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## Indigenous caretaking of beargrass and the social and ecological consequences of adaptations to maintain beargrass weaving practices

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**ABSTRACT.** Indigenous ecologies have persisted through major social and ecological changes including settler colonialism. Adaptations have been a necessary part of this resilience, however little attention has been given to the consequences of these adaptations for Indigenous Peoples and ecologies. Without exploring these consequences, we are left with an incomplete understanding of adaptation that potentially obscures social and ecological costs associated with resilience. Here we describe the contemporary caretaking of a culturally-significant plant used in weaving traditions called beargrass (*Xerophyllum tenax* Melanthiaceae), and discuss how adaptive practices to maintain biocultural connections to beargrass have influenced both socio-cultural and ecological systems. We ask: (1) How is beargrass stewarded and used today? (2) What are the adaptive practices that Indigenous communities in the Pacific Northwest have used to maintain cultural traditions through changing conditions? (3) What are some of the social and ecological consequences of these adaptations? Through semi-structured interviews with cultural practitioners we identified multiple reciprocal practices that form a basis of the caretaking relationship. In order to compensate for a lack of access to beargrass and lack of ability to exercise sovereignty in land management, practitioners described substituting other weaving materials for beargrass, as well as caretaking substitutions. These adaptations were not uniformly accepted and for some either represented significant cultural losses or placed additional burdens on communities. We also collected ecological field data on beargrass. Using structural equation modeling, we found that a key adaptive practice, the substitution of tree pruning for cultural fire, can replicate key short-term benefits of fire for beargrass populations, but does not appear to replicate longer term benefits. In sum, adaptive practices have allowed beargrass traditions to persist through colonialism, but cannot fully substitute for social and ecological benefits of pre-colonial caretaking, and also result in losses and/or additional burdens for communities. Investigating what adaptations to maintain resilience do in communities, and for whom, is necessary in order to fully appreciate the costs and benefits of adaptations that support resilience through various forms of perturbation.

**Key Words:** *basketry; biocultural conservation; non-timber forest products (NTFPs); resilience; stewardship; traditional ecological knowledge; wildland fire*

### INTRODUCTION

Despite the drastic and traumatic changes wrought by settler colonialism and the imposition of settler ecologies, fragments and even whole Indigenous ecologies remain intact, in part because communities and individuals adapted cultural practices to maintain the interwoven cultural, economic, spiritual knowledge and other practices associated with them (Hatfield 2009, Norgaard 2014, Long and Lake 2018). As such, lessons learned from what makes Indigenous ecologies resilient—defined in this paper following Kyle Whyte’s writing about Indigenous resilience as the building and maintenance of the complex and interdependent moral and cultural relationships Indigenous people have with Indigenous ecologies (Whyte 2018a, 2018b)—to changing conditions can contribute to a theoretical understanding of resilience in both Indigenous and non-Indigenous social-ecological systems (SES; Walker et al. 2004, Folke et al. 2010, Kramer et al. 2017). For example, kincentric relationships to place have been identified as central to Indigenous SES resilience because such relationships foster a sense of moral responsibility to care for the natural world (Ford et al. 2020). Here we define social-ecological systems as linked systems of people and nature (Ostrom 1990). The resilience we discuss in this article is consistent with the commonly used broader definition of

resilience as “the capacity to deal with change and continue to develop” (Stockholm Resilience Centre), but draws specific attention to sustaining moral and cultural relationships within Indigenous ecologies. Understanding what makes Indigenous ecologies resilient is particularly important given that climate and other social-ecological changes will exacerbate many of the challenges of adapting Indigenous ecologies to degradation caused by settler colonialism (Whyte 2017). Moreover, although researchers have examined what enables resilience (e.g., Trosper 2002), less well known are the costs or burdens of adaptation that help maintain this resilience for Indigenous ecologies (Gallardo et al. 2017, Whyte 2017, Mauer 2020). Given that adapting to climate and other social and ecological changes has been shown to confer resilience while simultaneously creating new vulnerabilities and risks (Veland et al. 2013, Burnham and Ma 2018, Eriksen et al. 2021), questions of what is changed, and for whom, through adaptive practices to maintain resilience of Indigenous ecologies, and what trade-offs these choices entail, become essential. Investigating these questions in a settler-colonial state may be particularly relevant because it can help reveal how contextual and historical factors constrain or enable resilience and adaptation and lead to either benefits or costs (Cote and Nightingale 2012).

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Maintaining the resilience of Indigenous ecologies through adaptation is likely to have costs, in part, because the adaptive practices Indigenous peoples choose are constrained by governance structures and political obstructions endemic to the settler-colonial state (Tyler et al. 2007, Whyte 2014, Whitney et al. 2020). Hill et al. (2020) describe the intersection of Indigenous practices and colonial society through the concept of articulation complexes, defined as the “social formations generated by linkages between place-attached Indigenous people” and the settler nation state in which they reside, and argue that these articulations constrain adaptation choices. For example, local and Indigenous communities dispossessed of their land or who have lost usufruct rights to particular places are unable to practice traditional land-dependent lifeways, which are intimately tied to particular places and human-mediated ecological processes (Charney et al. 2007, Norgaard 2014, Turner 2014). Further, some adaptations may be coercive or perpetuate unjust power structures (Gallardo et al. 2017), meaning that despite adaptation Indigenous ecologies are not fully rebuilt or maintained because articulation complexes that disrupted Indigenous ecologies in the first place remain intact.

