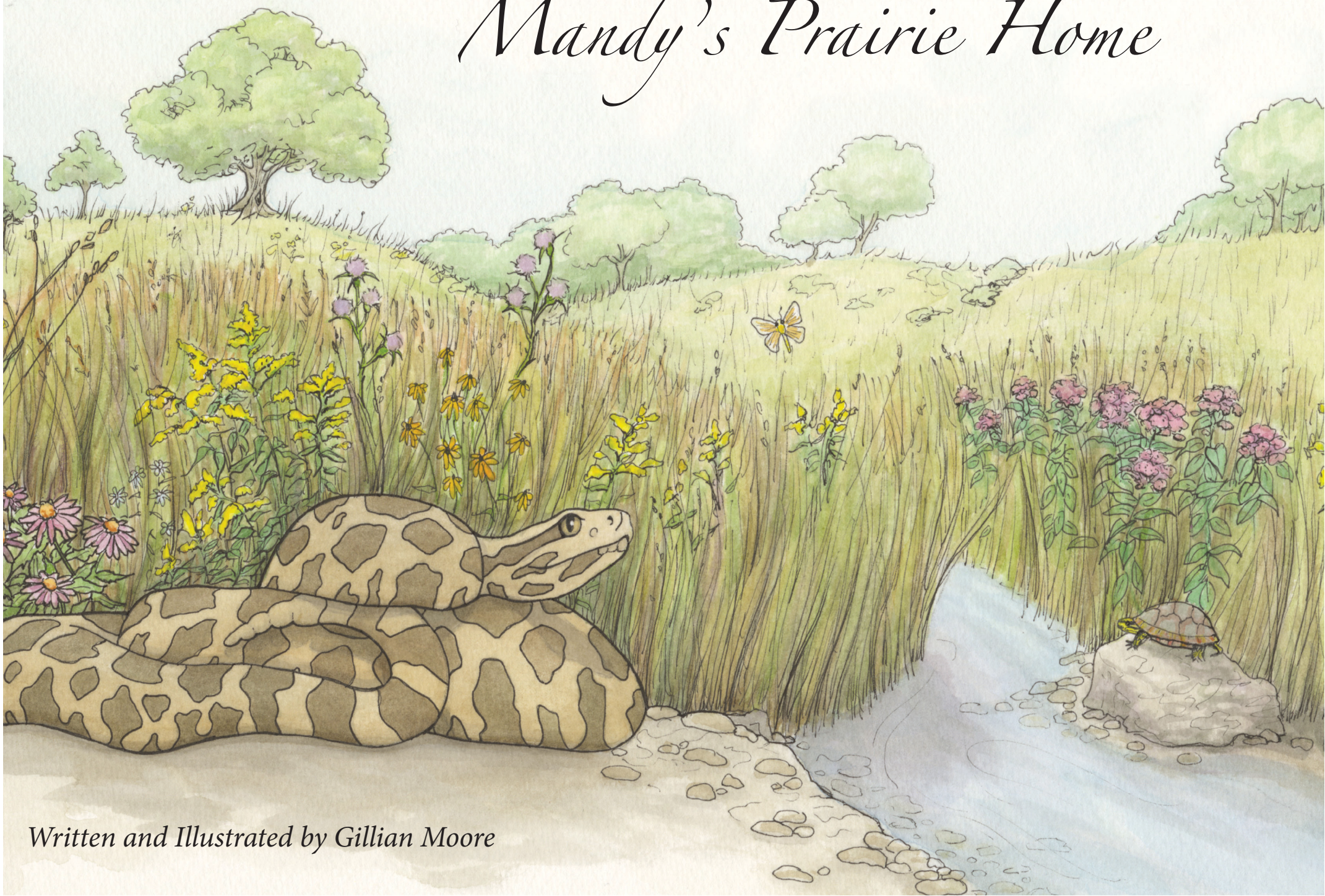
A note about the artist:
Gillian Moore is a master's student in Conservation Ecology at the University of Michigan School for Environment and Sustainability. Recognizing the need for actionable lessons from the environmental sciences to reach a public audience, she has chosen to focus her research at the nexus of ecology and the arts, expanding on her undergraduate B.A. in Visual Arts and Philosophy to design and produce this exhibition, Carrying the Torch.

Inspired by a deep love of fire and fire-adapted places, she has drawn upon her formal education and firsthand experience with wild and prescribed fire in Michigan and throughout North America. She has worked as a wildland firefighter for three years with the US Forest Service, carrying torches in Oregon, Washington, Colorado, New Mexico, and Alaska before moving to Michigan to become inspired by the unique fire ecology of the Ann Arbor area.

APPENDIX 3: CHILDREN'S BOOK

Please see following pages

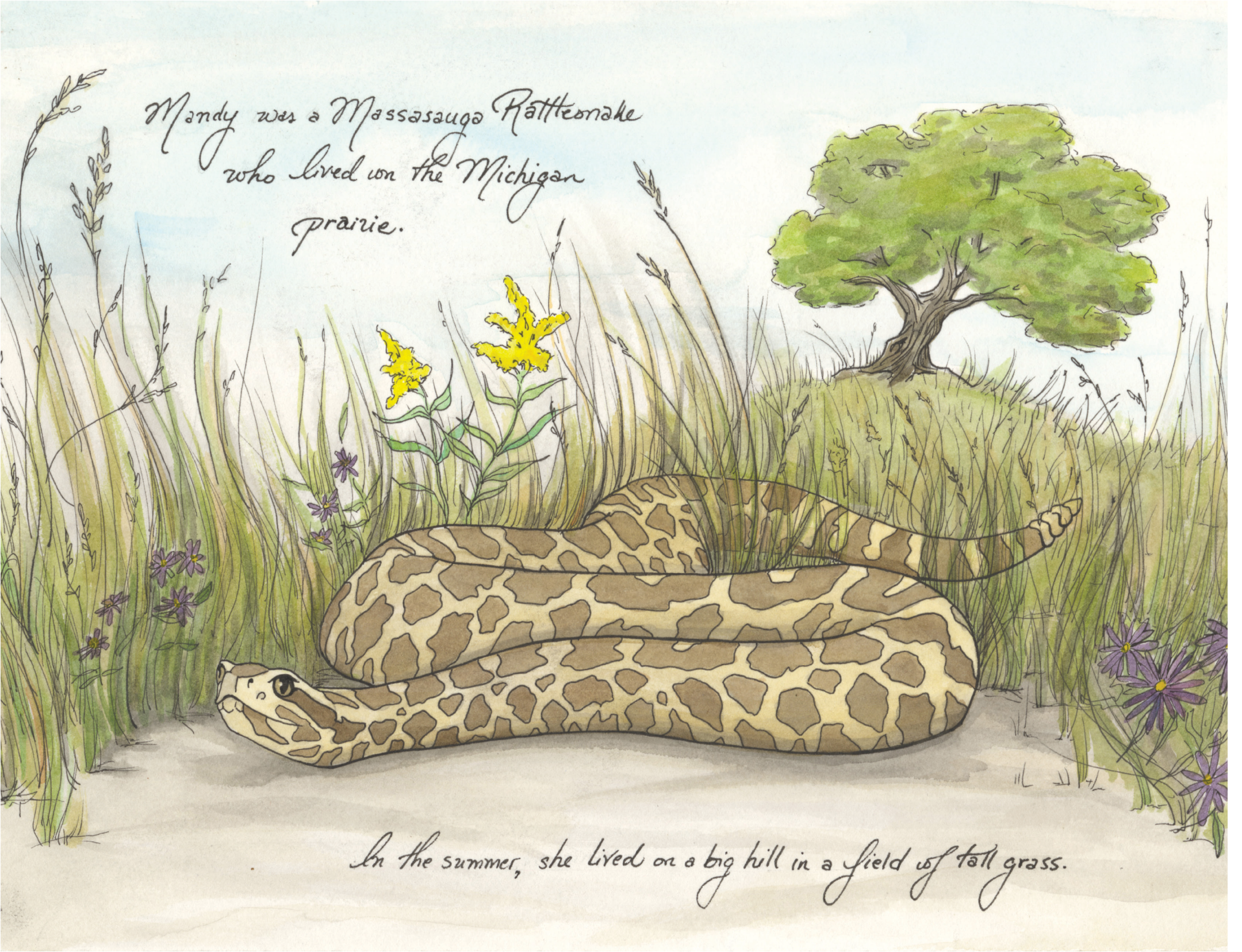
Mandy's Prairie Home



Written and Illustrated by Gillian Moore

Acknowledgments

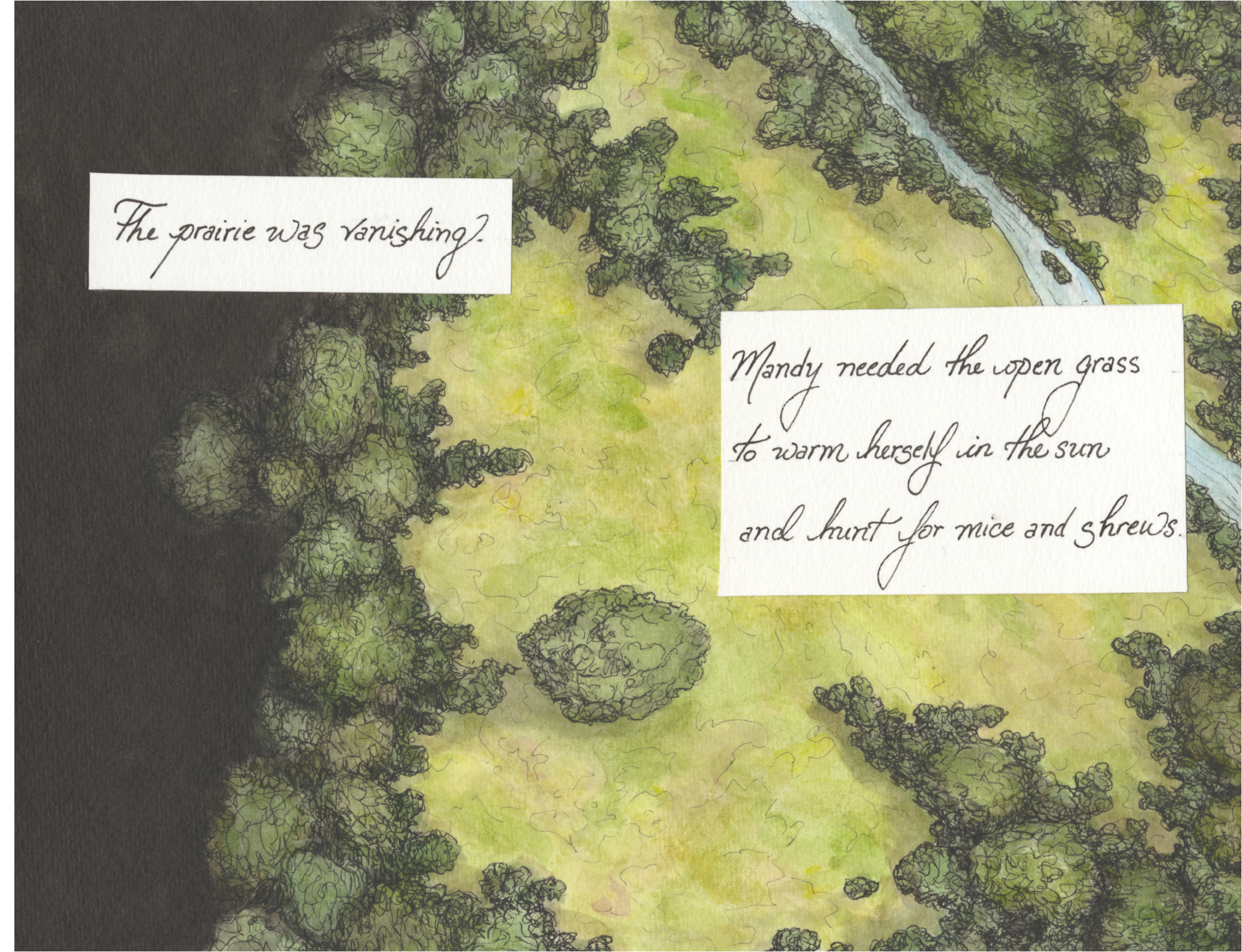
I would like to acknowledge the Keepers of The Three Fires: The Ojibwe, Ottawa, and Potawatomi peoples whose traditional burning and stewardship practices shaped the landscape of Mandy's prairie home. This book is dedicated to all who dedicate their efforts to understanding, protecting, and restoring the natural landscapes in which they live.


