What Ignited Forest Service Interest in Nonmarket Valuation in Fire Economics?[1]

John B. Loomis[2] and Armando González-Cabán[3]

Abstract

This paper traces the origin and evolution of the application of nonmarket valuation techniques to fire management within the USDA Forest Service. The motivation for contingent valuation (CVM) studies that quantify existence value is traced to the need for monetary benefits of protecting spotted owl old-growth forest habitat from fire in the early 1990s. Two large scale general public surveys successfully demonstrated that CVM could be used to estimate both state level and national level benefits for fire prevention and fire suppression of endangered species critical habitat. By the late 1990s the large-scale wildland urban interface fires resulted in the need to measure what the general public would pay for prescribed burning and mechanical fuel reduction programs. With the advent of conjoint and choice experiments joining CVM as applicable tools for estimating the nonmarket benefits of preventing and suppressing wildland fires, economists' capabilities have grown extensively. Due to the expense and time consuming nature of conducting these surveys, the greatest remaining challenge is formal and systematic incorporation of these types of use and non-use values into wildland fire planning and resource allocation models. Drawing upon the past results, we offer benefit transfer of the existing results as a plausible interim technique to estimate the publics' nonmarket benefits from fire prevention and suppression. We also offer some insights as to the next frontiers in CVM application.

Keywords: Contingent valuation, endangered species, mechanical fuel reduction, prescribed burning, willingness- to-pay.

---

[1] An abbreviated version of this paper was presented at the III International Symposium on Fire Economics, Planning, and Policy : Common Problems and Approaches, April 29 to May 2, 2008, Carolina, Puerto Rico.

2. Professor, Department of Agricultural and R esources Econom ics, Color ado State University, Fort Collins, CO 80523- USA; E-mail: John.Loomis@colostate.edu
3. Resear ch Economist, USDA Forest Service, Pacific Southwest Research Station, Riverside, CA 92507- USA; Email: agonzalezcaban@fs.fed.us

Introduction

The early 1990s saw a rapid change in forest management from an overwhelming emphasis on timber management and viewing the forest as a collection of multiple uses to viewing the forest as an ecosystem. A major catalyst for the change was the listing of the Northern Spotted Owl under the Endangered Species Act, and the designation of more than 4 million acres of old-growth forests on federal lands as critical habitat in Oregon, Washington and northern California for the Owl. The Thomas Report (Thomas and others 1990, 1993) and President Clinton's Forest Plan for the Cascades and coastal forests emphasized ecosystem management. A proactive effort to protect remaining old-growth forests in California for the California Spotted Owl soon followed. The National Forests weren't just for timber harvesting anymore. These plans spared the old-growth forests from logging but protecting the old-growth forest habitats from stand replacing fire was necessary for recovery of the spotted owl (Verner and others 1992).

The traditional justifications for protecting forests from fire were based primarily on protecting timber values. If the agency could no longer log the forests, how could it justify spending millions of dollars on fire prevention and fire suppression? The answer was in recognizing and valuing the public goods and services provided by the forest but not accounted for in traditional markets, such as habitat for endangered species.

It just so happened that during the previous decade environmental economists had been refining a technique that could measure the off-site or public good economic values of protecting habitat for threatened and endangered species. While the contingent valuation method (CVM) was originally designed to value recreation (Knetsch and Davis 1966), the method emerged in the 1980s as a technique that could value what economist John Krutilla (1967) called existence values. These existence values were benefits that non-visiting people might receive from the knowledge that a unique natural environment or habitat was protected for the current and future generations.

Applications of CVM to monetize the existence value of endangered species (Brookshire and others 1983) and wilderness (Walsh and others 1984) demonstrated the techniques would work with the general public. Test-retest studies demonstrated the reliability of the CVM technique to measure use and existence values of visitors and the general public, respectively (Loomis 1989).

Can CVM quantify the public's willingness-to-pay for forest fire prevention and suppression?

The USDA Forest Service's Pacific Southwest Station's Associate Research Director and a fire economist in the Forest Fire Lab in Riverside, California in 1992 became aware of the possibility of using nonmarket valuation techniques to determine the benefits of protecting old-growth forests (as habitat for the spotted owl) from fire. While the USDA Forest Service had relied upon nonmarket valuation techniques such as the travel cost and CVM to value recreation use (Sorg and Loomis 1984; Donnelly and Nelson 1986) it had been reluctant to include existence benefits when valuing wilderness despite documentation of such values' importance in the literature (Walsh and others 1984).

