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The Consequential Role of Aesthetics in Forest Fuels Reduction Propensities: Diverse Landowners' Attitudes and Responses to Project Types, Risks, Costs, and Habitat Benefits

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Abstract: Private landowners in the southern Willamette Valley of Oregon, USA were surveyed. The survey queried probabilities of implementing specific fuels reduction projects in extensive areas of specific forest types on their property. The projects were described in relation to the beginning and target forest types, the actions required, costs, and long-term maintenance. Forest types were first rated for scenic beauty and informed levels of wildfire risk reduction, scarce habitat production, and associated property rights risks. Propensities to perform each fuels reduction project were then obtained. These were adversely affected by disbelief in heightened wildfire risks or climate change, higher project costs, feelings of hopeless vulnerability to wildfire, and low aesthetic affections for target forests. Propensities were enhanced by aesthetic affection for target forests, belief in the efficaciousness of fuels reduction, previous experience with wildfire evacuation, and higher incomes. All landowners favored thinning of young conifer forests, but some were averse to thinning of mature conifer forests. Anthropocentric landowners, mainly farmers, foresters, and some small holders, tended to favor conventional thinnings toward commercially valuable conifer forests and avoided long-term habitat maintenance. Nature-centric landowners, mainly some rural residents and wealthy estate owners, leaned more toward long term habitat goals and oak forests.

Keywords: wildfire risk; fuels reduction; private forests; aesthetics; habitat restoration

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1. Introduction

Increasing incidence of wildfires due to climate change has instigated widespread advocacy to reduce fuels in forests to more natural levels that are resilient to fire [1]. The aim is to reduce wildfire intensity, rate of spreading, and ease of control to protect structures [2]. This study is the first to begin understanding one critical aspect of this agenda. It did not investigate production of defensible space around structures. It did not investigate perceptions of regional fuels reduction programs that mainly involve large public or corporate private land holdings. It focused instead on private landowners' propensities to perform extensive fuels reduction within their own lands in wildland–urban interface landscapes dominated by other small to medium sized private parcels.

Programs to produce fuels management in landscapes are complex across political, social, cultural, institutional, economic, and ecological dimensions [3,4], and people's aesthetic perceptions are a key component [5,6]. The U.S. has instituted a National Fire Plan that promotes Community Wildfire Protection Plans and this program has encountered implementation issues, including public perceptions of fuels managed landscapes [7,8]. These problems have instigated many studies into regions' social capacity to deal with wildfire mitigation strategies [9–11].

Other studies have focused on diverse aspects of landowners' general disposition to conduct fuels reduction by virtue of their environmental and social concerns, land use motivations, financial issues, opinions about incentives, institutional and policy barriers, attitudes, etc. [12–16]. These studies do not focus on the site-scale, project-specific goals, and issues that landowners face in selecting private fuels reduction projects. We are aware of no other published studies of private landowners' propensities to perform specific fuels reduction project types in particular forests they own, so there are no previous results for direct comparison to this study, although generic types of fuels reduction attributes across many forest types have been studied [17]. Public acceptance of generally described extensive fuels reduction programs on local public lands, regions, or large areas of private industrial forests, have been studied [5,14,15,18–22]. For such public projects, the need for wildfire risk reduction is usually an established policy objective and is subject to public contention but not obviation. Private decisions to reduce fuels are open to perceptions of little wildfire risk or helpless vulnerability and these have not been studied.

Project costs tend not to be a dominant or decisive factor in implementing large-scale public fuels reduction project because costs are borne by the public purse and are usually already purpose allocated. Among private forests, landowners typically must bear much or all costs, so these can become a paramount concern. The need for and effectiveness of such expenditures is debated at both public and private scales, but high costs can more easily win the day in private decisions. This problem has also been little studied with regard to specific, private fuels reduction project choices. This study aimed to do so, without previous findings as a guide.

Aesthetic perceptions have been found to be the second most important public concern in perceptions of extensive or public fuels reduction projects beyond individual private properties [23]. Inferences about such impacts have been compiled from studies of public perceptions of non-fuels-management-derived forest conditions [24]. This may also be true for private fuels reduction choices. Walpole et al. [17] point to a deficit in studies of aesthetic and other perceptions of fuels reduction programs. There is a critical, unmet need to focus on private landowners' propensity to implement fuels reduction with reference to the operational activities required, the on-the-ground changes in their forests, and the outcomes related to forest densities and wildfire risk. They focus on the defensible space around homes, as do others [25,26], but note that the same need applies to larger forests in whole private ownerships. Daniel [27] also pointed toward this need and highlighted the likely importance of aesthetic perceptions and people's interest in ecological outcomes. There have been very few studies of this kind, since Scott's [28] early and simple study, and this problem may be a key component in overcoming the slow progress of fuels reduction programs in the U.S. [10].

This study sought to focus on meeting this need with added attention to ecological restoration in relation to aesthetics. It queried the propensities of private forest owners to implement fuels reduction by reference to specific project activities and expected outcomes in specific areas and forest types. Different types of landowners estimated these propensities. They had various land use motivations, attitudes, such as those regarding climate change, or perceptions, such as vulnerability to wildfire. They did so in relation to wildfire risk reduction, scenic beauty, ecological values, and risks to property rights if they were to create legally protected habitats.

This study also investigated another open question: Do landowners tend to resist or avoid fuels reduction projects due to aesthetic affections for their existing forests, or disaffections for future forest projects would create? The opposite could be true because more open forests can gain perceived scenic quality [29]. This may be a common and influential consideration.

2. Methods

2.1. Landowner Sample

Two study areas on the periphery of the southern Willamette Valley of western Oregon, USA were targeted for a 2009 mail survey of landowners. These were mainly within the foothills of the Cascade Mountains and Oregon Coast ranges that encompass that valley and historically were dominated by fire-resilient oak woodland and savanna habitats, most of which have experienced encroachment by, or conversion to, less fire-resilient conifer forests. At the time of the survey, this region had only experienced sporadic and limited wildfires, but these were increasing and have subsequently become more frequent, more intense, and extensive [30]. The two landowner sampling areas were selected to include predominantly wildland urban interface with ownership parcels of many sizes and forest patches of many sizes. They were selected to include diverse land uses, land cover types, current forest types, landowner income levels, and political cultures.

The northern study area included much of eastern Linn County surrounding the small cities of Lebanon (population ~17,000 in 2010) and Sweet Home (population ~9000 in 2010). This 102,000-ha northern study area is less topographically diverse, dominated by lands zoned for agriculture and forestry, and has more extensive forests than the southern study area, but still with smaller patches of forests set among pastures and farm fields.

The 81,500-ha southern study area within Lane County surrounded the southern, eastern, and northeastern boundaries of the Eugene-Springfield metropolitan area, the second largest in Oregon (population ~235,000 in 2010). It consists mostly of hilly topography with larger and smaller blocks of forest-zoned lands interspersed with smaller parcels with zoning that also supports residential and micro-farming uses. It consequently contains many areas of exurban, low-density residential land uses that include a wide range of improvement values. This southern study area also includes three small towns: Creswell (population ~1600 in 2010), Lowell (population ~1000 in 2010), and Veneta (population ~5000 in 2010).

Sampling was derived from county-level GIS tax parcel data obtained from Lane and Linn counties. To the extent possible, based on landowner names and zoning, tax parcels were excluded if they were industrial, commercial, or public. Parcels inside urban growth boundaries and city limits, and lots smaller than 0.80 ha (2 acres) were also excluded. The sample frame was then stratified by county, parcel size (<4.05 ha, 4.05–20.23 ha, and >20.23 ha), parcels' improvement value (zero, <$212,000, and $\geq$$212,000–the median improvement value across both study areas), and the presence or absence of at least an acre (0.40 ha) of oak-dominant habitat (using digital land use/land cover data ca. 2000, http://www.fsl.orst.edu/pnwerc/wrb/access.html accessed 4 December 2008). We randomly selected 745 property owners equally representing all these strata as targets for the mail survey described below. A total of 12 were returned as undeliverable because the landowner had changed or died, yielding a final mailout of 733 surveys. In addition, 96 other respondents to an earlier survey that was identically targeted volunteered to also participate in this survey by returning a postcard. In total, 281 (38%) of the 733 newly sampled landowners returned the survey and 82 (85%) of the 96 volunteers did so; two of these surveys were too incomplete for use in this study. This yielded N = 361 (44%) returned and useful surveys.

2.2. Sample of Forest Types

Alternative fuels reduction projects were presented as conversions from one generalized forest type to another. There were seven forest types (Table 1). These were broadly described and representatively depicted in the mail survey, as explained below. The seven types included most forests in the study areas. Each was presented in the survey with three 'expert' average attribute ratings in Table 1, which respondents could adjust. (See Section 3.3.2) The fuels reduction options studied among these forest types are arrayed in Figure 1.

Table 1. Broadly defined forest types used in the study.

Forest Type Name	Expert Estimate: Wildfire Risk	Expert Estimate: Habitat Value	Expert Estimate: Property Rights Risk	Abbreviated Key Aspects of Much Longer Forest-Type Descriptions & Common Histories Provided in the Mail Survey
Oak Savanna	Very Low	Very High	Moderately High	Low density of various sized scattered oaks and other tree types. Grass, flowering plants, and shrubs. May be used as pasture.
Oak Woodland	Very Low	High	Moderate	Mainly well-spaced oak trees & other deciduous trees. Fairly open understory of shrubs, grasses, flowering plants, and fir seedlings.
Mixed Forest	Very High	Moderate	Very Low	Common, unmanaged forests. Few big oaks, ash, maple, shrubs, & other deciduous trees. Also, many small and medium evergreens.
Dense, Young Conifer	High	Low	Very Low	Dominantly tightly spaced small- to medium-sized Douglas fir. A few deciduous shrubs and trees. Often sparse ground vegetation.
Thinned, Young Conifer	Moderately Low	Moderately Low	Low	Mainly widely spaced smaller conifer trees. A few sparse shrubs and other tree types in open understory. 15–50 years old but thinned.
Dense, Mature Conifer	Moderately High	Moderate	Low	Common, not recently thinned, 50+ year old conifer dominated. Many larger trees. Fairly open understory with shrubs, and down logs.
Thinned, Mature Conifer	Low	Moderately High	Moderately Low	Mainly widely spaced older fir trees at least 10 inches diameter. Few maples. Often open understory with grass, shrubs, and ferns.

The attribute ratings of this set of forest types helped to define tradeoffs among two essential fuels reduction strategies: (1) Conversion of dense forests containing high fuel loads (often with more flammable conifer) to now scarce pre-European settlement oak dominated plant communities that historically prevailed in the landscape and that may offer habitats for associated species, some of which are listed as threatened or of priority in regional conservation planning. (2) Conversion of dense forests to conifer dominant thinned forests with reduced (substantially conifer) fuel loads that are less enabling of and susceptible to intense crown wildfires. More mature thinned conifer forests can take on some old growth habitat attributes and more rapidly grow toward highly valuable commercial harvests. Financial attributes of fuels reduction conversions were presented in the mail survey as described in Section 2.3.3.

The forest types' 'expert' average attribute ratings (Table 1) were obtained from consultations with wildfire scientists, wildlife biologists and conservation policy administrators. However, these were marginally modified to achieve a more stratified array of forest conversion options as much as possible within the bounds of realistic adherence to the experts' advice. Even so, the financial costs of implementing the conversions were moderately correlated with gains in their wildfire risk reduction and habitat values. This correlation was mainly related to the production of oak woodlands and savanna. (These projects are directed toward ecological restoration with careful logging and long-term prevention of woody plant growth and control of non-native vegetation.) This correlation between costs and habitat production is an unavoidable relationship among fuels reduction options in the study region and had to be understood in data analysis and interpretation.

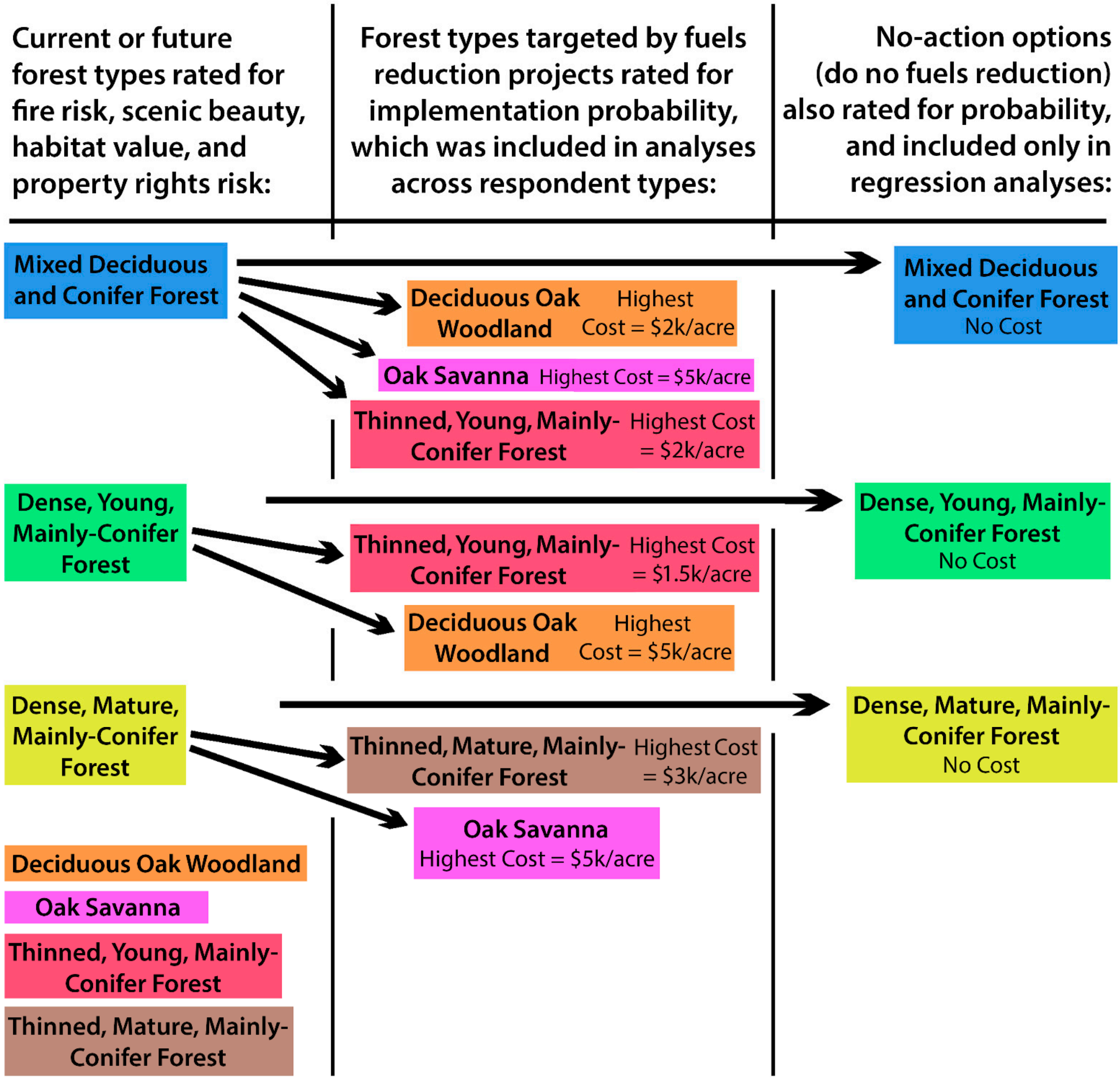


Figure 1. Structure and costs of fuels reduction project options in the study.

