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Does it matter if people think climate change is human caused?

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Comments

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Does it matter if people think climate change is human caused?

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ABSTRACT

There is a growing consensus that climate is changing, but beliefs about the causal factors vary widely among the general public. Current research shows that such causal beliefs are strongly influenced by cultural, political, and identity-driven views. We examined the influence that local perceptions have on the acceptance of basic facts about climate change. We also examined the connection to wildfire by local people. Two recent telephone surveys found that 37% (in 2011) and 46% (in 2014) of eastern Oregon (USA) respondents accept the scientific consensus that human activities are now changing the climate. Although most do not agree with that consensus, large majorities (85–86%) do agree that climate is changing, whether by natural or human causes. Acceptance of anthropogenic climate change generally divides along political party lines, but acceptance of climate change more generally, and concerns about wildfire, transcend political divisions. Support for active forest management to reduce wildfire risks is strong in this region, and restoration treatments could be critical to the resilience of both communities and ecosystems. Although these immediate steps involve adaptations to a changing climate, they can be motivated without necessarily invoking human-caused climate change, a divisive concept among local landowners.

Practical Implications

Despite scientific consensus that climate is changing, beliefs about causal factors vary widely among the general public in the United States, influenced by cultural, political, and identity-driven views. In eastern Oregon, a semi-arid region dominated by dry forest, the effects of a warmer climate during the next few decades include reduced productivity and health of forests, increased wildfire occurrence, and reduced water supplies. These effects would have a significant impact on both natural resource conditions and human welfare, especially in the Blue Mountains and adjacent communities.

Surveys of the public in this region have demonstrated that belief in human-caused climate change is relatively low compared to the national average, although most agree that climate is changing, whether from natural or human causes. Most people support active forest management (forest thinning, surface fuel reduction) and restoration to reduce the likelihood of high-intensity wildfires that would damage timber and threaten local communities. Fuel reduction and restoration are climate-smart management practices, regardless of the motivation.

In fact, collaborative efforts are already underway in eastern Oregon to reduce fuel loadings near communities. In addition, federal agencies, non-governmental organizations, and watershed councils are working with ranchers and farmers to explore ways to capture spring runoff and improve irrigation efficiency. These efforts reflect the perspectives of individual landowners focused primarily on short-term change and short-term management objectives, in contrast to the much longer temporal scale at which climate change is

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usually perceived.

Although ongoing actions may be adequate in the short term, planning and management at long temporal and broad spatial scales are less likely to occur if landowners do not believe that climate change is here to stay. Long-term planning is challenging and not typically a consideration for most landowners. Creating resilient landscapes at broad spatial scales (thousands of hectares) would encompass and/or overlap multiple ownerships, requiring collaboration to implement forest management practices and other activities. In addition, multiple constraints to active management—limited budgets, federal and state regulations, air quality restrictions for prescribed burning, complicated review processes—make it difficult to implement large projects.

A culturally attuned communication process that respects beliefs of local stakeholders and leadership can be used to overcome ideological barriers. Consensus messaging also provides a way to share evidence-based scientific agreement on climate change and related issues. Both approaches can facilitate progress on building resilience in local landscapes and communities without using climate change adaptation as the motivation. The recent emergence of forest collaboratives, which are working partnerships between public and private organizations, is an optimistic sign that individuals committed to working together are bridging logistical and cultural divides to improve resource management, regardless of climate change beliefs.

1. Introduction

Evidence for changing climate, associated with increases in atmospheric greenhouse gas concentrations, continues to increase. The year 2012 marked a milestone for the United States when it eclipsed 1998 by 0.6 °C to become the hottest year on record (NCDC, 2016). Then, 2014 became the warmest ever recorded, and 2015 was warmer still (NCDC, 2016). February 2016 broke the record for the largest monthly temperature anomaly (NASA, 2016). Furthermore, 2015 reached a new record high of global carbon dioxide levels for the 31st consecutive year (ESRL, 2016) and was accompanied by an increase of 0.23 °C over 2014, an increase of 1.8 °C since the late 1800s (ESRL, 2016).

Human activities have increased atmospheric carbon dioxide (CO_2) concentrations past 400 ppm, levels unseen for millions of years (Biello, 2015). Barring significant reductions in fossil fuel use and deforestation, a doubling of pre-industrial CO_2 levels (from about 280 to over 560 ppm) will occur in the first half of the 21st century. Analysis of climate data from the contiguous United States since 1895 shows the mean temperature rising at an average rate of 0.14 °C per decade (NOAA, 2016b). Warming accelerated in recent decades, with the U.S. trend becoming 0.50 °C per decade for 1975–2015. Under conservative scenarios, future climate changes are likely to include further increases in mean temperature (about 2–4 °C globally in this century), with significant drying in some regions, as well as increases in the frequency and severity of droughts, temperature extremes, and heat waves (IPCC, 2007).

Forest systems and changes in their complexity and structure are examples of complex feedbacks between changes in climate, resource availability, disturbance, and management in space and time (see Kerns et al., this issue). With U.S. forests occupying 300 million hectares, a changing climate affects the health, growth and productivity of these forests and exacerbates threats such as drought, wildfires, and insect outbreaks (Kurz et al., 2008; Allen et al., 2010; Waring et al., 2011). Climate change alters the distribution, extent, frequency, and intensity of these disturbances, and large impacts (e.g., loss of species regeneration) can be expected (Anderson-Teixeira et al., 2013). The effects on species and ecological communities at the margin of their range may be particularly severe (Dale et al., 2001; Turner, 2010).

The effects of climate change on wildfire, the most influential natural disturbance in temperate forest ecosystems (Bond and van Wilgen, 1996; Barnes and Spurr, 1998), is critically important socially and ecologically. In 2015, over 68,000 wildland fires covering 4 million hectares burned across the western United States. Suppression costs for the federal government were $2.1B (NIFC, 2016a,b). This cost is on the rise as fire seasons have grown longer in combination with increased settlement in the wildland-urban interface (Dale, 2006; Westerling et al., 2006). July 2012, the peak of that fire season, became the hottest month ever recorded in the contiguous US (NOAA, 2013). Much of the Intermountain West, including eastern Oregon, contains large areas of dense stands with fire resilient species (ponderosa pine [*Pinus ponderosa*], western larch [*Larix occidentalis*], and Douglas fir [*Pseudotsuga menziesii*]) in the overstory and fire susceptible species (e.g., grand fir [*Abies grandis*]) in the understory. In addition, mountain pine beetle (*Dendroctonus ponderosae*) has caused mortality in 20 million hectares of western North America (Kurz et al., 2008; Cain and Hayes, 2009). Together, the effects of changing fire regimes, increased fuel loads, and stressed forests, coupled with increasing impacts of fires on populated areas and demands for more fire suppression, has created a pathology of declining forest conditions, much of which is exacerbated by climate change (Fischer et al., 2016).