So what was different in 1992? It was the convergence of several factors. One was the growing awareness that to comply with the Endangered Species Act requirements to recover species, old-growth forests were to be protected from fire (Verner and others 1992). Another might have been the recognition that if the agency and society were to forego harvesting of commercially valuable old-growth trees, it would be wasteful to just let them burn due to a lack of fire prevention and fire suppression. Still another was the movement within the agency toward ecosystem management that recognized the forests were more than a collection of multiple uses and rather, were unique natural environments that represented interconnected wildlife habitat and watersheds. Finally, the USDA Forest Service was recognizing that its stakeholders included people who never have visited a National Forest, but were vociferous in their views of how public forests should be managed. This could be addressed by expanding survey sampling from visitors to the general public; the taxpayers who funded management of the National Forests needed to be included.

Estimating the total economic value to Oregon households from reducing wildfire

In response to these factors, Armando González-Cabán (1993) at the Forest Fire Lab, Pacific Southwest Research Station outlined a program on how to obtain and incorporate such information in the Forest Service Fire Management Planning system. Later on the same year, he funded and participated in a study designed to estimate the monetary amount Oregon households would pay to reduce wildfire across 4 million acres of critical habitat units (CHU) designated for the northern spotted owl. In cooperation with Robin Gregory at Decision Data, the authors developed a contingent valuation survey of Oregon households[4]. Respondents were

[4] This paper is not an exhaustive review of the literature available, but an effort to highlight the origins of the use of nonmarket valuation in fire economics in the Forest Service and where it may lead to.

asked if they would vote in favor of a program to reduce by half the amount of old-growth CHU that burned each year, from 7,000 acres to 3,500 acres. The program involved three elements: (a) greater fire prevention; (b) earlier fire detection; and (c) more aggressive fire response.

Using repeat mailings of the survey, the household survey achieved nearly a 50 percent response rate. Oregon households indicated they would pay an average of $77 per household per year. This translates into a WTP of $28 per acre protected[5] (see Loomis and Gonzalez-Cabán 1994 for more details).

This study led to a natural extension to broaden the study to protection of spotted owl habitat in northern California and Oregon. In addition, because the Spotted Owl was a federally listed threatened species under the Endangered Species Act and the CHUs were on National Forests, it was a natural extension to investigate the geographic extent of willingness-to-pay to protect the owls' habitat from wildfire. Thus, the sample frame included households in California and six New England states of Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island and Vermont. Respondents in each of the two geographic areas were asked their WTP for a program that would protect Spotted Owl critical habitat from wildfire in: (a) California; (b) Oregon; and (c) both California and Oregon.

The results shown in Table 1 are plausible given that they conform to what might be expected from economic theory. Households in California have a higher WTP to protect spotted owl critical habitat units in their own state ($79 per household per year) than in Oregon ($59), but California households still have a fairly high WTP to protect critical habitat units in Oregon. New England residents WTP for protection of California and Oregon critical habitat is similar at approximately $45 in each state and only somewhat smaller than California residents' WTP for protecting Oregon owl habitat. Despite the nearly 2,500 mile distance of New England households from the spotted owl critical habitat units, annual per household WTP is substantial. This suggests that there are national benefits to preventing wildfires on National Forests for federally listed species. This helped to broaden the USDA Forest Service's perspective and to recognize national stakeholders, in addition to local constituencies. Finally, the total WTP for the combined California and Oregon program was substantially higher than just the WTP for the Oregon program indicating that respondents' WTP was sensitive to acres protected. As a result, Loomis and González-Cabán (1998) were able to estimate a willingness-to-pay function for protecting acres of spotted owl habitat from fire that

[5] The value per acre protected is obtained by dividing the total WTP value estimated ($84.6 million) by the total acreage of old-forest in protected critical habitat units of Northern Spotted Owl (3 million acres).

could be used by managers in Oregon and California. For more details on the California and New England study see Loomis and González-Cabán (1997).