2.3. Survey Questionnaire

The mail survey is in the Supplementary Materials and was constructed using the Tailored Design Method [31], modified to use the full questionnaire as the first contact. It asked respondents to answer questions by reference to the "largest parcel, set of connected parcels, or nearby-to-each-other parcels you own." The primary questions that dominated the heart of the questionnaire asked respondents about the general types of forests found on their land and their propensities to perform fuels reduction there, as described in detail below. The 39 questions also queried other land cover types owned, as well as respondents' demographics, landownership motivations, perceptions of climate change, perceptions of wildfire policies and risks, land use decision making considerations and priorities, preferred land management techniques, and political attitudes. Only questions that proved predictively significant in the analyses reported in this article are described here.

2.3.1. Measurement of Propensities

Landowner respondents rated their percent probability of implementing fuels reduction projects in the next ten years, as described in Section 2.3.3. These were the measure of fuels reduction propensities and the dependent variable in all analyses. These propensity ratings meaningfully express relative dispositions toward implementing different fuels reduction projects 'in the near future' in forests that each respondent controls. Care must be taken not to over-interpret these data as strong estimates of project implementation probabilities. The structure of the survey did not compel respondents to report probabilities by forest type that added up to 100%. This was partly to make the survey cognitively manageable to increase response rates. It was also because many landowners would have several patches of a forest type on their land and it was more tractable to have them make an overall propensity estimate across some or all of these, instead of asking them to respond for each patch and make sure that their probabilities added up to 100%.

2.3.2. Perceptions of Forests' Qualities Affecting Decisions

The survey covered the seven generalized types of forests listed in the left column in Figure 1. These broadly defined types are inclusive of nearly all the forests found in the study areas. For each forest type, respondents read two pages and answered five questions, as shown in the example in Figures 2 and 3. These facilitated education in identifying owned forest types, how much of each the respondent owned, and ratings of scenic beauty, habitat value, risk to property rights, and wildfire risk. Each forest type was described and illustrated by four representative photos.

Ratings of 'scenic beauty' were elicited, as opposed to aesthetic preference, quality etc., to focus respondents on landscape amenity and promote a distinction from aesthetic evaluations that include ecological or habitat values, which were queried separately. Each forest type was rated for scenic beauty on a −5 to +5 with-zero bipolar scale (Figure 2). These ratings were cued by the four photos (some of which depicted soon-after-thinning conditions with some down wood on the ground), but respondents were not explicitly asked to rate this photo set. They were instead asked to rate the "forest type" so these scenic beauty ratings were assumed to also be based to an unknown degree on the appearance of any such forests on their own property or elsewhere. The aim was to elicit subjective, aesthetically focused ratings of landscape amenity value as it notionally influences private, land use and management decisions. These ratings were therefore subject to greater inter-respondent variability than if the respondents were instructed only to rate the photos in the questionnaire apart from other considerations. This study therefore focused only on the respondents' own ad-hoc ratings of scenic beauty and differences across these among the forest types without any analysis or claims regarding more universal or average public perceptions of the scenic beauty of the forest types.

Respondents were also presented with 'expert' general assessments of each forest type's wildfire risk and habitat value (Figure 3). They were asked whether these assessments under- or over-stated their own assessments. For analysis, the presented 'expert' values for both these questions were initially coded as: Very Low = −3, Low = −2, Moderately Low = −1, Moderate = 0, Moderately High = +1, High = +2, and Very High = +3. These ratings were then adjusted by one point up or down, or not, according to each respondent's answer to the corresponding questions illustrated in Figure 2. The resulting adjusted ratings were used in data analyses as expertly grounded, approximate measures of the respondents' perceptions of fire risk, habitat value, and rights risk. After respondents answered all these questions, they were asked whether and how much of the corresponding forest type was found on their property. This ordering solicited responses to all the above scenic beauty and expert questions even if they did not own the forest type because some forest types would subsequently be queried as target conditions for potential fuels reduction projects.

MIXED DECIDUOUS AND CONIFER FOREST

DOES THIS DESCRIBE ANY PATCHES OF FOREST ON YOUR LAND?
This is a common forest type in the Willamette Valley foothills. They are mostly unmanaged or along rivers. This forest type always includes bigger deciduous trees, like Oregon white oak, Oregon ash, big leaf maple or fruit trees gone wild. It must also include many evergreen conifer trees, which may be big or mostly smaller than the deciduous trees. Shrubs and young deciduous trees will usually also be growing in these forests, sometimes forming a dense understory.

DOES THIS DESCRIBE THE HISTORY OF ANY FOREST ON YOUR LAND?
Mixed deciduous and conifer forests usually develop when deciduous forests are little managed for many years so that lots of conifer trees have been allowed to grow into the forest. Some of these forests develop after a harvest or die-off in a conifer forest allows alder, big leaf maple and other deciduous trees to get established. The mix of trees and shrubs depends on how woodcutting or mowing has occurred, whether livestock have grazed the forest, and other factors.

29a. How much scenic beauty do you see in this mixed deciduous and conifer forest type?

○	○	○	○	○	○	○	○	○	○	○
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
very ugly	quite ugly	fairly ugly	a bit ugly	slightly ugly	neutral or don’t know	slight scenic beauty	a bit of scenic beauty	fair scenic beauty	high scenic beauty	very high scenic beauty

Figure 2. Example survey page where respondents identify and rate scenic beauty for a forest type.

SOME RISKS AND BENEFITS OF MIXED DECIDUOUS AND CONIFER FORESTS

Average Wildfire Risk = **Very High**

These forests are typically very dense, often with a dense understory of shrubs and young trees, with fire-prone conifers, and sometimes branches and logs on the ground. These can combine to provide lots of fuel for wildfires. Fires in these forests can therefore be very intense and spread quickly toward homes.

29b. Please check ✓ the one circle that best matches your evaluation of this expert opinion:

- ○ This opinion overstates the risk of wildfire.
- ○ This is about right.
- ○ This opinion understates the risk of wildfire.
- ○ I don't know.

Average Habitat Value = **Moderate**

These forests mainly offer habitat for common animals like western grey squirrel, Wilson's warbler, black-throated warbler, deer, and raccoons. They are not rare, and there is plenty of this forest type in the Willamette Valley foothills so that this forest habitat adds just moderately to regional habitat variety.

29c. Please check ✓ the one circle that best matches your evaluation of this expert opinion:

- ○ This opinion overstates the value of this habitat.
- ○ This is about right.
- ○ This opinion understates the value of this habitat.
- ○ I don't know.

Potential Property Rights Risk = **Very Low**

Because this forest type is plentiful and mainly offers habitat to non-sensitive species, there is very little chance that any government agency will limit landowners' rights to develop or harvest such forests.

29d. Please check ✓ the one circle that best matches your evaluation of this expert opinion:

- ○ This opinion overstates the risk of losing property rights.
- ○ This is about right.
- ○ This opinion understates the risk of losing property rights.
- ○ I don't know.

MIXED DECIDUOUS AND CONIFER FOREST

29e. Approximately how much of your property do you think is a lot like this forest type?

○ *None* ○ *1–10 acres* ○ *10–20 acres* ○ *20–50 acres* ○ *50–100 acres* ○ *more than 100 acres* ○ *I have some but don't know how much*

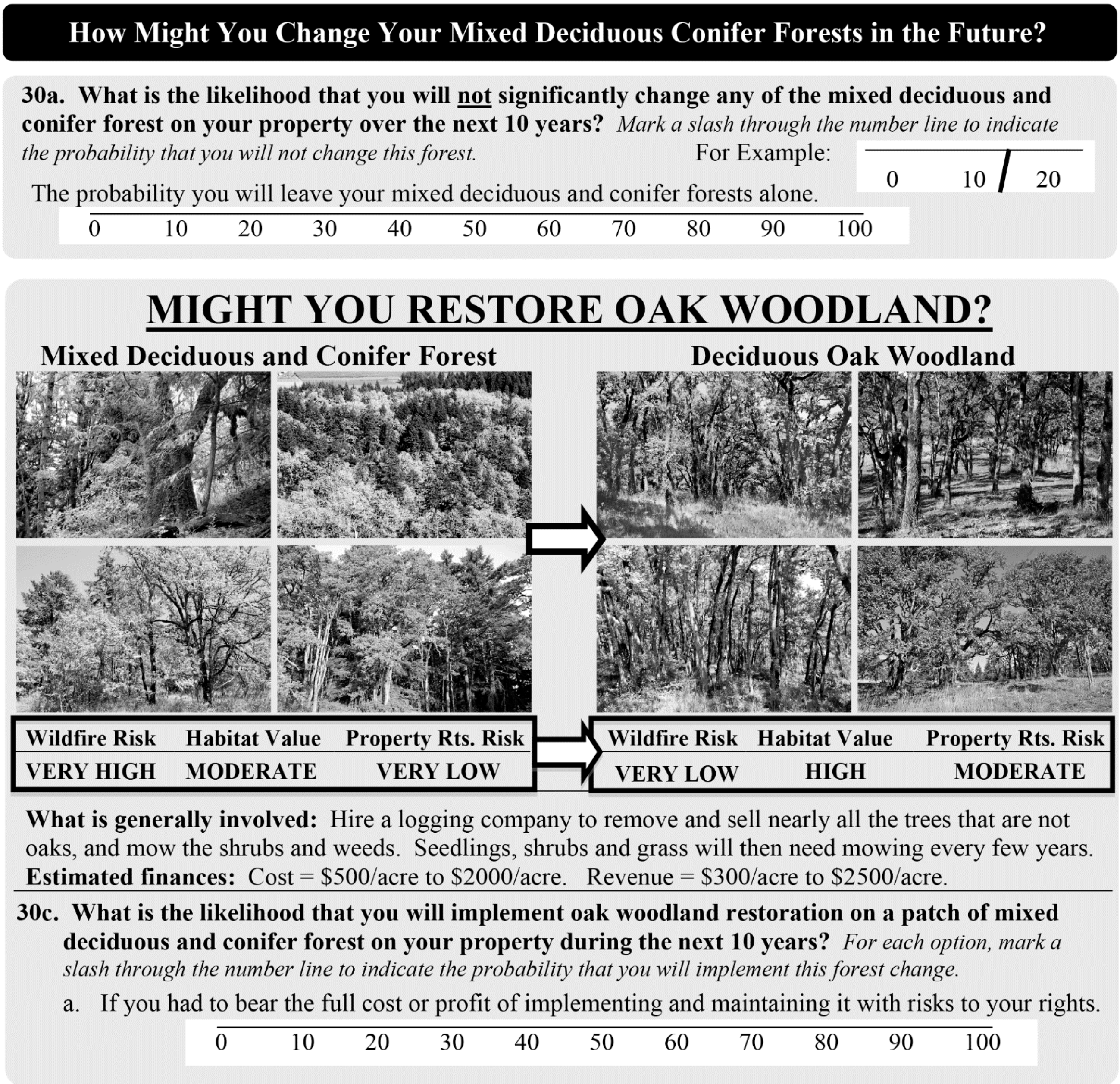
SKIP TO PAGE 16 if you do not have this mixed forest.

Figure 3. Example survey page where respondents rate key attributes for a forest type.

2.3.3. Propensities toward Fuels Reduction Options

Seven types of fuels reduction project opportunities were offered to respondents indicated by the arrows between the left and center columns in Figure 1. Three no-action options were also offered corresponding to the arrows all the way across Figure 1. If they did not already have a particular pre-fuels-reduction forest type on their property, they were asked not to answer any questions about any fuels reduction opportunities that began with these not-owned forest types.

Respondents rated their percent probability of implementing one or two available fuels reduction opportunities via questionnaire pages, such as the example in Figure 4. These pages first asked for a probability that they would not change their existing forest. A potential sequential forest transition was illustrated between the same two sets of representative photos for the forest types. A concise explanation of the required actions and costs to achieve fuels reduction was provided under these photo sets.



How Might You Change Your Mixed Deciduous Conifer Forests in the Future?

30a. What is the likelihood that you will not significantly change any of the mixed deciduous and conifer forest on your property over the next 10 years? *Mark a slash through the number line to indicate the probability that you will not change this forest.* For Example: 0 10 / 20

The probability you will leave your mixed deciduous and conifer forests alone.

0 10 20 30 40 50 60 70 80 90 100

MIGHT YOU RESTORE OAK WOODLAND?

Mixed Deciduous and Conifer Forest **Deciduous Oak Woodland**

Wildfire Risk	Habitat Value	Property Rts. Risk
VERY HIGH	MODERATE	VERY LOW

Wildfire Risk	Habitat Value	Property Rts. Risk
VERY LOW	HIGH	MODERATE

What is generally involved: Hire a logging company to remove and sell nearly all the trees that are not oaks, and mow the shrubs and weeds. Seedlings, shrubs and grass will then need mowing every few years.
Estimated finances: Cost = $500/acre to $2000/acre. Revenue = $300/acre to $2500/acre.

30c. What is the likelihood that you will implement oak woodland restoration on a patch of mixed deciduous and conifer forest on your property during the next 10 years? *For each option, mark a slash through the number line to indicate the probability that you will implement this forest change.*

a. If you had to bear the full cost or profit of implementing and maintaining it with risks to your rights.

0 10 20 30 40 50 60 70 80 90 100

Figure 4. Example survey section for rating a fuels reduction project option.

An estimated range of costs per acre and another for revenues were provided below this project description (Figure 4). These were averaged from consultation with local ecological restoration and logging contractors. Various metrics derived from these financial data were tested in modeling landowner propensities. These included: highest cost, highest revenue, worst-case scenario (highest cost with lowest revenue), best-case scenario (lowest cost with highest revenue), and the median scenario between the worst- and best-case scenarios. Only the first variable (HighestCost) consistently proved most statistically significant in regression analyses.

Another cost related factor derived from the survey was a three-way indicator variable that captured the level of implementation and long-term maintenance work each project entailed (LongTermCare). Project options that entailed doing nothing at all were assigned a value of −1. Other thinning options with descriptions in the survey that only mentioned tree removals were assigned a value of zero. Oak habitat restoration options with descriptions that included long-term intensive maintenance requirements, such as mowing, weeding, burning, and planting were assigned a value of +1. This variable was highly correlated with HighestCost (r = 0.87) so either of these, but not both, could be included in any regression analysis.

2.3.4. Predictive Survey Items

Five survey items related to attitudes and experiences were found to be statistically significant in the best regression models explaining respondents' fuels reduction propensities. These were in addition to those described above, which were directly related to attributes of the fuels reduction options. These are illustrated and underlined in Figures 5 and 6 with their data codes.