Duration of drought is expected to increase as snowpack decreases in the future, especially in the Pacific West (Clifton et al., this issue). The maximum number of consecutive dry days (precipitation < 1 mm) per year is projected to increase 5–10 days in the American southwest and Pacific Northwest (Vose et al., 2016). Since 1948, there was a significant decrease in the 25th percentile flow of rivers and streams in the Pacific Northwest, indicating that dry years are becoming drier. Winter streamflows will peak earlier and higher, and summer streamflows will be lower.

These past and projected changes impact human communities in the West, especially where livelihoods depend on natural resources. Ranchers may benefit as shifts in vegetation distributions favor expansion of grassland at the expense of forests. However, longer, drier summers and reduction in water availability from mountain streams (see Clifton et al., this issue) may pose additional challenges. Forests becoming denser and more uniform in species and age increases stress and facilitates insect outbreaks and crown fires. Frequent wildfire will also impact livestock producers if they lose forage and are forced to find alternative feed or reduce their herd size. In addition, increased forest fire severity may combine with hot summers and unsightly views of dead trees to deter tourists and amenity homeowners (those who buy second homes or live in the area for the visual and social opportunities of a rural community).

The scientific consensus about human-caused climate change has been extensively documented in reviews (IPCC, 2013; Melillo et al., 2014), statements by leading science organizations (e.g., Finn, 2013), surveys of scientists (Doran and Zimmerman, 2009), and published scientific reports (Oreskes, 2004; Cook et al., 2013). However, the issue of climate change remains divisive among U.S. politicians and the public. Politicians, ideological media, and some citizens line up with politically-framed views about this science-heavy topic. Core points of disagreement include whether climate change is happening now, and if so what the primary cause may be. A recent poll found that 63% of Americans are represented by a member of Congress who questions the science behind human-caused climate change (Ellingboe, 2016). The cause obviously matters for mitigation policies, but also for adaptation planning that anticipates continued warming.

Within this context of climate change and politics, we tested whether the issue of climate change was a salient one among the general public in eastern Oregon. The region has experienced frequent large wildfires along with an economic downturn in part caused by a decline in the forest products industry. Other studies have demonstrated a link

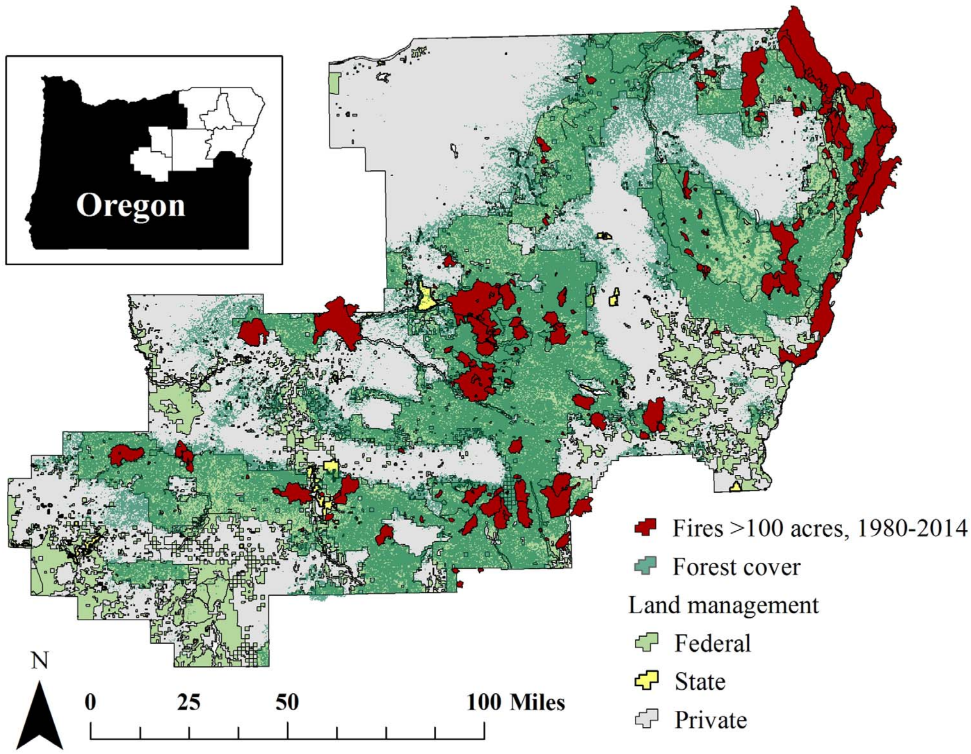

Fig. 1. Study area in the Oregon Blue Mountains province.

between belief in climate change and implementation of adaptive actions (Blennow and Persson, 2009), which is theoretically because "believers" also believe projected climate trends and want to adapt to changing conditions. Using a telephone survey, we asked residents for their personal beliefs about climate change. We asked respondents whether they thought climate change was happening and human-caused, as well as whether summer temperatures have increased over the last several decades, and if they expect them to increase in the future. We hypothesized that a belief in climate change would correspond with a belief in the upward trajectory of summer temperatures, which are associated with the wildfire and forest health issues discussed above.

2. Study area

The Communities and Forests in Oregon (CAFOR) project focuses on the Blue Mountains Province (6.2 million hectares), northeastern Oregon. This ecoregion is comprised of rugged mountains, steep valleys, and plateaus, ranging from 900 to 3000 m elevation. We examined 7 counties with significant forested area (Baker, Crook, Grant, Umatilla, Union, Wallowa, Wheeler) (Fig. 1); 45% is private land and 54% is managed federally. Grand fir, lodgepole pine (*Pinus contorta* var. *latifolia*), western larch, and Douglas fir dominate forests at mid-altitudes and wetter sites; ponderosa pine dominates at lower elevation, drier sites; and subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), whitebark pine (*Pinus albicaulus*), and lodgepole pine dominate at higher elevation, cooler sites (Hessburg and Agee, 2003). A high proportion of the land is designated as national forests (Malheur, Ochoco, Umatilla, Wallowa-Whitman).

