Evolution of Nonmarket Values Valuation in Wildland Fires: An Intertemporal Analysis[1]

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Abstract

Forest fires and their legacy form an inherently dynamic relationship between ecology and human uses of the forest. This paper provides an overview of the dynamic dimensions that are present in the aftermath of a fire. These include the evolution of social benefits as the ecology recovers and the role of discounting.

Keywords: Wildfire, non-market valuation, discounting

Introduction

Forest fires vary greatly in their ecological effects. In some fire adapted forests fire is a critical element in the reproductive cycle of the forest. One can think of the Jack Pine forests of central North America. The interruption of the fire cycle there resulted in a generational interruption in the forest's lifecycle. Or the Ponderosa Pine forests of the Sierra Nevada where the suppression of the fire cycle result in forest succession away from Ponderosa Pine and towards White Pine, a pine which is not fire tolerant. In other settings however, especially ones where the fire cycle has been interrupted and the fuel loads are very heavy, fires are quite destructive. The effect of fires is to savagely damage the ecology and make recovery very slow and perhaps impossible.

The social costs and benefits of recovery are dynamic. They evolve over time as the forest adapts to the fire and recovers. The path of recovery provides a path of costs and benefits to society. Englin et al (1996) were the first to suggest a shape to the recovery of benefits from a forest fire. They suggested a sudden loss in recreational benefits that slowly recovered through time as the forest returned with the maximum benefit coming when the forest had returned to old growth status. As will be expanded on later the Englin et al (1996) was naive and later work has fleshed out the actual path that recreational benefits take in recovery.

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Finally, one must also look carefully at the role of discount rates. There is a burgeoning literature (Arrow et al (2013) on the proper discount rates for projects that that are especially long lived. The return of many forests after a fire is an example of such a resource. This work suggests that evolving social values of forests may have important impacts on cost benefit analyses involving forests. Importantly, if the suggestion by Krutilla (1967) holds any merit the implications for forest policy.

The rest of the paper continues in the following way. It will discuss the issues with static analyses of the forest problem and discuss a case study in Jasper National Park in Alberta, Canada. It will include some observations about what this may mean for Central America. It will then present some findings on the way recreational values for forests are evolving through time. Krutilla's suggestions are fit into this framework. Finally, the paper sums up its suggestions going forward.

The problem with static analysis

Static analysis does not account for the dynamic evolution of the world. It does not account for either ecological or social change. It is well known that interference in natural fire cycles is problematic but even natural fire cycles are dynamic. This section focuses on the recovery of social values after a fire. Englin et al (2006) examined the ecological rate of recovery following a forest fire.

That study utilized the Canadian National Parks Inventory Program which produced a massive, carefully collected, database documenting ecological disturbances going back 700 years. Jasper National Park is a large national park covering 10,878 km^2. It has over 1,000 km of developed trails. It also maintains a mandatory permitting system which provides a source of behavioral data. Most trails start along river basins and precede either along the river or up into the mountains. Some reach 2200 meters. As a result there is a range of ecosystems that are encompassed in the data. Appendix A shows a map of the trails.

Englin et al (2006) analyzed of the Canadian National Parks Inventory and found three main vegetation types in Jasper National park. These include lodgepole pines, spruce-juniper and alpine meadows. In addition the fine detail of the ecological data allows the age of each stand to be identified. The tree cover was broken down to Lodgepole between 30 and 124 years old, Lodgepole between 125 and 299 years old, Lodgepole between 300 and 500 years old, Spruce/Fir between 30 and 124 years old, Spruce/Fir between 125 and 299 years old and Spruce/Fir between 300 and 500 years old. The model also included Alpine meadows and Tundra both measured in km^2.

Since the welfare effects of aging forests was measured using the Small and Rosen (1981) formula

$$Compensating\ Variation = \ 1\ /\ \beta\ \ \ln(\sum \exp(v\hat{}0\ ) - \sum expln(v\hat{}(1))$$

It is important to note that the value of old growth forests will vary considerably depending on the value of other attributes on the trail (see Lancsar and Savage (2004). The results reported in Englin et al (2006) have a couple of important attributes. One is that the lodgepole forest whether young or of medium age (up to 299 years old) has a small positive value. They mostly range from $0.50 to $4.00. The most valuable lodgepole old growth however adds $500 per trip for stands between 300 and 500 years old. This is substantial.

