RESEARCH ARTICLE

Public opinion about management strategies for a low-profile species across multiple jurisdictions: Whitebark pine in the northern Rockies

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Abstract
1. As public land managers seek to adopt and implement conservation measures aimed at reversing or slowing the negative effects of climate change, they are looking to understand public opinion regarding different management strategies.
2. This study explores drivers of attitudes towards different management strategies (i.e. no management, protection and restoration) for a low-profile but keystone tree species, the whitebark pine \textit{Pinus albicaulis}, in the Greater Yellowstone Ecosystem. Since the whitebark pine species has a range that traverses different federal land designations, we examine whether attitudes towards management strategies differ by jurisdiction (i.e. wilderness or federal lands more generally).
3. We conducted a web and mail survey of residents from Montana, Idaho and Wyoming, with 1,617 valid responses and a response rate of 16%.
4. We find that active management strategies have substantially higher levels of support than does no management, with relatively little differentiation across protection and restoration activities or across different land designations. We also find that support for management strategies is not influenced by values (political ideology) but is influenced by beliefs (about material vs. post-material environmental orientation, global climate change and federal spending for public lands) and some measures of experience (e.g. knowledge of threats).
5. This study helps land managers understand that support for active management of the whitebark pine species is considerable and non-partisan and that beliefs and experience with whitebark pine trees are important for support.

KEYWORDS
forests, Greater Yellowstone Ecosystem, human dimensions, New Environmental Paradigm, public land management, public lands, public opinion, whitebark pine
1 | INTRODUCTION

Natural resource managers look to the best science available to inform management decisions, and this science increasingly includes human dimensions research (Charnley et al., 2017). Human dimensions research focuses on the complexity of interactions between the natural and social worlds (Manfredo, 2008; Watson, McFarlane, & Haener, 2004). As natural resource managers work to adopt and implement conservation measures aimed at reversing or slowing negative effects of climate change, human dimensions research sheds light on support for management decisions as well as drivers that explain variation in attitudes (Bennett et al., 2017).

From the individual to the institutional levels, inputs into decision-making include factors such as beliefs, values, attitudes and experiences/knowledge (Ajzen, 1991; Bennett et al., 2017; Konisky, Hughes, & Kaylor, 2016). Empirical human dimensions work assesses these factors to inform environmental management decisions (Dressel, Ericsson, & Sandström, 2018; McFarlane & Boxall, 2000; van Riper et al., 2019). Studies tend to focus on the environment’s visible or tangible goods, such as accessible forests (Abrams, Kelly, Shindler, & Wilton, 2005), wildlife (Beckmann & Lackey, 2018), fish (Rodgers & Wilcox, 2018), open space (Barry, 2014) and invasive species (Marshall, Friedel, van Klinken, & Grice, 2011). However, what factors shape individual attitudes and public opinion (i.e. aggregate views) when the objects of management decisions are non-charismatic but critical parts of the environment that are not readily visible or accessible? Furthermore, do attitudes and public opinion vary depending on whether the natural resource is in designated wilderness areas or on federal land such as National Parks and National Forests? The purpose of this study is to understand public support for different management strategies for a critical, low-profile species whose range crosses political boundaries. Specifically, this study examines management strategies for whitebark pine (WBP Pinus albicaulis), a species found in upper subalpine habitat in the Greater Yellowstone Ecosystem (GYE).

2 | WHITEBARK PINE

Whitebark pine is a keystone species with a range in western North America (Tombback, Arno, & Keane, 2001; see Figure 1 for the GYE). WBP trees grow in harsh, high-elevation conditions and are thus largely out of the view of the average individual. Recent warm, dry winters; mountain pine beetle Dendroctonus ponderosae outbreaks and the emergence of the non-native disease white pine blister rust Cronartium ribicola are responsible for precipitous declines in WBP in western North America (Amberson, Keville, & Nelson, 2018; Bollenbacher, Graham, & Reynolds, 2014; Smith, Shepherd, Gillies, & Stuart-Smith, 2013). The long-term viability and function of WBP are non-trivial, as these agencies have different land management mandates. For example, the US Forest Service (USFS) and the Bureau of Land Management (BLM) are working collaboratively as members of the Whitebark Pine Subcommittee of the Greater Yellowstone Coordinating Committee to counter these threats to WBP (G.Y.C.C. Whitebark Pine Subcommittee, 2011). This inter-agency coordination to manage WBP is non-trivial, as these agencies have different land management mandates. For example, the USFS and BLM manage for multiple use, whereas the NPS manages for preservation and public enjoyment (Hoover, 2019). These agencies also manage federal lands designated as ‘wilderness’ areas. Sixty-eight per cent of the WBP distribution in the GYE is within designated wilderness areas (Hansen et al., 2016), where management plans undergo additional scrutiny to ensure any action is aimed at preserving the character of the wilderness as legislated in the Wilderness Act of 1964 (The Wilderness Act, 1964). Specifically, Section 2(a) of the Wilderness Act states that wilderness areas ‘shall be administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness’. These restrictions include bans on motorized and mechanized vehicles for recreation or resource extraction purposes. Section 2(c)

FIGURE 1 The range of whitebark pine in the Greater Yellowstone Ecosystem across multiple jurisdictions

services, there is greater potential for rock slides, erosion and flood conditions, disrupting water regimes on which people rely (Tomback et al., 2016). WBP trees also provide a food source for various wildlife, including grizzly bears (Iglesias et al., 2015); without high-elevation food sources, grizzlies are likely to forage at lower elevations, possibly increasing human-bear conflicts. Given the rapid loss of WBP, this tree species is considered an early responder to climate change and qualifies for endangered species protection (Sniezko & Winn, 2017), making strategic forest management of WBP critical.