Forests and wildfire have an important socioecological role here. Over a century of environmental alterations, including fire suppression and overstory logging, have altered forest structure, fire regimes, species assemblages, and riparian conditions, resulting in high levels of tree disease, mortality, and fire, which in turn has impacted visual quality, wildlife habitat, instream sedimentation, and timber values. Manufacturing, forestry, mining, and agriculture, which founded the region's modern economy, continue to have a strong presence in local communities, but have been in decline. Recently, concern about forest health, fire, and climate change has motivated increased support for thinning federal forests in the region (Cockle, 2013).

Although historically dominant industries associated with manufacturing, forestry, mining, and agriculture continue to have a strong presence in some rural communities, forestry activity has declined in the face of public land policy changes and rural economic diversification. This region has experienced economic declines and demographic change, including an aging population, typical of many rural areas in the USA. The median age of five counties surveyed (Baker, Crook, Wallowa, Grant, Wheeler) is 10+ years older than Oregon's median age, while Union county has the same median age as the state (39 years) and Umatilla was slightly lower (Table 1). Median incomes in these counties are below the national median household income of $53,889 (Oregon: $51,243), and the percent of college graduates, ranging from 15.4% to 24.3%, is also below the national average of 29.7% (Oregon: 30.7) (US Census Bureau, 2017).

3. Data

3.1. Wildfires, weather and climate

Long-term climate indicators were derived from National Oceanic

Table 1
American Community Survey estimates for demographic variables in study area counties (US Census Bureau, 2017).

	Population 2011–2015	Median Age	Median Income	Percent College Grad or Higher
Baker	16,100	48.2	$41,098	20.6
Crook	21,000	48.1	$37,106	15.4
Grant	7,300	51.1	$38,046	19.1
Umatilla	76,700	36	$48,101	16.3
Union	25,700	39	$43,822	23.2
Wallowa	6,900	52.2	$40,581	24.3
Wheeler	1,300	56.5	$33,487	15.4

and Atmospheric Administration data for eastern Oregon climate divisions 6, 7, 8 and 9 (NOAA, 2016c), which in turn derive from long-running records of individual stations in this region. We calculated temperature anomalies by re-expressing temperatures for each division and month as deviations from their respective 1901–2001 means. Anomalies were averaged across the four divisions for June through September. Average correlation among monthly temperature anomalies for the climate divisions is 0.91 over 1,452 months (1895–2015), and the first principal component explains 94% of total variance. Both results support their combination in a regional index (see Hamilton et al., 2016).

We derived two other long-term indicators to measure dryness (NOAA, 2016c): monthly precipitation (mm), and monthly Palmer Hydrological Drought index (PHD; Palmer, 1965), both of which were averaged for June through September. These are the warmest times of the year and correspond with higher wildfire frequency. Although precipitation and dryness correlate less strongly across divisions than temperature anomalies, Hamilton et al. (2016) found that these regional precipitation and dryness indicators significantly predict the frequency of large wildfires.

The research team extracted wildfire frequencies from a U.S. Forest Service dataset associated with the Fire Statistics System (FIRESTAT), which maintains Forest and District-level historical data. Our analysis focuses on predicting "large" fires of 100 acres (about 40 ha) or more. We considered lightning-caused fires of less than 100 acres as a rough proxy for the frequency of "dry thunderstorms" in this region, which often produce lightning without much rain.

3.2. Perceptions about climate

We conducted telephone surveys in late summer/early fall of 2011 and 2014 in eastern Oregon. In 2011, 1585 interviews were conducted in Wallowa, Union, and Baker counties (Hamilton et al., 2012). The study was expanded in 2014 to include these three plus four additional counties (Crook, Wheeler, Umatilla, and Grant), conducting another 1752 interviews.

Landline (2011 and 2014 survey) and cell phone numbers (included with the 2014 survey only) were selected at random within each county to obtain a representative cross-section of the public. Random numbers were generated separately for the 2011 and 2014 surveys, so it is possible that the same household was surveyed for both surveys. Surveys lasting 10–15 min were conducted by trained interviewers at the University of New Hampshire Survey Center. Questions focused on perceptions of climate change, wildfire, environmental policies and regulations, and land use. Probability weights allowed minor adjustments toward a more representative sample. The weighting scheme used (similar to that in Hamilton et al., 2014), while avoiding large changes, includes adjustments for design bias involving number of people in a household, and deliberate oversampling to achieve representation from smaller counties and forest landowners (those owning 4 or more hectares of forested land). Oversampling helped obtain a sharper statistical picture (narrower confidence intervals) of subgroups, but requires probability weighting in compensation to avoid biasing the overall analysis. Weights also adjust the demographic profile to match a census age/sex table for these counties. Boag et al. (2015) present summary results, including a graphical view of the weighting process, and comparisons between 2011 and 2014 survey results.

4. Results

4.1. Wildfires, weather and climate

Both wildfire frequency and fire-season climate in eastern Oregon have changed over the past four decades. Fig. 2 graphs observed frequencies of fires greater than 40 ha, together with frequencies predicted by a negative binomial regression model (Hamilton, 2013). The regression model finds that fire frequency is significantly affected by precipitation, drought, temperature, and lightning ignitions of small fires, along with a general upward trend that could reflect non-climate factors (e.g., higher fuel loads) (Hamilton et al., 2016). This model provides a rough fit to observed wildfire counts.

Plots of fire-season (June through September) temperature, precipitation, and drought reveal high interannual variability (Figs. 3–5). One can think of these variations as "weather." Each graph depicts the annual (fire season) data along with a lowess smoothed regression curve (bandwidth equal to 40 percent of the data; see Hamilton, 2013) to show decadal-scale trends. One can think of these smoothed curves as "climate." The past four decades (right panel in each figure) comprises the reference period for the survey question discussed later.

Fig. 3A shows eastern Oregon fire-season temperature anomalies for 1895–2015, derived from NOAA climate divisions data (NOAA, 2016c). The seasonal temperatures vary from one year to the next, but the smoothed curve depicts an underlying trend that gains 2.4 °C in a step-pause-step pattern. The step-pause-step pattern of early 20th-century warming, mid-century slowdown in the era of industry-driven "global dimming," and a new takeoff in warming since the mid-1970s follows the 20th-century pattern of global climate change (IPCC, 2013). Global climate change is visualized in by a second lowess curve for global temperature anomalies relative to the same 1901–2000 baseline (NOAA, 2016a) (Fig. 3A). Although eastern Oregon fire season temperatures follow the same pattern as global change, the Oregon index has warmed more steeply, especially over the past four decades (Fig. 3B).