Under these circumstances, to carry on traditions and to maintain their relationships with particular plants, animals, and places, Indigenous and other marginalized communities have adapted some cultural practices (Gallardo et al. 2017, Hill et al. 2020). In some cases, substitutions of one plant or animal for another within a cultural practice may be considered adaptive (Pfeiffer and Voeks 2008). In other cases, the substitution of management practices to maintain connection and fulfill stewardship responsibilities to particular places or species may be the chosen pathway (Gallardo et al. 2017). Substitutions are not necessarily a new approach nor do they necessarily have negative consequences for Indigenous ecologies. Substitution may be a long-standing practice (Prentiss et al. 2005) and may enhance the biocultural value of ecosystems, for example through the structural substitution by Native Hawaiians of native plants with plants of higher food or medicinal value in forest or wetland ecosystems in Hawaii (Winter et al. 2020). On the other hand, chosen adaptations may be far from the ideal pathway a community would like to pursue, and they also may have other consequences for place-based communities and for the relationships of people to the natural world. For example, the resettlement of Alaska Native communities due to coastal erosion caused by climate change has had disruptive economic and socio-cultural impacts (Dannenberg et al. 2019). Investigating the social and ecological consequences of adaptations for communities that choose them and understanding the costs and benefits of these adaptations from their perspective helps to fill a gap in our understanding of the costs of resilience for Indigenous ecologies, as well as how adaptation influences SESs more broadly.

Here we explore the consequences of adaptation and resilience for Indigenous ecologies through a case study of beargrass (*Xerophyllum tenax* Melanthiaceae) in the Pacific Northwest of the United States. Beargrass is a plant with deep cultural importance, one that has persisted in some Native American communities through colonization and other changing social-ecological conditions (O’Neale 1932, Trospen and Parrotta 2012, Baldy 2013, Hatfield 2009). Beargrass is a wild-gathered

understory plant used in a wide range of weaving technologies by Native Americans in the Pacific Northwest of the United States and beyond (Hummel et al. 2012, Baldy 2013). Beargrass is used for baskets, typically as weft, including as overlay, as well as for regalia. Regalia uses include wraps or braids for dresses, necklaces, quivers, and dance aprons (Hummel et al. 2012). Beargrass also provides food, habitat, and/or nesting material for animals from insects to grizzly bears (Hummel et al. 2012). Although the plant is not considered biologically rare or threatened, it is locally reported to be difficult to access in desired habitats for gathering (O’Neale 1932, Levy 2005, Shebitz et al. 2009, Hummel and Lake 2015, Dobkins et al. 2016). Beargrass is reported to be declining in parts of its range because of commercial leaf harvest for the floral greens industry and fire suppression and exclusion (Levy 2005, Peter and Shebitz 2006, Shebitz et al. 2008, 2009). The challenge these changes present to harvest and subsequent weaving is not only reduced plant abundance, but also changes in leaf characteristics that result from changing fire regimes. In the absence of traditional fire management, desirable leaf qualities, such as long, supple leaves, are becoming more difficult to find (Rantz 2003, Levy 2005, Shebitz et al. 2009, Hummel and Lake 2015, Hart-Fredeluces et al. 2021). In addition, insufficient access to quality leaves has also been reported as a result of confusing permitting processes, road closures, and lack of time and/or financial resources for gathering trips (Dobkins et al. 2016).

Because understanding both the social and ecological costs and benefits of adaptation is needed to ensure that the reciprocity of Indigenous ecologies is maintained or reestablished, we report on findings from semi-structured interviews focused on current care, use, and management of beargrass, as well as ecological data collected over three years on beargrass growth following wildfire to assess the costs and benefits of resilience. The ecological data is included because it provides an opportunity to understand the impacts of caretaking adaptations that were shared through interviews with Indigenous weavers. Our research questions are as follows: (1) How is beargrass stewarded and used today? (2) What are the adaptive practices that Indigenous communities in the Pacific Northwest have used to maintain cultural traditions through changing conditions? (3) What are some of the social and ecological consequences of these adaptations? We discuss interviewee descriptions of contemporary Indigenous caretaking of beargrass and the adaptive practices interviewees describe that have maintained these caretaking relationships through changing conditions. We explore the social and ecological consequences of these adaptations, including the ecological impacts of substituting tree pruning, the removal of tree branches, for the cultural fires that would have traditionally maintained quality beargrass habitat.

## METHODS

### Qualitative study

To better understand contemporary caretaking of beargrass and the benefits and costs of adaptive practices to maintain beargrass traditions, we rely on data collected through interviews and participant observation with weavers who use beargrass in baskets, braids, or other regalia in the Pacific Northwest United States. To start, the first author connected with weavers through

multiple avenues, including attending weaving or community gatherings, attending Tribal council committee meetings, and calling or emailing weavers directly after finding them through web searches. The first author also advertised the project through newsletters and social media, and received leads from Tribal council members and resource managers about weavers she could contact. Finally, the first author attended the Northwest Native American Basket Weavers Association annual basketry gathering and the Intertribal Timber Council's annual meeting in 2015 allowing her to connect with weavers and resource managers in person, facilitating later meetings and conversations. Two of the weavers in this project were also her weaving teachers. Two Native American youth (daughters of a weaver who uses beargrass) worked as field assistants on the ecological project described below. Some of the key data for this paper comes not from interviews, but from conversations, observations, and learning from these youth and Tribal collaborators through the above-mentioned activities.