Similar findings follow Spruce/Fir results, although young Spruce/Fir forests are actually negatively valued. This is most likely because young Spruce/Fir forests are thick, dark and house flies and mosquitos. Old growth Spruce/Fir (stands 300-500 years old) were worth $150 per trip.

To summarize the econometric findings there is a bump in amenity values for about 30 years after the initial fire. This is believed to be the result of the novelty value of the fire and the flowers and foliage that grows immediately after a fire. The fire also opens up views that did not exit previously. After that amenity values drop rapidly and become negative and then steadily climb back to zero at about 125 years. Then, the increase continues for more than 400 years! This is all consistent with the ecological changes that are playing out over those time periods. Old growth forests are messy places. They have fallen, rotted trees, which support moss and ferns which in turn support insects, birds and animals consistent with an old growth forest. The entire process of becoming a true old growth forest takes time. What is remarkable is that we can see in actual behavior that people do know the difference and that they value it.

The key finding here is that forest's aesthetic values can recover very slowly. Losses of old growth forests are multi-generational events. It takes a very long time for forests to return to true old growth states. Trees must die and fall and rot before the historical ecosystem can return. Centuries must pass. Recognizing the dynamic nature of these impacts is very important. Note that because of discounting of benefits it is not important to understand the preferences of generations several hundred years out but it does suggest that some of our old growth forests should be thought of a non-renewable. One cannot tree farm their way out of the loss of old growth forests.

Policy in the Long Run

Recently Arrow et al (2013) has raised the specter of uncertainty about of discount rates and its implications for climate change. Interestingly most of the high impact effects fall into the time frames of forestry management. The focus of their line of inquiry is what does it mean when real discount rates have a random component

They suggest the following mind experiment. Consider the case where the average discount rate should be 4%. In a non-random world the discount rate would be 4%; this is the typical application of the cost benefit analysis. Now suppose that the true discount rate 1% is equally as likely as 7%.

Table 1 presents discount value of $1,000 in year zero going forward. The top of the table labels each of the columns. The classic 4% discount case is under the 4% heading. The 1% and 7% cases are under the 1% and 7% headings. These streams behave as one would expect. The value of $1,000 in 100 years at a 7% discount rate is $0.91, not too much. Now examine the equally likely column, this is the average of the 1% and 7% columns. Early on the 4% column and the certainty equivalent column are close, but as time goes on they diverge significantly. The final column provides the certainty equivalent discount rate. Notice that it gets smaller and smaller as time goes on. By year 50 it is 1.28%!

Table 1. Certainty and Certainty Equivalent Discount: An Example

Year	1%	4%	7%	Equally Likely 1% or 7%	**Certainty Equivalent (%)**
1	$990.05	$960.79	$932.39	$961.22	**3.94%**
10	$904.84	$670.32	$496.59	$700.71	**3.13%**
50	$606.53	$135.34	$30.20	$318.36	**1.28%**
100	$367.88	$18.32	$0.91	$184.40	**1.02%**

This suggests that each year going forward should have its own, declining, discount rate. Projects that have benefits reaching out into the future should be discounted at lower rates to reflect the inherent uncertainty surrounding discount rates.

This has dramatic impacts on optimal forestry policies. Future damages that used to be discounted away are now relevant. When damages 30 years out are only discounted at a certainty equivalent discount rate they are valued at $318.36, not $135.34. Future damages will weight much more heavily in any analysis.

One can also speculate about the effects of rising social values. Suppose Krutilla's (1979) speculation that natural environments will grow in value through time is true. One can certainly see that rising values would act as a further reduction on discount rates. If eco-tourism continues growing in stable regions of Central America it means that much greater preservation of natural environments will take place under the certainty equivalent discounting rules.

As discussed below society is changing and certainty discounting rules would give greater voice to the future. Given the relative irreversibility of many change to forests certainty discounting has great value.

Forest Fires in an Evolving World

One also has to consider the evolution of society. Social values are not stagnant. Changes in national wealth, individual incomes, generational cohort effects and other concerns drive social values. These changes seem especially important if one adopts a certainty equivalent discount rate.