Wildfire seasons depend more directly on dryness than on temperature, although those dimensions are correlated. Fig. 4 shows eastern Oregon average monthly precipitation, with the 1895–2015 view on the left and recent data on the right (NOAA, 2016c). Recent seasons tended to have below-average precipitation (Fig. 4B). Global precipitation is not meaningful in this context, so Fig. 4 makes no global comparison.

Fig. 5 shows a similar comparison tracking Palmer Hydrological Drought Index (PHDI) for eastern Oregon fire seasons (NOAA, 2016c). A more general extension of the Palmer Drought Severity index (Palmer, 1965), PHDI reflects not only precipitation but hydrological conditions such as groundwater and reservoir levels. Negative PHDI values indicate dryness or drought; positive values indicate wetter conditions. Values of 0 are considered normal; negative 2 is moderate drought, negative 3 is severe drought, and negative 4 is extreme drought. Several fire season values over the past few decades indicate "severe drought."

4.2. Perceptions of climate

In summer and fall of 2011, the CAFOR research team conducted a random-sample telephone survey of 1500 residents in Baker, Union, and Wallowa counties (Hamilton et al., 2012, 2014; Hartter et al., 2015). The survey revealed differences between perceptions for climate change and wildfire: respondents had a high concern about wildfire and insects and a low concern about climate change. A follow-up survey in 2014 found somewhat higher (though still well below national levels) acceptance of human-caused climate change over an expanded 7-county region. The 2014 survey also revealed perceptions about temperatures which followed the same ideological pattern as beliefs about human-caused climate change (Hamilton et al., 2016). Fig. 6 summarizes key results from the 2011 and 2014 surveys; panels a and c show responses to the question:

Which of the following three statements do you personally believe?

-Climate change is happening now, caused mainly by human activities

-Climate change is happening now, but caused mainly by natural forces

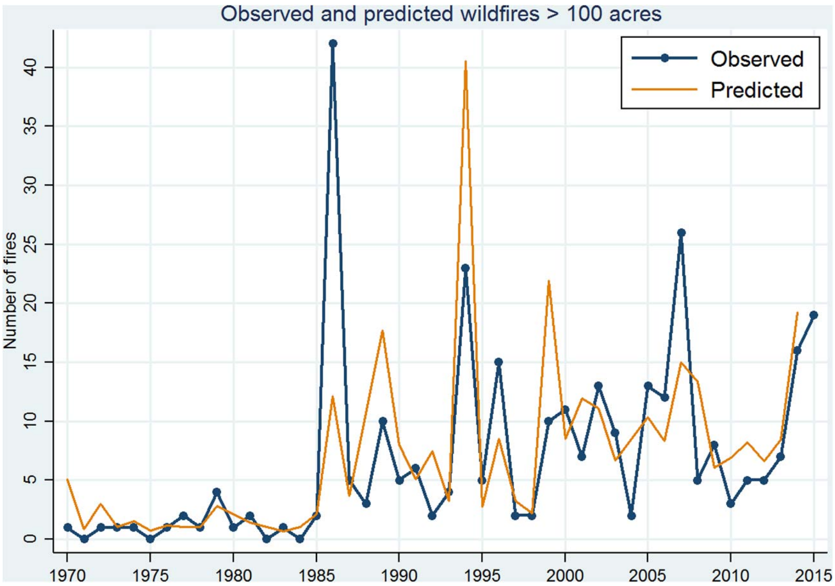

Fig. 2. Observed number of eastern Oregon wildfires larger than 40 ha, 1970–2014, with predictions based on negative binomial model with precipitation, drought, temperature, linear trend, and number of small lightning ignitions as predictors (from Hamilton et al., 2016).

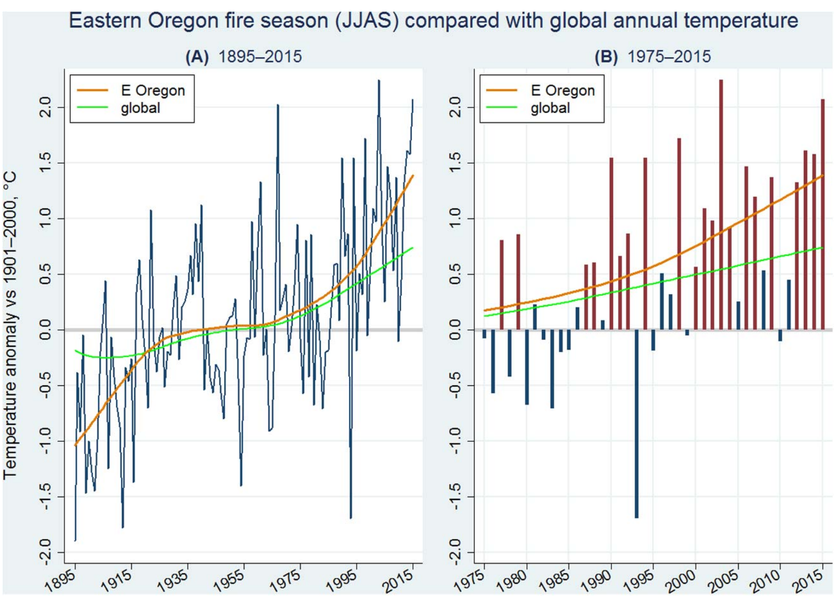

Fig. 3. Eastern Oregon fire-season temperature anomalies for 1895–2015 (A) and 1975–2015 (B). Lowess regression curves summarize the eastern Oregon fire-season trend, and also the trend in global annual anomalies relative to the same (1901–2000) baseline years.

-Climate change is NOT happening now.

Only 37% of the three-county respondents in 2011, and 46% of the seven-county respondents in 2014, agreed with the scientific consensus that human activities are now changing the climate. Following the three original counties through both surveys this increase is smaller (37–41%), but still statistically significant controlling for respondent demographics and political orientation. Nationwide U.S. surveys asking this same question in 2011, 2012, and 2014 found 52–54% agreement (Hamilton et al., 2015).