As has been described by other authors, past and continuing disrespect of Native American communities by researchers and the broader uninformed public meant that developing collaborations for this research occurred in sensitive socio-political territory, and that trust building was a slow and reiterative process (Smith 2013, Hummel and Lake 2015). In addition, other community concerns, including safety and financial security, sometimes superseded interest in spending time on this kind of project. Further, in some communities, beargrass is no longer well-known or used. One member of a Tribal community estimated that only two families on the reservation still used this plant. For these reasons, identifying and getting to know weavers for this study was not a simple process. Although the first author originally intended to work within a single Tribal community in Oregon, given the context described above, she decided to broaden the target community for the study to the Pacific Northwest region. This allowed the first author to increase the pool of potential Native American weavers in the study, and to explore some of the variability in care, gathering, preparation, and use of beargrass, as well as variation in the stage of cultural revitalization of beargrass traditions within different Tribal communities.

This study draws upon co-authors' knowledge, the experiences described above, the process of learning to weave with beargrass, and semi-structured interviews completed in 2017 and 2018 with seven Native American weavers who all use beargrass and are considered experts or leaders in their community for their cultural knowledge and/or skills. Weavers interviewed lived in Northern California, Oregon, or the Olympic Peninsula of Washington State and were members of The Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians of Oregon, The Confederated Tribes of Siletz Indians of Oregon, The Makah Tribe, The Tuscarora Nation, of Cherokee ancestry, or descendants of the Karuk Tribe. The Tuscarora and Cherokee Nations are located in the eastern United States. The weavers of these Tribal affiliations or of these ancestries have lived for decades in the Pacific Northwest and have learned to weave with beargrass from Native American weavers who are members of tribes in the Pacific Northwest. Though most forms of weaving were historically practiced by women (O'Neale 1932, Nordquist and Nordquist 1983, Suttles 1990), in this study, four weavers were women and three were men.

We have focused this article on themes common across interviews. Any knowledge or experiences only shared by a single participant are identified as such in the Results section. Given that we only had one interviewee participant from northern California, our results place more emphasis on experiences of weavers in Oregon and Washington who use beargrass. The interview process involved prior informed consent through signature for the interview and for the audio recording (University of Hawai'i at Mānoa, IRB Human Studies, CHS 23677). Interviews ranged from 50 minutes to 2.5 hours. Interviews were transcribed verbatim and returned to interviewees for their records and to correct errors. Each interviewee was invited to be an author on this paper and four of seven accepted this invitation. Each interview was coded in Atlas.ti version 9 and analyzed using the three-step process, noticing-collecting-thinking, described by Friese (2019), as well as through memoing, tables, and network diagrams (Friese 2019, Tracy 2019).

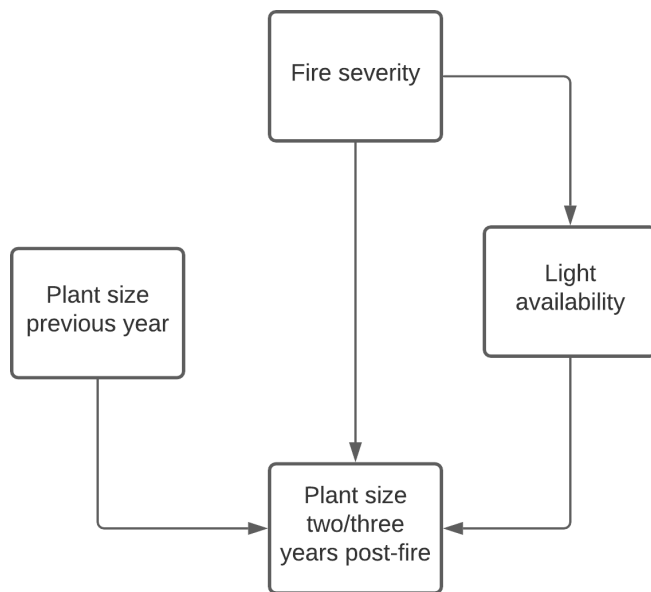
### **Ecological study**

To better understand how well tree pruning as an adaptive practice can substitute for cultural fire in order to promote resilience, as well as to understand the costs and benefits of this adaptation, we drew upon data collected by the first author for a study that investigated how fire, light availability, soil moisture, and leaf harvest influence beargrass growth, survival, and reproduction (Hart-Fredeluces and Ticktin 2019). Our analysis of this ecological data was motivated by the caretaking adaptations described by interviewees in this study. We were interested to see to what extent increased plant growth following fire was caused by increased light availability, which would suggest tree pruning may be a reasonable substitute as tree pruning also increases light availability for beargrass plants. In our plant demographic study, over 2000 beargrass plants across three sites on the Mount Hood National Forest in Oregon were tagged and monitored annually for three years. Each of the three sites experienced a wildfire in 2014 and were monitored from 2015 to 2017. At each site, one 4x4 m plot was established in each of three different fire severity areas using a stratified random approach. High-severity plots had nearly 100% mortality of trees, and most beargrass plants were partially or fully scorched with lower leaves burned off. Low-severity areas had < 50% tree mortality, and most beargrass plants with leaves singed to a white color, but not scorched or burned off (Hart-Fredeluces and Ticktin 2019).