Agencies such as the National Park Service (NPS), the US Forest Service (USFS) and the Bureau of Land Management (BLM) are working collaboratively as members of the Whitebark Pine Subcommittee of the Greater Yellowstone Coordinating Committee to counter these threats to WBP (G.Y.C.C. Whitebark Pine Subcommittee, 2011). This inter-agency coordination to manage WBP is non-trivial, as these agencies have different land management mandates. For example, the USFS and BLM manage for multiple use, whereas the NPS manages for preservation and public enjoyment (Hoover, 2019). These agencies also manage federal lands designated as ‘wilderness’ areas. Sixty-eight per cent of the WBP distribution in the GYE is within designated wilderness areas (Hansen et al., 2016), where management plans undergo additional scrutiny to ensure any action is aimed at preserving the character of the wilderness as legislated in the Wilderness Act of 1964 (The Wilderness Act, 1964). Specifically, Section 2(a) of the Wilderness Act states that wilderness areas ‘shall be administered for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and enjoyment as wilderness’. These restrictions include bans on motorized and mechanized vehicles for recreation or resource extraction purposes. Section 2(c)
further specifies that such areas retain their ‘primeval character and influence’ and that permanent improvements and human habi-
tations are therefore impermissible.

The Whitebark Pine Subcommittee, working collaboratively across agency jurisdictions and land designations, has identified two broad active management strategies for WBP (G.Y.C.C. Whitebark Pine Subcommittee, 2011). One is protection strategies (e.g. pruning, chemical treatment and prescribed fire) and the other is restoration strategies (e.g. planting, removing competing trees). Taking no action is another option. Thus, there are three potential management strategies for WBP—no management, protection and restoration—that would result in differing feedbacks in the ecosystem.

Understanding public support for different management decisions is widely recognized as important for the adoption of forest health policies (Guerrero et al., 2018) and is becoming common prac-
tice for managers (Bethmann, Simminger, Baldy, & Schraml, 2018). Consequently, land managers are interested in public opinion about WBP management. However, it is unclear how familiar people are with WBP given that it is not an attention-grabbing, charismatic spe-
cies and that its range is at high elevation. Additionally, most people likely have no tangible experience with WBP ecosystem services, making human valuation of this tree species difficult. Accordingly, we investigate the following research questions. First, what are individual attitudes and public opinion about general management strategies for a non-charismatic and relatively inaccessible but criti-
cal species across different land jurisdictions? Second, what factors shape such individual attitudes and public opinion?

3 | PUBLIC OPINION ABOUT MANAGEMENT STRATEGIES ACROSS JURISDICTIONS

Accounting for public opinion about forest and wildlife manage-
 ment decisions is well-travelled territory in the human dimen-
sions literature (Abrams et al., 2005; Barry, 2014; Bauer, Wallner, & Hunziker, 2009; Vaske & Donnelly, 1999). Attitudes towards and preferences for different management decisions are typically the phenomena researchers are trying to explain. Attitudes are positive or negative evaluations of an object (Fulton, Manfredo, & Lipscomb, 1996), while preferences typically involve some type of explicit comparison among alternatives. Investigators generally measure attitudes with an ordinal variable assessing the level of support for, acceptance of, agreement with, or satisfac-
tion with management options or strategies (Frank, Johannson, & Flykt, 2015; Rodgers & Wilcox, 2018; Urbanek, Nielsen, Davenport, & Woodson, 2015; Vining, 2003). We offer three ob-
servations about this human dimensions literature. First, studies of various place-based forest strategies often reveal higher levels of support than anticipated by forest managers (Fuller, Marzano, Peace, Quine, & Dandy, 2016; Urquhart et al., 2017). Second, the wildlife and land conservation decisions at the centre of similar research queries tend to involve tangible resources that people know and see. Third, these studies tend to focus on restoration strategies and do not sufficiently distinguish among restoration, protection and taking no action. Consequently, we examine the following hypothesis:

**Hypothesis 1** There are statistically different levels of support among management strategies (i.e. no management, protection and restoration).

Further, while some studies investigate species occupying mul-
tiple jurisdictions (Cumming et al., 2014; Kovacs, Haight, Mercader, & McCullough, 2014), little attention is paid to managing across political boundaries. The Whitebark Pine Subcommittee is charged with managing this keystone species to avert further mortality even though much of WBP’s range is in formally designated wil-
derness. Consequently, we explore public opinion about man-
gement strategies in areas formally designated as wilderness as compared to federal lands more generally. We propose the follow-
ing hypothesis:

**Hypothesis 2** There are statistically different levels of support for each management strategy (i.e. no management, protection and restoration) in wilderness as compared to other federal lands.