Although most eastern Oregon respondents did not accept human causation, large majorities (85–86%) nevertheless agree that climate is changing, whether by natural or human causes. From this, we might expect wider acceptance or awareness of local warming (Fig. 3), which has tangible consequences apart from beliefs about its cause. A question on the 2014 survey asked:

Which of the following statements about past climate in this region do you believe is most accurate? Northeast Oregon summer temperatures over the past 20 years …

-Have been warmer, on average, than summers 30 or 40 years ago

-Have been about the same, on average, as summers 30 or 40 years ago

-Have been cooler, on average, than summers 30 or 40 years ago

Only 40% agreed that recent summers have been warmer (Fig. 6B; compare with Fig. 3B). Although the past-temperature question says nothing about causes, analysis suggests that many people were responding to this question as if it had asked their opinion about human-caused climate change. A similarly-structured and causally agnostic question asked about future temperature (Fig. 6D):

Which of the following statements best describes your belief about future climate in this region? Northeast Oregon summer temperatures over the next 20 years are likely to be …

-Warmer, on average, than summers of the past 20 years

-About the same, on average, as summers of the past 20 years

-Cooler, on average, than summers of the past 20 years

Nationally, climate change has become a divisive issue, often split across political party lines (Hamilton et al., 2015). Testing whether that

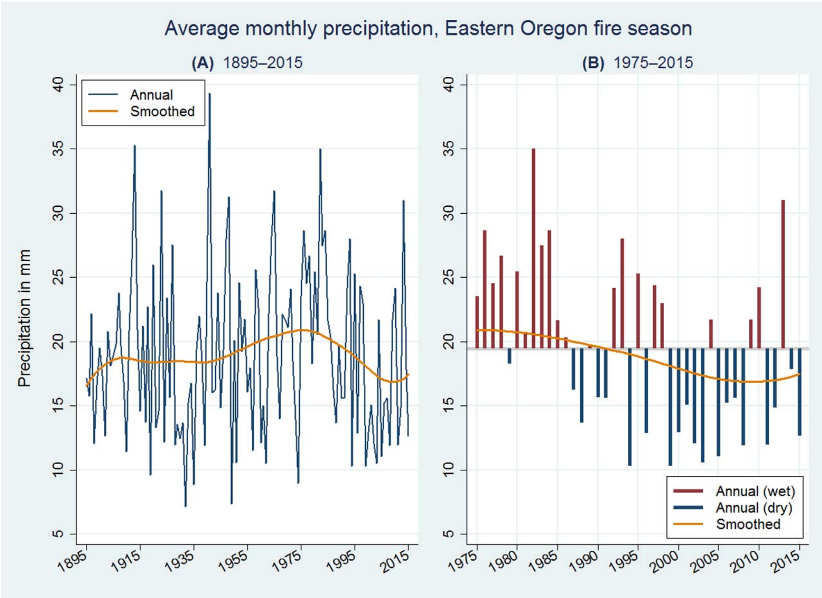

Fig. 4. Eastern Oregon fire season average monthly precipitation over 1895–2015 (A) and 1975– 2015 (B). Both are shown with lowess smoothed curves.

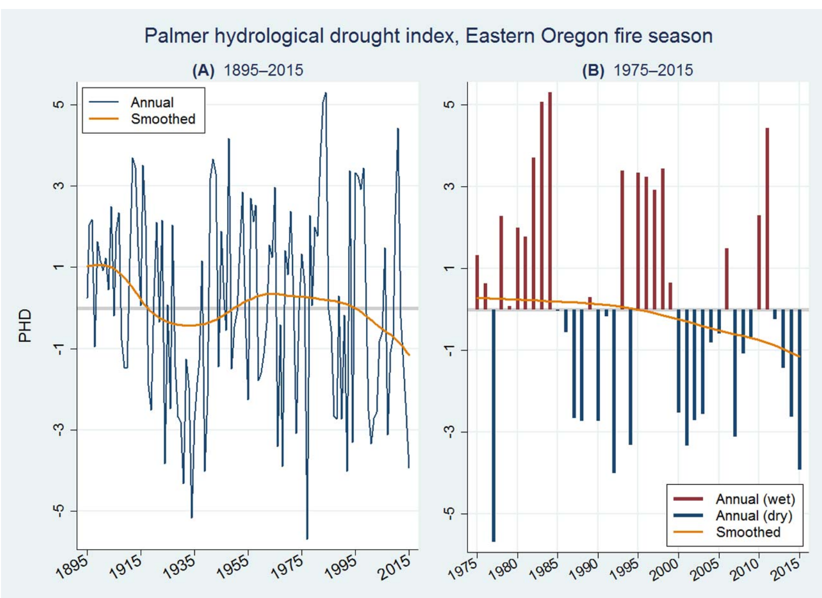

Fig. 5. Average Palmer Hydrological Drought for eastern Oregon fire seasons over 1895–2015 (A) and 1975–2015 (B).

pattern held in eastern Oregon, at the end of the telephone survey, each respondent was asked, "Generally speaking, do you usually think of yourself as a Republican, a Democrat, an Independent, or what?" In the 2014 survey, there was also a follow-up question, "Overall would you say you support the political movement known as the Tea Party, you oppose the Tea Party, or that you neither support nor oppose it?" Among 2014 survey respondents, Democrats were most likely and Tea Party supporters least likely to agree that humans are changing the climate, recent temperatures have been warmer than past, or future temperatures are likely to become warmer (Fig. 7). A similar pattern holds with the three-party scheme of the 2011 survey: Democrats were most likely and Republicans least likely to agree that humans are changing the climate. Partisan gaps for all questions were wide and statistically significant ($p < 0.001$) as tested by logit regression (see Hamilton et al., 2016 for examples using this approach).

Survey results demonstrate that most area residents agree that climate change is happening, but a decreasing majority do not accept human causation (Figs. 6, 7). Moreover, they did not perceive warming that occurred in the recent past, or expect warming to occur in the future. Both global and regional climate perceptions are more strongly related to political views (Hamilton et al., 2016).

5. Discussion

We documented evidence of regional temperature trends in eastern Oregon that are consistent with, but more rapid than, global temperature increases. This has recently been accompanied by increasing frequency of low precipitation, drought, and wildfires. By the 2080s, average winter temperatures in the Blue Mountains are projected to increase by 3.3 °C, and by 5 °C in summer (Halofsky and Peterson, 2017; Halofsky et al., this issue). Precipitation projections are uncertain, but most global climate models (GCMs) project higher precipitation in winter (15%) and lower precipitation in summer (17%) (Mauger and Mantua, 2011). April 1 snow water equivalent is projected to decrease 69–72%, with the date of 90% melt occurring 23–25 days earlier.