Both light availability and fire have been shown to have a positive impact on beargrass growth (Hart-Fredeluces and Ticktin 2019) and greater light availability is associated with denser populations of beargrass plants with higher frequencies of flowering (Peter et al. 2017). However, given that light availability is influenced by fire severity, regression models could not disentangle the effects of these two factors. For this study, we therefore built structural equation models to investigate the extent to which the positive impacts of fire on beargrass growth are due to the indirect effect of increased light availability that follows a fire, compared with the direct effects of fire such as nutrient inputs and reduced competition (Fig. 1). This mediation analysis was conducted in R (version 4.0.3; R Core Team 2020) using the "piecewiseSEM" function (version 2.1.0), also known as confirmatory path analysis (Shipley 2000, Lefcheck 2016). Individual models were built with "lmer" function in the lme4 package (version 1.1.23; Bates et al. 2015) with site included as a random effect. All variables were measured at the individual plant level. Light availability was

calculated as percent canopy openness from hemispheric photos taken above each plant. Plant size was the basal diameter of plants measured with digital calipers. Fire severity was measured as the degree of leaf-loss, leaf char, and leaf singeing on an ordinal scale from 0 to 3.5 in increments of 0.5 that was treated as continuous for this analysis. Given that we collected data over three years, we built the SEM models for growth from 2015 to 2016 (one to two years post-fire), and for 2016 to 2017 (two to three years post-fire). Plant size the previous year was included in all models because it was an important predictor of size in the subsequent year. We assessed model fit with Fischer's C and used tests of directed separation to examine missing pathways. Based on the results of the tests of directed separation, we added correlated error between light availability and size the previous year in the one to two years post-fire model. Non-significant pathways (only one pathway in one model) were removed to arrive at the best-supported model.

**Fig. 1.** Theoretical model to assess the relative strength of direct and indirect effects of fire on plant growth one to two and two to three years post-fire. All pathways are hypothesized as positive effects.



When interpreting our findings, we compared the relative strength of direct effects of fire on growth (the path from fire severity to plant size two/three years post-fire) to the indirect effects mediated by light availability (the path from fire to light availability multiplied by the path from light availability to plant size two/three years post-fire; Fig. 1). A finding that the indirect effects of fire through light availability better explain beargrass growth than direct effects suggests that tree pruning and other adaptive practices to increase light availability are good substitutes for cultural fire. A finding that there are stronger direct effects suggests tree pruning may be a poor substitute for fire from an ecological perspective.

## RESULTS

Although most interviewees described beargrass weaving traditions as uncommon or reawakening in their communities, with the exception of the northern California region where there are more weavers, the ceremonial significance of beargrass and its irreplaceability in particular weaving techniques and for regalia provided the motivation for adaptations to maintain beargrass traditions despite the ongoing challenges to accessing, caring for, and promoting the use of beargrass. Although the types of leaves desired by weavers and the preferred weaving styles varied somewhat by region, similar to reported by Hummel and Lake (2015), the importance of reciprocity between people and plants in beargrass caretaking and the connection of maintaining beargrass traditions to the well-being of the overall community were common themes across interviews. Environmental caretaking adaptations were described as placing extra burdens or risk on practitioners, while substitution of other weaving materials for beargrass was generally considered an unacceptable adaptation given the cultural losses that accompanied substitutions.

### Reciprocity and community cohesion through beargrass caretaking

Cultural practitioners described Native communities and beargrass populations as embedded in a web of reciprocity. Contemporary environmental caretaking practices provided benefits to beargrass populations, while these same practices, in addition to the associated weaving traditions, provided benefits back to the community. Caretaking practices described included monitoring the health of plants by visiting the plants across multiple, ecologically diverse sites throughout the year, offering prayers, pruning competing vegetation, burning individual beargrass plants, harvesting sustainably, and keeping areas hidden and therefore protected from other people including commercial harvesters (Table 1).

*We visit the gathering sites throughout the year to communicate with the plants, pray, check in on how they are doing and see if we need to care for them in any way. By doing this throughout the year we can see how the seasons are changing and be ready when it is time to gather, since each year things change.* Sara Siestroom (Hanis Coos)

Gathering leaves in a way that followed cultural protocols benefitted beargrass populations by reducing harvest intensity and increasing opportunities for gatherer observations of plant population status. Some practitioners described providing a gift of gratitude, such as a song, tobacco leaves, or other plant offerings when gathering. Some mentioned introducing themselves or asking permission of the plants to be gathered. In contrast to commercial harvest, beargrass leaves are harvested at a low intensity that is non-lethal. This practice of not overharvesting was mentioned by most interviewees.