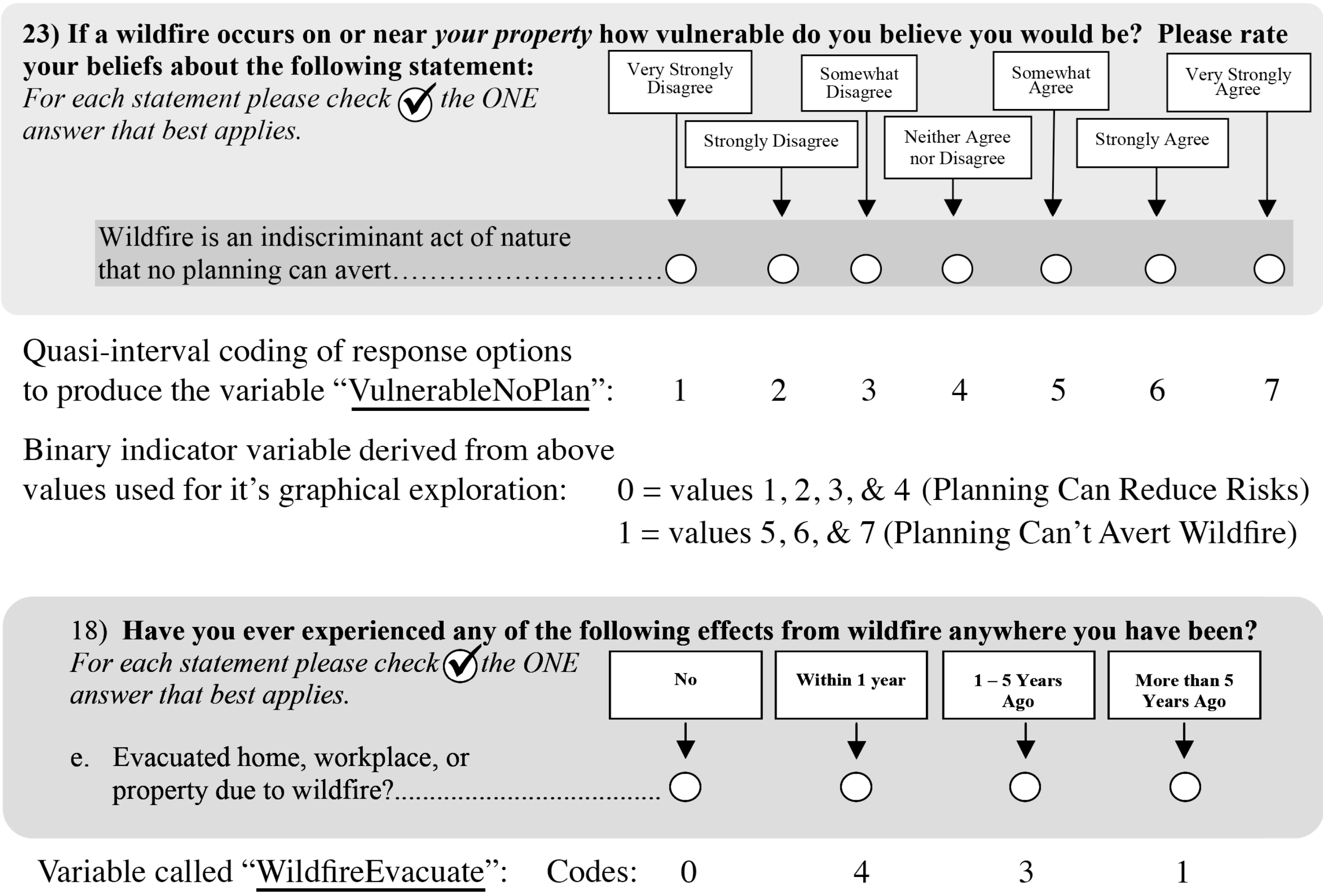


Figure 5. Survey sections querying vulnerability-agency and wildfire evacuation experience.

The first two items (Figure 5) queried aspects of perceived wildfire vulnerability and agency against it because this is an important factor [32]. The first queried whether anticipatory fire-prevention activities were not seen as worthwhile with no possible planning by virtue of indiscriminate wildfire (VulnerableNoPlan), with larger codes corresponding to greater perceived vulnerability. For graphical analyses outside the regression model, this variable was also coded as a binary indicator (Figure 5). The second queried whether the respondent had ever evacuated anywhere they had been due to a wildfire threat (WildfireEvacuate), with larger codes corresponding to greater implied levels of perceived vulnerability. This variable was not simplified for graphical analysis because of the small (but predictive) number of respondents (18) who had experienced evacuation.

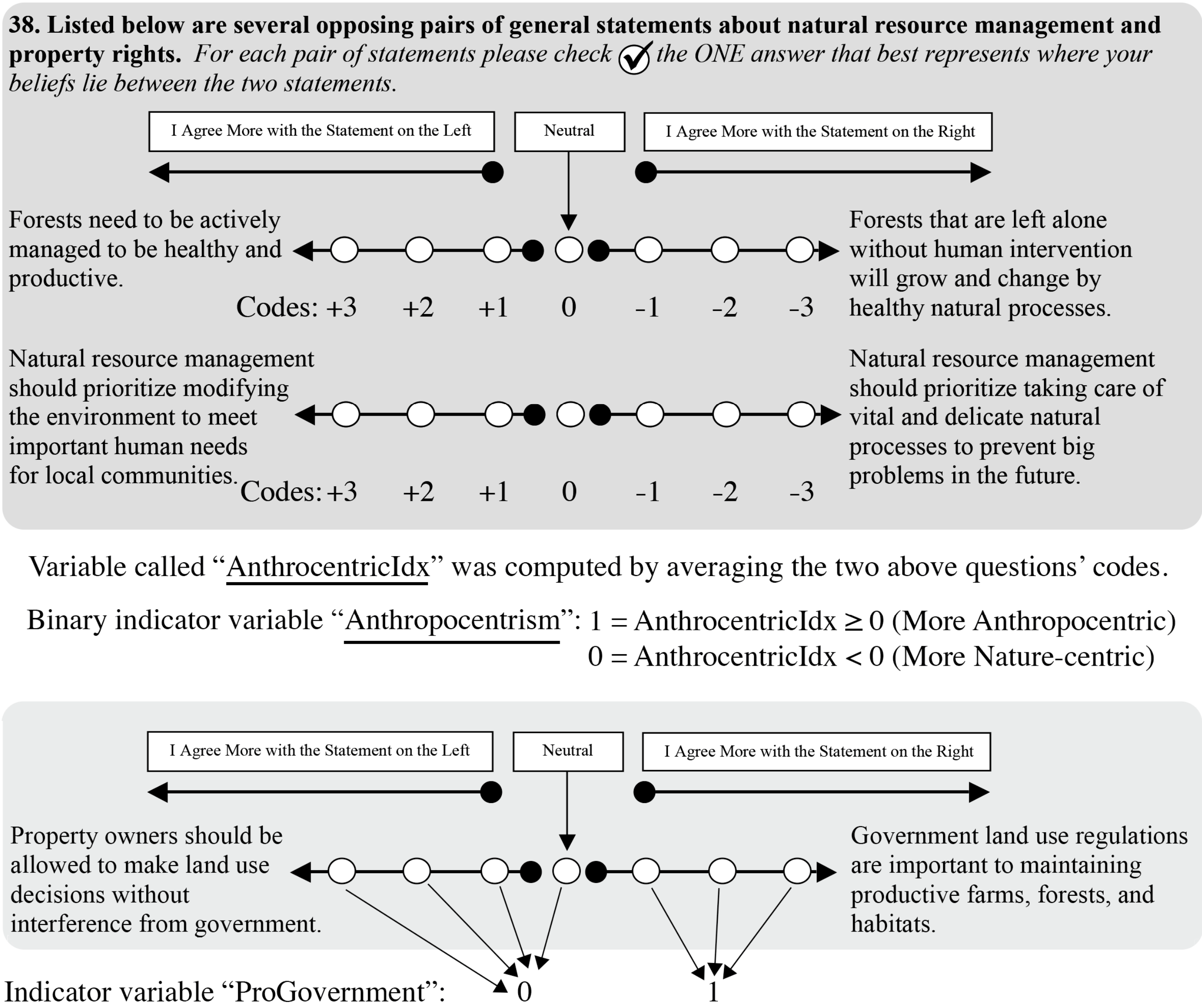


Figure 6. Survey sections querying anthropocentrism and attitudes toward government.

The third, fourth and fifth items were derived from three neighboring survey questions (Figure 6). An index variable measured respondents' degree of anthropocentrism (AnthrocentricIndex) in considering forest management [33]. It was computed as the average of the coded values from the first two questions in Figure 6. Larger values indicate greater anthropocentrism and lower values indicate greater nature-centrism. This index variable was also coded as a binary indicator variable (Anthropocentrism) as shown in Figure 6. The value of 1 was associated with respondents who tend to favor human needs, and the zero corresponding to the remaining respondents leaning more toward ecological considerations (Figure 6). Another binary indicator variable (ProGovernment) was derived from the bottom question in Figure 6, with the value of 1 associated with respondents who tend to favor land use regulations.

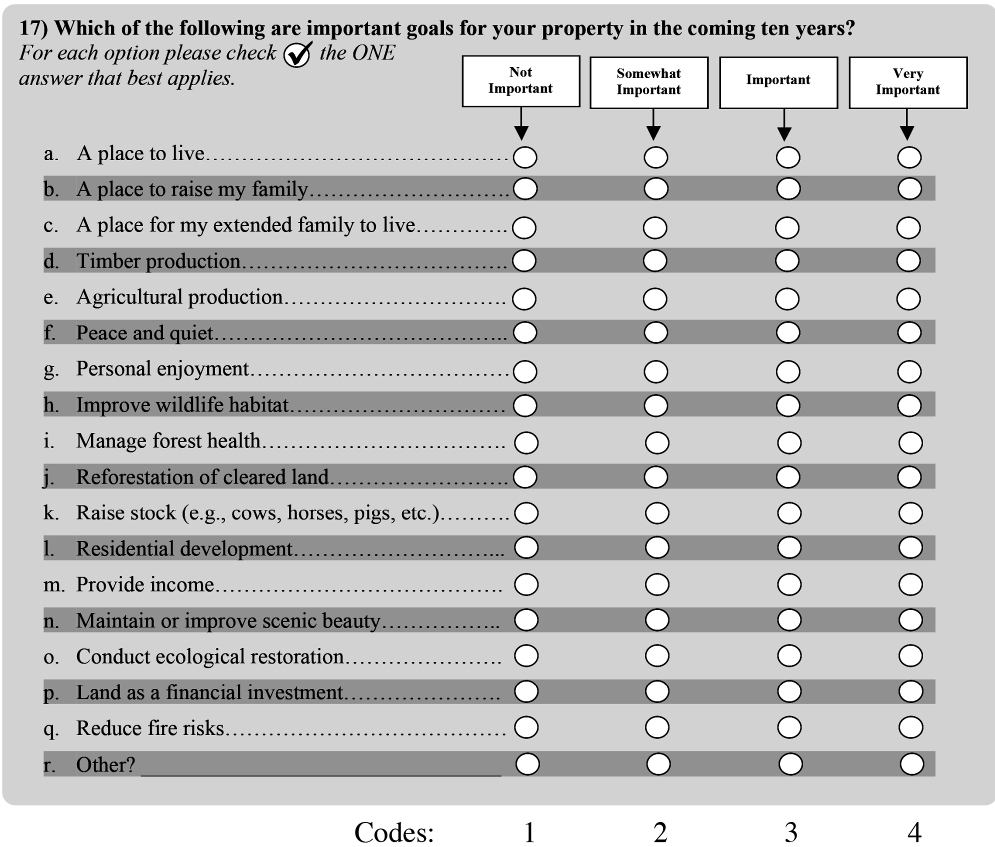
Respondents' annual household income was a significant predictive factor in one model described below. It was derived from a question in the survey that asked that one of eight income ranges be selected. This variable (Income) took on the dollar value of the midpoint in each respondent's selected range. The value of $200,000/year was coded for respondents who selected the '$150,000 or more' range.

2.4. Classification of Respondents

The classification of respondents in the survey is described in full detail in [34]. This previous article included all the respondents for the survey analyzed here as well as those from another larger survey in the same study areas that shared the same questions used to classify the respondents. The classification employed measurement of landowner motivations, propensities to engage in common land management activities (not fuels reductions), and property characteristics.

2.4.1. Landowner Motivations

17 landowner motivations were queried using a 4-point Likert-type response scale (Figure 7). A factor analysis of all these items was conducted using a principal components method with a varimax rotation, keeping only factors with an Eigenvalue >1.0. This identified five factors that explained 65% of variance, with factors' percent contributions noted below. These were named by inspection of the motivations that most loaded on each as follows: Amenities (Eigenvalue = 4.2, 24.9%) loaded on peace and quiet, personal enjoyment, improve wildlife habitat, scenic beauty, ecological restoration, a place to live, and reduce fire risks. Forest management (Eigen value = 2.6, 14.9%) loaded on timber production, manage forest health, and reforestation. Home and family (Eigenvalue = 1.9, 11.4%) loaded on a place to live, a place to raise my family, and a place for extended family to live. Agriculture (Eigenvalue = 1.3, 7.4%) loaded on agricultural production, raise stock, and provide income. Development (Eigenvalue = 1.1, 6.6%) loaded on residential development, financial investment, and provide income.


17) Which of the following are important goals for your property in the coming ten years?
For each option please check the ONE answer that best applies.

	Not Important	Somewhat Important	Important	Very Important
a. A place to live	○	○	○	○
b. A place to raise my family	○	○	○	○
c. A place for my extended family to live	○	○	○	○
d. Timber production	○	○	○	○
e. Agricultural production	○	○	○	○
f. Peace and quiet	○	○	○	○
g. Personal enjoyment	○	○	○	○
h. Improve wildlife habitat	○	○	○	○
i. Manage forest health	○	○	○	○
j. Reforestation of cleared land	○	○	○	○
k. Raise stock (e.g., cows, horses, pigs, etc.)	○	○	○	○
l. Residential development	○	○	○	○
m. Provide income	○	○	○	○
n. Maintain or improve scenic beauty	○	○	○	○
o. Conduct ecological restoration	○	○	○	○
p. Land as a financial investment	○	○	○	○
q. Reduce fire risks	○	○	○	○
r. Other? ______	○	○	○	○
Codes:	1	2	3	4

Figure 7. Survey section querying landowners' motivations for property ownership.

2.4.2. Landowner Type Motivation Analysis

Cluster analysis using all the factor scores from the factor analysis of landowner motivations was used to identify different landowner types [35]. A linear transformation was applied to these landowner motivation factor scores to improve cluster classification using the approximated, within-cluster covariance estimation technique [36]. A hierarchical cluster analysis on the transformed factor scores was then run using an expected maximum likelihood method [37]. Clusters were identified using heuristic guides for the Cubic Clustering Criterion (CCC), Pseudo F, Pseudo T^2 statistics, and visual examination of the tree diagram of the cluster hierarchy [38]. This yielded four tentative landowner types: rural residents, multipurpose small holders, farmers, and foresters, which are described below.

2.4.3. Face Validity Tests of Landowner Types

The validity of the cluster solution was examined by investigating whether landowners assigned to different types in the cluster solution exhibited statistical and meaningful differences in demographics, property characteristics, and propensities for pursuing different land management strategies. Differences in variable means were tested across landowner types using the Tukey–Kramer HSD test for multiple comparisons of means. Tests for differences in relative proportions for binary criteria variables (e.g., respondents with/without a college education) were also applied across landowner type clusters using chi-square tests against contingency tables of landowner types.

These examinations indicated that the 'foresters' landowner type was over-aggregated. A small and distinctive sub-branch of that type's tree diagram of the cluster hierarchy was clearly indicated as distinctive. These were owners of large, forested parcels with very high incomes, more education, very high property improvement values, and more liberal political views than the other foresters. These owners were separated out into a new type named 'forested estates'.

2.4.4. Rural Residents (n = 159, 44%)

Rural residents mainly simply choose to live in such areas. They are primarily motivated by amenities and their property's use as a family home. Their amenity motivations are significantly greater than other landowner types. Most had college education (63%), and approximately one third (35%) self-identified as politically liberal. Rural residents made up more than half of the survey respondents that self-identified as politically liberal. Rural residents were rarely absentee landowners (7%), and 56% of these reported having some experience with wildfire. Approximately one fifth of rural residents (21%) expressed disbelief in climate change and wildfire consequences.