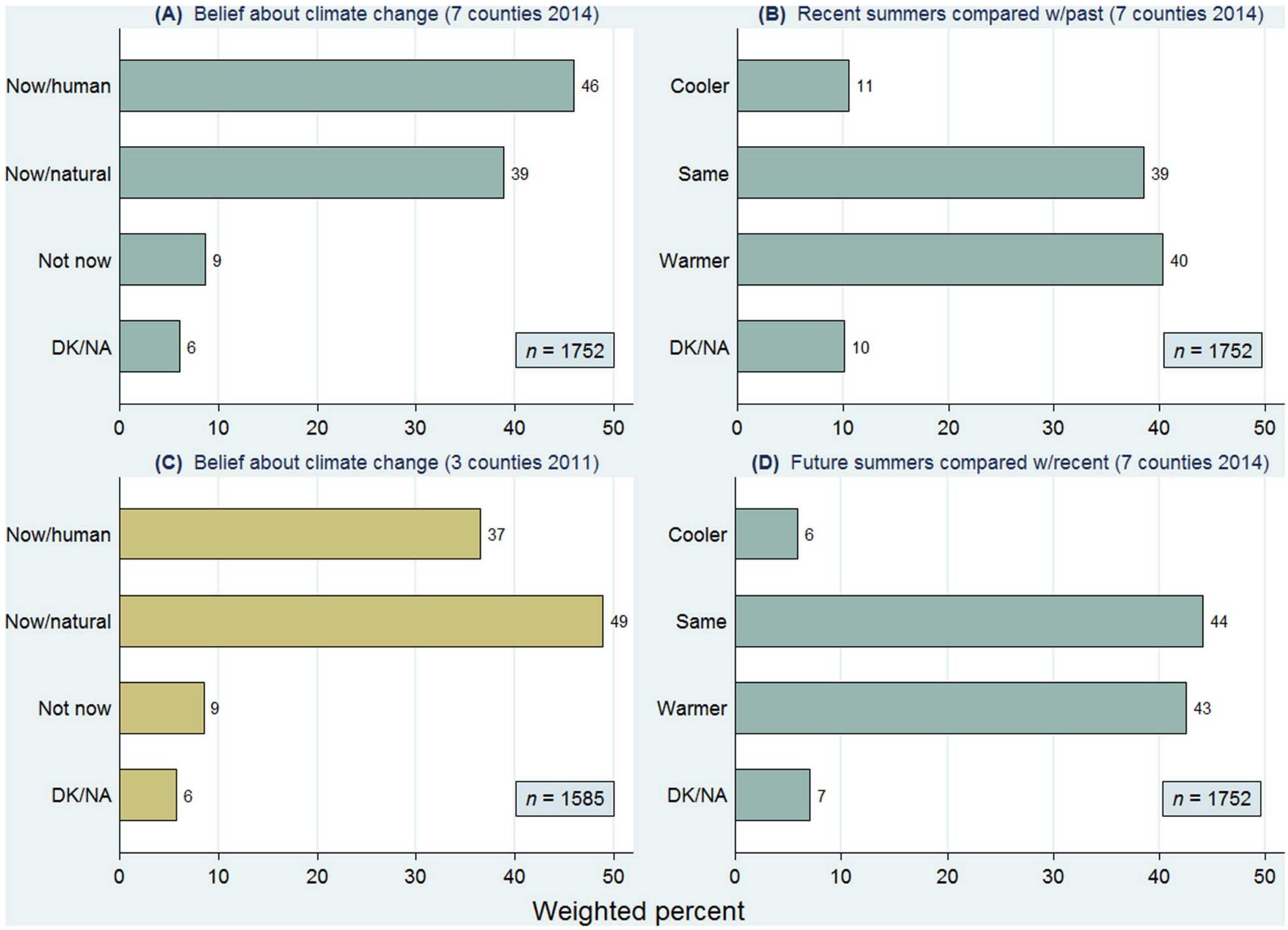

Fig. 6. Response percentages for general questions about climate change on the 2014 (A) and 2011 (C) eastern Oregon surveys; and 2014 survey responses about past (B) and future (D) local warming.

The changing climate will continue to affect eastern Oregon landowners, their lands, and their forests. In general, GCMs project that northeastern Oregon will continue to experience decreased precipitation and increased drought-like conditions, as well as variability in timing of precipitation (Halofsky et al., this issue). Decreased winter snowfall plus higher spring rainfall will decrease the duration of water availability to forests and grasslands over longer periods of the year (Clifton et al., this issue). Insect outbreaks are expected to increase in forests that are already stressed from high stem densities (Kerns et al., this issue). The legacy of overstory removal and fire suppression (dense stands, ladder fuels) has created a positive feedback that exacerbates fire hazard.

Complex feedbacks exist between stand density and streamflow, driven by changes in snow quantity, interception, and evapotranspiration. For example, high stand densities in the Blue Mountains can reduce water availability by capturing more snowfall in the canopy, resulting in direct evaporation from the canopy and a decrease in moisture entering the soil (Zou et al., 2008; Tague and Dugger, 2010). Warmer winters are projected to cause more precipitation to fall as rain instead of snow in eastern Oregon, particularly at lower elevations (Klos et al., 2014). Rain-on-snow events reduce soil moisture, snow accumulation, and the amount of water available from snowmelt. Therefore, climate change threatens natural storage of water in Pacific Northwest watersheds by changing the timing of snowmelt and amount of water available as streamflow throughout the year (Mote et al., 2014). Spring snowmelt is projected to occur 3–4 weeks earlier by mid-century, and summer streamflows are projected to decline (Mote et al., 2014).

Ranchers and farmers depend on the slow release melt in the spring and early summer for irrigation water. Rain-on-snow events can cause rapid snowmelt and flooding, which can overwhelm reservoirs and provide too much water too early. Rain-on-snow events have physical and ecological consequences when runoff causes mass wasting of hill slopes, damage to river banks, downstream flooding, and associated impacts on people. Increased flood risks around rivers that receive waters from both winter rains and peak runoff in late spring are expected (Mote et al., 2014). When streams stop flowing during very dry years, landowners utilize springs that can be directed to holding ponds to water their cattle. Several landowners have recently seen their ponds and springs dry up for the first time, and ephemeral water sources were going dry earlier than usual (Boag, unpublished data). Locally, discussions about forest conditions and hydrology are increasing. Potential solutions to water shortages include increased storage in tanks and removal of western juniper (*Juniperus occidentalis*).