*What I've always been taught is when you're gathering from the Earth you have that respect and understanding of what the Earth is giving back to us ... for our lives ... and going and asking. Sometimes a tree or plant are not ready to be harvested. I kinda know. I feel that I'm guided ... I usually know when it's time for me to stop harvesting.*



**Table 1.** Reciprocity within beargrass traditions.

How Native people care of beargrass	What beargrass provides to Native people
Prayer	Connection to ancestors and ancestral traditions
Offerings (song, sacred plants)	The ability to perpetuate traditional ceremonies
Periodically checking in on plant populations	Cultural and familial identity through weaving technologies specific to tribes and to families
Pruning surrounding vegetation	Connection to the world of nature through tending and gathering
Burning plants or populations	Flowering as an indicator that the huckleberries are ripe
Mindful, low impact leaf harvesting	Gifts (of leaves to baskets) as a way to show care and love for other family and community members
Protection from activities destructive to plant populations	Social cohesion through processing together and sharing
Appreciation	Artistic expression
	Confidence gained through learning and mastering weaving techniques
	Beauty appreciated in baskets or regalia
	Feeling of security and greater health for babies held in baby baskets
	A way to hold and carry important objects
	Survival skills
	Livelihood option

*It's just like a spirit tells me: "okay, that's enough," and "do you need all that for what you want to work with?" So that's how I do it, and I say thank you.* Elaine Rice St. Martin (Tuscarora/Seneca)

Practitioners described the many roles and values that beargrass, in turn, provides to community members, including supporting Tribal identity, filling ceremonial roles, and connecting community members to traditions and to ancestors (Table 1). Most interviewees described gathering leaves for others, including those who were not physically able to gather. One participant described leaving areas close to roads and easier to access for elders to gather leaves, while younger and able-bodied people traveled further to gather. Beargrass traditions provided an opportunity for cultural practitioners to teach others in their community and provided a way for community members to connect with the outdoor environment. Finally, the cleaning and preparing of leaves is something described as done together with others, contributing to a sense of community.

*The processing of it, you can do it by yourself, but I find there is a lot more social strength together. When people are around, you know, and you are like, hey, I got a big old thing of beargrass I just got and drying it out in park or something, out in the sunlight, and you get together and have a few friends help you sort it and like, hey, I would like to weave with bigger stuff and I would like to weave with smaller stuff and see people kinda divvy up what they have ... getting together and many hands, light work ... and for sure a little story and you have a little transfer of knowledge in the process of preparing your beargrass.* Frank K. Lake (Karuk descendant/USFS)

**Adapting to a lack of access to beargrass and a lack of ability to exercise sovereignty in land management**

Major barriers to the continued practice of beargrass traditions included lack of access to areas with suitable beargrass, as well as lack of sovereignty over areas where beargrass occurs, resulting in a lack of ability to employ fire as a management tool, which in turn degrades leaf and habitat quality. In addition, commercial harvest and industrial forestry practices, such as the use of herbicide, were mentioned as barriers to access and continued practice. Another major barrier to continued practice of beargrass traditions was the time, labor, and skill involved in

carrying for, gathering, preparing, and weaving with beargrass. The modern demands on people's time made continuing these practices challenging.

In response to these challenges, cultural practitioners have adapted in numerous ways. Given the lack of sovereignty over areas where beargrass occurs, which are often federal lands, practitioners have worked to keep beargrass areas on public lands hidden from outsiders. In response to the inability to broadcast burn beargrass habitat, practitioners have gathered in places after they are burned by wildfires, have built partnerships with outside forest management agencies to promote desired forest management, have conducted informal patch burns, or have employed pruning of surrounding and competing vegetation to allow beargrass plants to receive more light, simulating some of the effects of fire.

*We do a lot of pruning activity and so far, that is getting us at least usable materials and maybe not the best quality, but we are able to get good volumes of it for teaching others and for our own uses.* Getting by. Robert Kentta (Siletz)

*In our contemporary times our land management strategies are severely inhibited by outside (state, federal, and private) interests in many of our traditional sites. Our beargrass gardens are on state lands. Fortunately, they happen to be in a protected area, so they will not be subject to disturbance by construction, etc. and we have rights to use the space and gather the plants uninhibited (kind of). That means, we can gather there but we could not say, use burn management. The kind of management we do is to remove litter or trees or such that might have fallen on the beds and keep the beds hidden from view by blocking any trails to them that may have emerged in our absence.* Sara Siestrem (Hanis Coos)

*... A lot of people are culturally taught by an elder or a weaver that they go out with and then they go back to those same places, but without the frequency of fire and without the rotational burns that get in certain areas, you are more or less, say the weavers in California, following the smoke. You see wildfire or a prescribed fire someplace, and you have slightly beargrass habitat, you go check and see.* Frank K. Lake (Karuk descendant/USFS)

Several practitioners discussed substituting other materials for beargrass as an adaptation to lack of access, lack of time, or lack of skill in processing the leaves. Most interviewees, however, considered beargrass irreplaceable because of its specific ties to ceremonial use, and because beargrass is required for specific weaving styles and various types of regalia items.