Table 1 summarizes the annual values per household from the Oregon, California and New England studies, along with the respective values per acre of spotted owl habitat protected from wildfire. For example, the California and New England values per acre of spotted owl protected ($772 and $256, respectively) is more than 25 and ten times, respectively, higher than Oregon state residents' values. Because the values per household are similar in magnitude between Oregon, California and New England residents, the large difference in values per acre is due to the fact that far more people live outside of Oregon, and these people would pay for protection of a federally listed species on their National Forests.

Table 1–*Annual State and Regional Benefits per Household and Benefits Per Acre Protected*

State/Regional Residents	California Program	Oregon Program	Combined CA & OR Program	Benefits Per Acre of Habitat Protected
California $7	8.69	$58.56	$94.77	$772
New England	$45.70	$44.70	$61.17	$256
Oregon	N/A	$77.00	N/A	$ 28

The wildland urban interface explodes!

Not long after the spotted owl crisis, the national attention shifted to dramatic large-size fires that threatened the wildland-urban interface including the Daytona Beach, Florida in 1998 and the fire complex in the Bitterroot Valley of Montana in 2000. Specifically, it was the Florida fires occurring during 4th July weekend that shut down the Daytona Beach 500, and the Interstate Highway that garnered policy makers' attention. In response to the events in Florida the Joint Fire Science Program[6] funded work to design a survey on the effects of these fires and whether these effects had changed public support for fuels reduction programs such as prescribed burning and mechanical fuels reduction. The success of the Florida work led to application of the same survey instrument in California and Montana.

Survey design

A survey booklet was initially developed in conjunction with forestry professionals in Florida and subsequently adapted for California and Montana to convey information

[6] Joint Fire Science Program is a forest fire research grants program funded jointly by the USDA Forest Service and the USDI Bureau of Land Management.

on the extent of the problem, and two possible programs to reduce the problem (i.e., prescribed burning and mechanical fuels reduction).

The survey booklet described the acreage that is burned by wildfires in an average year in each state, as well as the typical number of houses lost to wildfire each year in each state. The effect of wildfire on forests, houses and air quality was illustrated with a color drawing showing the flame height and rate of fire spread[7].

A program increasing the use of prescribed fire or controlled burning in California, Florida, or Montana was described and illustrated next. Specifically, respondents were told that the prescribed burning fuels reduction program would reduce potential wildfire fuels through periodic controlled burning. It was acknowledged that prescribed burning does create smoke, although far less than a wildfire. Then, the survey booklet provided additional information and drawings contrasting wildfire and prescribed fire.

The cost of financing this prescribed burning program was described as a cost-share program between their state government and the county the individual lived in.

The wording used in the survey was identical for California, Florida and Montana, except the number of acres and numbers of houses burned were changed to correspond with particular state numbers.

For the mechanical fuel reduction program, the survey booklet stated the same wildfire acreage reduction as achieved with the prescribed burning program, and stated that only one of the two programs would be implemented.

Again, identical wording was used in all 3 states of California, Florida and Montana, except the number of acres burned and numbers of houses were changed to correspondent with particular state numbers discussed after the wording of the prescribed burning WTP question (for additional information see Loomis and González-Cabán 1998).

While conducting the CVM in California, Florida and Montana we realized that a segment of the population was not accounted for, Native Americans. To estimate Native Americans willingness-to-pay for the same fuels reduction programs we revised the survey instrument to represent their lands and experiences. Because Native Americans represent an important demographic of Montana we conducted a CVM study comparing Montana general population and Native Americans. The survey instrument used was the same as that used in the California, Florida and Montana study, except that it was revised to account for Native Americans lands and characteristics.

[7] A copy of the survey can be obtained by contacting Armando González-Cabán.

Data collection and survey mode

The surveys were conducted in Florida in 1999 and in 2001 in California and Montana through a phone-mail-phone process in all three states. To obtain a representative sample of households, we used random digit dialing. An additional sample from Montana's general population and of the Blackfeet and Salish-Kootenai Tribes members was collected. The counties were selected to include a mix of counties with a range of wildfire experience and exposure. This variation had two useful features. First, it ensured variation in responses to questions like whether the respondent "had seen a wildfire". Second, targeting this sample aided in generalizing the results to all areas of the state.