4 | PREDICTORS OF MANAGEMENT ATTITUDES

Studies typically include some explanation for variation in atti-
tudes towards particular management options or strategies. Many human dimensions studies use a cognitive hierarchy framework to inform statistical models predicting support for natural resource management decisions (Jacobs, Vaske, & Sjøtma, 2014; Vaske & Donnelly, 1999). The basic idea of the cognitive hierarchy framework is that stable, deep values provide the foundation for belief patterns, which, in turn, shape more specific attitudes and then behavioural intentions and behaviours themselves (Fulton et al., 1996; Jacobs, Vaske, Teel, & Manfredo, 2012).

Basic or core values (e.g. freedom, security) are posited to be stable and difficult to change (Jenkins-Smith & Sabatier, 1994; Rokeach, 1973). By definition, values are how important something is to someone (Weisberg, Krosnick, & Bowen, 1996). Value conflict theory is premised on the idea that beliefs and attitudes can be predicted by differing political values (Chambers, Schlenker, & Collisson, 2013; Segal & Cover, 1989). As such, it is common in evaluating environmental preferences to account for political ideol-
ogy as an expression of core fundamental values (McCright, Xiao, & Dunlap, 2014). In this study, we propose the following hypothesis:

**Hypothesis 3** Support for WBP management strategies (i.e. no man-
gagement, protection and restoration) is explained by political values.
Again, core values are foundational and inform beliefs in the cognitive hierarchy framework (Vaske & Donnelly, 1999). Beliefs are internal thoughts about what is true in the world, regardless of the veracity of the thought (Weisberg et al., 1996). An individual’s belief system is independent from any one particular environmental topic. For example, scholars apply beliefs about material (e.g. economic and physical security) versus post-material (e.g. self-expression and belongingness) environmental orientations (Dunlap, 2008; Inglehart, 1997; Riepe & Arlinghaus, 2014) across a variety of management issues. Researchers similarly apply beliefs about climate change (Konisky et al., 2016) and about the role of government in solving environmental problems (Steel & Weber, 2001) across management issues. In this study, we propose the following hypothesis:

Hypothesis 4 Support for WBP management strategies (i.e. no management, protection and restoration) is explained by beliefs (environmental orientation, climate change and government spending).

Studies using the cognitive hierarchy framework also often account for knowledge or experience (Frank, Glikman, Sutherland, & Bath, 2016; Teel & Manfredo, 2010), even though such concepts are not explicit parts of the framework. Knowledge about science, hazards or natural resources has been found to shape attitudes towards these phenomena (Sturgis & Allum, 2004; Watson et al., 2004), although knowledge deficit theory has come under considerable criticism (Jones & Crow, 2017). Furthermore, personal experience is generally understood to inform attitudes and risk perceptions (Ejeta, Ardalan, Paton, & Yaseri, 2018; Wachinger, Renn, Begg, & Kuhlicke, 2013). For example, a growing body of literature finds that children experiencing nature as young people are more likely to have nature-friendly attitudes as adults (Collado, Staats, & Corraliza, 2013). Thus, the examination of attitudes towards management strategies often includes some assessment of experiences (Hajar & Kozak, 2015). In this study, we propose the following hypothesis:

Hypothesis 5 Support for WBP management strategies (i.e. no management, protection and restoration) is explained by experience.

Finally, cognitive hierarchy framework studies typically control for demographic variables previously found to have some association with attitudes or beliefs. Researchers often account for variables such as sex, age, education level, ethnicity and income in some fashion (Abrams et al., 2005). Despite some mixed results (Marquart-Pyatt, 2012), most studies find that individuals from higher socio-economic levels (Sulemana, James Jr., & Valdivia, 2016), women (Xiao & McCright, 2015) and younger individuals (Jones & Dunlap, 1992) have higher levels of environmental concern. Based on such previous findings, we propose the following hypothesis:

Hypothesis 6 Support for WBP management strategies (i.e. no management, protection and restoration) is predicted by demographics.

5 | METHODS, DATA AND ANALYSES

Our study employed a cross-sectional design with a survey methodology to test our hypotheses. Below we describe our sample, our ethics statement, the survey instrument and variables used in our specifications, and our methods of statistical analysis.

5.1 | Sample

We distributed the questionnaire initially to 9,000 randomly selected addresses in Montana, Wyoming and Idaho, proportional to the population in each state (Table 1). We made multiple efforts to increase response rates (Dillman, Smyth, & Christian, 2014). Two letters were sent in 2-week increments to direct potential respondents to a web version of the survey into which they would enter an authentication code to prevent duplicate entries; a hard copy of the survey with a business reply envelope was sent to non-respondents after another 2 weeks. We then drew another random sample of 1,000 new addresses, again proportional to state population. In this round, we sent only a paper version of the survey, with no web option. For all 10,000 randomly selected residents, we also randomly assigned an incentive value ($0, $1 or $2), with corresponding response rates of 9.9%, 17.3% and 21.7%.

This human subject research was approved by Montana State University IRB #ES040215-EX. We obtained informed consent on both the paper and web versions of the survey. We explained that the purpose of the survey is to understand opinions about management of whitebark pine trees on federal public lands from residents who live in or near the region where these trees grow. We also indicated that they were randomly selected; their participation is voluntary; they must be 18 years of age or older to participate; they may skip questions they prefer not to answer; the survey would take about 15 min to complete; all results are reported collectively, which means their responses are never connected to them individually.