*For us, we haven't done a lot of switching ... especially when you get to something like basket caps that are for ceremonial use ... for our style of southern Oregon/northern California, it pretty much takes those traditional materials to make a decent cap. There is something about that not wanting to break with those traditions, especially for those ceremonial use pieces. ... I am glad that we haven't found an easily accessible commercial material to replace our roots and sticks. That is part of the connection, to places, but also the ancestral tradition. It's kinda something special, I guess, to work with sticks and roots.* Robert Kentta (Siletz)

### **The social and ecological consequences of adaptations to maintain beargrass traditions**

#### *Interview results*

Substitution of other materials for beargrass has an array of consequences for cultural traditions and communities. On the one hand, substituting an easier-to-access or easier-to-weave-with material may allow traditions to persist despite a lack of access or lack of skill, interest, or time to learn to weave with beargrass. On the other hand, weavers described a number of losses that accompany this substitution. Among these were: a loss of family identity in terms of basket weaving style as all baskets would start to look similar, a loss of connection to ceremonies that require the beargrass including rites of passage and funerary traditions, a loss of weaving techniques as some techniques cannot be duplicated with other materials, a loss of connection to the natural environment as some substituted materials such as raffia are store-bought rather than wild-harvested, and a loss of the beauty, color contrast, and natural color fading that occurs on baskets and regalia woven with beargrass.

*A lot of people don't like using beargrass in basketry because it's too much work. Reed canary grass is sometimes used as the substitute for beargrass because it's more accessible; it's invasive actually here in western Washington and you don't have as much preparation work to do for using it in basket making ... Weavers are all switching to other materials. They're using artificial sinew for wrap twining now which works but doesn't even look the same because they don't get that slant in the stitches so I think it looks terrible. The stitch is more straight up.* Jo Ann Hart (Cherokee descendant)

In response to the question: What is lost when people are no longer using beargrass and are substituting other materials? June Ward explained the following:

*The history and the carrying on of the family traditions, and of patterns and styles ... when they start doing all these similar raffia and sinew baskets, you don't know who they belong to because there is not history of color, of style, it's all gone ... so it's hard to differentiate, who it belongs to. That is a really serious concern of losing*

*style and techniques ... the families of the beargrass weavers ... they'd make a different whale or a different bird, or bright vibrant colors, or some families would just stay with certain colors.* June Ward (Makah)

Similar to the substitution of other weaving materials for beargrass, substituting novel environmental stewardship practices for pre-colonial caretaking practices has both social and ecological consequences. Stewarding beargrass habitat on public lands, keeping those areas hidden from others, and conducting informal patch burns entail risks to those practitioners as these caretaking practices are not sanctioned by state or federal resource managers. In the case of tree pruning as a substitute for cultural burning, the time and effort involved to achieve the desired effect is much greater, presenting further burdens upon community members.

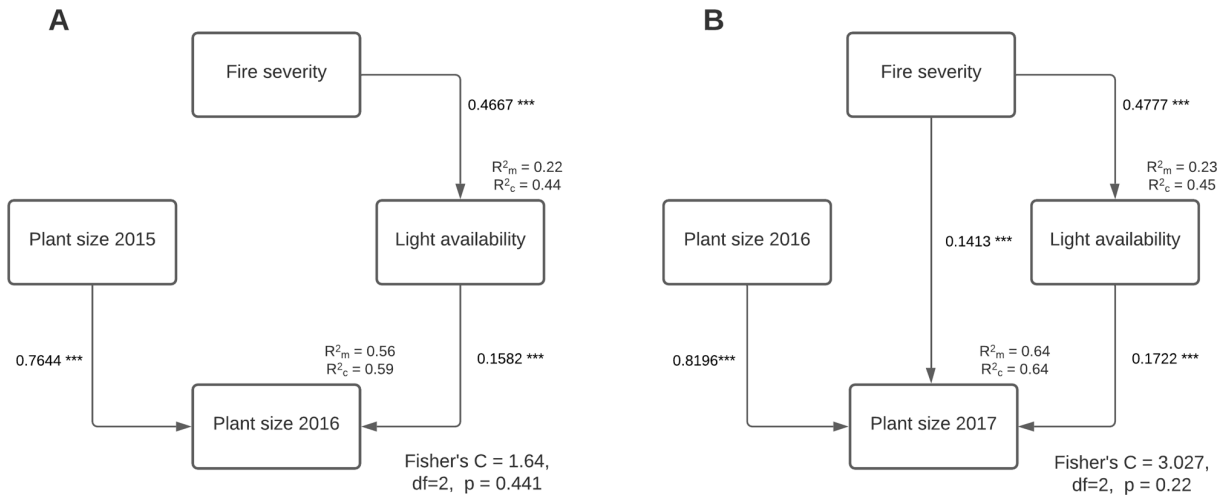
#### *SEM results*

From an ecological perspective, our structural equation models suggested tree pruning was potentially a good substitute for fire one to two years post-fire (Fig. 2A), whereas direct effects of fire became more important to beargrass growth two to three years post-fire, suggesting pruning may not substitute well for the longer term ecological benefits of fire (Fig. 2B). One to two years post-fire, all the significant effects of fire severity on plant growth could be explained through the impact of fire on light availability. This suggests that light availability is a major driver of increased plant growth shortly after fire and that other ways of increasing light availability may substitute well for fire in this time period. Two to three years post-fire, the best-supported model retained the pathway for direct impacts of fire on growth and this path was somewhat stronger than the indirect path, suggesting that other impacts unrelated to light availability are important to plant growth in this time period and therefore that environmental caretaking practices that only increase light availability may not substitute well for the impacts of fire on growth that occur two to three years post-fire.