2.4.5. Multipurpose Small-Holders (n = 81, 22%)

Multipurpose small-holders were typically rural residents who also use properties to engage in micro farming, horse keeping, mechanical shops, or other such activities. They had more diversified motivations than rural residents. They favor amenities and use of their property for their home and family but tend to favor development and farming more than rural residentials. Just under half of multipurpose small-holders reported having a college education (47%), and only 25% of them self-identified as politically liberal, with over half self-identified as decisively conservative. Multipurpose small-holders also tend to live on their properties (86%), and they reported the most experience with wildfire (61%). Like the rural residents, only one in five diversified small-holders (20%) expressed disbelief in climate change and its wildfire impacts.

2.4.6. Farmers (n = 63, 17%)

Farmers exhibited the greatest diversity of landowner motivations, but they also clearly indicated that farming was the most important. Farmers' average farming motivation score was an order of magnitude greater than all but two of their other motivations: property use for a home, and a place to raise a family. Similar to multipurpose small-holders, less than half of farmers (48%) reported a college education, and only 19% of this landowner type self-identified as politically liberal. Farmers were more likely to be absentee landowners (18%) compared to rural residents (8%). Approximately half of farmers (47%) reported having some experience with wildfire. Nearly one in three farmers (32%) expressed disbelief in climate change and its wildfire impacts.

2.4.7. Foresters (n = 47, 13%)

Foresters had significantly greater forest management and development motivations than any other landowner type. Their amenity and home and family motives were typically unimportant. Foresters were the most educated with over 60% reporting a college degree or higher. Foresters were the most politically conservative, with only approximately 17% self-reporting as politically liberal. In contrast to all other landowner types, only 16% of foresters lived on their property, but all reported living in the study areas for more than 10 years. Foresters reported the least experience with wildfire (40%), and more than one third of foresters (38%) expressed disbelief in climate change and its wildfire impacts.

2.4.8. Forested Estates (n = 11, 3%)

The sample size of the forested estates landowner type was too small to report meaningful percentages for their characteristics. They all owned large parcels typically greater than 8.09 ha (20 acres) with a very-high-value home to live in. They tended to be motivated by amenities and forest health and reforestation but not primarily for timber production or income. They were well educated, lived in the study areas for shorter periods than the other landowner types, had mixed political ideologies, and mixed views about climate change and attendant wildfire risks.

2.5. Data Analyses

The useful study variables are listed and defined in Table 2. Data were initially explored via graphs. These and other explorations indicated a need to understand how multiple variables interact in association with fuels reduction propensities via regression models. The regression models indicated further graphical explorations of fuels reduction propensities by project type.

Table 2. Variables used in modeling fuels reduction propensities.

Variable	Definition	Scale
PropensityFR (dependent variable)	A respondents' reported probability that they will execute a particular fuels' reduction project within ten years.	0 to 100 percent
WildfireRisk	Expert estimation of average wildfire intensity risk in a forest type adjusted one level up or down, or not at all, by each respondent's opinion about the expert estimation.	Very low = −3 up to Very high = +3 with Moderate = 0 *
HighestCost	The high end of the estimated cost range to execute a particular fuels' reduction project provided in the mail survey.	Dollar value per acre
LongTermCare	Does the description of a project in the mail survey include long-term maintenance work, just thinning, or do nothing at all?	0 = do nothing, 1 = thin only, 3 = ongoing care
HabitatValue	Expert estimation of sensitive species average habitat value for a forest type adjusted one level up or down, or not at all, by each respondent's opinion about the expert estimation.	Very low = −3 up to Very high = +3 with Moderate = 0 *
NextHabitatValue	For a fuels' reduction project, a respondent's HabitatValue estimate (from above) for the forest type after project completion.	Very low = −3 up to Very high = +3, Moderate = 0 *
HabitatValueChange	For a particular fuels' reduction project, a respondent's NextHabitatValue rating minus the HabitatValue rating they assigned to the pre-project forest type they started with.	−6 up to +6
RightsRisk	Expert estimation of potential risk to property rights due to habitat protections for a forest type adjusted one level up or down, or not, by each respondent's opinion about the expert estimation.	Very low = −3 up to Very high = +3 with Moderate = 0 *
NextRightsRisk	For a fuels' reduction project, a respondent's RightsRisk rating (from above) for the forest type when project is completed.	Very low = −3 up to Very high = +3, Moderate = 0 *

Table 2. *Cont.*

Variable	Definition	Scale
RightsRiskChange	For a particular fuels' reduction project, a respondent's NextRightsRisk rating minus the RightsRisk rating they assigned to the pre-project forest type they started with.	−6 up to +6
ScenicBeauty	A respondent's scenic beauty rating for a forest type.	Same as just below.
NextScenicBeauty	For a particular fuels' reduction project, a respondent's scenic beauty rating of forest type produced at project completion.	Very ugly = −5 up to Very high = +5
ScenicBeautyChange	For a particular fuels' reduction project, a respondent's NextScenicBeauty rating (above) minus the scenic beauty rating they assigned to the pre-project forest type they started with.	−10 up to +10
VulnerableNoPlan	A respondent's opinion whether wildfire risks can be reduced by planning, or not because wildfire is indiscriminate.	See Figure 5.
NoPlanIndicator	An indicator variable simplifying the above variable.	See Figure 5.
WildfireEvacuate	How recently has a respondent evacuated due to a wildfire?	See Figure 5.
AnthrocentricIndex	A respondent's combined attitudes favoring human versus natural needs and whether forests should be left alone or not.	See Figure 6.
Anthropocentrism	An indicator variable simplifying the above variable.	See Figure 6.
ProGovernment	Indicator variable: respondent favors or opposes land regulation.	See Figure 6.
Income	Midpoint of selected range of annual household pre-tax income.	Dollars per year.

* In a few rare cases, respondents rated 'very high' expert estimates as too low, resulting in a +4 adjusted final rating code, or 'very low' expert estimates as too high resulting in a −4 adjusted rating code.

2.5.1. Regression Analyses

Question 'a' at the bottom of Figure 4 queried the percent probability of independent fuels reduction project implementation, without any subsidies. It is the propensity value each respondent reported for each project option and was the dependent variable in all the regression analyses. These analyses also included respondents' reported propensities that they would not do any fuels reduction at all. For these, a zero value was assigned to variables measuring changes in forests' scenic beauty, wildfire risk, habitat value, and rights risk because these would not change if the forest is not to change.

Best regression models were found to predict these landowner propensities across all the respondents, for each landowner type, and for two indicator-variable sub-categories. These latter two were identified as important factors in the best regression model across all the respondents (vulnerableNoPlan and anthropocentrism).

The data set for each of these respondent type regression models included every fuels reduction option that each respondent rated a likelihood for (because they owned the initial forest type), including no-action options. For example, in the case of the all-respondents model, if every respondent hypothetically had all the initial forest types on their land, then they would have rated likelihoods for all seven fuels reduction projects plus all three no-action options shown in Figure 1, for a total of ten ratings. Multiplying this by the 361 total respondents would have produced 3610 cases for the all-respondents regression analysis. After subtracting the ratings that were not made because a respondent did not have the required initial forest type or they did not complete the survey for an available fuels reduction option, the final case count for the all-respondents regression was 1723.

Numerous models were tested using sets of independent variables derived from among single items in the survey, indicator variables derived from single items, computed indices derived from subsets of items, or binary indicator variables for computed indices. Only the independent variables included in the final, best models (described below) were described above in the description of survey-derived measurements. The importance of each factor in these final models was estimated by both its main and total effects [39]. These estimates were calculated to sum to approximately 1.0 across all the factors in a model, so each can be roughly interpreted as the percent of a factor's contribution to the model's explained variance [40].

All best regression models were identified using the same rule set. Each sought to maximize explanation of variance and employ all significant factors that evidently affect decisions to implement fuels reduction, no matter how much they contributed to explanation of variance. The initial model was the one with all individual factors statistically significant at the $p_t < 0.05$ with power > 0.50, provided that adding any variable did not cause a model's overall statistical significance to fail against a test value of $p_F = 0.01$. Factors significant at the $p_t < 0.10$ or power <0.50 were included only if their addition reduced one or more correlations between another independent variable and the model's errors to below r = 0.40 to improve accurate specification. If two factors were correlated at r > 0.40 only the more theoretically reasonable or statistically significant factor was retained. Such an intercorrelated factor was retained in a model if it improved its specification by all these criteria: (1) It contributed less than 3% to explanation of variance; (2) was correlated with another within the range of r = 0.40–0.70; (3) its inclusion enabled one or more other factor to become statistically significant; and (4) doing so only slightly impacted the power and other statistical attributes of all the main factors in a model. A final model could not exhibit autocorrelation by the Durbin Watson test or heteroscedasticity by inspection of the plot of Studentized residuals.

2.5.2. Analyzing Aesthetic Affections

The influence of aesthetic affections for present or future forests upon fuels reduction propensities was assessed by graphically exploring the relationship between scenic beauty ratings and propensity ratings by project type within different sets of landowner types. Simple linear functions were least-squares fitted between these variables. The direction, steepness and statistical significance of these lines were compared across projects and owner types.

3. Results

3.1. Basic Results

Average propensities by landowner types are found in Figure 8. Propensities diverged among these types most for thinning of mature conifer forests. The propensities of farmers, multi-purpose small holders, and rural residents otherwise track each other closely with high propensities for inaction and implementation propensities below 25%. Foresters exhibit high propensities if they are considering thinning to conifer forests, and low propensities if they are considering creating oak habitats. Forested estate owners exhibit the lowest propensities for inaction and their moderately high implementation propensities are evenly distributed across all the project options, including the highest propensity to create oak habitats.

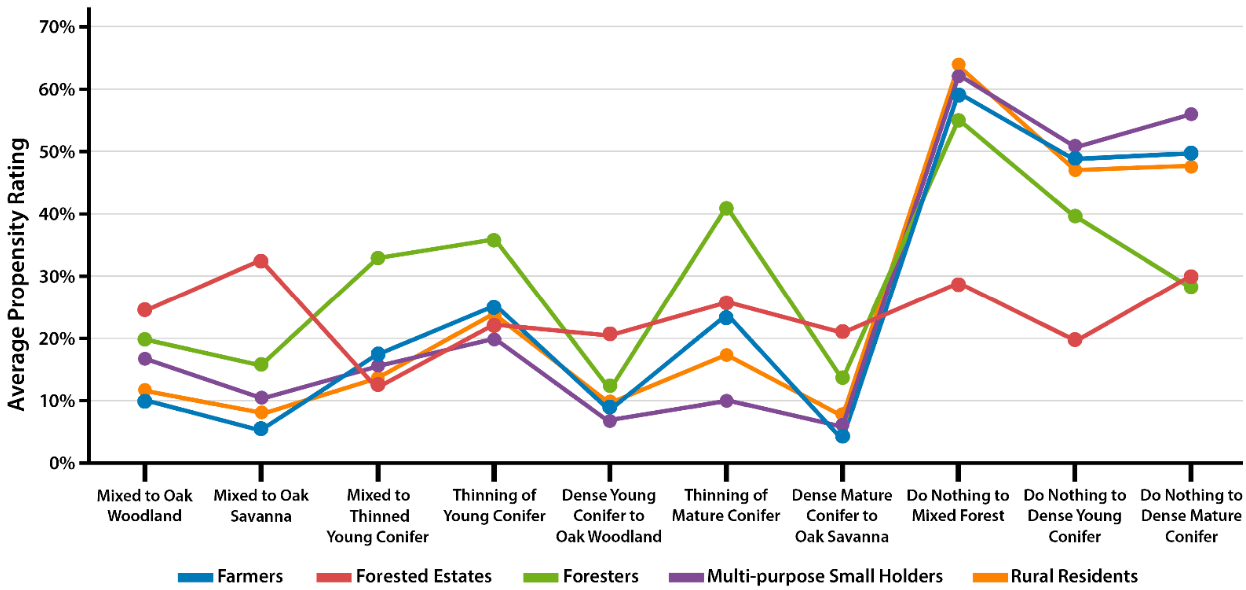


Figure 8. Average fuels reduction propensities across project options by landowner types.

3.2. Exploration of Simple Relationships

Figure 9 shows simple relationships between the respondents' propensities toward performing fuels reduction projects and the corresponding projects' broad evaluative attributes. Each labeled graph point maps each fuels reduction option's average propensity rating against its post-project forest type's average evaluative attribute rating (graphs A,C,E,G) or change in average attribute rating from the pre-project forest type to the post-project forest type (graphs B,D,F). Polynomial best-fit curves are plotted through these points with their statistical test values noted at the top of each graph.

The most important essential and statistically significant relationship is exhibited in graphs A and B in Figure 9. Propensities toward performing fuels reduction projects go markedly down as their effectiveness in reducing wildfire risks goes up (toward the left in these graphs), contrary to reasonable expectations. This unexpected, inverse relationship held in every multivariate model tested from the data even if the 'do nothing' projects options (that do not reduce wildfire risk) were excluded. Most of the respondents did not favor projects that reduce wildfire risks, particularly those that restore historic, fire-resilient oak habitats.

It seems theoretically unreasonable that most landowner respondents were disinterested in reducing wildfire risks at the time of the survey. The data patterns in Figure 10 suggest otherwise. There was no consensus among the respondents that climate change is occurring (Graph A), nor that climate change will produce big wildfires (Graph B). There was only a slight but statistically insignificant tendency to believe that the local region faced higher wildfire risks (Graph C), but individual respondents who were more concerned about wildfire risks did exhibit statistically significantly higher fuels reduction propensities (Graph D).

Figure 10 clearly suggests that fuels reduction projects' implementation propensities are not clearly related to projects impact on wildfire risks, even as there always was a statistically significant inverse relation between higher propensities and higher wildfire risks. Accepting this factor, as such, would assert that landowners wish to maintain higher wildfire risks, and this would be a miss-specification of predictive models. Other factors must be at work that are correlated with wildfire risk levels and should correctly account for this variation in propensities.

One statistically significant explanation for this variation, accessible by the survey data, is exhibited in graph H in Figure 9. More effective projects at reducing wildfire risks are potentially more financially expensive to execute (irrespective of concomitant and uncertain revenue amounts) and this trend is accentuated when creating oak habitats. The regression results presented below found that the most consistently powerful variable in predicting fuels reduction propensities is the high end of the range of estimated potential project costs presented in the survey. These are plotted in Graph H in Figure 9. The respondents evidently tended strongly to focus more on the risk of highest potential project cost than any other financial (or other) consideration. This evidently transcended/canceled their interest in reducing wildfire risks.

Another simple explanation for variation correlated with wildfire risk is exhibited by the statistically significant relationship in Graph G in Figure 9. Fuels reduction project options that tend to reduce wildfire risks more effectively can incur greater risks to property rights because valuable habitat for sensitive and threatened species may be created. The regression results below found this factor to be a minor but significant factor in predicting respondents' propensities only among some landowners.