Once initial contact was established, elicitation of initial attitude and knowledge of wild and prescribed fire occurred, followed by the scheduling of appointments with individuals for detailed follow-up interviews. During the interim time period, a color survey booklet was mailed to the household to assist with interviews. These interviews were conducted with the aid of this color booklet. The booklet was sent in English to Caucasians and in Spanish to Hispanic households in California and Florida. The individuals were asked to read the survey booklet prior to the phone interview. Phone interviews were conducted in either English or Spanish depending on the language of the booklet received.

Results

Descriptive statistics by fuel reduction program and samples

The percentage of respondents answering yes to the dichotomous choice CVM question for each state and each program are instructive. The prescribed burning program consistently received 60 percent or higher positive responses, ranging from a high of 84 percent among Hispanics in California to 60 percent among Caucasians in Montana. The same is true for Native Americans with almost a 93 percent Yes responses. The mechanical fuel reduction program support was much lower among Caucasians, being only 34 percent to 50 percent, but 50 percent to 68 percent among Hispanics. However, Native Americans positive response rate, although lower than for the prescribed burning program, is high at 78 percent.

Willingness-to-pay results

Mean WTP was estimated for Caucasians and Hispanics using a logistic regression model. Mean WTP of Caucasians for prescribed burning was $460 in California, $392 in Florida, and $323 in Montana. For the mechanical fuels reduction program the mean WTP of Caucasians in California was $510, while it was much lower in Florida at $239 and Montana at $186. These results are consistent with the lower percent positive values, and suggest far less support for the mechanical fuels reduction program than prescribed burning in these three states.

Hispanics in Florida mean WTP is $473 for the prescribed burning program, about half what Hispanics in California would pay, $838. Hispanic's in Florida WTP for the mechanical fuel reduction program is $373.

The ranking of mean WTP per household follows the magnitude of acres protected from fire and houses saved. While all the state programs represented an equivalent proportional reduction (25 percent reduction) in acres and houses burned, the absolute magnitude or amount of fewer acres that burned and number of houses saved did vary across states. In terms of the three states program, California would protect 90,000 acres and 18 houses; Florida would protect 50,000 acres and 18 houses; and Montana would protect 35,000 acres and 12 houses. The ranking of mean WTP per household is in the same order as the number of acres prevented from burning and houses saved. In particular, mean WTP by California households is noticeably higher than for Florida households, which is noticeably higher than Montana households.

When comparing Montana's general population households with Native American households we find that the general population WTP for the prescribed burning program is larger than that of Native Americans, $174 vs. $135 (González-Cabán and others 2007). For the mechanical fuels reduction program the opposite is true and Native Americans WTP is $305 vs. $286 for the general population. However, statistical analysis shows that there are no statistical significant differences between the two populations for the prescribed burning or the mechanical fuels reduction programs.

Table 2–*Mean WTP for Prescribed Burning and Mechanical Fuels reduction programs in California, Florida and Montana.*

	Prescribed Burning		Mechanical Fuel	
State	Caucasians	Hispanics	Caucasians	Hispanics
California (89,500 acre reduction)				
Mean WTP	$460	$838	$510	n/a
Florida (50,000 acre reduction)				
Mean WTP	$392	$473	$239	$373
Montana (35,000 acre reduction)				
Mean WTP	$323		$186	

With mean willingness to pay of more than $400 per household, and more than 13 million households in California, the willingness to pay for either of these fuel reduction programs is about $5 billion. In Florida, with 7.6 million households this translates to about $3 billion for the prescribed burning program and $2 billion for the mechanical fuels reduction program. In Montana, with only 366,000 households, state level benefits would be close to $118 million for prescribed burning and $68 million for mechanical fuels reduction. Note, the survey explicitly indicated that only one of the programs would be implemented, so that it would be incorrect to add the values of these two fuels reduction programs together. However, these state level values reflect only what state residents would pay for the program, and Loomis and González-Cabán (1997) found that non-resident households often have a willingness-to-pay to prevent wildfires in ecologically important forests in other states.

What's next in the future of fire economics?

Visual representations in fire surveys

Given the dynamic nature of fire and fuel treatment programs such as prescribed burning, diagrams used in previous work are rather static, two dimensional representations. With the advent of videotape, DVDs and the Internet the potential exists to more realistically represent the "with" fire treatment program and the wildfire consequences of the without program. Furthermore, DVDs and the Internet give rise to the opportunity to provide context-sensitive information to respondents at critical points in the survey where some respondents might want it. In addition, DVDs, videotape or Internet provides the opportunity for an onscreen interviewer to conduct a mock in-person interview.

