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Economic and legal action(s) that should governments take in response to the increased likelihood of annual severe losses from western U.S. Forest fires?

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ABSTRACT

This paper is based on the forest fires induced economic and environmental losses faced in the western USA, and the actions and initiatives US government should take to tackle this economic and environmental loss. To conduct this research, we use different data sources, and all our data is related to the western USA. By using the cost-benefit analysis technique, we answer both of our research questions. Our results show that if governments and non-profit organizations use cost-benefit technique to measure the forest fire losses, they can minimise the losses. Our research shows that this technique is very efficient to serve this purpose. Due to the unique data set along with a new model, it is sometimes challenging to execute the model. We also showed as to how government and other non-profit organisations can be benefited if they use cost-benefit technique.

Keywords: Economic, Legal, Forest, Fire, Government

1. INTRODUCTION

Analyses of, and projections for, forest management, and particularly management of forest fires, have generally projected gradual changes due to climate change. For example, Creutzburg et al (2017), felt confident in projecting forests' carbon levels, timber volume, old forest area, early-seral forest area, average temperatures, average precipitation and more out to the year 2100—with only gradual changes over an 80+ year period. Buotte et al. (2018) likewise made reassuring projections about the western US forests, such as a projection that from 2020 to 2049, fire vulnerability will not change for 87% of land, it will increase in 3% of land, decrease in 3% of land, and become uncertain in 7% of land (Colorado Rocky Mountains and eastern Washington). However, such projections, based on projecting historical averages and considering theorized positive as well as negative impacts of global climate change, now seem outdated, optimistic and maybe naive. As the Center for Disaster Philanthropy (CDP) summarizes it (2020 North American Wildfire Season, 2020), "The 2020 season was a record-setting one for the state of California and the United States as a whole. NIFC reported that as of Nov. 27 there were 52,113 wildfires that had burned 8,889,297 acres in 2020. This is approximately 2.3 million more acres burned than the 10-year average and almost double the acreage burned in the 2019 season." According to the CDP, there were 9,279 fire events in California as of December 3, 2020, resulting in 4,197,628 acres burned. There were at least 31 fatalities and 10,488 structures damaged or destroyed. CalFire recorded 4.2 million acres burned in 2020, the most in a single year since records began, and more than the previous three years combined. In California's recent history (since 1932), five of the six largest fires occurred in 2020.." About Oregon, CDP reported, "Fires in 2020 burned approximately 1 million acres of land in Oregon, almost double the 10-year average of 557,000 acres. Thousands of structures were destroyed, over 2,200 of which were homes. There were 11 deaths including two firefighter fatalities." Other states in which more than 50,000 acres burned in 2020 were Colorado, Ida-ho, Utah, and Wyoming. Considering lightning strikes, arsons, campfire and other accidents, and other causes, combined with the projected long-term continuation of a decades-long "megadrought" and possible "permanent drought" (Bernardelli, 2021), no one can

can assume any longer that 2020 was an outlier year and that forest conditions and forest fires will change only slowly until 2049 (see Buotte et al., 2018) or 2100 (see Creutzburg et al., 2017). The year 2020 may, in fact, be typical of the years to come until the end of the current "megadrought," which assumes no "permanent drought." Economic, environmental, and other relevant studies about forest management and forest fires need to re-view at least for updating, if not starting over with new assumptions and may be justified to calling for major law and policy changes.

Rest of the paper organised as follows. In the second section we explain our research question. In section 3 we provide our literature review. In section 4 we explain our methodology and dat. Our results are described in section 5 and in section 6 we conclude this research paper.

2. RESEARCH QUESTION

What is the cost-benefit analysis of current practices and policies in the Western USA affecting forest fire prevention minimization, fire suppression, and recovery from forest fires (including insurance payments, government funds, grants from non-profit organizations) by government agencies, timber, and other companies, and non-profits?

Secondarily, can the cost-benefit analysis be improved by making changes in those current practices and policies related to fires in western USA forests?

3. LITERATURE REVIEW

Research about the forest fires aspects of forest management in the United States is done and published primarily by scientists and not economists. However, financial and economic issues are usually addressed in that research because researchers for many reasons: private ownership of forests (a large minority in the western USA), forests as both an asset and an income source for companies and communities, towns in forested areas that are economically dependent on the forest, and costs of forest management (including fire prevention, suppression, and recovery).