Mandy was a Massasauga Rattlesnake who lived on the Michigan prairie.
In the summer, she lived on a big hill in a field of tall grass.

In the winter, she moved to the bottom of the hill.
There she hid from the snow and the cold wind in a burrow by the stream.

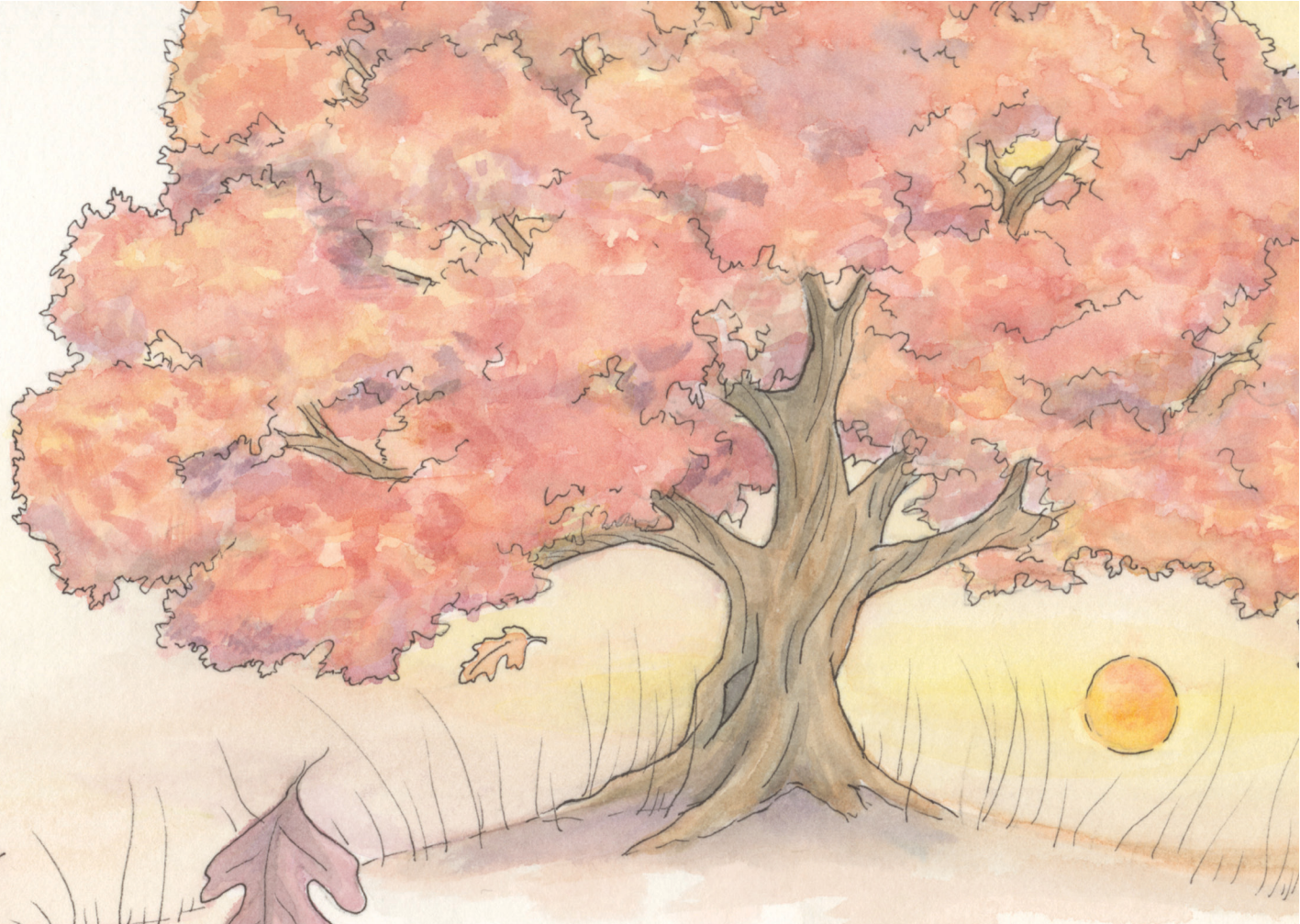
Mandy loved her prairie home...

But something was wrong.


The prairie was vanishing.
Mandy needed the open grass
to warm herself in the sun
and hunt for mice and shrews.

Now instead of grass, strange bushes and trees were invading the meadow.
These plants grew into a cold, dark forest that held no food for a hungry snake.

As the weather got colder,
Mandy knew it was time
to leave her sunny hillside
for the winter.



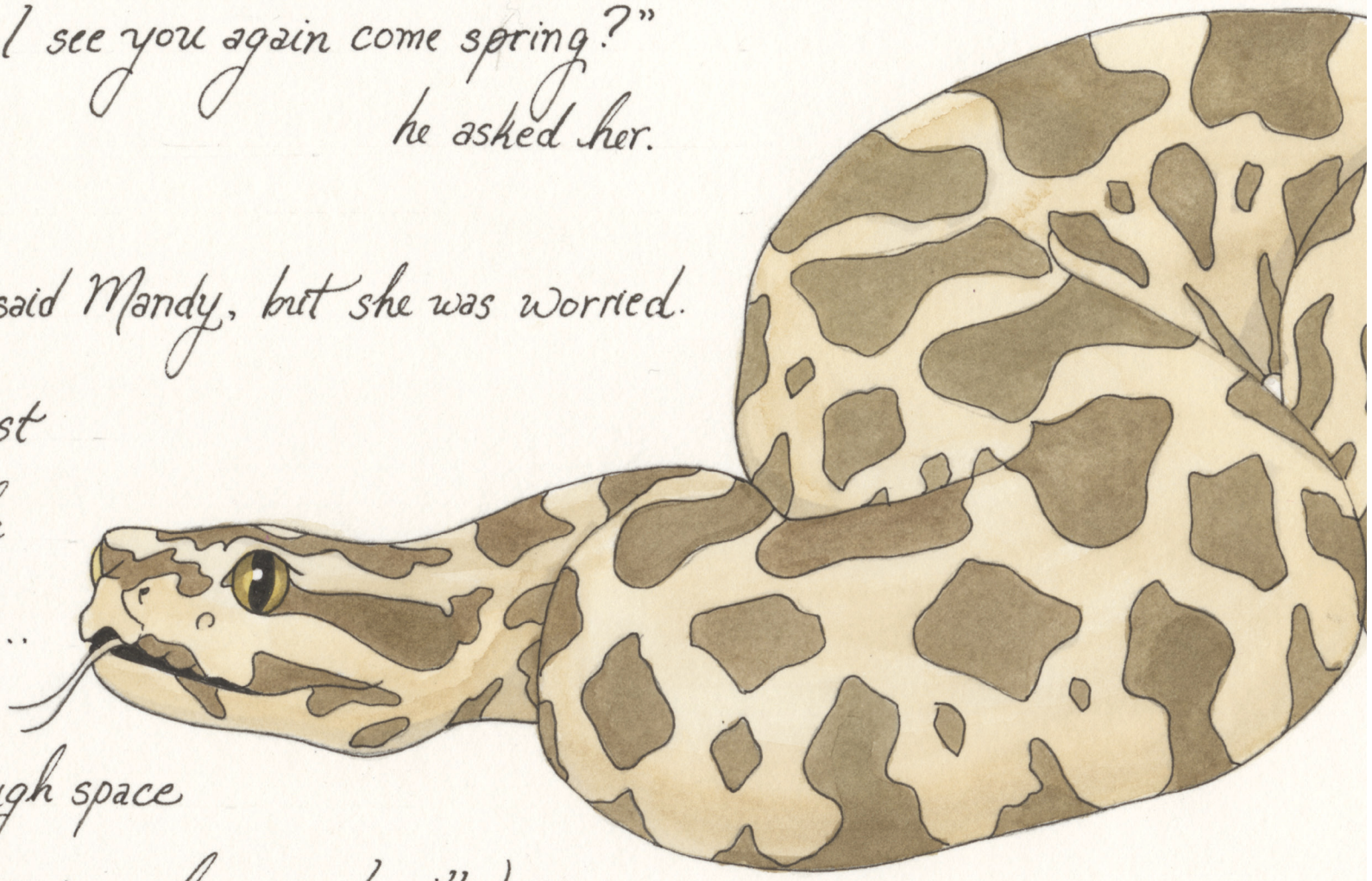
She stopped to say goodbye to the Wise Old Oak
who stood at the top of the hill.

"Goodbye friend," she told him.

"Will I see you again come spring?"
he asked her.

"I think so," said Mandy, but she was worried.

"Each year, the forest
gets bigger and the
prairie gets smaller...



I hope there is enough space
for me here in the spring, for soon I will have
no home at all."

"I hope so too," said the Wise Old Oak.

Honeysuckle, Buckthorn, and Autumn-Olive are the bushes who are taking over our home. They traveled here on the wind from far away. They are selfish plants who grow quickly and take all the sunlight for themselves.