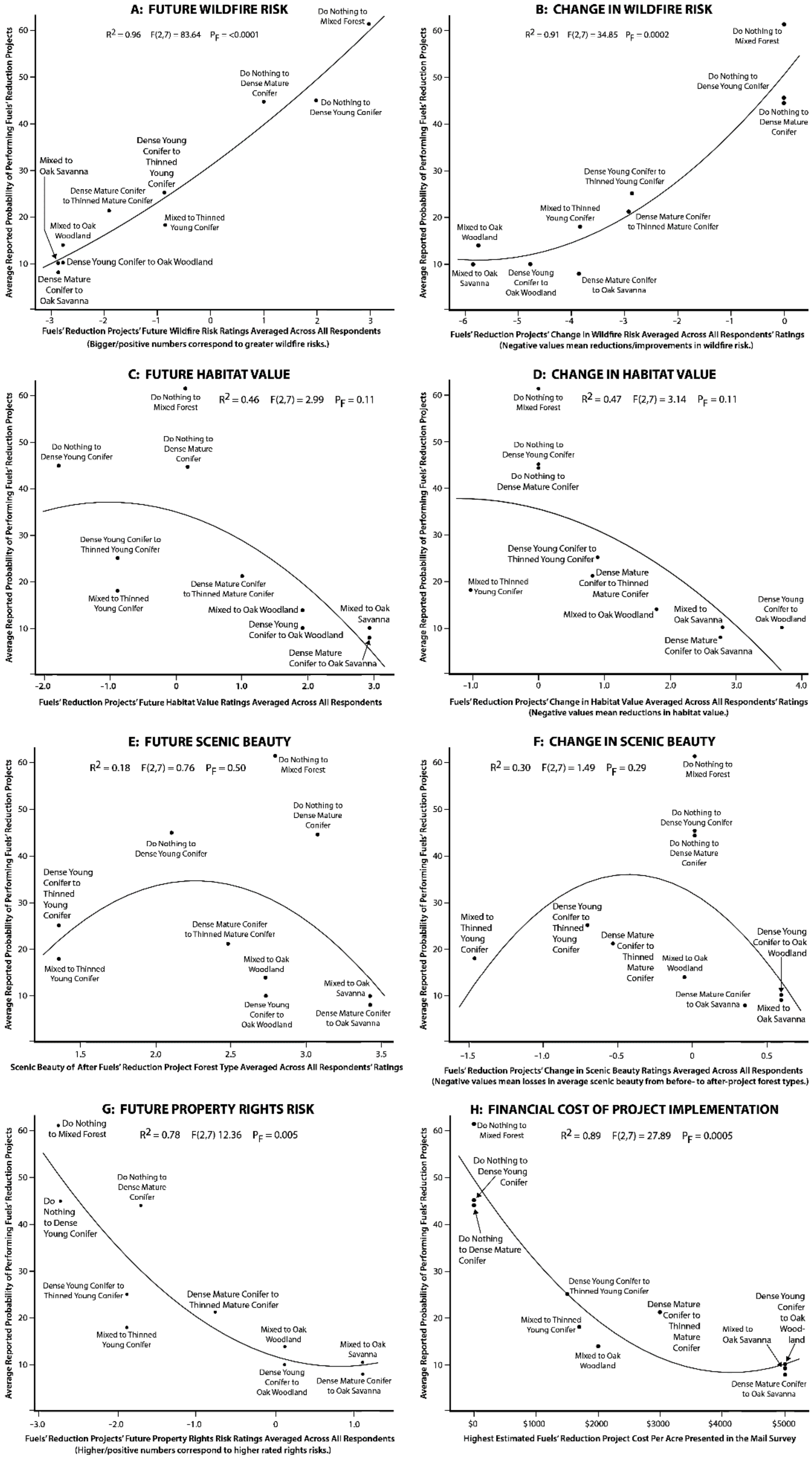


Figure 9. Relationship between fuels reduction propensities and attendant average ratings of corresponding forest attributes prior to regression analyses.

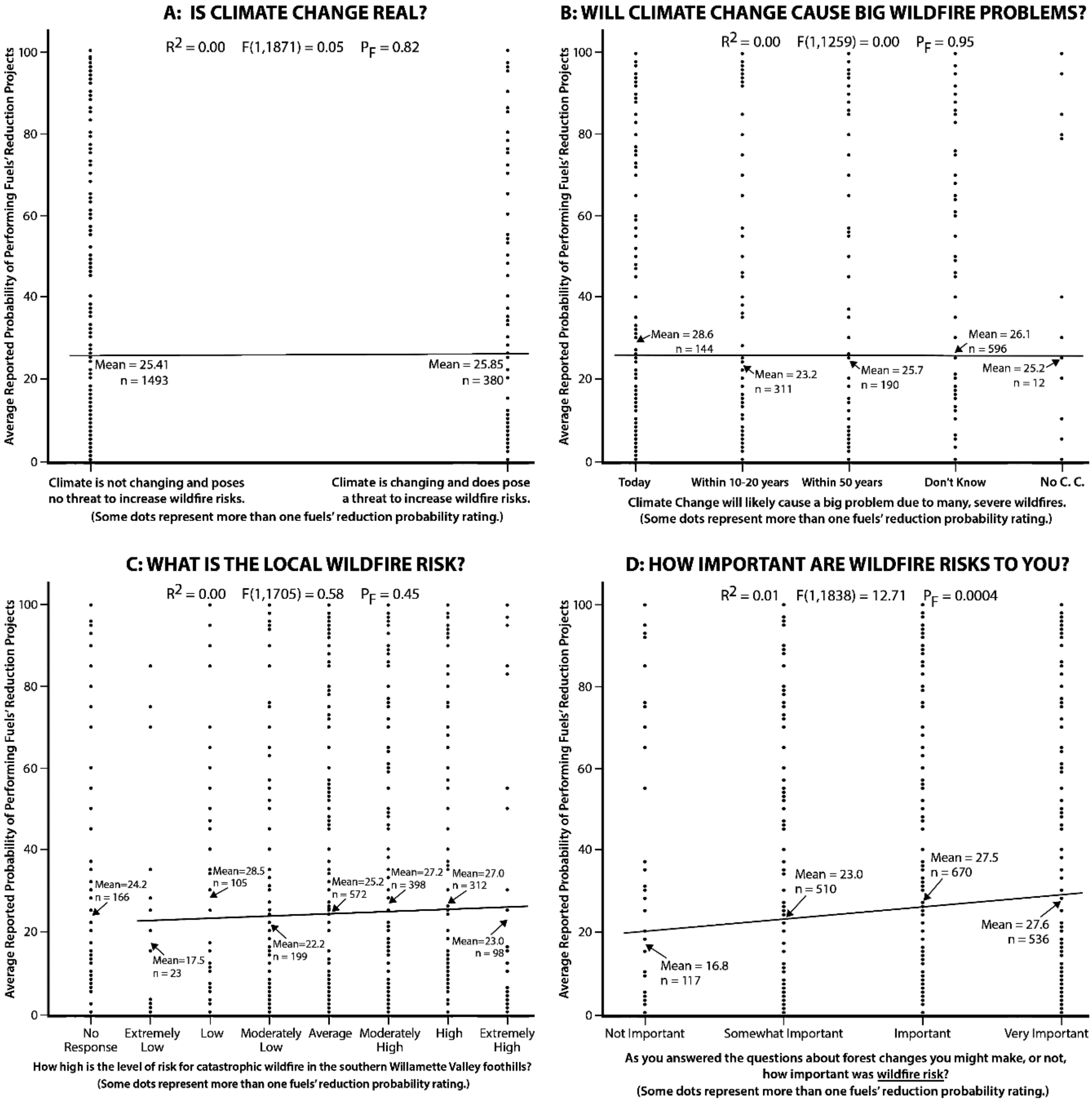


Figure 10. Respondents' dispositions related to climate change and wildfire risks.

Graphs C and D in Figure 9 exhibit similar relationships as the wildfire risk graphs A and B, but with much weaker statistical significance. Lower average fuels reduction propensities are associated with higher habitat values. This, again, suggests the respondents did not tend to value habitat improvements in making these land management choices. In this case it seems more theoretically plausible that many landowners simply do not value habitats, particularly oak habitats, enough to contribute to wanting to produce them even if they also reduce wildfire risks. This postulate was not supported by the regression analyses below because habitat value was rarely a significant and powerful factor in predicting propensities. Yet, when it was so, it tended to be positively (not negatively) related to higher propensities and only among certain types of landowners. For most respondents, financial project costs evidently supersede habitat values.

Graphs E and F in Figure 9 do not clearly exhibit a clear relationship between respondents' average fuels reduction propensities and their average scenic beauty ratings for forest types associated with potential projects. The best-fit curves there are not statistically significant. The regression analyses presented below did, however, find that scenic beauty is consistently a statistically significant positive predictor of project propensities, after accounting for the interaction of other factors.

3.3. Regression Results

All the best complete regression models are found in the Supplementary Materials. Figure 11 compiles the essential results across all the models (columns) estimated within different sets of respondents. It only includes statistically significant factors colored by their relationship to fuels reduction propensities. The values shown are each factor's total effect in explaining propensities within each model (column). Higher values correspond to more explanatory power, and these add to approximately 1.0 within each model.

Independent Variables	**A** All Respondents	**B** Farmers	**C** Forested Estates	**D** Foresters	**E** Multi-purp. Small Hold.	**F** Rural Residents	**G** Planning Can Help	**H** Vulnerably Helpless	**I** Anthropo-centric	**J** Nature Centric
LongTermCare	**0.704*** **	**0.711*** **			**0.711*** **	**0.563*** **	**0.751*** **	**0.738*** **		**0.670*** **
NextScenicBeauty	**0.218*** **	**0.284*** **	**0.606** **		**0.047** **		**0.222*** **	**0.131*** **	**0.234*** **	**0.101*** **
ScenicBeautyChange				**0.509*** **		**0.312*** **				
VulnerableNoPlan	**0.021** **		**0.410** **			**0.019*** **				**0.033*** **
WildfireEvacuate	**0.053** **			**0.166** **				**0.066*** **	**0.087*** **	
AnthropocentricIndex	**0.025* **					**0.014* **				
Anthropocentrism							**0.017** **			
ProGovernment					**0.014*** **		**0.027*** **			
HabitatValueChange					**0.227*** **					**0.184*** **
NextHabitatValue						**0.092*** **		**0.065** **		
Income				**0.177*** **						
HighestCost									**0.404*** **	
$HighestCost^2$				**0.026* **						
NextRightsRisk				**0.119*** **						
RightsRiskChange									**0.259*** **	
Whole Model R^2	**0.288*** **	**0.383*** **	**0.285** **	**0.213*** **	**0.364*** **	**0.360*** **	**0.284*** **	**0.305*** **	**0.210*** **	**0.399*** **

Green total effect values correspond to positive relations with fuels reduction propensities.
Red total effect values correspond to negative relations with fuels reduction propensities.
***** p_t or p_F < .01 ** p_t or p_F < .05 * p_t or p_F < .10 (p_F are for R^2 values in bottom row.)**

Figure 11. Total effects of variables (rows) in predicting project propensities across respondent types (columns).

3.3.1. Long-Term Maintenance Costs and Fuels Reduction Propensities

Extra project costs, activities, and maintenance requirements over time are the most powerful factor adversely associated with fuels reduction propensities among all the respondents and six of the subsets in Figure 11. The propensities of two of the three other subsets (foresters and anthropocentric respondents) instead exhibited similar, but less powerful, negative associations between financial costs and propensities. This was only true for foresters if costs were very high, as indicated by the squaring of costs to produce a significant factor. Forested estate owners' propensities are not significantly associated with any cost factor.

3.3.2. Scenic Beauty and Fuels Reduction Propensities

Two alternative variables that measure respondents' perceptions of projects' scenic beauty impacts are ScenicBeautyChange or NextScenicBeauty. One or the other is positively associated with fuels reduction propensities for every respondent set in Figure 11. It is second most powerful in explaining variance in propensities across all the respondents, and for all landowner subsets, except for multi-purpose small holders and nature centric respondents for whom it is third most effective.

3.3.3. Other Factors and Fuels Reduction Propensities

Reading across the columns in Figure 11 provides a way to see which factors were significantly associated with different landowner subsets' fuels reduction propensities. Below are descriptions of significant regression factors associated with propensities within each landowner or attitude type.

3.3.4. All Respondents and Fuels Reduction Propensities

The total effects in column A in Figure 11 correspond to the model that explains fuels reduction propensities across all the respondents. It explains 29% of variance. More complex restoration projects with greater maintenance requirements reduce propensities and contribute approximately 70% of this model's predictive effectiveness. Higher levels of perceived scenic beauty in the post-project forest type increases propensities and contribute approximately 20% of explanatory effectiveness. Previous experience with wildfire evacuations increases propensities and explains approximately 5%. This is notable due to the small number of respondents with such experiences. More anthropocentric landowners tend to be a bit less likely to favor fuels reduction projects, contributing approximately 2%, and feelings of hopeless vulnerability have the same negative effect.

3.3.5. Farmers and Fuels Reduction Propensities

The total effects for the model that explains farmers' propensities to implement fuels reduction are in column B in Figure 11. This simple model explains approximately 38% of variance with strong statistical significance. Projects' complexity and maintenance requirements reduce propensities and explain approximately 70% of predicted variance. (A weaker model that substitutes highest estimated financial costs is similar.) Post-project perceived scenic beauty increases propensities and explains approximately 30%. Farmers' anthropocentrism was negatively related to propensities but fell short on statistical significance to be included in a model.

3.3.6. Forested Estate Owners and Fuels Reduction Propensities

Total effects in the model that explains propensities among owners of forested estates are in column C in Figure 11. It is unique among the landowner types in not including any cost (or fire risk reduction) factors, albeit from the smallest respondent sample in the study. This model has only two statistically significant factors and significantly explains 29% of variance in propensities. The perceived scenic beauty of the post-project forest (which could be the same as the pre-project forest in the case of 'do nothing' options) explains an increase in project propensity by approximately 60%. Perceptions of hopeless vulnerability reduce propensities, contributing approximately 40% to prediction.

3.3.7. Foresters and Fuels Reduction Propensities

Column D in Figure 11 lists the total effects for factors in the commercial foresters' model. It significantly explains only 20% of variance in fuels reduction propensities. Scenic beauty change from pre-project to post-project forest type contributes approximately half the predictive effectiveness. Previous experience with wildfire evacuation increases predicted propensities by approximately 15%.

Three factors are unique to this landowner type: Higher annual income uniquely contributes to increased fuels reduction propensities, at approximately 17% effectiveness. Concern about loss of property rights is also a unique forester factor, reducing propensities at approximately 11%. Costs are the least, not the most, powerful factor. (Project complexity and maintenance is a weak negative explanatory factor in an alternative model that explains much less variance.) The adverse effect of projects' financial costs exhibits an exponential growth factor curve such that only very high project costs predict lesser propensities, with approximately 2% effectiveness.

3.3.8. Multi-Purpose Small Holders and Fuels Reduction Propensities

The total effects of four factors that explain variance in fuels reduction propensities among multi-purpose small holders are in column E in Figure 11. This model explains approximately 36% of variance with strong statistical significance. Increased project complexity and maintenance reduces propensities with approximately 70% predictive effectiveness. (A weaker model that substitutes highest estimated financial costs is similar.) Higher habitat value change from the pre- to post-project forest increases propensities among these landowners, accounting for approximately 23% of the model's effectiveness. Unlike any other respondent type, this habitat factor's predictive effectiveness is much higher than scenic beauty, which only accounts for approximately 5% among multi-purpose small holders. If such a landowner favors government regulation, they are more likely to implement fuels reduction, with approximately 1% effectiveness.

3.3.9. Rural Residents and Fuels Reduction Propensities

Column F in Figure 11 lists the total effects for factors in the rural residents' model. It explains 36% of variance in fuels reduction propensities with strong statistical significance. Project complexity and maintenance requirements strongly reduce propensities, at approximately 56% of predictive effectiveness. (A weaker model that substitutes highest estimated financial costs is similar.) Expectations of improved scenic beauty increases propensities, with approximately 31% effectiveness. Three other factors are less effective: Greater habitat value in the post-project forest increases propensities (~9% effect); perceived hopeless vulnerability reduces propensities (~2% effect); and greater anthropocentrism reduces propensities (~1% effect).

3.3.10. Proactive Planners and Fuels Reduction Propensities

The total effect values in Figure 11, Column G correspond to the model that explains 28% of variance in fuels reduction propensities among respondents who believe they can act to reduce wildfire risks. Higher project complexity and maintenance requirements reduce their propensities, with approximately 75% predictive effectiveness. (A weaker model that substitutes the highest estimated financial costs is similar.) Perceived scenic beauty of future forest types increases propensities, with approximately 22% effectiveness. Attitudes favoring government regulation are associated with higher propensities, at approximately 3%. More anthropocentric attitudes explain reductions in propensities, at approximately 1%.