A large amount of data is available about the forest fires problem in the USA and how it's been getting worse (Hoover & Hanson, 2021; Congressional Research Service, 2021a, 2021b, 2021c). To analyze the cost-effectiveness of various practices and policies of forest fire prevention, suppression, etc., and whether they should be retained or changed, one must read scientific as well as business/economic research. Coupled human and natural systems (CHANS) is one approach. CHANS refers to the complex, dynamical, interconnected systems that have feedback across social and environmental aspects. That interactivity between humans and nature makes establishing cause-effect relation-ships difficult, but it is the most comprehensive and realistic way to study problems such as forest fires, pollution, and others. Few CHANS studies have been conducted on forest fires (Charnley et al., 2017, citing Moritz et al., 2014, and Spies et al., 2014).

Charnley et al. (2017) noted that much previous research on forest fires has focused on the Wildland Urban Interface (WUI) and on protecting homes and structures. But that research is narrow, not a CHANS approach or an approach that weighs costs and benefits of all aspects of forest fire practices and policies, much of which has little or nothing to do with only protecting buildings. (Charnley et al's (2017) research was intended to support "management goals" of "reducing the vulnerability of things like wood assets [as a natural resource, not a financial asset], biodiversity, cultural resources, water quality, wildlife habitat, and recreation opportunities to wildfire." Because they are completely subjective, they are not included in this proposed cost-benefit analysis.) Current forest fire management policies and practises, according to Charnley et al., have resulted in "maladaptive feedback loops in which efforts to decrease wildfire risk through fire suppression, insurance policies, and post-government aid programmes increase the wildfire problem."

Charnley et al's (2017) research involved interviewing US Forest Service employees, relevant state government employees, and private timber company executives about their forest fire prevention and management policies and practices (particularly forest structure and timber harvesting) in southcentral Oregon. Researchers gathered data about commercial timber harvests, tree thinning, mechanical service fuel treatments, intentional controlled burns, and other topics, asking questions about tree size, canopy cover, etc. In the geographical study area, 45% of land is owned by the federal government, 1.1% by the Oregon state government, and 16.7% by only five private companies.

Because public and private lands are contiguous, and fires spread from one owner's land to another, smart fire management decisions by one owner benefit everyone and less smart (or stupid) fire management decisions by one owner can harm everyone.

Respondents showed a "high degree of response diversity in their forest and wildfire management activities" and even the five timber companies had five different goals. (Private timber companies also generally believed that federal forests were badly man-aged and posed the most threat to their privately owned forests, and their own diversity of approaches to forest management helps limit forest fires.) Projecting current forest/fire management practices out for 50 years, Charnley et al. (2017) concluded that current federal practices will result in declines in potential fire hazards, while current state and private management practices will result in no change in their fire hazards. In fact, "potential fire loss in private corporate forests was disproportionately higher than what would be expected…," so private forest owners' perceptions of both federal practices and their own are the opposite of the facts. Charnley et al. (2017) credited the federal Forest Service's practices of cleaning forests of materials that catch fire or burn easily and allowing trees to grow old and large, since "bigger trees are more resistant and resilient to wildfire." To protect or

or even increase employment in forested areas, Charnley et al. (2017) propose more companies to process removed "smalldiameter biomass." Their policy proposals also included giving private forest owners incentives to grow big trees, financially assisting private forest owners who are reducing fire risk and also recovering from fires in scientifically sound ways, developing programs to encourage "prescribed fire" (controlled burns) on corporate and state land, and facilitating more communication among all parties since government employees and corporations talk very little.

Creutzburg et al. (2017) also concluded with a preference for federal forestry management practices in the Oregon Coast Range mountains, which are heavily forested and heavily logged on privately owned lands. Their study said federal practices of minimizing logging would help limit global climate change by storing carbon. They also said other researchers' projections of huge increases in forest fires because of climate change alone do not consider helpful forest management practices that in the Oregon Coast Range are "extensive," including private companies' "shortrotation timber production ….dense road network, heavy fire suppression efforts to prevent the loss of timber, and vegetation treatments to limit seedling competition from shrubs" (p. 514).

However, a series of four massive fires that burned 350,000 acres, the Tillamook Burn of 193351, were in the Oregon Coast Range, and scientists believe the Coast Range's Forest is so dense because of massive fires that have happened repeatedly every 150-300 years.