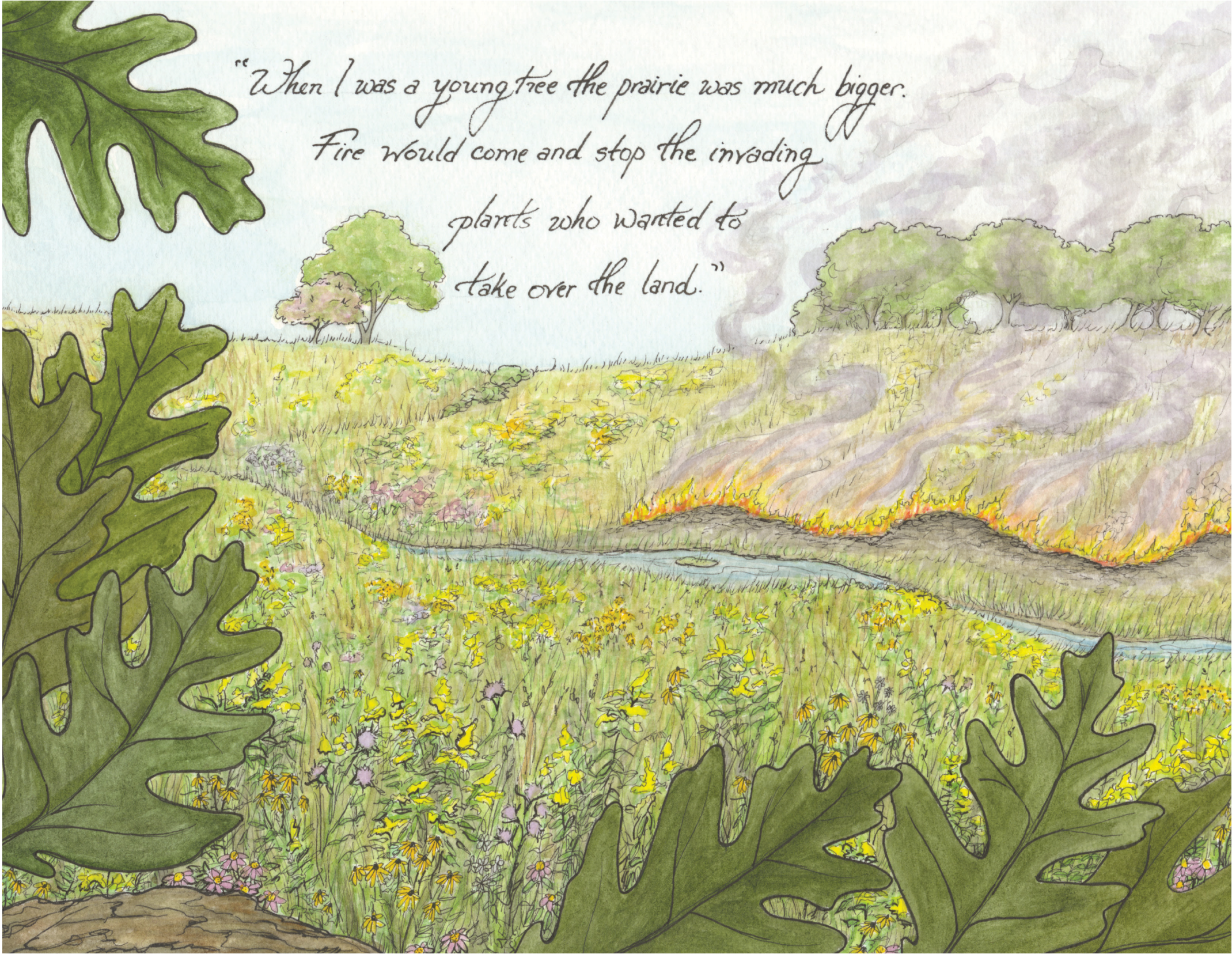
For many years, I have watched my acorns fall into their shade. Not one has become a seedling, and so I have no children."

The Wise Old Oak rattled his leaves sadly. "When I die, there will be no oak trees left on this hill."

Mandy couldn't imagine a world without the Wise Old Oak.
He had been there for as long as she could remember.

"Why is this happening to us?"
she asked.

The Wise Old Oak sighed...


"When I was a young tree the prairie was much bigger.
Fire would come and stop the invading
plants who wanted to
take over the land."

"I have not seen fire for many years," the Wise Old Oak said.
"It is the only thing that can save us now."

Mandy had never seen fire. She had many questions,
but it was too cold to stay on the hill any longer.

She crept down to her burrow and fell asleep.

Mandy slept for many months through the cold Michigan winter.

She dreamed she was lost in the forest. She tried to escape to the sunshine of the prairie, but could not find her way through the dark, tangled foliage.

One spring day, Mandy awoke to the smell of smoke. She peeked outside of her warm burrow.


High on the hill, she saw bright flames dancing through the grass.
Strange, tall creatures moved across the prairie, catching the grass and bushes on fire.

The Wise Old Oak stood tall with fire all around him.

His bark shimmered in the heat, but he did not seem afraid.

When the flames burned out, Mandy climbed the hill.

"Are you alright?" she asked her friend.

The Wise Old Oak laughed.

"This is how it should be! Many creatures are afraid of fire. They see only the blackened grass and the smoke that blocks the sun...

But look around Mandy! The fire brings new life to the prairie! It gives nutrients to the grasses and chases away the invading plants who steal the sunlight!

Mandy knew he was right.

Everywhere she looked, there were little stalks of new grass poking through the blackened ground.

The Honeysuckle, Buckthorn, and Autumn-Olive bushes drooped with withered leaves.

They could no longer invade the prairie.

As seasons came and went,
fire returned to the prairie many times.

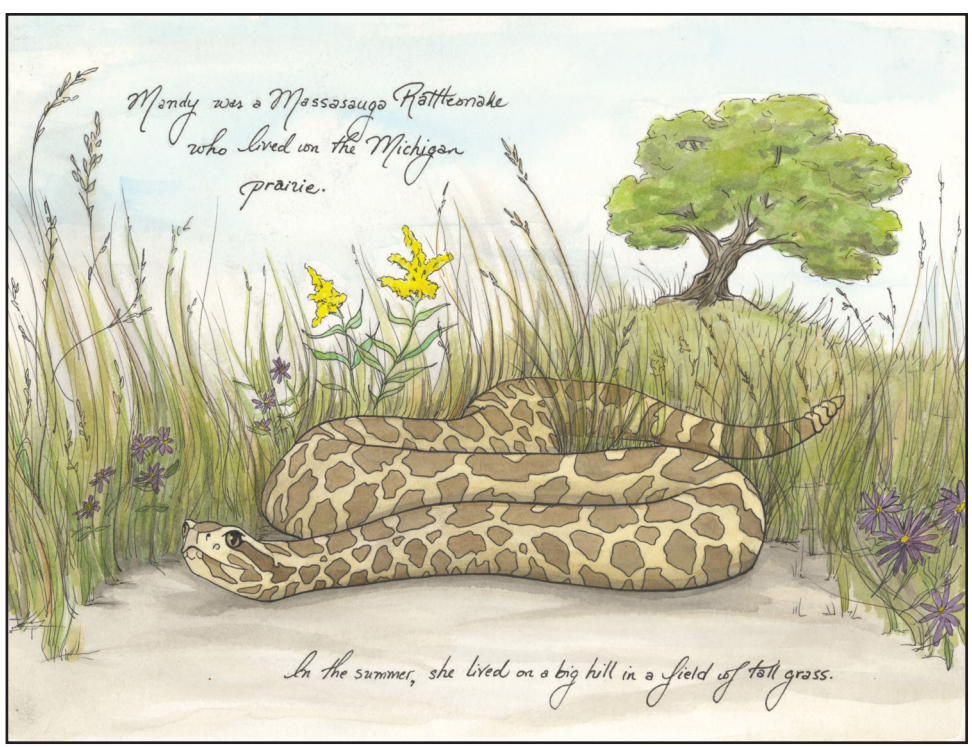
The Wise Old Oak swayed joyfully
in the breeze as his acorns grew
into seedlings.

In time, Mandy brought her own
children to visit them, and the whole
prairie bustled with new life.


So long as fire returned,
Mandy never worried about losing her home again.

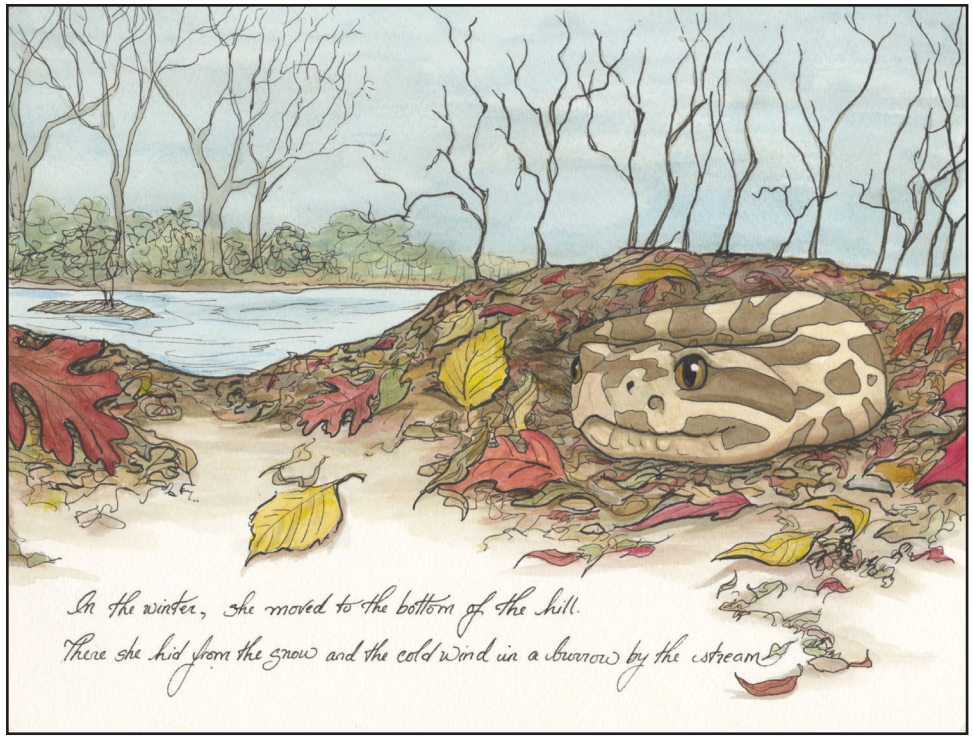
Annotations

Mandy's Prairie Home was originally conceived as part of coursework for a graduate-level Restoration Ecology course at the University of Michigan School for Environment and Sustainability. Written and illustrated as a children's book for all audiences, an Eastern Massasauga Rattlesnake named Mandy and her friend, the Wise Old Oak, grapple with the loss of their prairie home in the face of fire exclusion and invasive species. The annotations provided here about the biology, ecology, and history of the species and places featured in the story deepen the narrative for readers who wish to learn more.