3.3.11. Hopeless Vulnerability and Fuels Reduction Propensities

Column H in Figure 11 lists the total effects for factors in the model for respondents who feel helplessly vulnerable to wildfire. It significantly explains 30% of variance in fuels reduction propensities. These respondents are more averse to complex projects with long-term maintenance requirements than in any other model in Figure 11 with predictive effectiveness of approximately 74%. Perceived scenic beauty improvement for the post-project forest is associated with gains in propensities, at approximately 13%. Two factors have positive effectiveness of approximately 6%: experience with wildfire evacuations and expected improvement in habitat value.

3.3.12. Anthropocentrism and Fuels Reduction Propensities

The total effect values in Column I of Figure 11 are for the model that explains 21% of variance in fuels reduction propensities among landowners with an anthropocentric stance toward land management. Highest estimated financial costs of projects are a more effective factor instead of project complexity and maintenance requirements in explaining reductions in their propensities, with approximately 40% prediction effectiveness. Greater estimated changes in property rights risk reduced their propensities, with approximately 26% effectiveness. Higher perceived scenic beauty of future forest types increased propensities, at approximately 23%. Previous experience with wildfire evacuation also increases propensities, at approximately 9%.

3.3.13. Nature Centrism and Fuels Reduction Propensities

The total effect values in Figure 11, Column J are for the model that explains 40% of variance in fuels reduction propensities among landowners with a nature centric stance toward land management. Complex projects with ongoing maintenance requirements explain reductions in their propensities, with approximately 67% prediction effectiveness. Expected improvement in habitat value increases propensities, with approximately 18% effectiveness. This factor is much more predictive than scenic beauty, with approximately 10% effectiveness among nature centric landowners. If such landowners perceive greater hopeless vulnerability to wildfire, their propensities fall, at approximately 3%.

3.4. Dissecting the Influence of Scenic Beauty

Measures of costs and scenic beauty most frequently occur in the above models explaining fuels reduction propensities. Implementation and maintenance costs are usually the most important in reducing propensities, but the next most frequently important factor is complex (Figure 9E,F) and more nuanced in relation to different projects and landowners. Scenic beauty is always positively associated with fuels reduction propensities in ways that vary in valence and strength across specific project options, types of landowners, and their key attitudes. Graphs that illustrate all the interactions of scenic beauty perceptions and fuels reduction propensities by project and landowner types are found in the Supplementary Materials. (The depict simple two-way relationships and do not account for the effects of other factors found in the regression models in Figure 11).

The average scenic beauty ratings by landowner types are shown in Figure 11. A key feature of that graph mitigates against fuels reduction propensities. Most pre-fuels-reduction, high-wildfire-risk forest types are rated as more beautiful than the low-wildfire-risk forest types they can be converted to: (1) Dense mature conifer tends to be more beautiful than thinned mature conifer. (2) Dense young conifer is more beautiful than thinned young conifer and most strongly so among rural residents and multi-purpose small holders. (3) Mixed forests are more beautiful than oak woodlands among foresters, forested estates, and multi-purpose small holders, and equally beautiful among farmers and rural residents. (4) Mixed forests are more beautiful than thinned young conifer forests. (5) Dense mature conifer forests tend to be about equally beautiful as oak savannas, and more beautiful among forested estate owners. Among the options queried in the mail survey, only conversions of mixed forest to oak savanna reliably tend to favor fuels reduction by virtue of scenic beauty perceptions.

The average ratings in Figure 12 track each other well with some key exceptions. Forested estate owners tend to find distinctly lower scenic beauty in any oak forest type and find the most beauty in thinned mature conifer. Setting aside these forested estate owners, foresters find less scenic beauty in mixed oak and conifer forests than the other landowner types, and their ratings otherwise track the other owner types well, with two exceptions: multi-purpose small holders and rural residents find distinctly lower scenic beauty in thinned young conifer forests.

3.4.1. Scenic Beauty and Vulnerability Perceptions

The most interesting graphs of interactions between scenic beauty perceptions and fuels reduction propensities entail perceptions across all the project types between landowners with different stances regarding vulnerability to wildfire. The most statistically significant of these are compiled in Figure 13. If one ignores the two projects that result in thinned young conifer forests, ‘planning’ landowners who believe they can reduce wildfire risks tend to increase fuels reduction propensities with perceived gains in scenic beauty. The opposite applies to the other landowners who feel hopelessly vulnerable to wildfire. Their propensities tend to decline with gains in perceived scenic beauty or are little affected in the case of major projects from conifer to oak forests. There is no significant difference between 'planners' and 'helpless' landowners for projects that execute forest thinnings that mainly leave young conifer trees. Both tend to exhibit gains in propensities with perceived gains in scenic beauty.

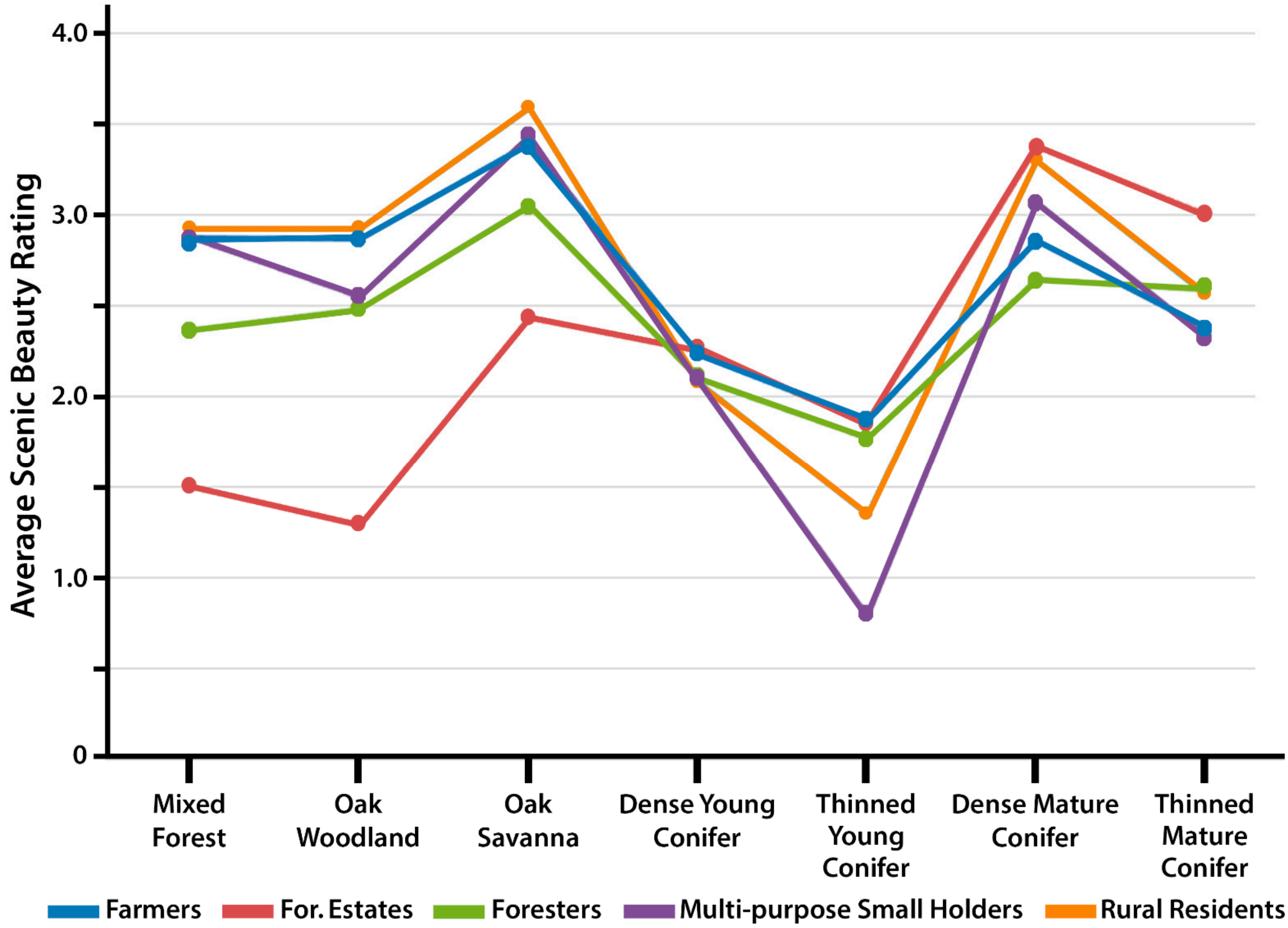


Figure 12. Average scenic beauty ratings of forest types by landowner categories.

3.4.2. Scenic Beauty and Anthropocentrism

Another interesting set of interactions between scenic beauty and fuels reduction propensities involves landowner stances toward land management. The most statistically significant of these are compiled in Figure 14. With one exception, projects that move toward ecological restoration of oak woodlands or savanna tend to gain propensities with scenic beauty more among nature centric landowners than anthropocentric ones. The exception is projects that work from dense mature conifer forest to oak savanna. It yields the most logging revenue to anthropocentric landowners and entails a smaller change in perceived habitat value. Conventional forest thinnings of mature forests, including mixed forests, to thinned conifer forests exhibit greater gains in propensities with gains in scenic beauty among anthropocentric landowners than nature centric ones. In the case of young conifer forest thinnings, both these landowner types exhibit similar gains in propensities with scenic beauty gains. These thinning projects are more neutral with respect to habitat value.

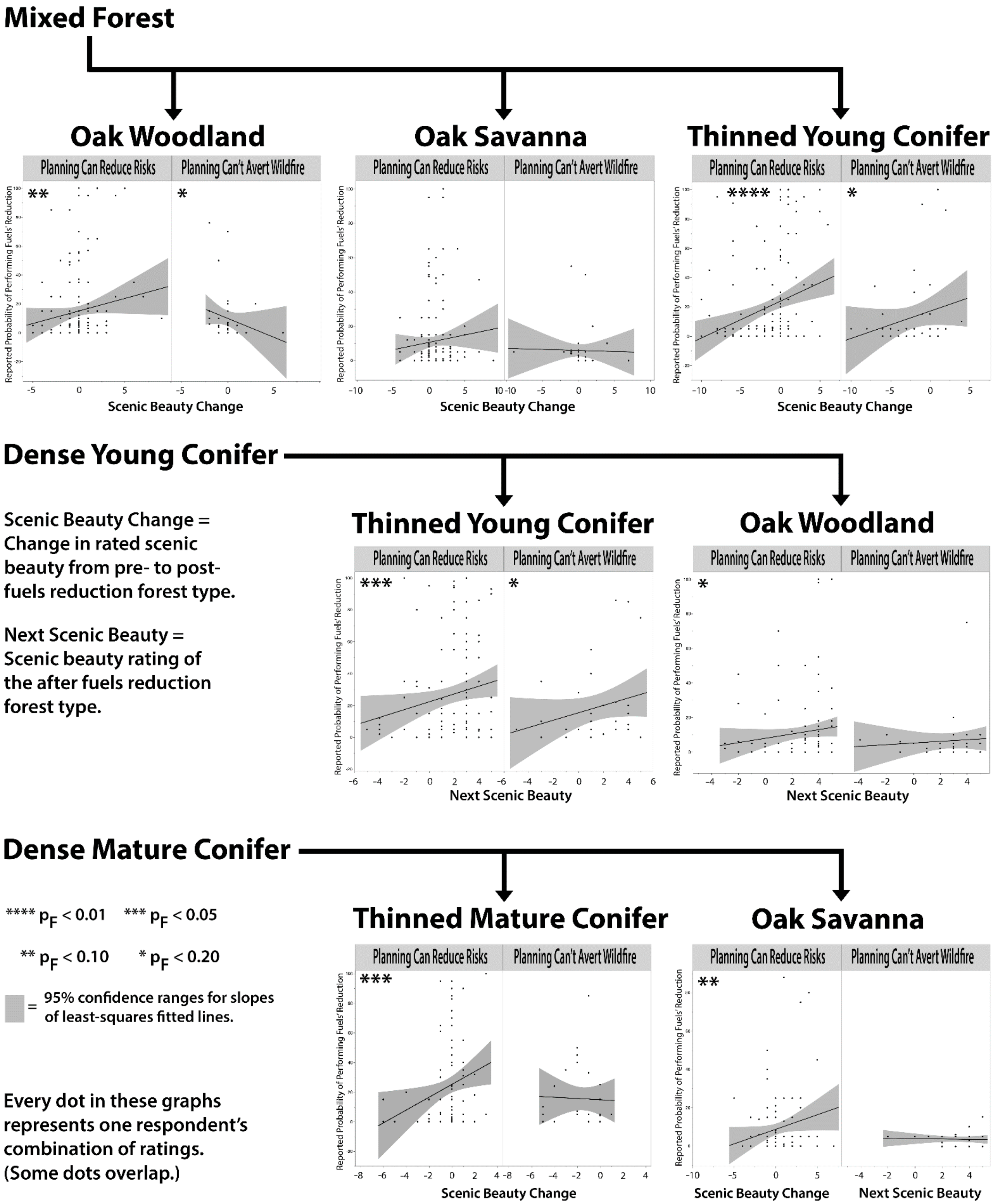


Figure 13. Attitudes toward planning against wildfire risk in relation to how scenic beauty perceptions correlate to fuels reduction propensities across all seven project types.

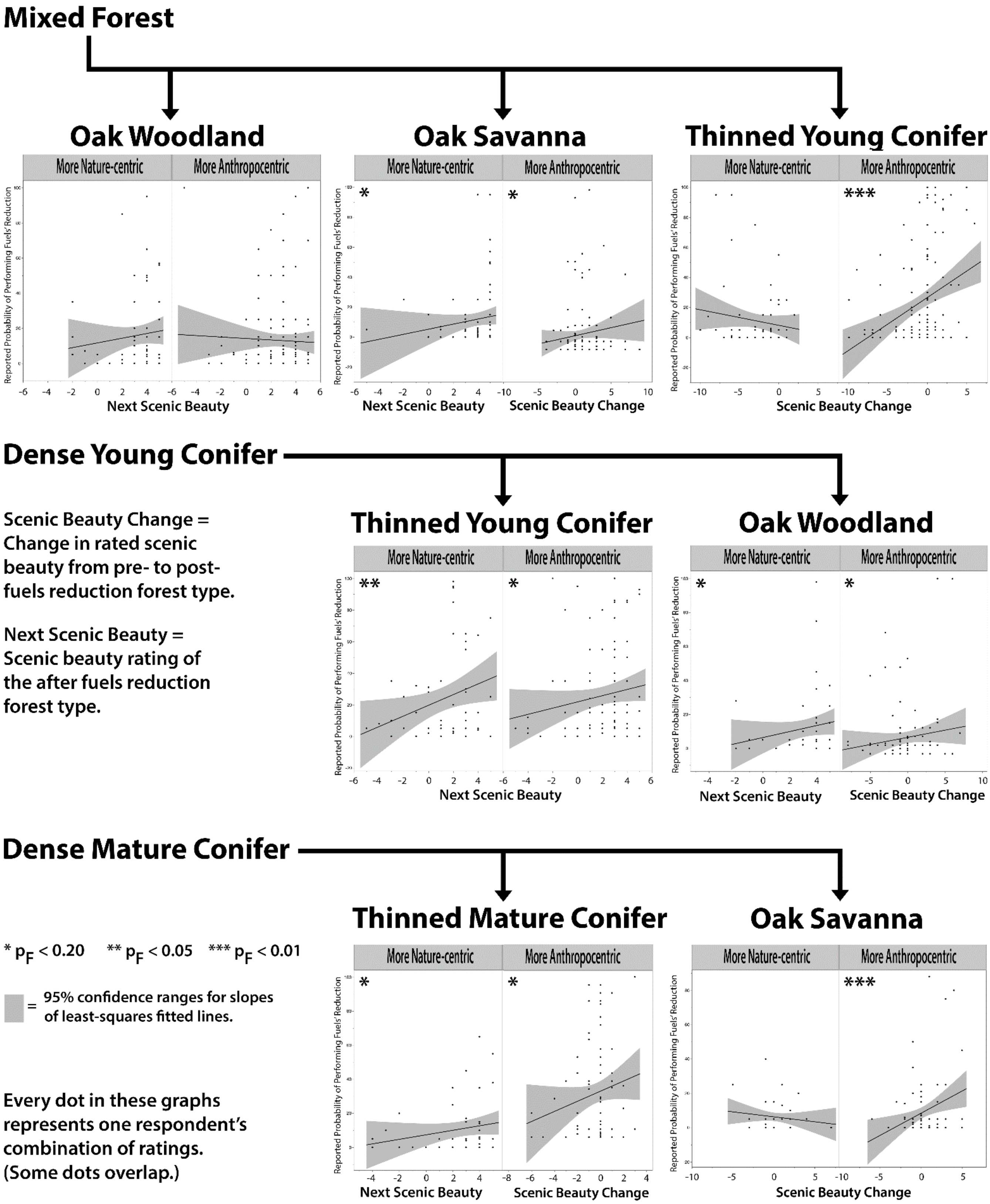


Figure 14. Attitudes toward nature and land management in relation to how scenic beauty perceptions correlate to fuels reduction propensities across all seven project types.