We have recently experimented with using videotape as a survey delivery mechanism with some success. This small pilot demonstrated it was feasible to conduct wildland urban interface surveys identical to the California WUI survey described above. There was no statistical difference between the annual WTP obtained using videotape and that of the original phone-mail-phone interview approach. See Loomis and others (2006) for more details.

In an exciting application of virtual reality to economic valuation of fire, Fiore and others (2007) use the FARSITE[8] simulation model and virtual reality headsets to expose the survey respondents to the dynamic progression of a wildfire. Risk information is then communicated and respondents are asked a valuation question to reduce the likelihood of the wildfire they "observed" in the virtual setting. As noted

[8] A fire growth simulation model developed by the Forest Service.

by the authors this is truly the cutting edge of virtual reality in attempting to create a simulated field experiment in a safe lab experiment environment.

Multi-attribute stated preference surveys

Many times fire management programs such as creating defensible space or using mechanical fuel reduction such as thinning involves tradeoffs between competing desirable attributes. Homeowners move to the forest to be surrounded by vegetation. Thinning and removal does reduce the fire danger, but at the expense of reducing the very amenities they sought. Understanding tradeoffs such as these is the strength of attribute-based valuation methods (Holmes and Adamowicz 2002). Recently, Holmes and others (study in progress) have applied a multi-attribute choice experiment to value homeowner and community fire risk reduction programs. Often, the resulting WTP functions from a multi-attribute approach lend themselves to benefit transfer to other settings even better than CVM. This is because the choice experiment allows unbundling of the attributes of a fuel reduction program. Thus, with a choice experiment, WTP can be calculated for the type and levels of attributes of interest in the new application, as long as those attributes were included in the original choice experiment.

Benefit transfer

The values in *Table 1* allow managers to perform an average point estimate benefit transfer per acre. But a more suitable benefit transfer to provide a marginal or incremental benefit per additional acre of reduced wildfire can be calculated using the respective study's WTP functions.

Following the procedure of Cameron (1988) the logit equations used to estimate mean and median WTP based on CVM responses can be reparameterized into WTP equations for reductions in acreage burned. This will yield a straightforward WTP function for reducing acres burned. For example, dividing the constant and acres by the absolute value of the bid coefficient we therefore obtain WTP per household as a function of acres burned for Caucasian households in California, Florida and Montana for the prescribed burning program:

WTP per household = \$174.06 + 0.002578 (Acre Reduction)

WTP equations such as these can be calculated from Loomis and others (2008) and applied by managers to estimate the economic value per household for reducing acres of wildfires due to the prescribed burning program.

Conclusion

As our understanding of fire ecology and appropriate fire management responses evolves, there will be a continuing need to quantify the benefits and costs of the new fire management responses. The strength of stated preference methods such CVM and choice experiments is that they are limited only by natural scientists' abilities to predict the effects of the fuels treatments, and social scientists' abilities to communicate those effects to the public. Stated preference methods also have the ability to value broader forest management programs inter-relating fire, invasive species and watershed protection. Thus, stated preference methods may hold the key to integrated fire management planning. Finally, as public land management agencies continue their move to ecosystem management and begin to value ecosystem services, stated preference methods may move into the forefront of forest economics as they are the primary technique to value many of the nonmarket ecosystem services provided from public lands.

Acknowledgments

We want to thank Juan Marcos González Sepúlveda, Jonathan Yoder and Hayley Hesseln for reviewing an earlier version of this paper.

References

Brookshire, D.; Eubanks, L.; Randall, A. 1983. **Estimating Option Prices and Existence Values of Wildlife Resources.** Land Economics 59(1): 1-15.

Cameron, Trudy. 1988. **A new paradigm for valuing market goods using referendum data: Maximum likelihood estimation by censored logistic regression**. Journal of Environmental Economics and Management 15: 355-379.

Donnelly, D.; Nelson, L. 1986. **Net Economic Value of Deer Hunting in Idaho**. Resource Bulletin RM-13. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station, USDA Forest Service; 27 p.