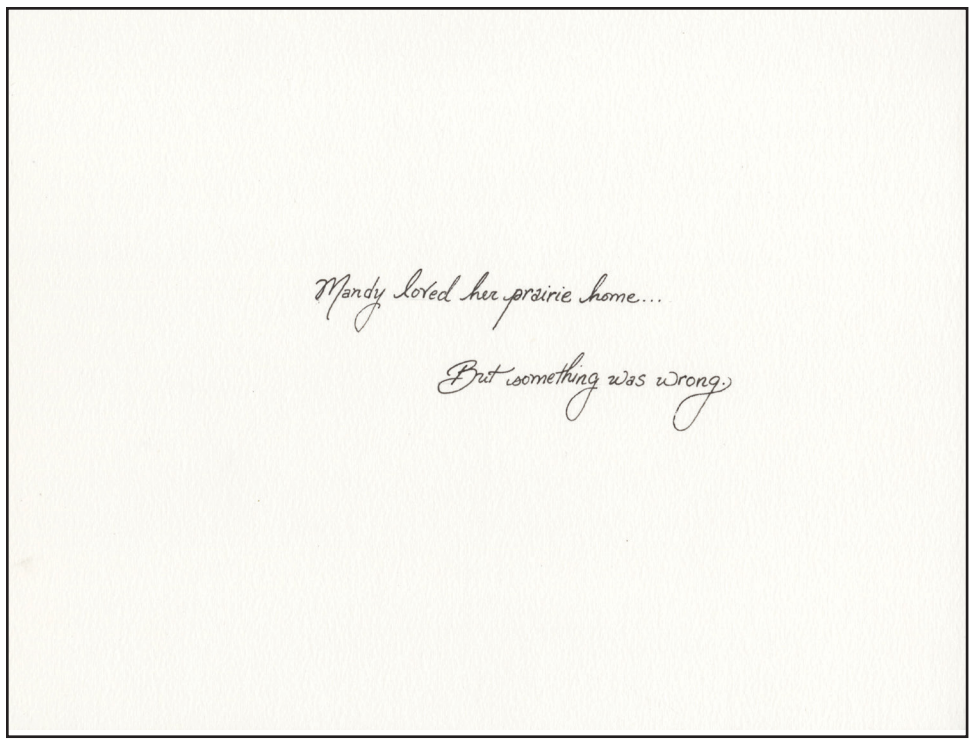
Eastern Massasauga rattlesnakes (Sistrurus catenatus) are small, docile snakes that once inhabited large portions of the upper Midwest from Western New York to Minnesota. Less than half of historical populations are estimated to persist today, primarily due to habitat loss and landscape fragmentation. Massasauga rattlesnakes are considered a keystone species because of their significant ecological impact both up and down the food chain even in small numbers. They are currently recognized by the state of Michigan as a species of special concern and by the U.S. Fish and Wildlife Service as a threatened species under the Endangered Species Act.

Spot these species in the illustration:
New England Aster (*Symphytotrichum novae-angliae*)
Tall Goldenrod (*Solidago altissima*)
Indian Grass (*Sorghastrum nutans*)
White Oak (*Quercus alba*)



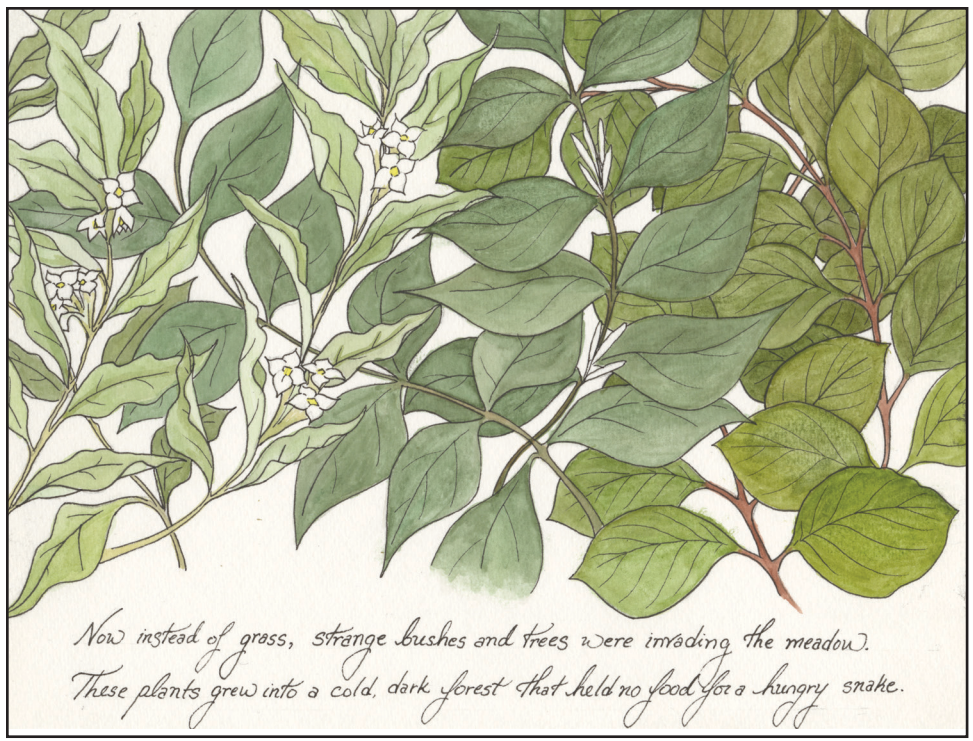
Eastern Massasauga rattlesnakes have seasonal differences in habitat needs. During the warm summer months, they inhabit open upland areas where they can forage and mate. When the weather cools, they move to low, open canopy wetlands where they seek out hibernacula—burrows just above the waterline which are often made by crayfish or other wetland species. They remain in their hibernacula throughout the dormant season until the weather warms sufficiently in the to allow them to return to their upland range.

Look for these species in fallen leaves:
White oak (*Quercus alba)*
American beech (*Fagus grandifolia*)
Smooth sumac (*Rhus glabra*)
Sassafras (*Sassafras albidum*)



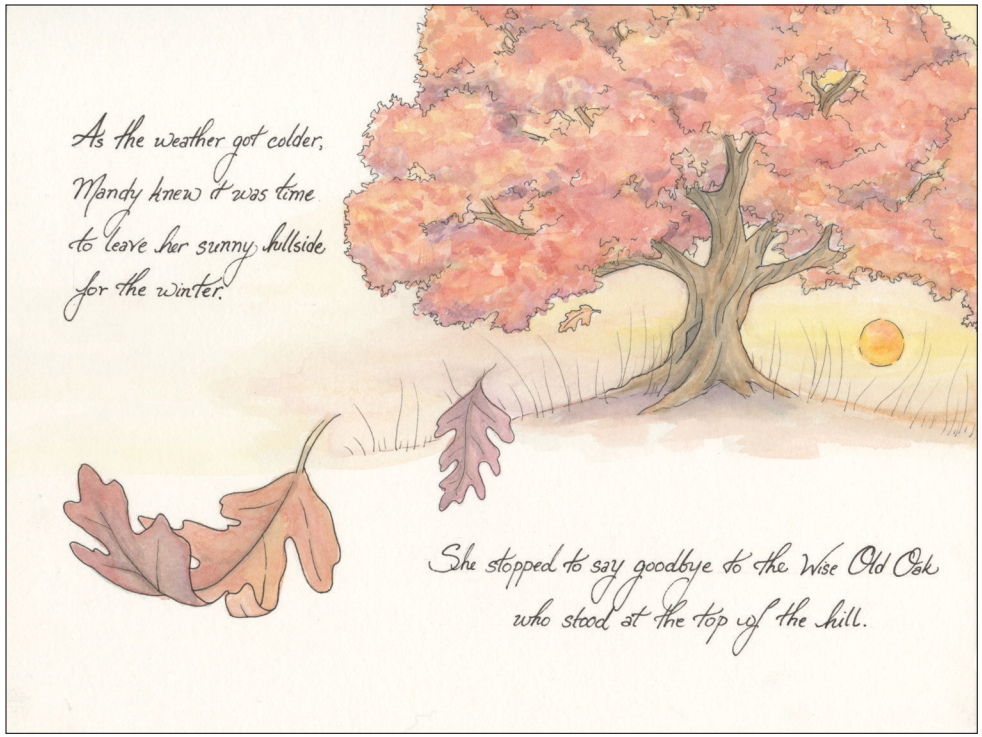
Historically, Massasauga Rattlesnakes have been known by many names such as the “Spotted Rattler” or “Swamp Rattler.” They have also been referred to as “Prairie Rattlesnakes,” a name that reflects their profound ties to the prairie ecosystem.

Open prairies and savannas are increasingly rare in Michigan, reduced to fragments of their historical extent that represent only 0.1% of the 2.23 million acres estimated to exist prior to European settlement (Chapman and Brewer 2008).



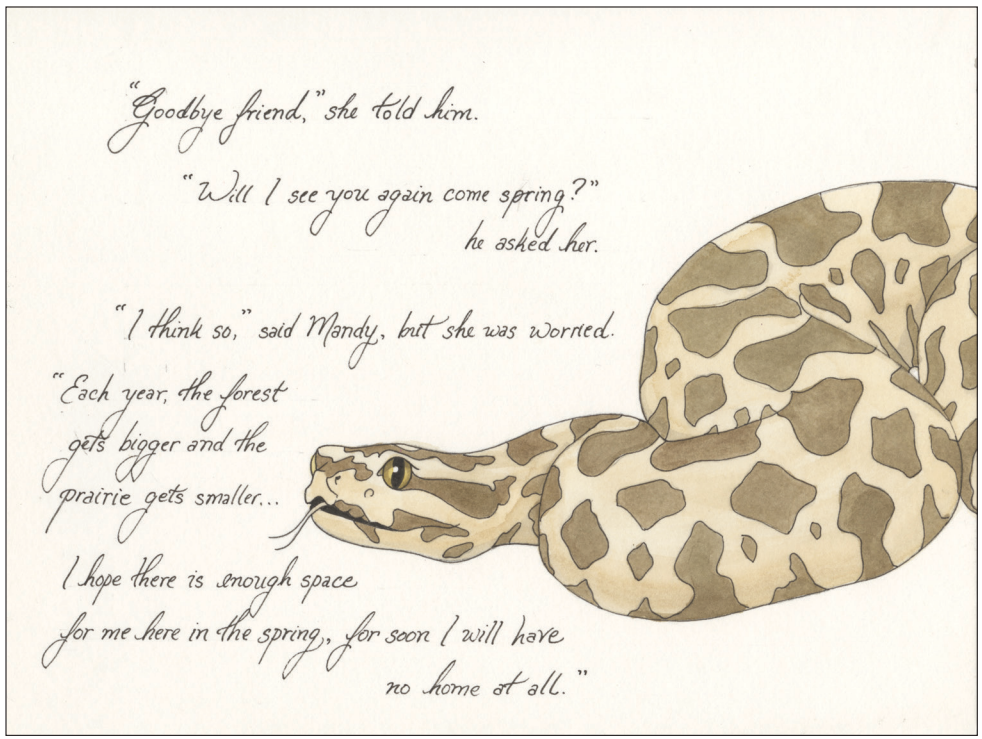
Invasive species are a growing concern for land managers in Michigan. The bushes in the story are Autumn-olive, Honeysuckle, and Buckthorn, all of which are common invasive woody plants which grow quickly under a wide variety of conditions. Left unchecked, these invasive plants can reduce local biodiversity by outcompeting native species in both prairie and forest understory communities. They can also impact habitat quality of many other species reliant on native vegetation composition such as Eastern Massasauga rattlesnakes.