In conducting robustness checks of results, we found (a) no inter-state variability; (b) no differences between web and paper samples.

TABLE 1 Survey samples, responses and modes

| State   | Valid sample | Responses (rate) |
|---------|--------------|------------------|
| Idaho   | 5,010        | 742 (15%)        |
| Montana | 3,135        | 627 (20%)        |
| Wyoming | 1,785        | 248 (14%)        |
| Total   | 9,930        | 1,617 (16%)      |

| Mode     | Responses (rate) |
|----------|------------------|
| Web      | 1,010 (63%)      |
| Mail     | 607 (37%)        |
| Total    | 1,617 (100%)     |

Note: Of the 10,000 total addresses sampled, 70 were invalid due to an inability to deliver or the individual being deceased.
5.2 | Questionnaire and variables

The questionnaire (web and paper) was designed first to assess people’s experience with WBP by asking whether participants had seen WBP and two of the major threats to WBP—mountain pine beetles and white pine blister rust. Given that the researchers expected respondents’ experience to be limited due to the high elevation of the species and its non-charismatic nature, the next section of the survey provided information and basic educational materials about WBP trees and their decline in the Northern Rockies. These materials included a picture of the tree and a map of its range (Figure 1).

Using the management strategies identified by the Whitebark Pine Subcommittee (G.Y.C.C. Whitebark Pine Subcommittee, 2011), the questionnaire then provided the following definitions and examples to ensure validity of responses about management strategies.

- **No management**: allow changes (like tree mortality) to occur without human intervention.
- **Protection**: active steps to reduce known threats to the ecosystem (e.g. pruning branches with blister rust, preventative chemical treatments for insects, prescribed fires to remove competing species).
- **Restoration**: active steps to return an ecosystem to a previous condition (e.g. planting new whitebark pine trees, removing competing trees).

To assess attitudes towards these management strategies (i.e. positive or negative evaluations of management strategies as attitude objects), one question asked respondents to identify their level of support for each of these three strategies on federal lands using a 5-point Likert response scale. Then, we provided a brief explanation of wilderness designation, followed by a question asking respondents to identify their level of support for each of these three strategies in wilderness designated areas, using the same 5-point Likert response scale (Table 2).

Following the assessment of management strategies, the questionnaire consisted of items that operationalized the concepts of **values**, **beliefs** and **demographics**. We asked a question about political ideology for values and questions about the New Environmental Paradigm (NEP) orientation (Dunlap, 2008), global climate change and federal spending to measure beliefs. Finally, we accounted for sex in the demographics (Table 3). Supplement A

### Table 2: Descriptive statistics for management strategy variables

| Management strategy on federal lands | No management % (n) | Protection % (n) | Restoration % (n) |
|--------------------------------------|---------------------|------------------|-------------------|
| **Strongly support**                 | 4.3% (54)           | 33.8% (438)      | 41.3% (536)       |
| **Support**                          | 10.7% (135)         | 47.6% (617)      | 39.9% (518)       |
| **Neutral**                          | 25.3% (318)         | 12.7% (165)      | 14.0% (182)       |
| **Oppose**                           | 32.6% (411)         | 3.9% (50)        | 3.9% (51)         |
| **Strongly oppose**                  | 27.1% (341)         | 2.1% (27)        | 0.9% (12)         |
| **Total**                            | 100.0% (1,259)      | 100.1% (1,297)   | 100.0% (1,299)    |
| **Range**                            | 1–5                 | 1–5              | 1–5               |
| **Mean**                             | 2.325               | 4.071            | 4.166             |
| **Standard deviation**               | 1.111               | 0.896            | 0.875             |

| Management strategy in wilderness areas | No management % (n) | Protection % (n) | Restoration % (n) |
|-----------------------------------------|---------------------|------------------|-------------------|
| **Strongly support**                    | 7.3% (92)           | 27.8% (360)      | 32.6% (424)       |
| **Support**                             | 13.5% (170)         | 42.4% (549)      | 36.8% (479)       |
| **Neutral**                             | 27.0% (340)         | 18.0% (233)      | 19.3% (251)       |
| **Oppose**                              | 30.0% (378)         | 8.0% (104)       | 8.1% (105)        |
| **Strongly oppose**                     | 22.2% (279)         | 3.8% (49)        | 3.2% (42)         |
| **Total**                               | 100.0% (1,259)      | 100.0% (1,295)   | 100.0% (1,301)    |
| **Range**                               | 1–5                 | 1–5              | 1–5               |
| **Mean**                                | 2.538               | 3.824            | 3.875             |
| **Standard deviation**                  | 1.184               | 1.044            | 1.057             |

Notes: Not all columns sum to 100.0% exactly due to rounding. The table only includes cases used in the later regression analyses. Consistent with the later regression analyses, ‘unsure’ responses have been recoded to the ‘neutral’ category for construction of the table. Coding began with ‘1’ for ‘Strongly oppose’ and increased to ‘5’ for ‘Strongly support’.
provides the text and coding for items used in constructing variables for this study.