### **DISCUSSION**

Achieving resilient Indigenous ecologies requires attention to the underlying social and political processes that may undermine or enable adaptation pathways toward resilience (Cote and Nightingale 2012, Hill et al. 2020), as well as to the additional consequences of adaptation beyond helping to confer resilience (Veland et al. 2013, Burnham and Ma 2018). In this study, we found that adaptations to maintain resilience were accompanied by both social and ecological costs. Environmental caretaking adaptations in the context of a lack of sovereignty in land management and particularly the loss of ability to burn beargrass habitat, were described as placing extra burdens or risk on practitioners, while substitution of other weaving materials for beargrass was generally an unacceptable adaptation given the cultural losses it entailed. The lack of ability to access appropriately stewarded beargrass is also a violation of Indigenous rights, as it impedes the continuation of cultural practices protected by the UN Declaration of Rights of Indigenous Peoples. Oberholzer Dent et al. (in press) further describe the Indigenous environmental justice concerns around denied access to the gathering sites used by basketweavers. Knowledge shared in the qualitative study inspired the construction of structural equation models of ecological data,

**Fig. 2.** In the best-supported model for plant growth one to two years post-fire, light availability mediated the impact of fire severity on plant growth, whereas direct effects of fire on plant growth were not significant ( $p = 0.44$ ;  $n = 858$ ) (A). From two to three years post-fire, in the best-supported model, the direct effects of fire on growth were somewhat larger (0.14) than the indirect impacts mediated by light availability (total indirect:  $0.4777 \times 0.1722 = 0.0823$ ;  $n = 852$ ) (B). Shown are standardized path coefficients. \*\*\* indicates  $p < 0.001$ . Site was included as a random effect in both models. Site explained about half of the variation in light availability and very little to none of the variation in growth. Fisher's  $C > 0.05$  indicates a good model fit.



which suggested that a key environmental caretaking substitution, tree pruning, cannot fully compensate for the benefits of fire to beargrass plant growth. At the same time, reciprocity in beargrass caretaking and the connection of maintaining beargrass traditions to the well-being of the overall community were common themes across interviews. Given this reciprocity, our study explores both social and ecological costs and benefits of adaptations to maintain resilience, and it suggests that considering these costs and benefits is essential to developing a complete understanding of resilience.

The costs and benefits of adaptations to maintain resilience seen in our study can be understood in the context of articulation complexes (Slack 1996, Hill et al. 2020), or intersecting settler-colonial and Indigenous ecologies that constrain or enable these adaptation choices. One key aspect of the current articulation complex between Indigenous and colonial ecologies in the Pacific Northwest of the United States is that property ownership and land management rights are mostly retained by the colonial state, despite some recognition of Tribal retained rights (e.g., U.S. Forest Service 2007). In this context, we find that adaptive practices to allow for continued caretaking of beargrass are heavily constrained by such property rights, creating new risks and burdens for Indigenous communities even as they sought to mitigate the risk of losing beargrass ecologies. At the same time, the articulation complex enables some opportunities for beargrass caretaking through partnerships.

Imposed constraints in the current articulation complex include the criminalization of Indigenous cultural practices, such as subsistence hunting and gathering, by the settler-colonial state (Deur and James 2020), which can have wide-ranging negative impacts on Indigenous communities, from financial to spiritual (Norgaard and Reed 2017, Norgaard 2019). Because adaptive

practices intended to maintain moral and reciprocal relationships with living and nonliving components of Indigenous ecologies need to replace or simulate these criminalized practices, they are likely to pose legal risks to cultural practitioners. In our study, this was the case for adaptive practices intended to replace the use of cultural fire, a key part of beargrass caretaking. Even seemingly innocuous adaptive practices described in this study such as pruning vegetation or keeping areas hidden from the public may fall into a fuzzy legal territory because of property ownership laws, or may invite questioning or harassment from land managers and federal/state law enforcement. In addition to legal risks, practices such as informal patch burns, gathering beargrass after wildfires, or pruning surrounding trees all place a heavier time and financial burden on cultural practitioners than more traditional methods.

Although current property rights that comprise the contemporary articulation complex impose legal risks and time burdens on beargrass gatherers, they also may enable adaptation through partnerships between Tribal Nations and federal land management agencies (Hunter 1988, Marks-Block and Tripp 2021). In interviews, these partnerships were described as helping to achieve fire and fuels management that supported the needs of beargrass cultural practitioners by building mutual understanding with partners and creating space for Tribal advocacy. In some cases having Tribal citizens working on federal and state land management crews facilitates this understanding. Though Tribal Nations also conduct their own cultural burns, such partnerships also allow for the combining of resources between Tribal and federal land managers for management actions, such as cultural burns, and may provide a space to advocate for increased Tribal self-determination (Diver 2016).