Spot these invasive species in the illustration:
Autumn-olive (*Eleagnus umbellata*)
Maack's Honeysuckle (*Lonicera maackii*)
Glossy Buckthorn (*Frangula alnus*)

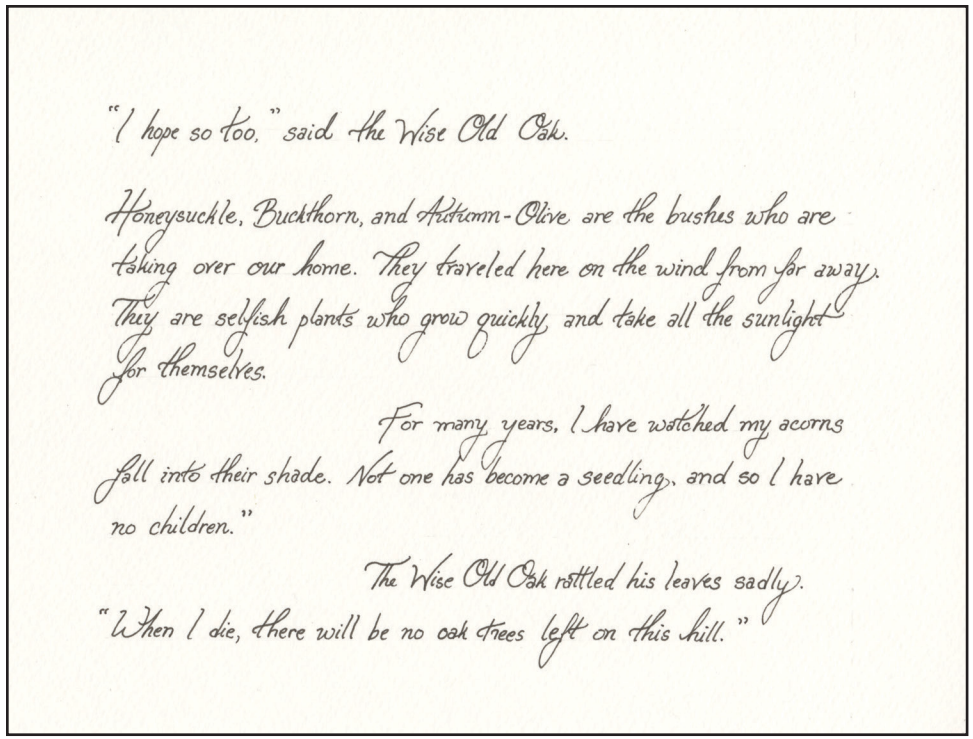


The Wise Old Oak in this story is a white oak (Quercus alba). White oaks and other oaks in the white oak family can often be identified by their distinctive leaves with rounded lobes and deep sinuses as depicted in the illustration. They grow on well-drained upland slopes like that of Mandy's prairie and exhibit a wide-spreading crown when grown in the open, with wide horizontal branches that become gnarled with age.

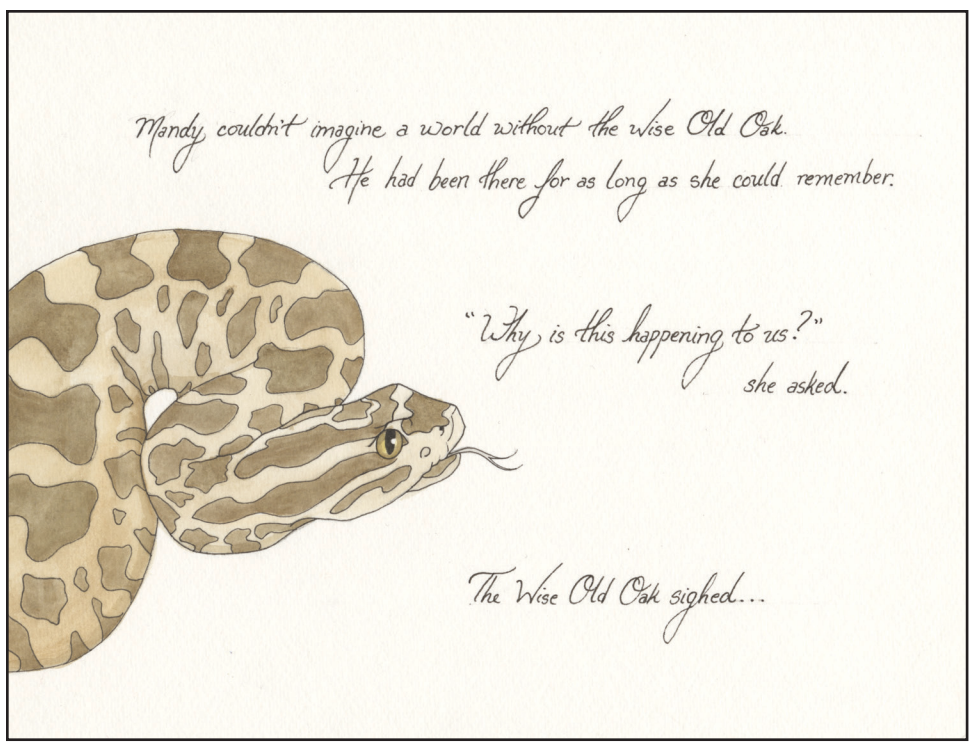
Check out the characteristics of this species in the illustration:
White oak (*Quercus alba)*



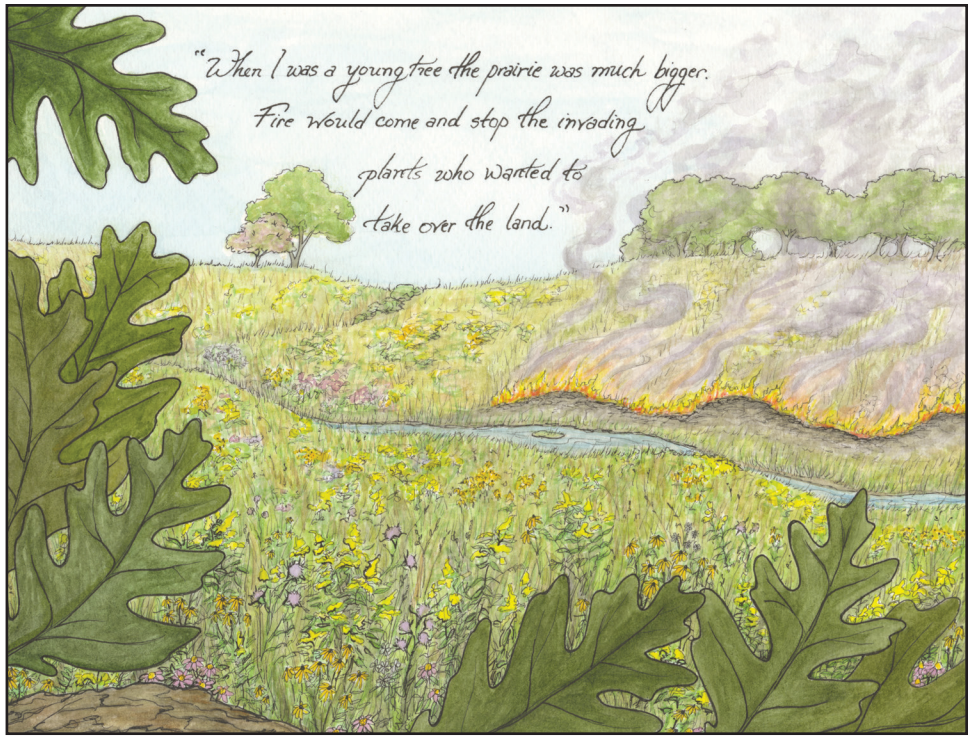
Without regular disturbance such as fire, prairies and other open systems like savannas will experience encroachment by woody plants that grow from the forested edges towards the center of the prairie. Prairie grasses and forbs are adapted to thrive following disturbance by fire but cannot tolerate an excess of shade. In contrast, the woody plants that replace them grow well without fire and can perpetuate in shaded conditions. The preservation of prairie ecosystems depends on the dynamic return of disturbances that favor the evolutionary strategies of fire-dependent species.

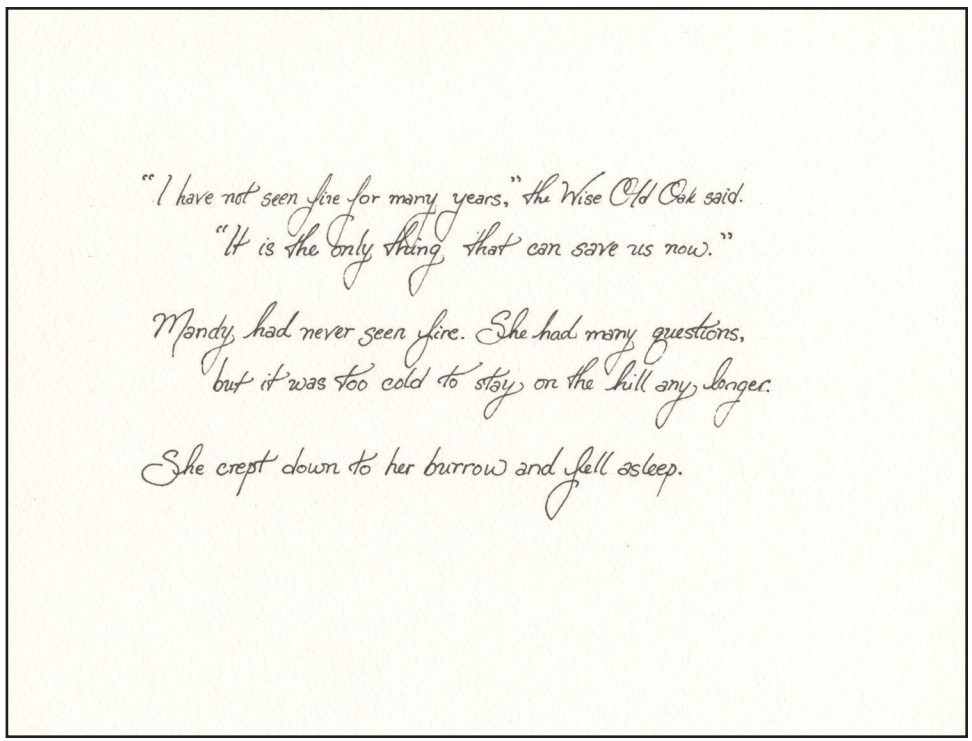


Oaks of all species are in decline across much of their range, but white oaks are especially rare when compared to pre-settlement distributions (Abrams 2003). Although oaks were dominant in Eastern deciduous forests prior to European settlement, a combination of extensive land-clearing, fire suppression, increased deer browsing, and the introduction of new pests, diseases, and invasive species has profoundly altered the character of forests in the region, restricting oak recruitment. A common result is the widespread replacement of oak with shade-tolerant native species such as red maple (Acer rubrum), and invasive species such as those identified in the story.



White oak trees are long-lived and individuals have been dated at over 400 years old. The oldest known member of the species is the Mingo Oak in West Virginia, which was estimated by the Smithsonian to have seeded in the 1350s and survived until 1938. To put it in perspective, the Mingo Oak came into existence around the dawn of the Renaissance and had been dropping acorns long before the apple tree that dropped the famous apple on Isaac Newton's head inspired his theory of gravity in 1687.