Most local residents "believe" climate is changing in eastern Oregon, but many attribute change to mostly natural causes, providing little guidance to anticipate future change. Acceptance of human-caused climate change did rise somewhat between 2011 and 2014, consistent with nationwide trends attributed to gradually rising public awareness of the scientific consensus (Hamilton, 2016). However, 63% of all respondents in 2011 and 54% in 2014 (or 57% in Wallowa, Union, and Baker counties in 2014) do not think humans are changing the climate. If people do not believe that greenhouse gas emissions are changing the climate along a predictable warming trajectory, they may not be compelled to support or implement adaptive actions.

Attributing climate change to a natural cycle, as many residents expressed in interviews, suggests that today's warming and drying could be followed by tomorrow's cooling and wet weather. One long-time resident explained, "Things are changing, but they always change

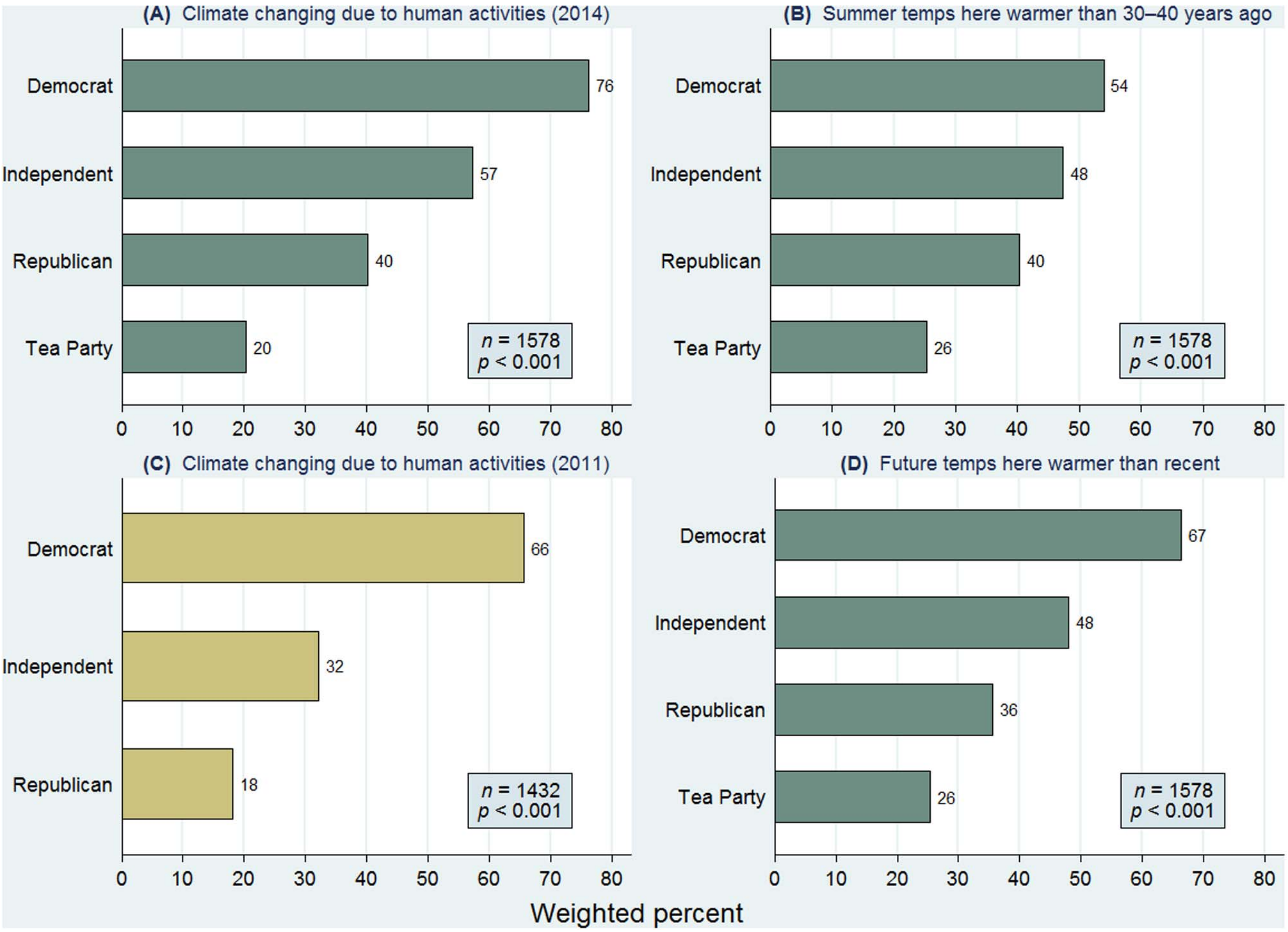

Fig. 7. Percent responding that climate change is happening now, caused mainly by human activities, on the 2014 (A) and 2011 (C) surveys; and percent who think that recent summers have been warmer than 30 or 40 years ago (B), or summers will be warmer in the next few decades (D).

around here. Yeah, I don't expect every year to be the same, but it is part of the normal cycle of things. Some years are wetter, some are drier…" Those believing in natural cycles may be less likely to support alternative approaches for management of public and private resources. However, federal agencies, non-governmental organizations, and watershed councils are working with ranchers and farmers to explore ways to capture spring runoff and improve irrigation efficiency. A county/community adaptive response may be having more influence than is reflected in the perspectives of individual landowners.

People in eastern Oregon are focused primarily on *short-term* environmental change, because that is the time horizon at which landowners can manage resources. A time scale of 5–10 years is more relevant than projections of what *might* occur in 50–100 years. Some landowners engage in long-term succession planning, ensuring that land and resources exist for children and grandchildren. In contrast, commercial forest operations operate on harvest rotations of 35–50+ years, with the flexibility to change planting and harvest strategies. The spatial scale at which actions take place is also important. An individual who owns a parcel that is 10–1,000 ha may feel that operations at this scale are not subject to broader impacts from climate. Therefore, they may choose to do conduct business as usual or may not know how to respond to a changing climate.

This is not to say that people do not recognize change and that they are not doing anything related to climate change mitigation or adaptation. In fact, many people are taking action, but may not directly relate their actions to climate change. These actions tend to be in response to what *has* happened rather than a plan for what *will* happen. People are investing in water storage, removing juniper near water sources, and thinning forest stands to lower densities. Many landowners are concerned with wildfire (Hamilton et al., 2012) and are thinning forest stands, creating firebreaks and defensible space around structures, and reducing surface and understory fuels.