Additional scientific and economic research building on Charnley is urgently needed given rapidly changing environmental conditions. Even Charnley's 50-year projections in 2017 probably are not still valid, and the 100-year projections by Creutzburg et al. (2017) now surely are invalid, if not ridiculous.

Also helpful is Creutzburg et al (2011), which integrated risk management of natural hazards to forests. (Their research covered a lot more areas than only fires but pointed out that suppressing US wildfires costs more than $1 billion in 2000, 2002, and 2003 and that both the frequency and magnitude of forest fires were expected, by 2007, to continue increasing.) Creutzburg et al. (2017) suggested a three-step process: 1) "analyze the framework for the development of different hazards under changing environmental conditions"; 2) "derive probabilities associated with different hazards for a given area" (see the Creutzburg et al. model in this paper's "Analysis" section); and 3) "estimate cost of potential damage in relation to risk management actions to be taken"—in other words, perform a cost-benefit analysis of the same overall concept as in this research proposal; and 4) "choice of action by decision making under uncertainty" (pp. 331-332).

Creutzburg et al. also cited Shea (2008) when it said that, due to increasing costs of fire suppression and better understanding of forest ecosystems, the US and Canada have "shifted from fighting all fires to letting some fires burn" and coordinating efforts to predict fire behavior (p. 337). Finally, they said that studies on forest fire risks would benefit from analyzing "long-term historical data sets," which is "rare" (p. 331), and that forest management practices should adjust to changes in in risks—rather than change, or not change, for other reasons (p. 343).

This research would both update previous research on the economic impacts of forest fires (costs of fire prevention and minimization; costs of fire suppression; costs of fires to insurance companies, governments, corporations and other organizations, and individuals; etc.; direct and indirect economic benefits from those expenditures, etc.) and go a step farther. It is probable that previous economic and environmental projections that assumed gradual changes in the number and severity of forest fires in the western USA must be recalculated because the conditions on which they were based have changed. The western USA is now facing a megadrought lasting decades if not a "permanent drought," and the number and severity of fires has hugely increased in the last few years and is expected to continue into the future because of the drought and other aspects of global climate change.

The goal of the cost-benefit analysis is two-fold:

1. To assess whether costs outweigh benefits or benefits outweigh costs of current policies and practices of fire management in western US forests.
2. To assess whether current policies and practices of fire management in western US forests should be changed in ways that make the cost-benefit analysis less negative, positive rather than negative, or more positive, depending on the results of the analysis.

4. METHODOLOGY AND DATA

4.1. Measurement

The research involves performing cost-benefit analyses related to various possible policy recommendations for the western United States. Costs that must be measured include current expenditures (both public and private) by government agencies and timber companies on preventing and minimizing fires; current expenditures by insurance companies, governments, corporations, non-profit and other organizations, and citizens on recovery and rebuilding from fires; current expenditures on containing and extinguishing forest fires; losses from allowing some fires to burn; and costs of alternative solutions, which may include government subsidies of private fire prevention efforts, government purchases of privately owned forests for better management, government purchase of at-risk homes and other buildings; increased firefighting equipment and personnel; and others.

Measuring benefits means estimating increased value of assets, increased revenues and decreased other expenses resulting from current expenditures to prevent and minimize forest fires; current expenditures (by governments, non-profits, insurance companies and others) to help individuals, corporations, communities, and others recover and rebuild after forest fires; benefits of extinguishing forest fires versus letting them burn; and estimated benefits of governments, corporations, individuals and others changing current practices and policies to alternative practices and policies.

Alternatives have very different cost-benefit analyses. For example, passing new state and federal legislation mandating the ways that forests must and must not be managed to minimize forest fire damage over the short-term and long-term may result in governments incurring no new costs but cause new costs for private landowners. Governments taking ownership of more western USA forest lands through market purchases or through eminent domain has upfront costs for government as well as increased forest management costs over the short-term and long-term. However, best forest management practices (which science shows the federal government does much more so than private owners of forests) being used in a higher percentage of western US forests will decrease everyone's losses from forest fires, short-term and especially long-term.

4.2. Data Sources

4.2.1. Fire prevention and minimization

Data on fire prevention and minimization costs by governments. Federal, state, and local governments in areas that regularly or occasionally have forest fires budget for programs to prevent and minimize forest fires. Research needs to include seeing relevant sections of state and local government budgets over a period of years. Federal information also is available (such as Congressional Research Service, 2021c).