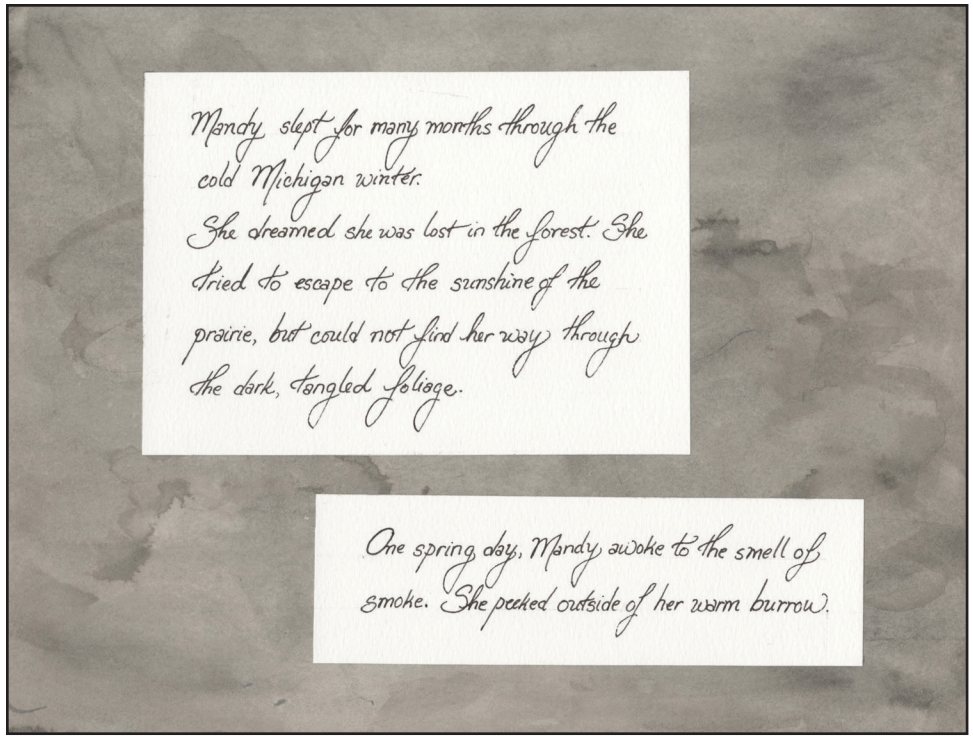
Fire could have been ignited by lightning but much more commonly would have been lit by native peoples who used it to modify the landscape to encourage foraging and hunting opportunities. The dominant cultural group in Michigan was the Anishinaabe, a collective of the Ojibwe, Odawa, and the Potawotomi peoples who collectively form the "Keepers of the Three Fires" or the "Three Fires Confederacy." Their cultural attitudes around fire and traditional practices of burning sustained the oak savanna and prairie ecosystems of Lower Michigan for thousands of years.

Note in this illustration that the leaves are on the trees and the prairie flowers are in bloom. Although burns are more commonly conducted in the early spring and late fall, summer burns, also referred to as "growing season burns" can also provide ecological benefits by favoring different plant species and modifying fire behavior. The low, creeping intensity of the fire behavior and the wispiness of the smoke portrayed in the illustration partly illustrate these dynamics. A diversity of fire contributes to a diversity of landscapes!

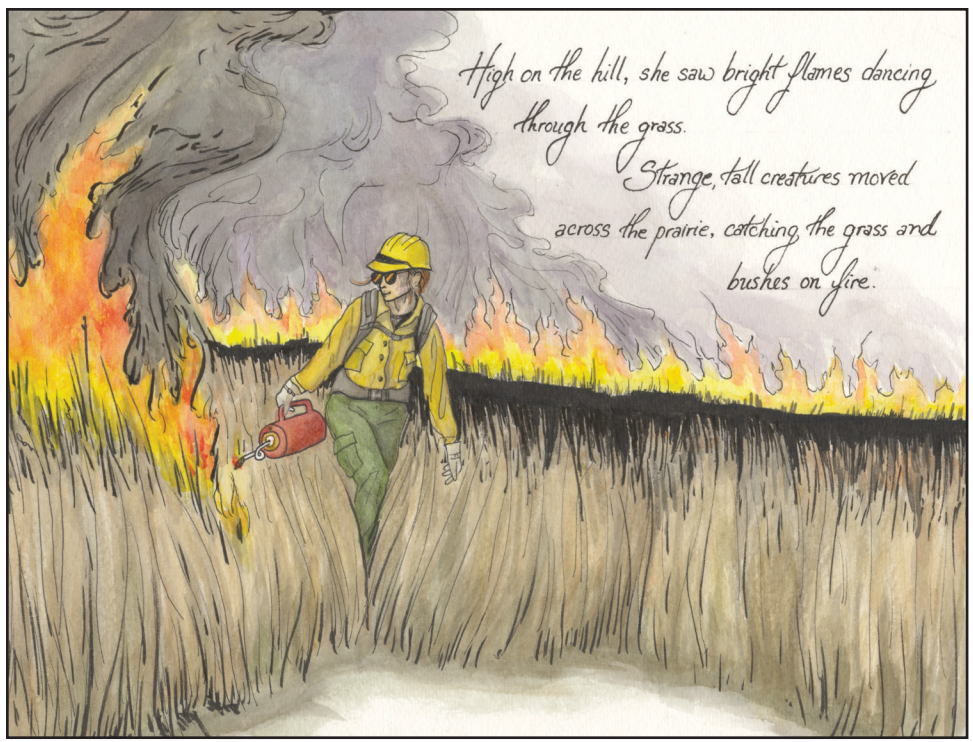
Look for these species in the illustrated prairie landscape:
Tall goldenrod (*Solidago altissima*)
Purple coneflower (*Echinacea purpurea*)
Black-eyed Susan (*Rudbeckia hirta*)
Hill's thistle (*Cirsium hilii*)
White oak (bark and leaves) (*Quercus alba*)

Following European settlement, a widespread practice of fire suppression all but erased fire from the Southern Michigan landscape. Given the relatively short lifespans of Eastern Massasauga Rattlesnakes, Mandy almost certainly would not have seen fire in her lifetime.

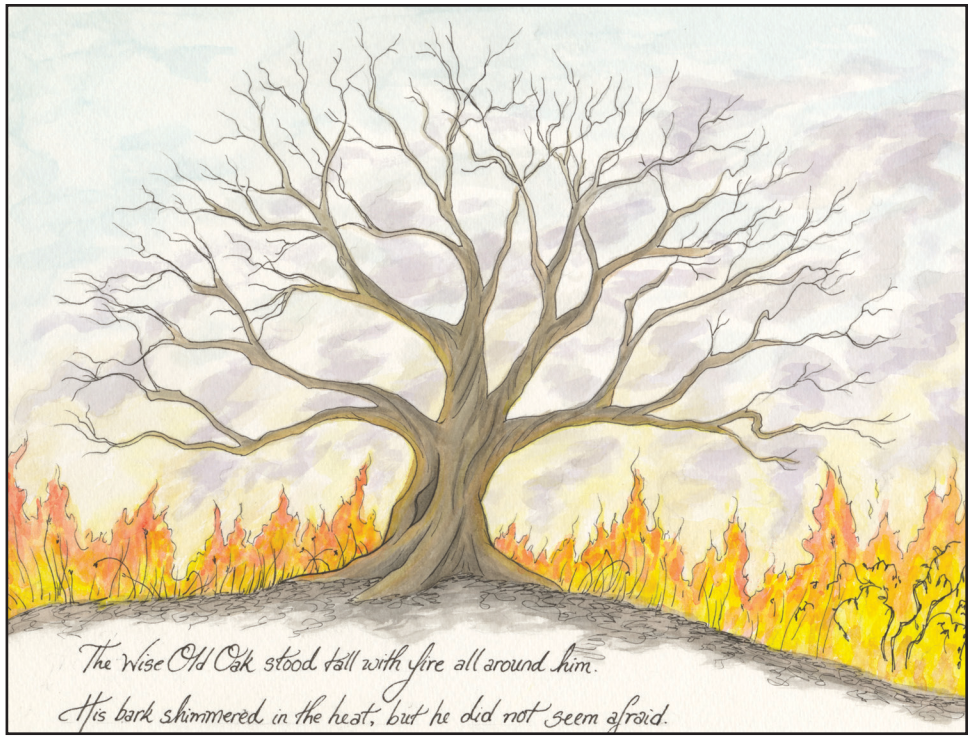
Eastern Massasauga Rattlesnakes rely on the adjacency of their upland and lowland habitats. Snake mortality commonly occurs during this transition between summer and winter sites as they are often exposed to road crossing and other human-created barriers. Mandy is lucky to have a home that, at least for a time, satisfies all three of the following conditions: upland prairie or savanna, open-canopy wetland, and adjacency of the two habitats.



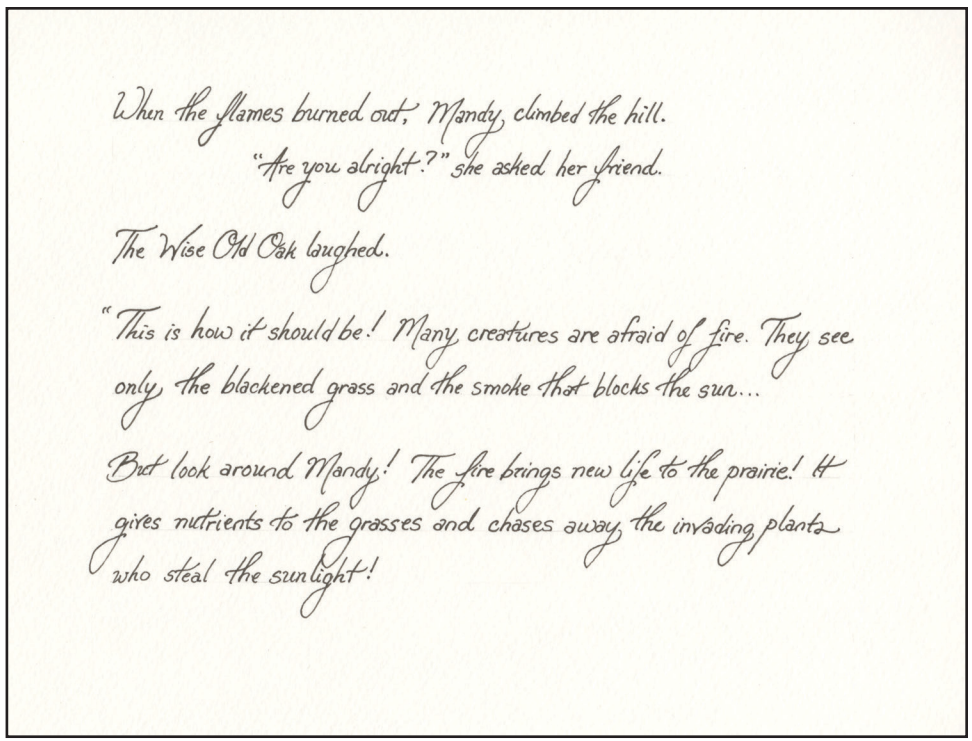
Mandy smells smoke in the early spring while she is still in her hibernaculum. Land managers seeking to improve Eastern Massasauga Rattlesnake habitat often conduct their burns in the early spring or late fall when the snakes are in their lowland habitats. This practice ensures that snakes are not harmed by prescribed burning.