González-Cabán, Armando. 1993. **The Economic Impact of Fire: Improving the Forest Service's Fire Management Planning System Capabilities to use Non-Market Values**. Wildfire 2(4): 16-21.

González-Cabán, Armando; Loomis, John B.; Rodriguez, Andrea; Hesseln, Hayley. 2007. **A Comparison of CVM Survey Response Rates, Protests, and Willingness-to-Pay of Native Americans and General Population for Fuels Reduction Policies.** Journal of Forest Economics 13: 49-71.

Holmes, T.; Adamowicz, V. 2003. **Attribute Based Methods**. In: Champ, P.; Boyle, K.; Brown, T., editors. A Primer on Nonmarket Valuation. Boston MA: Kluwer Academic Publishers: 171-220.

Krutilla, John. 1967. **Conservation Reconsidered**. American Economic Review 57: 777-786.

Knetsch, Jack; Davis, Robert. 1966. **Comparison of Methods for Recreation Evaluation.** In: Kneese, A.; Smith, S., editors. Water Research. Baltimore, MD: Johns Hopkins University Press: 125-142.

Loomis, J. 1989. **Test Re-test Reliability of the Contingent Valuation Method: A Comparison of General Population and Visitor Responses.** American Journal of Agricultural Economics 71(1): 76-84.

Loomis, John; González-Cabán, Armando. 1994. **Estimating the Value of Reducing Fire Hazard to Old Growth Forests in the Pacific Northwest: A Contingent Valuation Approach.** International Journal of Wildland Fire 4(4): 209-216.

Loomis, John; González-Cabán, Armando. 1998. **A Willingness-to-pay function for protecting acres of spotted owl habitat from fire.** Ecological Economics*,* 25: 315-322

Loomis, John; González-Cabán, Armando. 1997. **Comparing the Economic Value of Reducing Fire Risk to Spotted Owl Habitat in California and Oregon**. Forest Science 43(4):473-482.

Loomis, John; Miller, Julie; González-Cabán, Armando; Champ, Joseph. 2006. **Testing the Convergent Validity of Videotape Survey Administration and Phone Interviews in Contingent Valuation.** Society & Natural Resources 19: 367-375.

Loomis, John; Hung, Le Trong; González-Cabán, Armando. 2008. **Willingness to Pay Function For Two Fuel Treatments to Reduce Wildfire Acreage Burned: A Scope Test and Comparison of White and Hispanic Households.** In: González-Cabán, Armando, technical coordinator**,** Proceedings of III International Symposium on Fire Economics, Planning, and Policy: Common Problems and Approaches, April 29 to May 2, 2008, Carolina, Puerto Rico. Albany, CA: Pacific Southwest Station, USDA Forest Service.

Sorg, C.; Loomis, J. 1984**. Empirical Estimates of Amenity Forest Values: A Comparative Review.** General Technical Report RM-107. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station, USDA Forest Service. 23p.

Thomas, J.W.; Forsman, E.D.; Lint, J.B.; Meslow, E.C.; Noon, B.R.; Verner, J. 1990. **A conservation strategy for the NS Owl: a report of the Interagency Scientific Committee to address the conservation of the northern spotted owl.** U. S. Department of Agriculture Forest Service, Portland, Oregon.

Thomas, J.W., Raphael, M.G.; Anthony, M.G.; Forsman, E.D.; Gunderson, A.G.; Holthausen, R.S.; Marcot, B.G.; Reeves, G.H.; Sedell, J.R.; Solis, D.M. 1993. **Viability assessments and management considerations for species associated with late-succession and old-growth forests of the Pacific Northwest—the report of the Scientific Analysis**

Team. U.S. Department of Agriculture Forest Service, National Forest System, Washington, D.C.

Verner, J.; McKelvey, K.S.; Noon, B.R.; Gutiérrez, R.J.; Gould Jr., G.L.; Beck, T.W. 1992. **The California Spotted Owl: A technical assessment of its current status.** General Technical Report PSW-GTR-133. Albany, CA: Pacific Southwest Research Station, USDA Forest Service 285 p.

Walsh, R.; Loomis, J.; Gillman, R. 1984. **Valuing Option, Existence and Bequest Demands for Wilderness**. Land Economics 60(1): 14-29.