3.4.3. Scenic Beauty and Landowner Types

The most informative interactions between scenic beauty and fuels reduction propensities across landowner types are found in Figure 15. All the graphs there represent projects that begin with mixed oak and conifer forests. Those across the top are for projects that remove the conifer trees toward restoring the oak woodland that existed before the encroachment of conifers –largely due to fire suppression. The bottom graphs are for an opposite, more utilitarian, fuels reduction project. This entails removing oaks and retaining an open density of the younger, encroaching conifers, which will become more commercially valuable. Paying more attention to the statistically significant graphs yields some observations.

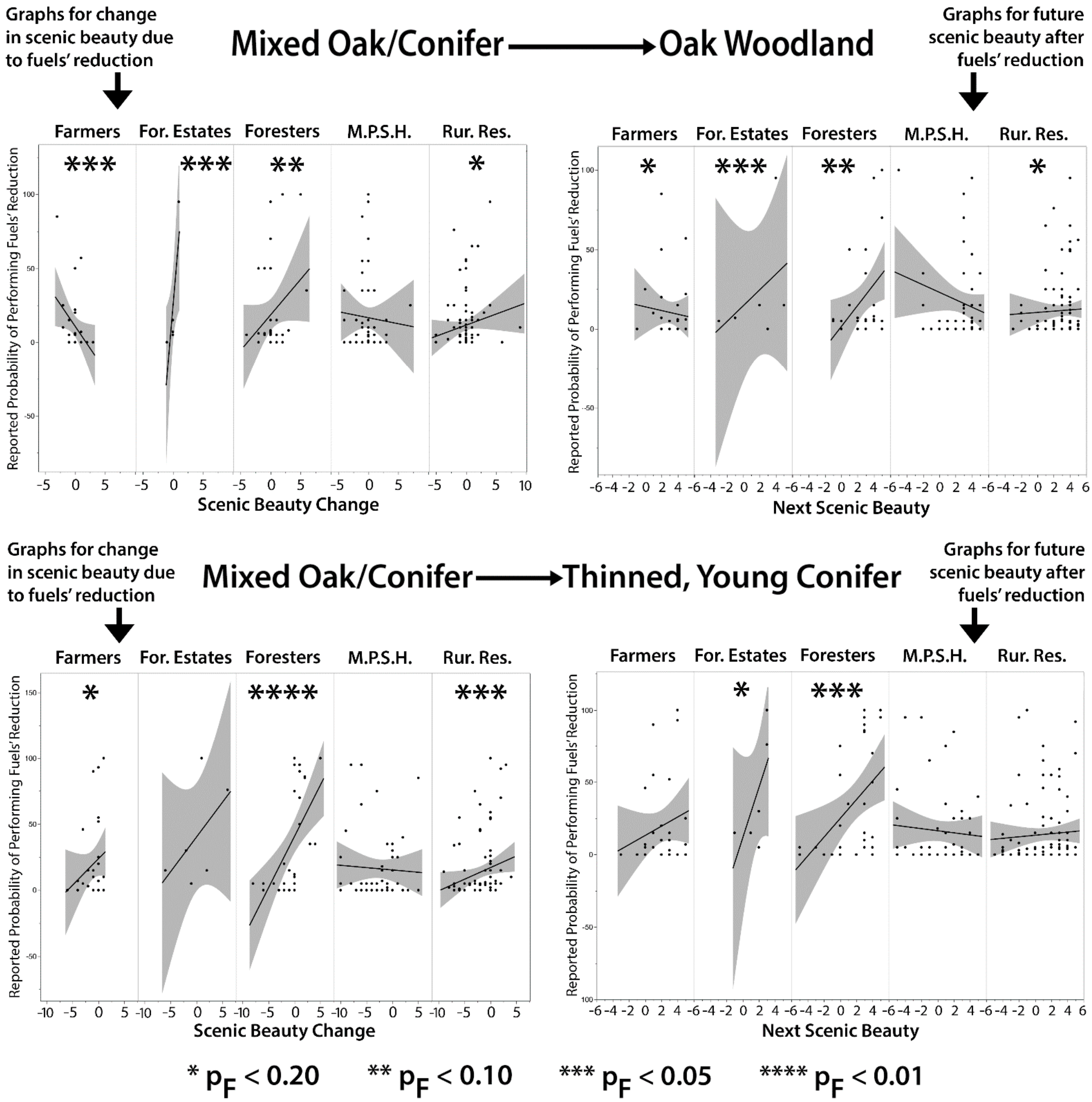


Figure 15. Landowner types in relation to scenic beauty correlations to fuels reduction propensities for two contrasting project types that begin with mixed forests.

Farmers tend to find gains in aesthetic affection for producing oak woodland, but their propensities fall with these gains in scenic beauty. Instead, they tend to favor the more utilitarian target forest type for which gains in perceived scenic beauty correspond to gains in propensities. Forested estate owners' propensities grow rapidly with gains in perceived scenic beauty for both project types, but more significantly for restoring oak woodlands, indicating some preference for that target forest. Foresters strongly favor both kinds of fuels reduction projects and they tend to find aesthetic affection for either kind of target forest. Their graphs are more significant in targeting thinned young conifer, indicating some preference for creating that forest.

Rural residents most significantly favor creating thinned young conifer forest and tend to find gains in scenic beauty there. They also tend to exhibit gains in propensities with gains in scenic beauty for producing oak woodland, albeit with marginal significance because their responses were clustered within narrow ranges of scenic beauty. Multi-purpose small holders do not exhibit significant relationships between perceived propensities and scenic beauty. Their propensities tend to decline with scenic beauty for producing oak woodlands and to stay about the same across scenic beauty levels for producing thinned young conifer forests. These 'indifferent' results are likely due to their many differently mixed and prioritized motivations for land management.

4. Discussion

4.1. General Differences across Landowner Types

The basic propensities in Figure 8 exhibit average within-ten-year fuels reduction implementation propensities in the 10% to 30% range (higher for foresters). If these values are cautiously accepted, they are somewhat encouraging because this would correspond to widespread implementation within fifty years. Of course, the distribution around these averages includes landowners who will not reduce fuels. Rural residents, farmers and multi-purpose small holders' propensities track each other closely. They have the highest average propensities to do nothing and the lowest propensities to act.

Rural residents, farmers, and multi-purpose small holders exhibit the lowest average propensities (<25%) across all the actual fuels reduction projects. Forested estate owners exhibit the highest project propensities (usually > 20%) and the lowest do-nothing propensities (<30%). Foresters exhibit the highest project propensities (>30%) unless projects aim to produce oak habitats (<20%). (Oak is not a commercial forest species in the region.) Propensities to do nothing are typically high (>30%) across all owner types except the forested estate owners.

The greatest divergence in propensities occurs for simple thinning of dense mature conifer forests (middle of Figure 8) and is not readily attributable to aesthetic affections (Figure 12). Rural residents and multi-purpose small holders do not favor this project (<20%) perhaps because these landowners value undisturbed mature conifer forests as habitat which matters more to them (Figure 11). Recent controversies in the region favor the habitat value of old-growth conifer forests similar to mature conifer forests. Farmers and foresters likely tend to favor thinning of mature conifer forests more because of the commercial value of the removed trees and the remaining trees at final harvest. These landowners tend to be more anthropocentric (Figure 11).

The least divergence in propensities occurs for projects that produce thinned young conifer forests from either dense young conifer forests or mixed forests (3rd and 4th from the left in Figure 8). All but one landowner type favors thinning of young conifer forests at 20 to 25%, which is as high as their average project propensities tend to be, except for forested estate owners. The same as true for thinning mixed forests to young conifer forests at a lower propensity range of 13 to 18%. Foresters favor thinning of young forests the most at 33 to 36%. Evidently, the most fuels reduction can be achieved across the landscape if thinning to young conifer forests is promoted.

Fuels reduction projects that aim toward ecological restoration of oak habitats (and reduce wildfire risk the most) tend to have lower and more divergent propensities across landowner types (Figure 8). Foresters and forested estate owners are most likely to favor these projects at 15 to 40%. This is likely because they can often better afford the costs and often own larger patches of forest where such projects can most fruitfully be done. Oak restoration is best targeted to such landowners and rural residents with more nature-centric stances and willingness to bear the costs.

4.2. Wildfire Risks and Fuels Reduction Propensities

Perceptions of wildfire risks did not increase landowners' fuels reduction propensities in this study. Fuels reduction projects that most reduce wildfire risks produced the lowest propensity ratings (Figure 9A,B). No multivariate model to explain landowners' propensity ratings could produce a positive relation between wildfire risk reduction and fuels reduction propensities. The data here demonstrated no consensus that climate change is real or that it would create serious wildfire risks at the time of the mail survey (Figure 10A–C). More importantly, landowner respondents that did believe in climate change, or that it will create wildfire risks, did not report significantly higher propensities to conduct fuels reduction projects than other landowners (Figure 10D). However, 2/3 of the landowners did report that wildfire risks are important or very important in forest management decisions and these exhibited slightly higher propensities (Figure 10D).

There has recently been a marked increase in wildfire frequency, intensity, and extensiveness in the region surrounding the study areas sampled for this study [30]. This study should be repeated to see if wildfire risks now contribute to greater fuels reduction propensities.

Recent experience of evacuation under wildfire threats is a frequent factor in the propensity prediction models here (Figure 11), despite the small number of landowners with such an event in the sample (and its consequent small contribution to explaining variance in propensities). It therefor seems likely that recently imperiled regions or neighborhoods with fearfully adverse experiences with wildfire may have increased fuels reduction propensities [15], although the gambler's fallacy [41,42] and other social factors [43] might contribute to a reverse effect. Such experiences may reduce fuels reduction cost aversion enough so that more effective projects at reducing wildfire risk will gain average propensities compared to less effective projects.

4.3. Costs Are Paramount

The costs of implementing fuels reduction options are the most important factor that explains propensities across all landowners (Figure 9H) and categories of landowners, except foresters and forested estate owners (Figure 11). Costs, and particularly long-term maintenance requirements, work against the likelihood that many landowners will pursue projects that work toward ecological restoration, as opposed to one-time forest thinnings. The fuels reduction projects employed in the mail survey were realistic. Some mainly entailed one-time thinnings. Respondents also rated 'do-nothing' options that are obviously inexpensive and therefore garner high propensities (Figure 9H) particularly if landowners do not fear wildfire (Figure 10B,C). Some options proposed directions toward ecological restoration of historic, wildfire resilient oak habitats with higher financial costs and long-term maintenance requirements. These long-term, ongoing tasks were the greatest deterrent among all types of landowners except forest estate owners, foresters, and landowners with strongly anthropocentric perspectives. These latter three categories were instead more deterred by higher short-term financial costs, although foresters tended to be deterred mainly by very high costs.

The realism of the projects offered in the mail survey produced a set of options where greater wildfire risk reductions tended to be correlated with higher implementation and maintenance costs. The landowner respondents presumably rated these with low propensities due to these costs and not because they reduced wildfire risks. Costs trumped risk reductions. The study might have better independently tested the impact of wildfire risk reductions on propensities if the survey's set of project options had included some 'artificial' projects with very low cost and very-high risk reduction, or by excluding options that pursued extra, ongoing tasks toward ecological goals, as have other studies.

4.4. Fuels Reduction Aesthetics

Landowners' ratings of scenic beauty are usually the second most powerful and significant positive factor in this study's models explaining higher fuels reduction propensities across landowner categories (Figure 11), duplicating previous findings [22]. Aesthetic affections for forests evidently weigh on most landowners' decisions about mitigating wildfire risks, albeit distinctly less than project costs. How these do so is complicated because aesthetic affections for different forest types can be influenced by landowners' land use motivations and attitudes.

Projects that produce improvements in forests' perceived beauty usually correspond to higher fuels reduction propensities, but highly fuels loaded forests can garner high aesthetic perceptions that mitigate against change. An example is dense mature conifer forests. These are viewed as more beautiful (on average) than fuels reduced alternatives among all landowner types except foresters (Figure 12) and therefore gain high propensities to do nothing (Figure 8). Another example is mixed oak and conifer forests with average aesthetic affections about the same as fuels reduced alternatives (Figure 12), except among forested estate owners, which again garner high propensities to do nothing (Figure 8). All landowner types agree (on average) that dense or thinned young conifer forests have low scenic beauty. They also agree (except multi-purpose small holders) that thinned young conifer forests are a bit less beautiful than dense young conifer forests (Figure 12) but nevertheless favor these thinnings to less beautiful forests to achieve fuels reduction (Figure 8). Aesthetic affections evidently only mitigate against fuels reduction among existing high beauty forests.

Farmers and multi-purpose small holders tend to favor fuels reduction despite losses in perceived scenic beauty if projects aim toward ecological habitat restoration (top of Figure 15), but this relation reverses only among farmers if a project aims for a commercially managed forest type (bottom of Figure 15). In contrast, foresters always favor fuels reduction with gains in perceived scenic beauty whether a project aims toward ecological or commercial values (Figure 15). Foresters must tend to 'see' more beauty in open oak habitats than farmers do. Multi-purpose small holders (on average) always gain fuels reduction propensities with losses in scenic beauty (in the examples in Figure 15) because they tend to share land use motivations and attitudes with farmers. If they emphasize farming, they do not favor production of oak forests despite their higher beauty, while those who emphasize forestry favor gaining oak dominated forests with increased beauty.

4.4.1. Attitudinal Dispositions and Aesthetic Affects

Landowners who tend to believe that planning and action can reduce their wildfire risks tend to exhibit significantly positive associations between higher fuels reduction propensities and gains in perceived scenic beauty than others who tend to feel hopelessly vulnerable and believe planning and action are ineffective (Figure 11). Perhaps an affirmative attitude toward active risk management is associated with greater aesthetic affection for managed forests. Landowners who feel hopelessly vulnerable to wildfire lean more against thinning projects, perhaps because the costs of such 'pointless' projects often overcome their aesthetic possibilities.