Prescribed fires are often conducted using drip torches as depicted in the illustration. Professionals and trained volunteers carry fire across the burn unit which has been carefully planned and prepared to ensure that fire remains inside the desired area.



Oaks have evolved thick, heat resistant bark which shields them from the radiant heat of low-intensity ground fires. Because oaks are early- to mid-successional species, they rely on fire to provide the disturbance conditions under which they thrive. They can re-sprout readily after fire and their leaf litter is much more flammable than that of late-successional species whose leaves have evolved to act as fire arrestors. As such, oaks perpetuate a delicate equilibrium in which fire plays a critical role: rather than "fearing" fire, they embrace it.



Studies have demonstrated that repeated low-severity fire can increase both soil nutrient availability and herbaceous plant diversity—both benefits referenced by the Wise Old Oak (Scharenbroch et al. 2012).

Smoke is a common concern for prescribed fire practitioners. There are strategies that are used to manage smoke and keep it from posing adverse risks to communities. Managers wait for the perfect window of temperature, humidity, time of year, and wind conditions to conduct a burn.

Mandy knew he was right.

Everywhere she looked, there were little stalks of new grass poking through the blackened ground.

The Honeysuckle, Buckthorn, and Autumn-Olive bushes drooped with withered leaves.

They could no longer invade the prairie.

Vegetation returns quickly to a prairie after a low severity fire. While small woody plants can be successfully managed by burning, larger bushes and trees may need to be manually removed with hand tools or power equipment prior to the application of fire. If woody vegetation is sufficiently established, the cost of restoration may increase significantly. It is therefore much more effective to act quickly to preserve the prairies and savannas that remain rather than waiting until they require more substantial intervention to be restored.

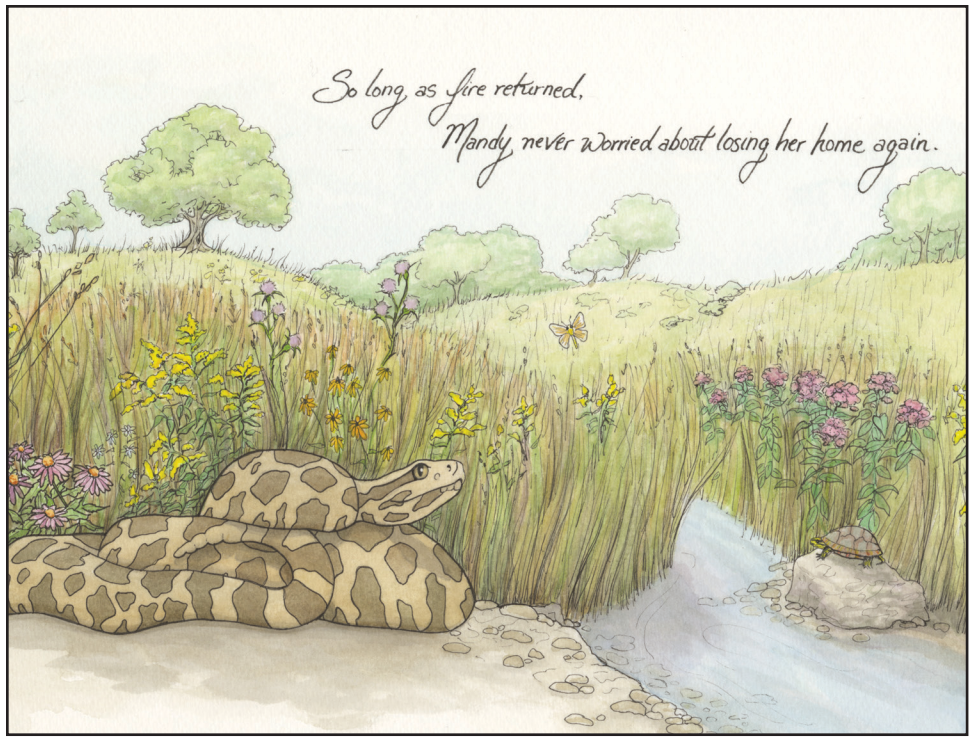
As seasons came and went, fire returned to the prairie many times.

The Wise Old Oak swayed joyfully in the breeze as his acorns grew into seedlings.

In time, Mandy brought her own children to visit them, and the whole prairie bustled with new life.

Female Eastern Massasauga Rattlesnakes reach maturity during the summers of their second to sixth years depending on their location within their range. They give birth to live young, and their brood size can vary widely from roughly 3 to 11 young in Michigan populations.

Newborn snakes, known as neonates, carry the same spotted markings as their parents but are paler with yellow tails and “buttons” instead of the fully formed rattles exhibited by the adults of their species. The young snake in this illustration exhibits a button characteristic of a snake in between its first and second shedding if its skin.



Look for these species in the illustration:
Tall goldenrod (*Solidago altissima*)
Purple coneflower (*Echinacea purpurea*)
Black-eyed Susan (*Rudbeckia hirta*)
Hill's thistle (*Cirsium hilii*)
Joe Pye Weed (*Eutrochium purpureum*)
Indian grass (*Sorghastrum nutans*)
White oak (*Quercus alba*)
Poweshiek skipperling butterfly (Oarisma poweshiek)
Painted turtle (Chrysemys picta)

Works Referenced

Abrams, Mark D. (2003) Where has all the white oak gone?. Bioscience 53(10), 927-939.

Chapman, Kim Alan, Richard Brewer (2008). Prairie and savanna in southern lower Michigan: history, classification, ecology. The Michigan Botanist, 47, 1-48.

Scharenbroch, B.C., B. Nix, K.A. Jacobs, M.L. Bowles (2012). Two decades of low-severity prescribed fire increases soil nutrient availability in a Midwestern, USA oak (Quercus) forest. Geoderma 183, 80-91.

US Fish and Wildlife Service (2016) Species status assessment for Eastern Massasauga Rattlesnake (Sistrurus catenatus). SSA Report Version 2, July 2016.

About the Author

Gillian Moore is a Masters student in Conservation Ecology at the University of Michigan School for Environment and Sustainability. Committed to the use of fire to restore ecosystems, Gillian has worked as a wildland firefigher throughout the Western United states for four fire seasons, and has participated in many prescribed burns across the West and Midwest. As an artist, she combines her ecological knowledge with drawing, painting, and writing to make lessons about the natural world available to public audiences.

APPENDIX 4: SURVEY

Carrying the Torch
Visitor Survey

1. Background and Affiliation

   A. Are you a fire management professional? (Circle Yes / No)
   Yes *(If indicated "yes," please skip to Question 8)*
   No

   B. Please indicate your educational/professional background (Circle corresponding letter)

   a. Environmental Sciences
   b. Arts
   c. Humanities
   d. STEM
   e. Social Sciences
   f. Medicine
   g. Business
   h. Other:_____

2. Prior to attending the exhibition, how would you rate your level of understanding of the ecological role of fire in Michigan ecosystems? *(Please circle)*

   Advanced *Moderate* *Basic* *Poor* *None*

3. After attending the exhibition, how would you rate your level of understanding of the ecological role of fire in Michigan ecosystems?

   Advanced *Moderate* *Basic* *Poor* *None*

4. Prior to attending the exhibition, how would you characterize your level of support for the use of prescribed fire as a land management tool?

   High *Moderate* *Neutral* *Low* *None*

5. After attending the exhibition, how would you characterize your level of support for the use of prescribed fire as a land management tool?

   High *Moderate* *Neutral* *Low* *None*

6. Prior to attending the exhibition, how would you characterize your level of concern regarding the exclusion of fire in Michigan ecosystems?

   High *Moderate* *Neutral* *Low* *None*

7. After attending the exhibition, how would you characterize your level of concern regarding the exclusion of fire in Michigan ecosystems?

   High *Moderate* *Neutral* *Low* *None*

8. Which element(s) of the exhibition were most effective at conveying ecological information?
    a. *Video installation*
    b. *Sculpture ("Carrying the Torch")*
    c. *Paintings and print ("That Which We Protect" and all paintings)*
    d. *Found-object collage ("It's Your Choice?)*
    e. *Text accompaniment*
    f. *Other/additional comments:* _____
    _____

9. Which element(s) of the exhibition were most engaging or thought-provoking?
    a. *Video installation*
    b. *Sculpture ("Carrying the Torch")*
    c. *Paintings and print ("That Which We Protect" and all paintings)*
    d. *Found-object collage ("It's Your Choice?)*
    e. *Text accompaniment*
    f. *Other/additional comments:* _____
    _____

10. *For fire management professionals only:* After viewing the exhibition, how would you characterize the effectiveness of the exhibition as a tool for public engagement?
    Very effective
    Moderately effective
    Somewhat effective
    Not very effective
    No effective
    *Other/additional comments:*_____
    _____

11. Would you be willing to participate in a short follow-up interview between February 14 and March 31, 2022?
    Yes
    No

    If yes, please provide contact information:
    Name: _____
    Email address: _____
    Phone number (optional): _____

APPENDIX 5: SURVEY COMMENTS

General Comments

“I think it all plays well together. I think the sculpture and children's book really catch the general public's attention though. The text is definitely a must just because RX fire is such [a] complex topic and there are certain pieces (sculpture, book, etc.) that really draw you in visually, and from there discussion and thought can form. I think we do a very poor job of getting "fire" into the public's mind, and this draws people in and can get them actually thinking about fire as a tool and not just worries about not bringing a bucket and shovel on their camping trip.”

“The curation and movement of the exhibit was extremely effective in building understanding”

“The exhibit was a dream come true! Thank you so much”

"I am on the board of the Washtenaw Elementary Science Olympiad. I do nature ed programs for elementary students. Your book is beautifully educational and emotional. If you don't have the desire to turn your work into a book, I'd still highly recommend making it a web resource. It's outstanding.”

"Yes! How can we get more people to see it and can we use some elements somehow in the future?"

"I'm an artist focused on climate issues. Your children's book is charming, informational and engaging. Terrific exhibition--congrats!"

"I'm not an art major student, but one thing I want to comment is that the high quality of the artwork makes me "forget" to think about the idea it's trying to convey. For example the "Succession I, II, III"'s excellent color and stroke overwhelmed me so that 99% of my mind is appreciating the artistic merit instead of thinking ecosystems."

"I think the video and sculpture draws people in while the text provides great context."

"Loved experiencing the flipped narrative on what they're been saying about fires for years."

"Cover the main points. Information given through text, realistic image, artistic image, plus for kids. Very thorough!"

"I live close to arboretum where there is management fires annually, so it was nice to see the video."

"Loved all of it. Thanks for doing this!"

"All elements form a cohesive whole. I love the way you situated MI Rx in the context of fire more generally."

"Amazing and beautiful"

Comments associated with survey question 8 ***(Which element(s) of the exhibition were most effective at conveying ecological information?)***

“Sequence of displays"

"I loved the series of 3 paintings on the back wall--felt a sense of "flames of green" overtaking the prairie and it was an effective metaphorical reversal."

"Especially on the found object collage"

"I think it was the combination of all exhibitions conveys it! I especially loved the sound effects thrown in."