5.3 Methods of statistical analysis

We test our hypotheses primarily using Wilcoxon signed-rank tests for matched pairs (Wilcoxon, 1945) and ordered logistic regression analysis. We use the Wilcoxon tests in comparing attitudes across management strategies and land types, as the data for the ordinal variables are matched at the individual respondent level. These tests are appropriate as the hypotheses (H1 and H2) deal with comparison of variable distributions rather than association between variables. However, we apply Chi-square tests in a follow-up analysis exploring relationships among the six ordinal management strategy variables in an attempt to clarify the substantive significance of the Wilcoxon signed-rank test findings.

We employ ordered logistic regression to account for the ordinal nature of the dependent variables (Long & Freese, 2014) in testing the remainder of the hypotheses, some of which involve continuous independent variables. Ordered logistic regression permits the calculation of post-estimation statistics to assess the marginal influence of one variable on the other. To facilitate interpretation of the regression results, we calculate changes in predicted probabilities for the dependent variables taking on particular values as the independent variables change values. Predicted probabilities are a common way to demonstrate marginal effects with ordinal dependent variables, as the regression coefficients can be difficult to interpret otherwise.

6 RESULTS

We first examine differences in support for the three management strategies (H1 and H2). We then explore how different factors contribute to variation in attitudes towards management strategies in wilderness areas and on federal lands more generally (H3–H6). We present our results by hypothesis.

Hypothesis 1 There are statistically different levels of support among management strategies (i.e. no management, protection and restoration).

For WBP management strategies on federal lands, the Wilcoxon tests show statistically significant and substantively large differences between attitudes towards no management and towards active management strategies (both restoration and protection; Table 4). To exemplify the substantive meaningfulness, many more respondents chose a higher response category of support for restoration (1,104) than for no management on federal lands. The reverse was true for only 104 respondents. The results are similarly significant and substantively meaningful when asking about wilderness. Furthermore, support for restoration is higher than for protection on federal lands in a statistically significant manner. However, we question the substantive meaningfulness of this particular finding. Of the 1,546 respondents, 1,068 provided the same response for the two variables, and the number of respondents choosing a higher response category for restoration over protection (276) is similar to the number choosing a higher response category for protection over restoration (202). The statistical significance in

| Variable                     | Description                                                                 | Mean | SD  | Observed range |
|------------------------------|-----------------------------------------------------------------------------|------|-----|----------------|
| Values                       | Political ideology 7-point response scale from strongly conservative (=1) to  | 3.593| 1.598| 1.00–7.00      |
|                              | strongly liberal (=7)                                                       |      |     |                |
| Beliefs                      | Post-material environmental orientation 9-item New Environmental Paradigm     | 3.392| 0.686| 1.22–5.00      |
|                              | averaged scale; higher values indicate more post-material belief (α = 0.81) |      |     |                |
|                              | Global climate change index 2-item index combining concern and perceived     | 3.674| 1.272| 1.00–5.00      |
|                              | problem status with regard to global climate change; higher values indicate  |      |     |                |
|                              | greater concern                                                            |      |     |                |
|                              | Pro-government spending View of federal spending on land management; highest  | 0.620| 0.331| 0.00–1.00      |
|                              | value indicates too little spending                                         |      |     |                |
| Experience                   | Whitebark experience index 3-item additive index of experience with whitebark| 2.054| 0.800| 0.00–3.00      |
|                              | pine, beetles and blister rust; higher values indicate more experience      |      |     |                |
|                              | Recreation How often respondents recreate on public lands on an annual       | 4.004| 1.304| 1.00–5.00      |
|                              | basis; increasing categories of frequency                                   |      |     |                |
| Demographic                  | Female Respondent sex (female = 1, all others = 0)                           | 0.341| 0.474| 0.00–1.00      |

Note: Means and standard deviations are calculated based on the largest number of cases included in the regression analyses (1,301).
this case seems to be mostly a function of the large sample size. Additionally, this same comparison for wilderness does not reveal a statistically significant difference \((p = 0.087)\). Overall, however, there is considerably more support for active management strategies on federal lands and in wilderness areas as compared to the no management option. \(H_1\) is mostly supported.

**Hypothesis 2** There are statistically different levels of support for each management strategy (i.e. no management, protection and restoration) in wilderness as compared to other federal lands.

Table 5 shows the results of Wilcoxon signed-rank tests for each of the three management strategies, comparing wilderness areas and federal lands more generally. Statistically significant differences emerge across all comparisons. Respondents are more likely to favour no management in wilderness areas than on federal lands more generally. Similarly, respondents are more likely to favour protection and restoration activities on federal lands than in wilderness areas. \(H_2\) is supported. However, respondents largely support active management strategies on both forms of land while opposing the no management strategy. Furthermore, the vast majority of respondents chose the same response category for the two variables involved in all pairwise comparisons, again raising some questions about substantive meaningfulness.

Another way to explore and delimit the substantive meaningfulness of these findings is further examination of the extent to which individuals responded to the various management strategies similarly. The Chi-square test of independence is useful for assessing association between these ordinal variables. Table 6 presents the results from Chi-square tests for all 15 pairwise comparisons of the six management strategy variables. In all cases, the responses are highly related. This suggests individuals have a relatively broad attitude towards management strategies that manifests across the six different items. However, as revealed by the Wilcoxon signed-rank tests, individuals do clearly tend to favour protection and restoration activities over no management. Such attitudes are simply related to one another in a strong negative way (e.g. high support for protection tends to go with low support for no management). Finally, some individuals—though relatively few—also distinguish between federal land and wilderness.
Next, we examine the predictors potentially explaining variation in each of the six dependent variables (H3–H6). Table 7 shows the results of six ordered logistic regression analyses on the dependent variables. In general, the independent variables as a whole are more predictive for the federal land dependent variables than they are for the wilderness dependent variables.