More anthropocentric landowners typically exhibited gains in propensities with gains in their aesthetic affections for almost all the projects queried. They tend to gain propensities most significantly with gains in aesthetic perceptions for thinnings of conifer forests and conversion of mixed forests into conifer forests (Figure 14). Their aesthetic affections seem to lean toward more open forests but most so for conifer forests.

Nature-centric landowners exhibit a different pattern (Figure 14). They do not always associate gains in propensities with gains in perceived aesthetic affection. They only do so for projects that target oak habitats unless the starting forest is dense mature conifer.

Nature-centric landowners tend to favor fuels reduction toward ecological goals unless they have a mature conifer forest, which they view as more valuable as habitat (but less beautiful) than oak savanna. They also favor thinnings of young conifer forests in concert with gains in scenic beauty.

4.4.2. Aesthetics and Wildfire Risk Mitigation

The above interpretations suggest landowners' aesthetic affections are consequential upon fuels reduction propensities and mediated by personal values and motivational interests in managing their property. The possibility of modifying landscape affections, at least on the margin, to promote more fuels reduction activities is under recognized in the literature and policy debates. These affections may be substantially 'set' by landowners' values and interests, but deeper personal and community understanding of how more fire resilient forests can produce both utilitarian and ecological services might inspire more affectionate desire to produce such forests. People can appreciate and value what they understand, and environmental disruptions can produce new understandings [44,45].

4.5. Impact of Habitat and Property Rights Concerns

Habitat value improvement is not an effective fuels reduction incentive across the general population of landowners (Figure 9C,D) but can be influential among particular landowner types. Fuels reduction projects toward reestablishing scarce oak habitat types found the most favor among multi-purpose small holders (total effect ≅ 23%, Figure 11) and nature-centric landowners (total effect ≅ 18%, Figure 11). This factor was also significantly influential among rural residents (total effect ≅ 9%, Figure 11) and landowners who feel hopelessly vulnerable (total effect ≅ 7%, Figure 11). Habitat production can motivate fuels reduction projects mainly among non-traditional rural residents who seek a rural context for living and typically own smaller parcels. These landowners tend to be more nature centric but are more likely to feel a lack of effective agency against wildfire risks.

Concerns about losing property rights if they pursue oak habitat production tends to reduce fuels reduction propensities among more anthropocentric landowners (total effect ≅ 26%, Figure 11) and foresters (total effect ≅ 12%, Figure 11). (This factor missed inclusion in the farmers' best fit regression model with a $p_t = 0.12$). These landowners are more concerned about maintaining land use and development options, and this presumably correlates with preferences for commercial production of utilitarian goods instead of projects that aim toward habitat restoration. They tend to own larger parcels, and farmers' parcels probably tend to include smaller forested areas. Potential fuels reduction adopted on these is more likely to emphasize thinning forests toward more conifer content, and this is more likely among foresters with high incomes.

4.6. Impact of Perceived Vulnerability and Agency

Perceptions of hopeless vulnerability and lack of planning agency to reduce wildfire risks were common in the survey sample (n = 82, 23%). Such perceptions were slightly but significantly effective in negatively predicting propensities across all respondents (total effect ≅ 2%, Figure 11), but this small effectiveness was only found among nature-centric landowners (total effect ≅ 3%, Figure 11) and rural residents (total effect ≅ 2%, Figure 11). A much larger and statistically significant effect occurs among the small number of forested estate owners (total effect ≅ 41%, Figure 11). This indicates these estate owners largely account for the significant effectiveness of this factor in the all-respondent prediction model (Figure 11). Perhaps the 'vulnerable' forested estate owners (who tend to have lived in the region for shorter periods of time) earn their incomes in ways separated from forests and are not as socially or experientially embedded in rural landscapes with attendant understanding of forests and wildfire risks. Or they may tend to view forests as an amenity context for their homes with little attentional engagement and thereby have a passive disposition toward their forests that leans toward a preference for not planning against wildfire risks. These conjectural explanations need further research and may also apply to a small but significant number of rural residents and nature-centric landowners.

Landowners who reported vulnerable lack of agency against wildfire tend to gain propensities if they care about habitats (total effect ≅ 7%, Figure 11) or have recently experienced wildfire evacuation (total effect ≅ 6%, Figure 11). This suggests those who perceive hopeless lack of agency may gain propensities for fuels reduction if they start experiencing fearful wildfire threats and believe such projects can be environmentally beneficial.

The propensities for landowners who reported agency against wildfire (Figure 11) align with other landowners in avoiding long-term maintenance costs and favoring more scenic beauty. If they favor government land use regulations, they can gain some propensity (total effect ≅ 3%, Figure 11). This suggests that government programs promoting fuels reduction should work more among landowners who perceive agency. Figure 11 also shows that diminished propensities occur among these landowners who are anthropocentric. Such government programs will tend to be ineffective there.

4.7. Ineffective Factors in Explaining Propensities

Many variables, and combinations, from the survey were tested within models explaining fuels reduction propensities. Only the small subset in Table 2 is successful and the models are only modestly explanatory. There are many unshared attributes of landowners' perceptions, knowledge, experiences, and attitudes that idiosyncratically affect individual's fuels reduction propensities in complex ways [46]. These include responses to survey questions about climate change attitudes, attitudes toward wildfire policies, and preferred land management practices. Assisting landowners in making fuel's reduction decisions therefor entails individual-level counseling and education, social learning, community capacity building, collaborations, and well-tailored incentives [47,48]. The importance of aesthetics found in this study suggests that this assistance will be complicated by the challenges of framing and affective forecasting [49].

4.8. Anthropocentrism and Habitat Value

More nature-centric landowners tended to exhibit higher fuels management propensities in this study because all the fuels reduction target forest types offered in the mail survey were informed by higher expert habitat value assessments than corresponding starting forest types. All the fuels management options did offer various timber harvest benefits, but the survey offered only one that achieved timber harvest values with only a small gain in habitat value. The target forest types in this research were therefor likely to offer more to nature-centric landowners than anthropocentric ones. Another survey with target forests stratified to balance economic and habitat value tradeoffs, if realistic, might not identify anthropocentrism versus nature-centrism as a significant factor in explaining fuels management propensities.

The statistically significant differentiation of respondent types by anthropocentrism occurred only in regression models across large numbers of landowners. This helps to explain why all survey-derived variables related to habitat value were not statistically significant in any of the same, large-sample regression models. More statistically significant 'centrism' variables displaced the somewhat correlated predictive potential of habitat variables. Habitat value factors do appear in models in some smaller categorical subsamples of landowners, where habitat factors are more statistically significant than, or not correlated with, 'centrism' variables.

5. Conclusions

Private landowners' propensity to reduce fuels is substantially dependent on their belief that their wildfire risks are significant and growing. Our 2009 landowner survey found widespread perceptions of low risks and little climate change concomitant with low fuels reduction propensities. These perceptions also affect preferences favoring less effective risk reduction projects. These preferences for less effective projects seem largely related to their lower short- and long-term financial and maintenance costs.

Private landowners are typically free to dismiss fuels reduction as a land management objective, judge it hopelessness to achieve [41], and decline to allow climate change or risk concerns to affect their interest in fuels reduction, as this study demonstrates. This phenomenon is compounded by the common pool nature of wildfire spread and risk reduction [4,10,12]. Private forest owners who appreciate wildfire risks and are prone to act against it are less likely to act unless they know that many of their neighbors will do the same. A survey question in this study sought to ascertain such perceptions but was found to be unrelated to fuels reduction propensities and requires further research. This study found that recent adverse experience with wildfires elevates interest (but not necessarily action) in fuels reduction among most landowner types, consistent with previous studies [41,50].

Even though fuels reduction propensities reported in this study's survey were low, they are, on average, high enough to impact a substantial portion of the private forest landscape over time. Habitat considerations are a significant consideration in boosting these propensities but are important to only a minority of landowners.

5.1. Perceived Agency and Fuels Reduction Options

Landowners' perceptions of hopeless vulnerability to wildfire and lack of effective agency in mitigating wildfire risks substantially reduce fuels reduction propensities. These 'vulnerable' landowners are less affected by perceived potential gains in scenic beauty in reporting higher propensities than other landowners. As with most landowners, 'vulnerable' landowners do report higher propensities if thinned young conifer forests are targeted by projects.

Other 'planning' landowners who do perceive effective agency tended to report higher propensities if they were more anthropocentric, conifer forests were the outcome of projects, and/or they perceived such target forests to be beautiful. A lesser number of other 'planning' landowners gained propensities favoring creation of more fire resilient oak dominated forests if they were nature centric, perceived gains in habitat value, favored government land use regulations, and/or perceived such target forests to be beautiful. Some of these landowners who lean toward restoring oak forests exhibit some propensity to go the 'extra-mile' in these projects if their traits include some combination of high incomes, nature-centric land management stances, pro-government attitudes, and/or are little motivated by financial gains from their land.

5.2. Aesthetics-Centered Fuels Reduction

Aesthetic considerations are under-appreciated regarding their influence on landowner decisions to reduce fuel loads. These are often second only to financial costs in importance. Public education and incentive programs often emphasize issues, such as wildfire behavior, project logistics, financial costs and ecological risks and benefits. However, perceptions of scenic beauty of before- and after-project forests often drive fuels reduction propensities more than these technical aspects. Landowners should be encouraged to openly and safely discuss their aesthetic concerns and all engaged in decision making should respect the nuances of affections for alternative forest landscapes. These include more than simple appearances or scenic amenities. They are also affected by landowners' way of life, motivations, and management philosophies toward their forests.

Aesthetic perceptions are often among top-level concerns in large-scale public fuels reduction projects across landscapes. Legal environmental planning requirements and political circumstances typically compel aesthetic design and management considerations driven by public feedback. This study indicates that private aesthetic decisions should be equally engaged and not viewed as personal and subjectively capricious across landowners. Such fuels reduction decisions may best be fully engaged and resolved through 'landscape design' assistance and open qualitative discussions about place attachments and meanings. Landowners are more likely to implement projects when they perceive their future forest as more beautiful than the current one. Perceived reductions in aesthetic appeal strongly deter fuels reduction and more so if financial costs are high. Each landowner will have their own perception of costs and aesthetics, but these may be influenced by 'deep' environmental information in relation to wildfire hazards and by local social reference groups informed by fuels reduction programs.

We argue that those charged with promoting extensive fuels reduction in private forests (as opposed to defensible spaces around structures) should consider taking an 'aesthetics-centered' approach at least as much as a wildfire-hazard centered approach. This study shows how different landowners tend to integrate other values into their influential aesthetic evaluations of forest changes. Each landowner's perceptions are complex and unique but there are useful general expectations in approaching and assisting different kinds of landowners, as described below. (Some of these are derived from the detailed results found in the Supplementary Materials).

5.2.1. Farmers and Foresters

Farmers and foresters tend to share utilitarian or anthropocentric approaches to forest management. They tend to favor affections for thinned forests by virtue of their managed 'health' and commercial growth rate, and this coincides with more resilience to lower intensity wildfire. Foresters much more than farmers can be receptive to thinnings that aim for habitat benefits if they are not too costly, although a minority of foresters with higher incomes and more nature centrism find aesthetic value in extra expenditures for habitat restoration. Farmers and foresters, as larger-scale landscape managers, tend to feel they have agency against wildfire risks, and this contributes to greater fuels reduction propensities. As other landowner types, foresters and farmers project propensities will be low if three or four factors reinforce each other: (1) lack of a meaningful sense of agency against wildfire, (2) disapproval of land use regulations, (3) low income, and (4) high project costs. Unlike other landowner types, concerns about property rights makes farmers and foresters a bit less likely to favor projects that aim for habitat restoration.

5.2.2. Forest Estate Owners

Wealthy owners of large, forested parcels with estate homes are different than commercial foresters. They tend to be unconcerned with fuels reduction costs. They are more amenity oriented and receptive to aesthetic affections for ecological restoration projects that reduce wildfire fuels and intensity. This is more so if they are more nature-centric and support land use regulations. These estate owners tend not to feel effective agency against wildfire, and this reduces their fuels reduction propensities. This may be because they are more disconnected from scientific and local community natural resource knowledge. Promoting such engagements, if possible, could increase their feelings of agency and fuels reduction propensity.

5.2.3. Rural Residents and Multi-Purpose Small Holders

Landowners of smaller parcels tend to have more diverse sources of affection for forests. They are more likely to favor scenic beauty and habitat qualities in making forest change decisions, particularly if they use their land mainly as a home site or are nature-centric. Opening views from homes often favors fuels reduction but many small landowners have affection for dense mature forests (conifer or mixed) that they wish to keep. Where strong nature centrism dominates scenic beauty motivations, particularly among small landowners who do not farm, it can shift high fuels reduction propensities toward ecological restoration, albeit within small parcels. This is more so among amenity-centric landowners who feel they have agency against wildfire. If small landholders prioritize land use motivations other than home sites or wildlife habitat, such as micro-farming, small-scale forestry, or speculative investment, they are less prone toward affection for more open and wildfire resilient forests, irrespective of their ecological values. This disaffection toward fuels reduction grows if such small landholders feel they lack agency against wildfire, do not approve of land use regulation, or are strongly anthropocentric.

5.3. Research Needs

This study was conducted before the landowners had experienced historically-rare, large, widespread and intense wildfires in 2020 [30]. Their concerns about wildfire hazards were low and did not markedly influence fuels reduction propensities. More studies like this one are needed both before and after such events and in many regions around the world, especially in Mediterranean climates. This should inform how perceived trade-offs between project costs versus wildfire risk reduction evolve over time as climate change and wildfires advance, as mediated by aesthetic perceptions. Fuels reduction propensities in different regions' forest types with their unique fuels reduction options might produce different results, or the underlying factors that affect people's choices might reflect those reported here.

Costs are a major impediment to fuels reduction in private forests. We recommend studies to investigate how different forms and values of project subsidies might increase implementation of projects among different landowners and why. Such findings might enable efficient targeting of payment levels to landowners who would be least likely to otherwise participate.

Qualitative studies of landowners' rich, complex, and place-based aesthetic perceptions of forests in relation to wildfire are needed. These could provide insights for promotion of aesthetics-centered approaches to promoting and planning fuels reduction on private lands. These should help to explain some of the unexplained variance in propensities in this study's quantitative models.

Studies of fuels reduction propensities toward specific projects should be made across more fully stratified sets of fuels reduction options. These could include unrealistic options that can help to ascertain the full decision structure of people's choices. For example, inexpensive projects that produce high risk reduction with both high and low habitat values could produce interesting results.

Wildfire risk is complex, contingent, and uncertain [2,46]. Fires ignite in many possible ways and places so when and how fires may enter a particular forest can confound optimal fuels reduction. How each possible fire could behave within a landowner's forest is crucial but contingent on many factors. The ways and extent that landowners understand these set of factors and their probabilities might affect fuels reduction propensities [41,51–53], but this has been little studied. The limited power of wildfire risk reduction opportunities in effecting propensities in this study suggests robust understanding of wildfire risks might have only a minor impact on propensities. A public survey that attempted to robustly explain wildfire risks in different forest types would risk reduced response rates due to complex cognitive demands. A survey investigating the relation between risk understanding and fuels reduction propensities would have to be dedicated only to this question. Our study only briefly described wildfire risk and simply provided landowners with expert estimates of average risk for alternative forest conditions (that they could marginally modify). Higher risk estimates did not correlate with increased fuels reduction propensities. They might if the risks were more richly understood by landowners. Public information and community engagement processes may be optimized to promote robust risk perceptions, and this is being studied [48,49]. However, risk perceptions are complex and emotional with many sources of bias [16,25,32,42,54].

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