"Succession"

"Text was very informative. Pictures capture the eye, text captures the mind. Would like larger print captions.".

"I think that my primary source of new information was the print (text), but they were emotionally supported by the artwork."

"Great for kids!"

"I like the combination. They all reinforce each other."

“"What about how humans can live beside fire again? How do we mitigate public fear over legitimate fears of accidental fire line-jumping or air quality?”

"All! Amazing job, each piece worked to teach!"

"Water color paintings, Gillian Moore's paintings super. They are 3D effect paintings and very impressive techniques and thoughts! Thank you, acknowledgement was very appreciated. It is very important!"

"Loved it ALL, really impressive and important work."

"These artworks are very good at expressing feelings, real information is also needed"

"Wide range of styles--could be effective as a group show or competition"

Comments associated with survey question 9 ***(Which element(s) of the exhibition were most engaging or thought-provoking?)***

"Great work"

"Succession series especially"

These one needs to interpret somewhat rather than just being told. So use one's brain differently" (about the paintings and print)

"Very impactful and effective in all ways."

"This looks negative to fires" *referring to the sculpture*

"Cranston II--nice"

"I especially love the last painting" *referring to the self portrait of the artist*

APPENDIX 6: SAMPLE INTERVIEW GUIDE

Carrying the Torch Interview Guide

Interviewee:
Interview Date:

Hello, thank you so much for taking the time to meet with me to talk about your experience of the Carrying the Torch exhibition. I so appreciate your willingness to contribute to this research, both through filling out a survey and agreeing to this interview. The interview will take approximately 20 – 25 minutes, during which time I will ask you some questions about your visit.

To take a step back, the study I am conducting evaluates the arts as a means of communicating scientific concepts from ecology. Were you able to review the short video summary of the show? [If "No": Would you like to take a few minutes now to review on your own?

Link to Video: https://drive.google.com/file/d/1u32yCLXk-NxnqoSoaGK7NiaqrR8LlYUq/view?usp=sharing

Link to Catalog: https://drive.google.com/file/d/1EecDsZkDn-PMat9cFZCAEGktWWR7NJf1/view?usp=sharing

Icebreaker questions

Can you tell me a little bit about yourself?

What sorts of past experiences have you had with fire?

Introductory *(2 – 5 minutes)*

1. Could you try to take yourself back to before you saw the show. If I asked you about your opinions about wildfire, or fire on the landscape, what sort of things might've come to mind?

2. What sort of things were you thinking about once you left the show?

As you likely recall from the survey you filled out, I asked three sets of questions: one about how the exhibition may have contributed to building ecological understanding, how it may have increased support for the use of prescribed fire, and how it may have inspired increased concern about fire exclusion in southern Michigan. The next few questions will cover the responses you indicated for those three categories. [Include survey in chat]

A. Level of Understanding *(3 – 5 minutes)*

So according to your survey, you went into it with _____ understanding, and you left with a _____ level of understanding.

1. Can you tell me a little bit about what happened there? How did your understanding change?

2. Can you remember anything about the show that influenced your understanding?

3. What was it about [them] that shaped your thinking?

B. Level of Support *(3 – 5 minutes)*

According to your survey response, you said that you were _____ supportive of prescribed fire before the show, and after the show you were _____ supportive.

1. I'm interested in reconstructing that with you. Can you try to recall how you support changed over the course of the exhibition?

2. Can you remember anything about the show that influenced your support?

3. What was it about [them] that shaped your thinking?

C. Level of Concern *(3 – 5 minutes)*

According to your survey response, you said that you had a _____ level of concern about the ecological repercussions of fire exclusion before the show, and after the show you had a _____ level of concern.

4. Can you try to recall how your concern changed over the course of the exhibition?

5. Can you remember anything about the show that influenced your concern?

6. What was it about [them] that shaped your thinking?

D. Concluding Questions *(5-10 minutes)*

7. Were there any other dimensions of your experience that weren't described by understanding, support, or concern? Did you take something else from it that I haven't asked about?

8. Some people might say that we just need more data to be available to the public to increase awareness in the face of environmental challenges. Others say that providing more facts isn't going to change anything and people need to connect with science emotionally. What do you think about this debate?

9. Is there anything you would like to add about your visit to the exhibition?

APPENDIX 7: STUDENT RESPONSES

After students from EAS 501-119 visited the *Carrying the Torch* exhibition on February 15, they were asked to reflect on their experience of the exhibition and the assigned reading for the week as part of a written assignment for the course. The assigned reading was a past study investigating visitor responses to an integrated art-science exhibition about the role of climate change in influencing fire behavior in the Western U.S. (Colavito et al. 2020). Excerpts from their written reflections are provided here as supporting evidence.

"I also thoroughly enjoyed Gillian's Carrying the Torch exhibit. My favorite pieces were the succession piece and the one with the oak tree carrying fire cans. I think these two did the best job of telling a compelling story that would get someone to change their mind about fire, particularly the oak tree installation, as this directly shows nature embracing fire. I will be really interested to know what the end results of her surveys end up being. I wonder if placing the exhibit on a college campus will make any difference from having it in a public place away from college, since you're more likely to get children, families, and a wider-range of educational levels somewhere else."

"This experience was genuinely my favorite presentation yet. It was so empowering to see a student not much older than myself elevate their coursework beyond the classroom. It was eye-opening to learn that the reading for this week prompted some of Gillian's pieces. I appreciated the way her exhibit visualized her professional and personal trajectory. It integrated her experience as a Forest Service employee, curiosities and curricular exploration as a student, and her current residence in Ann Arbor. In this way, it was not only her work on display, but her person as well, and I think that is truly beautiful. It was clear that Gillian has so much passion for fire ecology, and since it is also a subject that I am very interested in, this was a great experience. I am eager to learn more about her experience and the ways in which other artists are grappling with this conflict between the cultural rejection of fire and the ecosystem's thirst for it."

"From the reading (and the exhibit) I liked the idea of a survey to measure how awareness of fire for restoration had increased in the visitors. In previous classes we discussed not being able to know who and how we are impacting so this is a great solution to that. The three outcomes of the collaborative art exhibit in the reading shows that art can tackle multiple climate change issues and get multiple points across rather than just one. Unfortunately I missed the class to go see Gillian's 'Carrying the Torch' so I went the next day on my own time. It was a beautiful set up and I loved every piece that was in the gallery. There was a clear theme of fire and she had multiple different mediums (sculptures, paintings, sound, etc). The first piece you see when you walk in is her biggest piece of an oak tree holding many drip torches with its branches. I loved this message

because people often suppress fire and think that it is bad for the environment, however the tree is embracing it and the torches are one with the tree. My favorite thing about the paintings is that they had movement to them even though they are paintings, which made the flames feel alive and real."

"I really enjoyed going to see Gillian Moore's exhibit. I knew her from a class on forest fire systems, but did not know about her artistic skills and so the event was illuminating and inspiring. It was brave of her to display her art publicly like that, and it was very good. I especially liked the large fabric piece and the succession painting sequence.

I think the idea of communicating restoration ecology science through art is creative. I have subscribed to the understanding coming from BEC that learning facts by themselves can have little effect on pro-ecosocial behavior. However, approaching the underlying emotional and value profiles of individuals is shown to have more significance in determining pro-ecosocial behavior. Perhaps the communication of scientific fact in an artistic package is more conducive to long-term behavioral changes, as the information is processed on a more personal level.

There is a big issue with forest fire prevention in the American West. Smokey the Bear was an effective campaign in that it is memorable. However, I'm not sure that it was the driving cause of unhealthy prevention of forest fires. The campaign was successful in tandem with the reality that the managing agencies subscribed to the same prevention policy. If there was a Smokey the Bear campaign, but it was associated with managing agencies, I doubt it would have had the same impact on citizen forest fire behavior. Nor do I think that citizens are the major preventers of forest fires; I think that once again falls on the managing agencies. It is possible that this kind of exhibit may help Forest Service administrators change the way they manage land, and that is something I support. From the forest fire class, it is clear that the NFS and BLM are lagging dangerously when it comes to institutions' adaptive management policies. Though there is no substitute for seeing the forests burn in terms of impacting behavior, hopefully exhibits like these can combine effective science with value statements around our forests to start making progress on institutional change."

"Going to North Campus to see "Carrying the Torch" by Gillian Moore was a super fun experience and I learned a lot more than I expected to. I love Gillian's work and how she uses many different mediums and styles to express how important wildfires can be. Going into the exhibit, I had known that forest fires could restore habitats with nutrients and allow re-growth, but I thought we should avoid them at all costs. After the exhibit, I realized that controlled wildfires can be helpful and some organisms need plains to survive. I previously thought that forest growth was a good thing no matter what! I also did not know that Michigan in the past did not have so many forests and contained more plains than the present day. In addition, I did not know that indigenous tribes used

wildfire to control habitats and ecosystems which is another example of Native American culture and traditions being denied."

"The exhibits at Gillian Moore's presentation were equally interesting and informative. I really liked the piece with the green colors and gold leaf to show the disappearing of certain types of ecosystems. I also liked how she asked for our interpretations of the pieces before explaining her intention with them. She was right that, while art and science collaborations like the one in the reading are becoming more common, you don't usually see the same person doing both the art and the science.

My favorite part was at the end when she had us create our own art. This allowed me to express my only disagreement with Gillian's work. I disagreed with her conception of Smokey the Bear – I do not think that the science communicators who created him were trying to say that all forest fires are bad. Instead, I think they were trying to keep people from being careless, just like a warning about preventing kitchen fires does not mean that you oppose using fire to cook with. Still, I agree that the forest service should do more to teach people about the ecological benefits of fire.

"Gillian's exhibit was wonderfully done at conveying the importance and miscommunication of fires in the US. We are all taught at young ages to fear fire and that they are a dangerous, out-of-control force that destroys all life. Gillian helped to change that narrative, however, by showing that fires do not have to be big or dangerous and often actually help natural life thrive. Fires were used by indigenous peoples for generations to help maintain ecosystems, and by suppressing them, more damage has occurred. Reflecting all of this through art as Gillian did showed her personal connection to fires alongside acting as a way to celebrate science through art. I thought her goal with the questionnaire was a great way to interweave these two areas, to see if art can act as a way to present scientific facts."

"It improved my understanding of prescribed burns as a whole as well as throughout Michigan. I was able to recall examples of over-vegetation from my childhood and how landscapes (notably farms) can suffer from improper fire management. I feel this will forever impact my perception of "natural" areas, such as forests, national/state parks, etc. which might suffer from over-vegetation or lack of biodiversity."

"I thought visiting the art exhibition was very insightful on the use of art on educating the public on environmental issues. I initially didn't know much about how prescribed fires could be beneficial to the environment. I knew that fires were used to combat invasive species here in

Ann Arbor but I did not think that native species also relied on them for a healthy ecology. I believe the installation greatly affected my appreciation of prescribed fires not only in MIchigan but all over the United States."

"I really like the idea of analyzing the effectiveness of art installations as is done in the Colavito reading. Is there research on which specific aspects of art installations make them more effective at communicating scientific information? For example, that installation had scientist talks to give more context; are installations that don't provide this context less effective?"