In tandem with the regression results, Figure 2 presents the changes in predicted probabilities for the six dependent variables (using the prchange command in STATA 14). The figure includes only calculations for independent variables with statistically significant effects in Table 7. Again, this is a standard method for showing influence on ordinal dependent variables. Each bar in Figure 2 represents the change in likelihood that an individual will choose the particular response given movement from the minimum to the

**TABLE 6** Chi-square tests of association among management strategies

| No manage: federal | No manage: wilderness | Protection: federal | Protection: wilderness | Restoration: federal | Restoration: wilderness |
|---------------------|-----------------------|---------------------|------------------------|---------------------|------------------------|
| No manage: wilderness | >1,700.00 (0.001) | >1,700.00 (0.001) | >2,100.00 (0.001) | >1,700.00 (0.001) | >2,800.00 (0.001) |
| Protection: federal | 738.46 (0.001) | 488.94 (0.001) | 979.53 (0.001) | 860.29 (0.001) |
| Restoration: federal | 610.54 (0.001) | 388.41 (0.001) | >1,700.00 (0.001) | >2,800.00 (0.001) |
| Restoration: wilderness | 387.53 (0.001) | 886.51 (0.001) | 711.03 (0.001) | >1,800.00 (0.001) |

Notes: Variables were measured identically, with codes ranging from 1 (‘strongly oppose’) to 5 (‘strongly support’). The main number in each cell is the $\chi^2$ for the test of independence between the ordinal variables, with the associated $p$ value in parentheses. Rejection of the null hypothesis (i.e. $p \leq 0.05$) indicates that the two variables are associated with one another.

**TABLE 7** Ordered logistic regression analyses for management strategy variables

| No manage fed lands | No manage wilderness | Protection fed lands | Protection wilderness | Restoration fed lands | Restoration wilderness |
|---------------------|----------------------|----------------------|-----------------------|-----------------------|-----------------------|
| Values               |                       |                      |                       |                       |                       |
| Political ideology   | 0.000 (0.040)         | −0.017 (0.039)       | −0.034 (0.042)        | −0.056 (0.040)        | −0.031 (0.041)        |
| Beliefs              |                       |                      |                       |                       |                       |
| Post-material        | −0.206 (0.101)*       | −0.110 (0.100)       | 0.382 (0.108)***      | 0.304 (0.102)**       | 0.362 (0.107)***      |
| environmental orientation |                       |                      |                       |                       |                       |
| Global climate change index | −0.178 (0.059)** | −0.053 (0.059) | 0.316 (0.062)*** | 0.180 (0.059)** | 0.206 (0.061)*** |
| Pro-government spending | −1.165 (0.176)*** | −1.255 (0.178)*** | 1.510 (0.188)*** | 1.375 (0.181)*** | 1.560 (0.186)*** |
| Experience           |                       |                      |                       |                       |                       |
| Whitebark experience | −0.225 (0.068)***     | −0.158 (0.068)*      | 0.233 (0.070)***      | 0.069 (0.067)         | 0.292 (0.070)***      |
| Recreation           | −0.074 (0.041)         | −0.033 (0.041)       | 0.019 (0.043)         | 0.010 (0.041)         | 0.048 (0.042)         |
| Demographic          |                       |                      |                       |                       |                       |
| Female               | 0.014 (0.111)         | −0.125 (0.109)       | 0.375 (0.119)**       | 0.226 (0.112)*        | 0.303 (0.117)**       |

Notes: The main reported values are estimated coefficients, with standard errors in parentheses. All tests are two tailed. The number of cases included for each specification, in order by column, are: 1,259; 1,259; 1,297; 1,295; 1,299 and 1,301.

*p ≤ 0.05; **p ≤ 0.01; ***p ≤ 0.001.

FIGURE 2 Changes in likelihood for supporting or opposing particular management strategies
maximum value of the variable specified along the horizontal axis. Amounts have been converted from probabilities to percentage points for interpretability. All other independent variables in the equations are set at their mean values when making calculations.

**Hypothesis 3** Support for WBP management strategies (i.e. no management, protection and restoration) is explained by political values.

The results reveal that political ideology, as a measure of values, has no predictive power for management strategies (Table 7). Further analysis shows that, on average, respondents identifying as conservative and liberal both support protection and restoration activities and both oppose no management action in federal and wilderness areas. H3 is not supported.

**Hypothesis 4** Support for WBP management strategies (i.e. no management, protection and restoration) is explained by beliefs (environmental orientation, climate change and government spending).

The concept of beliefs is operationalized using three variables. The NEP, measuring one’s material versus post-material belief about the environment, produces statistically significant effects for all dependent variables except for no management in wilderness areas (Table 7). In terms of predicted probabilities (Figure 2), an increase from the minimum (dominant world view) to maximum value (NEP) on the NEP environmental attitude scale increases the likelihood that an individual will ‘strongly support’ protection and restoration strategies across federal and wilderness land designations, with results ranging from 20.3 to 30.9 percentage points. For no management, the NEP only predicts for federal lands, with a 14.2 percentage-point increase predicted for participants to choose ‘strongly oppose’.