4.2.2. Data on fire prevention and minimization costs by timber companies

Data will need to be gathered from a representative sample of timber companies to obtain generalizable data on their fire prevention and minimization costs.

4.2.3. Data on fire prevention and minimization costs by others

Data will need to be gathered from a representative sample of timber companies to obtain generalizable data on their fire prevention and minimization costs.

4.2.4. Data on fire suppression costs

Data on fire suppression costs is available. It will be necessary to contact multiple federal and state agencies to obtain full government costs, and to contact a sample of private owners of forest lands that have burned to obtain generalizable estimates of how much companies contributed to extinguishing fires. Government costs appear to be tracked on an ongoing basis, resulting in news stories soon after forest fires reporting how much they cost (for example, see: Wildfires Are Among 4 Recent Disasters Costing at Least $1 Billion [2020]).

4.2.5. Recovery Costs

As the CDP's 2020 report said, "Recovery needs for each wildfire area vary, but attention should be given to long-term support for rehousing, income recovery, agricultural needs and additional preparedness support to vulnerable populations. The enormity of this year's fire season combined with the stress of the pandemic and trauma from past fires means there will be a significant demand for mental health and counselling services.

"Many of the areas affected by 2020's fires are critical agricultural communities where laborers are often migrant workers or undocumented individuals. Support and information need to be provided in the appropriate languages and with cultural competency. These groups will also need wage replacement and recovery support as many cannot access federal dollars."

4.2.6. Data on fire recovery costs incurred by insurance companies

This information is tracked by individual insurance companies, of course, but also by insurance industry trade associations, surely by the federal government, and also by the insurance industry's trade publications, such as Insurance Business Magazine. For instance, that magazine recently reported (Smith, 2020): "Estimated insured losses from the record-breaking west-ern US wildfires will be between $7 billion and $13 billion, according to catastrophe risk solutions company RMS. The losses reflect estimates as of December 01 and represent an update from the previously estimated wildfire losses up to September 20, according to RMS…..

"RMS insured losses represent estimates from major wildfires in California, Ore-gon, Washington and Colorado as of December 01: Northern California: $5 billion to $9 billion; Oregon and Washington: $1 billion to $3 billion; Colorado: Up to $1 billion. The estimate includes losses from property damage, including evacuation and smoke damage, business interruption, and additional living expenses (ALE), across residential, commercial and industrial lines. RMS said that smoke and evacuation were expected to be 'significant contributors' to wildfire losses this season, accounting for about 20% of losses in California and Colorado and about 35% of losses in Oregon and Washington. The estimate also accounts for post-event loss amplification from property damage (25%-30%) and business interruption/ALE (up to 100% or greater)."

4.2.7. Data on fire recovery costs incurred by local, state, and federal governments

This information also is readily available from both government (see, for example, Congressional Research Service, 2021a and 2021b) and other sources. For example, the CDP's 2020 report says, "FEMA has provided millions of dollars in assistance through 82 major disaster and fire management declarations. Most of these declarations are for fire management and don't have any funding listed, however, there are three major disaster declarations: DR-4558 was issued on Aug. 22 for 19 areas in California, mostly for Individual and Public Assistance, though five of those areas only received Public Assistance designations. As of Dec. 7, 2,750 applications for individual assistance had been approved for a total of $18.2 million in obligations. DR-4562 was issued on Sept. 15 for 20 regions in Oregon. 12 regions received only Public Assistance while the remainder received both Public and Individual Assistance. As of Dec. 7, 2,824 applications for individual assistance had been approved for a total of $28.5 million obligated, along with $410,308 in public assistance. DR-4569 was issued on Oct. 16 for 12 areas across California after further fires burned across the state. Ten areas received both individual and public assistance designations, while two were designated for public assistance only. As of Dec. 7, 239 applications for individual assistance had been approved for a total of $3.4 million in obligations."

4.2.8. Data on fire recovery costs incurred by timber companies
Data will need to be gathered from a representative sample of timber companies that recently have had forest lands burn in order to obtain generalizable data on their fire recovery costs. In addition to any buildings or equipment they may have lost, recovery costs would include clearing roads obstructed by burned trees and other debris, planting new trees where trees were burned, and any efforts at removing burned logs and other debris from the forest floor, and from rivers, creeks, and lakes. Timber companies also may have other expenses.