In addition to the risks and burdens that attend adapting beargrass caretaking practices, the adaptive practice of tree pruning to replace cultural fire also may have negative consequences for beargrass populations and habitat. From an ecological perspective, our work suggests that tree pruning to increase available light to beargrass plants may be an adequate substitute for fire as a caretaking adaptation in terms of its impacts on beargrass growth in the short term, but that it cannot replicate the longer term (2+ years) benefits of fire. This may be due to the additional ecological benefits fire brings to beargrass populations, including reduced competition among plants and changing ratios of available soil nutrients (Peterson and Reich 2008, Kong et al. 2018). Further, beargrass is not the only plant or animal that benefits from Indigenous fire management and therefore substituting tree pruning for cultural fire is inherently limited in its capacity to mimic the more holistic benefits of pre-colonial caretaking. For example, cultural fire is used to reduce insect pest populations (Kimmerer and Lake 2001), and insects were reported by several interviewees at beargrass gathering sites. These interviewees mentioned that a fire would likely help reduce insect pests that degrade leaf quality, but they did not have the authority to conduct cultural burns. It is also unclear from our interviews and SEMs if tree pruning would adequately substitute for other aspects of the beargrass life cycle beyond growth, as we did not investigate impacts on beargrass flowering, vegetative reproduction, and survival. However, an experiment on the Olympic Peninsula showed that mechanical removal and clearing of understory vegetation did increase beargrass shoot production, demonstrating the benefits of pruning likely extend beyond growth alone (Shebitz and James 2010). Despite its benefits, our results suggest that tree pruning cannot fully substitute for fire in order to maintain the resilience of Indigenous ecologies.

In addition to adaptive caretaking substitutions, cultural practitioners discussed when and how they and others might replace beargrass with other weaving materials, as well as the intangible losses accompanying such substitutions. Similar to the broader ethnobotanical literature (Pfeiffer and Voeks 2008, Fonseca and Balick 2018), substitution was discussed as part of ongoing processes of adaptation to changing conditions. Although substituting other weaving materials for beargrass was an unpopular adaptation among interviewees, substituting one material for another has occurred broadly in weaving traditions for a fairly long time (O'Neale 1932, Schlick 1994). Substitution of other weaving materials for beargrass demonstrates the adeptness and strength of weavers in maintaining cultural traditions through changing conditions and benefitted Indigenous ecologies by maintaining weaving traditions in some form. For example, novice weavers may be introduced to basketry with materials that are easier to obtain and work with, increasing the likelihood they would continue with the practice before graduating to use more challenging materials like beargrass. Potential costs of substitution included the reduced integrity of ceremonial uses and partial loss of family identity. As shared by some interviewees, the presence of beargrass on baskets and regalia signifies that those items are intended to be used in ceremony; raffia or other substituted weaving materials would not be able to replace that ceremonial purpose. Further, when baskets and regalia are woven with replacements for beargrass the basket

or regalia lack specialized weaving techniques that can only be produced with beargrass. Those techniques may be particular to families, and so the substitution of weaving material homogenizes the weaving products. As all baskets start to look similar, there is a loss of family-specific identity formerly produced through a diversity of weaving styles. Further, the use of store-bought replacement materials like raffia may lead to a loss of spiritual connection to the forest as gathering and caretaking are no longer required, and this disconnection to the forest is known to have negative emotional and psychological consequences (Norgaard and Reed 2017). Such substitutions may also erode the quality of connections between people within communities, as the practices of harvesting and processing leaves are no longer practiced together.

## CONCLUSION

The care of culturally significant species and places is integral to the resilience of Indigenous ecologies. Although maintaining these caretaking relationships through changing conditions has always required adaptation, this is particularly true in response to the violence and disruption of colonialism. Although Indigenous ecologies have sometimes been touted as exemplars of resilience, several authors have pointed to the flaws in the resilience framework as applied to Indigenous ecologies. This paper contributes to these critiques by bringing into view the often ignored consequences of adaptations to maintain resilience in the context of ongoing colonialism. In this study, we found that adaptations to maintain beargrass weaving traditions in the Pacific Northwest of the U.S., while helping to confer resilience, tended to result in additional risks and burdens for communities. These adaptations, in some cases, also entailed cultural losses as well as ecological changes that may not be conducive to long-term maintenance of beargrass habitat. This study highlights the importance of investigating what adaptations to maintain resilience do in communities, and for whom, in order to fully appreciate the social and ecological costs and benefits of adaptations to maintain resilience through various forms of perturbation.

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## Data Availability:

*The data that support the ecological findings of this study are openly available in the Forest Service Research Data Archive: <https://doi.org/10.2737/rds-2019-0028>. The specific .csv file used for analysis and the accompanying R code are available through the Open*



Science Framework at <https://osf.io/edfrhl>. Apart from two interview transcripts that were published in the PhD dissertation available here, <https://www.proquest.com/dissertations-theses/fire-ecology-native-american-cultural-use/docview/2305944723/se-2?accountid=11563>, no other interview data are publicly available because interviewees did not grant permission for full transcripts to be publicly available. Ethical approval for this research study was granted by University of Hawai'i at Mānoa, IRB Human Studies, CHS 23677.

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