In examining the extent to which beliefs about global climate change (greater concern about climate change and belief about immediacy of the impact) predict levels of support for management strategies, we find that beliefs about climate change produce a statistically significant effect in four of the six specifications (Table 7). The predicted probabilities (Figure 2) reveal an increase from the minimum to the maximum value on the global climate change index increases the likelihood that an individual will ‘strongly support’ protection on federal lands by 24.2 percentage points and by 12.9 percentage points for wilderness areas. An equivalent change in the global climate change index increases the likelihood that an individual will ‘strongly oppose’ no management on federal lands by 12.6 percentage points. Furthermore, the likelihood of an individual strongly supporting restoration management activities increases by 18.8 percentage points for federal lands, in contrast to no significant result for wilderness areas.

The results about beliefs surrounding federal spending on land management consistently reveal large effects across all three management strategies in both federal and wilderness land designations (see Table 7). An increase from the minimum (too much spending) to the maximum value (too little spending) for federal spending views increases the likelihood that an individual will ‘strongly oppose’ no management activity by 20.3 percentage points on federal lands and 19.1 percentage points in wilderness areas (Figure 2). In other words, individuals who believe the federal government is spending too little on federal land management are much more likely to express strong opposition to a strategy of no active management. Similarly, an increase from the minimum (too much spending) to the maximum value (too little spending) increases the likelihood that an individual will ‘strongly support’ protection and restoration strategies across federal and wilderness land designations, with these results ranging from 24.1 to 34.2 percentage points. H4 is largely supported.

**Hypothesis 5** Support for WBP management strategies (i.e. no management, protection and restoration) is explained by experience.

The effects for experience with WBP trees are more moderate (Table 7). Time spent recreating on public lands has no explanatory power for any management strategy. However, some statistically significant effects appear when respondents report higher levels of exposure to WBP and its threats. Whitebark experience produces significant effects for no management across both federal lands and wilderness. As seen in Figure 2, an increase from the minimum (no exposure) to maximum value (highest level of exposure) for the Whitebark experience index increases the likelihood that an individual will ‘strongly oppose’ no management strategies across federal and wilderness land designations, 11.9 and 7.4 percentage points, respectively. Such exposure has statistically significant coefficients for active management strategies only on federal lands, with an increase of 14.0 and 19.8 percentage points in the likelihood that an individual would ‘strongly support’ protection and restoration activities, respectively. H5 is partially supported.

**Hypothesis 6** Support for WBP management strategies (i.e. no management, protection and restoration) is predicted by demographics.

Females are generally (but not always) found to be more supportive of environmental protection. In this study, the effects for the female variable are relatively modest, with statistically significant coefficients for three of the six equations (Table 7). As seen in Figure 2, identifying as female increases the likelihood that an individual will ‘strongly support’ protection management strategies across federal and wilderness land designations, 8.1, and 4.4 percentage points, respectively. There is a similar increase of 7.3 percentage points in the likelihood that an individual will ‘strongly support’ restoration activities on federal lands. H6 is partially supported.

**7 | DISCUSSION**

The management of species across political boundaries and land designations (e.g. National Park, National Forest, wilderness area) is a great challenge, given variation in agency missions. Over the last decade in the GYE, public agencies have worked together on bison
(Interagency Bison Management Plan, 2020) and grizzly (USGS Northern Rocky Mountain Science Center, 2020) management solutions. Similarly, the Greater Yellowstone Coordinating Committee is working to straddle these different missions to develop a cohesive management strategy for WBP in the GYE. In contrast to sustained public involvement in bison and grizzly management decisions, there is little public input for management of the non-charismatic WBP. Thus, managers in the GYE are wondering what the public thinks about different management strategies across different jurisdictions.

The case of WBP is of particular importance, as this is a keystone species that qualifies for the endangered species list. Understanding public opinion surrounding management decisions in the GYE is critical to WBP survival in its historical habitats. Restoration management strategies are the most aggressive, whereas protection management strategies are a less aggressive active form of intervention. Importantly, a strategy of no management offers no human intervention, allowing for current changes to occur. Each strategy forecasts different effects on the biophysical environment. In making these decisions, public land managers want to understand public support for management strategies, as well as some of the drivers for varying levels of support. Such information constitutes an important feedback in the system and is a crucial part of human dimensions research (Charnley et al., 2017; Decker, Riley, & Siemer, 2012).

Many human dimension studies on public opinion focus on specific management activities such as different hunting methods (Ryan, Edwards, & Duda, 2009) or different forest controls such as prescribed burning versus thinning (Meldrum, Champ, Bond, & Schoettle, 2020). In contrast, this study seeks to understand public opinion of broader management strategies as defined by their general goals. Though the questionnaire listed specific examples of active management strategies, the attitude questions themselves focused on these three strategies more broadly. Overall, survey respondents express much stronger support for an active management approach (restoration and protection) than for a strategy of no management. This finding is consistent with other studies that find restoration strategies preferable to passive ones (Ostergren, Abrams, & Lowe, 2008).