For private landowners, these actions may be sufficient in the short term. However, long-term planning is more challenging. Long-term actions might involve thinning forests to lower densities than current practice would suggest in order to increase tree survival under drought and minimize mortality from wildfires (Hessburg et al., 2015). It may also require an assessment of whether some lower elevation sites can support healthy forests in the future. If owners maintain a patchwork of successional stages may be more resilient to projected changes, requiring varied management prescriptions and collaboration among landowners (Hessburg et al., 2015; Peterson et al., this issue).

Three other important considerations affect long-term planning by landowners in this region. First, federal lands, which account for 70% of eastern Oregon forests, contain much of the wildfire hazard. Fuel treatments are limited by federal agency capacity, air quality constraints for prescribed burning, and a complicated review process including appeals by advocacy organizations. Therefore, actions on private land can affect only a portion of the landscape. Second, private landowner response is limited by the high cost of understory thinning (with little or no market for harvested material) and surface fuel treatments. Third, actions by small landowners (e.g., water storage, thinning) are on relatively small parcels and typically done independently of their neighbors and adjacent property. A strong sense of individual autonomy and private property rights are common in rural Western culture (Fischer and Charnley, 2012). Even if large landowners may be thinking about climate change and longer time horizons, small landowners may not.

Given the impacts of climate change and polarizing nature of climate change as a topic, communication from the scientific community and dialogue among various stakeholders and user groups is important. Scientists and planners are seeking effective ways to communicate across cultural and ideological barriers (Kahan et al., 2011; Bowman, 2016). Some argue for a culturally attuned communication process, with emphasis on local stakeholders and leadership across partisan lines, holding participatory meetings and forums (Kahan, 2015). In regions that are not faced with immediate climate risks, there may be no imperative for people to change their views and work across partisan divides. Consensus messaging, which seeks straightforward ways to share evidence-based scientific agreement on climate change, offers a more superficial but more general approach to communicating the reality of climate change. Survey and experimental research support this approach as well (Ding et al., 2011; Maibach et al., 2014; Van der Linden et al., 2014).

Applied to eastern Oregon where declining forest health and rising wildfire risk could, in the near future, attain the salience of sea level rise in vulnerable coastal regions, an adaptive communication strategy might employ both cultural and consensus elements. Respected local leadership, participatory meetings, and identification of practical mitigation and adaptation steps are likely prerequisites for constructive change. At the same time, basic science communication could be improved, especially at the local level. For example, response to our survey question on past warming (Fig. 6B) suggests that many people have not encountered data on the observed regional climate (e.g., Fig. 3). Communication about such data, and what scientists make of it, could be more effectively accomplished by sources with local credibility and connections (e.g., extension). This process has been initiated by at least one local group, the Umatilla County Climate Change Focus Group, which is comprised of federal, state, tribal and private forest and rangeland owners (Plaven, 2016).

In eastern Oregon, as in the rest of the United States, there are ideological and cultural divides, mostly aligned with identities attached to the political spectrum. Barriers to implementation of adaptation strategies exist regardless of the human/non-human causal influence on climate change. Lack of engagement by private family forest landowners in stewardship of their properties is consistent across the United States. There is an 18–20% engagement (i.e., those who have participated in extension activities and forest management training, worked with the Oregon Department of Forestry Stewardship Forester, work in the forestry sector, or cooperate with local user groups) rate in Baker, Umatilla, Union, and Wallowa Counties (500–600 landowners out of 2900) (Christoffersen, unpublished data). Out of 454 forest landowners surveyed in Baker, Union, and Wallowa Counties, only 16% reported that they had participated in extension activities within the last 5 years, a proxy for engagement in forest management and planning (Hartter et al., 2015). A new partnership (My Blue Mountain Woodlands) is trying to encourage engagement by working together with other organizations on messaging and providing a variety of opportunities to get technical advice (Oregon State University Extension, Oregon Department of Forestry, and a Neighbor Network). Wallowa Resources, a nonprofit organization located in Enterprise, Oregon is providing the central coordination and administration for this partnership. Forest collaboratives, which are working partnerships between public and private organizations, and individuals who commit to working together may offer a way forward for bridging logistical and cultural divides regarding forest management.

6. Conclusions

The climate is changing and will affect people and ecosystems in eastern Oregon. Although scientists agree on the reality of human-caused climate change, a majority of residents in northeastern Oregon do not. We observed some increase in acceptance in surveys conducted in 2011 and 2014, but continued monitoring is needed to assess whether this is the beginning of a longer trend. In this region, many people acknowledge that "something is going on," but attributing climate change to human activities encounters political and cultural barriers. Many say that things are changing, but it has "always been this way" and that "things will change again." There is a pervasive notion that this recent warming is part of a cycle that will reverse at some point in the future. Because of the supposed cyclic nature of warming, some may believe that there is no reason to adapt to change except perhaps in the short term. This belief may support the notion that there is no reason to support national or state policies (or personal behavior) intended to make climate change less severe or adapt to its effects.

Does it matter what causes climate change or whether or not people subscribe to the notion that the climate is changing? It matters in the sense that people are engaged actively in managing their land and forests, and that people are preparing for a hotter, drier future. It also matters because climate change is an issue that no one person can address alone. By accepting that the climate is changing, more and more people can be involved, and new knowledge, skills, and social networks can be leveraged to promote collaborative, cross-ownership management. On the other hand, if people do not believe that people are the cause of climate change, do they believe there is nothing that can be done?

Acceptance of human-caused climate change divides along party lines, but acceptance of climate change more generally, and concerns about wildfire, transcend political divisions (Hamilton et al., 2014). Dry years have become more common, along with upward trends in temperature, and in area burned by wildfires. Scientists know that these trends are linked, and are likely related to global climate change. Perceptions by the general public remain deeply divided, although our two surveys suggest this could be slowly changing. However, shifts in firmly held beliefs about climate change may not be a prerequisite for taking near-term actions that could contribute to climate change adaptation.

Active forest management already has strong public support in this region, and forest restoration treatments in these forests could be critical to the resilience of human communities as well as ecosystems. However, the costs of active management in both private forest lands and federal lands are typically high, thus constraining timely application of actions that would increase resilience to a warmer climate. Such efforts could be motivated, in part, through the grounded pragmatism and strong sense of independence that characterize landowners and local culture in working landscapes of eastern Oregon.

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