4.2.9. Data on grants/donations from non-profit organizations
As the CDP (2020) re-ported, forest fire recovery and rebuilding money comes from many sources, insurance being the largest but only one. Its report, for example, said, "The Gordon and Betty Moore Foundation made a $3.2 million donation to the X Prize Foundation to support a global XPRIZE competition to drive innovation and hardware able to rapidly detect and extinguish wildfires. The Foundation also provided a $1.2 million donation to the Wind-ward Fund in support of accelerating development and deployment of a wildfire management and evacuation platform in two high-risk, low-income Northern California regions and to enable rich data exchange with early detection sensors, satellite imaging, fire spread models, vegetation/fuel models and community notification." Other similar donations included $500,000 from Boeing Company Charitable Trust to the Windward Fund, $200,000 to provide food assistance, $100,000 to Northwest Harvest in Washing-ton, and $50,000 each to the Oregon Food Bank and Redwood Empire Food Bank in California. Similarly, the Pacific Life Foundation made $125,000 in donations to fire relief efforts, including $50,000 to the American Red Cross; $50,000 to the California Community Foundation's Wildfire Relief Fund; and $25,000 to the California Fire Foundation's Wildfire Relief, with other donations by the Seattle Foundation and other grantors.

5. ANALYSIS

The analysis is both simple and not simple. Fire-related (from prevention to fire recovery) costs incurred by governments, corporations, non-profits, and individuals are known or can be estimated with some confidence. Benefits of current practices and processes may seem more speculative, but they are not. Research can compare the costs and benefits of numerous fire prevention and fire minimization practices because practices vary among the federal government, state governments, and private companies on very similar, often contiguous, pieces of land. A cost-benefit analysis of fire suppression efforts can be conducted by comparing real data about different fire suppression strategies/tactics and also comparing and contrasting the costs and benefits of fire suppression with decisions to allow fires to burn. Cost benefit analyses can be performed on government and nonprofits' disaster recovery aid. In other words, how cost-effective is that aid in the short-term and long-term? The goal, once again, is to assess current policies and practices and to make policy recommendations—particularly about whether state and federal governments need to implement new regulations on forest management by private companies or governments taking ownership of even more of the western USA's forests. Analysis can be performed annually, both currently and retroactively. Because costs vary dramatically from year to year (for example, some years have much bigger fires than others) and benefits can range from immediate to long-term, a variety of ana-lyses should be conducted with average annual numbers adjusted for inflation, and projected into the future. The best starting point located so far is from Hanewinkel et al (2011):

$$DT = p(IT = 1) \times DT|1T=1 + VART(p) + E$$

Where DT equals total damage (in this case, by forest fire), p(IT = 1) is the probability of damage occurrence, DT|1T+1 is the amount of damage, VART(p) is an autoregressive component, and E is random noise.

6. CONCLUSION AND IMPLICATIONS

It is anticipated that the findings will show that the economic impacts of forest fires in the Western United States in coming decades are simply unsustainable. Under the current system, insurance companies will pay out billions of dollars per year that cannot be recouped from premium increases, or vast numbers of people and businesses at risk for western USA forest fires will be uninsurable and uninsured unless some sort of insurance is available from the federal government. Forest fires will also cost billions of dollars in the financial markets, affecting everything from the price of insurance company stock to commodity prices (as documented by the 2020 report by the U.S. Commodity Futures Trading Commission). Asset and income losses of people whose homes, businesses or other property are destroyed by wildfires will not be completely paid for by insurance, and it is possible that some people and businesses will suffer losses more than once, either in the same year or different years. Costs of fire prevention, minimization and suppression (by timber corporations, other businesses, individuals, governments at all levels and even non-profits) also are in the tens or hundreds of millions of dollars just in the Western USA.

Scientific evidence shows that forests managed by the federal government are most resistant to fires, while privately owned forests relatively suffer the most fire damage. The clearest reason is that federal forest managers can prioritize non-financial goals such as minimizing forest fires over the short-term and long-term, general forest preservation and habitat preservation for wild animals, and short-term and long-term recreation opportunities for the general public. Privately owned forests have primary goals related to money: short-term goals of harvesting as many trees as quickly as possible, maximizing long-term profits from the forest with a steady approach to harvesting, configuring harvesting in whatever way is necessary from year to year to maximize profits, or managing the forest in ways to make it as attractive as possible for potential buyers.

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