While some existing research focuses on management challenges across political boundaries (Garrick, Schlager, De Stefano, & Villamayor-Tomas, 2018), this study investigates whether support for various management activities changes as a function of land designation. Even after defining wilderness areas in the questionnaire, our survey finds that respondents extend their support for active management to this more restricted designation. Across both federal land and wilderness jurisdictions, the interested public supports some management activity over doing nothing.

While respondents generally favour active management, the vast majority of them do not make meaningful distinctions between restoration and protection strategies. Instead, we find that respondents appear to be applying more fundamental beliefs to their assessment of specific management activities. Such a finding fits well with the cognitive hierarchy framework, which proposes that broader values and basic belief patterns serve as antecedents for more specific attitudes and behaviours (Fulton et al., 1996; Vaske & Donnelly, 1999; Vaske, Donnelly, Williams, & Jonker, 2001). A consequence of this finding is that federal land managers concerned with having a cohesive WBP management strategy will find general support for protection and restoration strategies, with little concern about the details, among the interested public.

Managers may find it helpful to understand what factors predict support for management strategies in wilderness areas and on federal lands. The cognitive hierarchy framework suggests that values are the base for attitude formation and decision-making (Vaske & Donnelly, 1999). Interestingly, values, as operationalized through political ideology, have no predictive effect in this case. Human dimension studies have found political ideology to be a factor in some cases (Mayer, Shelley, Chiricos, & Gertz, 2017; Nielsen-Pincus, 2011) and not predictive in others (Hiroyasu, Miljanich, & Anderson, 2019; Seidl & Klepeis, 2011). The difference in predictive power may rest on the extent to which the natural resource being managed has been politicized. For example, political ideology captures the typical political value schism found in highly politicized environmental debates such as the debate about climate policies, as these political values influence value orientations in the cognitive hierarchy (Vaske & Donnelly, 1999). Interestingly, those who report conservative and liberal ideologies are supportive of active management interventions for WBP. Knowing that conservation of a relatively obscure tree species is not a partisan issue may be of some relief to land managers, as land use debates can still politically wrought battles (Davis, 2018). However, we cannot rule out the possibility that selection bias in responding to the survey may be influencing this result. Specifically, non-supportive conservatives may have ignored the requests to complete the questionnaire. Additionally, most of our respondents have seen WBP trees, which suggests our sample is more of an interested public than a generally representative one. While the cognitive hierarchy framework proposes that different values lead to different attitudes, our results may indicate that WBP management simply has support across political ideological values.

In contrast, and in line with the cognitive hierarchy framework, beliefs are generally strong predictors of attitudes towards different management strategies. Individuals who have a more post-materialist orientation towards the environment, see greater threat from global climate change and believe federal spending on public lands could be higher all tend to be more supportive of protection and restoration activities. These results largely comport with findings in the human dimension literature, in which beliefs related to biocentrism (Vaske et al., 2001), climate change (Eriksson & Klapwijk, 2019) and trust in federal government (Flint, Qin, & Ganning, 2012) are typically found to predict support for management or policy preferences. The results of our study may reflect a diversification of beliefs within political ideology, as explored by some scholars studying the New American West (Wright, Caserta, & Lund, 2003) or others finding a general ‘greening’ of conservatives (Bliese, 2018).

Experiences may also shape attitudes. The human dimensions literature sometimes finds that experience increases knowledge and familiarity with a natural resource and thereby influences management preferences (Seidl & Klepeis, 2011). While time spent outdoors has no
significant influence on attitudes, this study reveals that experience with the species and with its threats explains support for active management. This result underscores the importance of managers engaging in experiential and other forms of education, especially for species that are non-charismatic and generally out of the public’s view.

Our study has certain limitations that present opportunities for future research. As mentioned, our sample is likely more of an interested public than a generally representative one. We have been careful to couch our claims accordingly, but the true size of this interested public is an open question. Additionally, our measure of values (i.e., self-reported political ideology) is more proxy than direct measure. The quality of measurement could be responsible for the non-result, as could relationships between this variable and our belief variables.

In conclusion, protecting and restoring environmental health through active management means reversing negative feedbacks to the ecological system. To do this, some accounting of human dimensions is necessary. Given our changing environmental conditions due to climate change, land managers are pressured to enact management strategies aimed at sustainability of WBP as a keystone species. We find that land managers have public support for active management strategies for WBP across jurisdictions in the GYE, despite some of the practical difficulties of actively managing in formally designated wilderness areas. Given the lack of politicization of WBP, the opportunity exists for managers to educate the public on the importance of WBP and its ecosystem services to ensure enduring support for management decisions.

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CONFLICT OF INTEREST
The authors declare no conflict of interest.

AUTHORS’ CONTRIBUTIONS
E.A.S., E.D.R. and H.T.N., conceived of the project and led coordinating meetings; All authors contributed to the design of the study and development of the questionnaire; E.D.R. and M.P.W. largely coordinated the administration of the survey; E.A.S. led the writing and the revisions of the manuscript with contributions from E.D.R.; With input from E.A.S., E.D.R. led the data analysis and was largely responsible for the iterations of the methods and results sections. All authors approved the manuscript for submission.

DATA AVAILABILITY STATEMENT
Data deposited in the Dryad Digital Repository: https://doi.org/10.5061/dryad.d2547d80k (Shanahan, Raile, Naughton, Wallner, & Houghton, 2020).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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