Englin and Holmes (2016) have undertaken a study of the long run evolution of recreational values of backcountry hiking. This activity is has been studied extensively and is well understood. The question they sought to address is whether Krutilla's (1967) conjecture that wild places were going to become more valuable in the United States was supported empirically.

Englin and Holmes (2016) based their analysis on backcountry hiking permits. They combined backcountry hiking permits for 21 US Forest Service wildernesses (Alpine Lakes, Ansel Adams, Black Elk, Boundary Waters, Emigrant, Glacier View, Goat Rocks, Golden Trout, Indian Heaven, John Muir, Mokelumne, Mount Adams, Mount Hood, Mount Shasta, Salmon Huckleberry, Sawtooth, Selway Bitterroot, Tatoosh, Trapper Creek, Weminuche, William O. Douglas) with hiking permits from Yosemite National Park.

They were able to develop ecosystem data from the US Environmental Protection Agency's Level 3 ecosystem categorization. The ecosystem types covered by the data included Blue Mountains, Central Basin and Range, Eastern Cascades Slopes and Foothills, High Plains, North Cascades, Northern Lakes and Forests and Sierra Nevada. These ecosystems cover a broad range of United States ecotypes.

They also developed demographic characteristics using the US Census. They interpolated between the 1980, 1990 and 2000 censuses by zip code to create a series of demographic characteristics. For the years after 2000 they extrapolated from earlier censuses. It should be noted that there is dramatic demographic migration over this time period. Finally, travel costs were assigned using US Internal Revenue tables of the cost per mile to drive. All costs, incomes and other pecuniary variables were brought up to current dollars.

Their econometric analysis was based on the linear exponential demand model (see LaFrance (1990), von Haefen (2002)). Linear exponential model use the exponential link function to link quantity demanded to exogenous regressors. The model is specified as:

$$\lambda_{ij} = e^{(P_{ij}, Z_j, \beta)} \qquad i = 1, 2, \ldots N \qquad 1$$

where λ_{ij} is the i[th] person's trips of the j[th] park, P_{ij} is the travel cost for the i[th] person to the j[th] park, and Z contains the characteristics of the parks and individuals and β is a vector of parameters to be estimated. The model is estimated as a log linear model:

$$\ln(\lambda_{ij}) = \alpha + \beta_p P + \sum \beta_k Z_k$$

Where P is the travel cost and Z_k are individual and site attributes.

Welfare calculations in count models are straightforward. One integrates the demand curve with respect to price ($\int \lambda_{ij}\, dp$) and the result is λ / β_p where λ is the trips taken and β_P is the coefficient on the travel cost. A commonly used welfare measure is the per trip consumer surplus which is simply $1/\beta_p$. The econometric results are all well behaved and show the usual signs. Demand curves are downward sloping and all the parameters are significantly different from zero at conventional levels.

The critical finding is that consumer's willingness to pay is rising through time. As a result there is support for Krutilla's supposition that wilderness may grow in value over time. Income elasticity drops over time. The growth in consumer's willingness to pay is small annually, on the order of 0.05%. Nevertheless the growth is significantly different from zero.

In an interesting sidebar Englin and Shonkwiler (1995) developed a model to correct for endogenous stratification and truncation in a negative binomial model of recreational site demand. They apply the model to a 1981 survey of on-site surveys of backcountry hikers in the Cascade Mountains. Using the estimated parameters they forecasted consumer surplus going forward to 2020 using forecasted population characteristics based on census data. This is of course a rather different methodology than using backcountry hiking permits. Nevertheless they projected a growth in consumer willingness to pay of about 0.05% per year. It is striking that the two approaches converge in their estimates of the growth in consumer willingness to pay despite the differences in methodology and time frames of the samples.

This is an important finding if one wishes to consider the effects of certainty equivalence discounting. If certainty equivalent discount rates effectively fall through time and values are growing through time then the appropriate discount rate should fall even faster since it will be the net of the negative effective discount rate and the growing consumer willingness to pay.

Simulations using the findings suggest that the net certainty equivalent rapidly approaches zero near year 50. This suggests that benefits far into the future are essentially undiscounted in a conventional sense.

Conclusions and Observations

Despite the evidence against it static forestry management continues to be practiced regularly. There are many dynamic and uncertain forces arrayed against the static approach. Change matters. Both eco-systems and societies change. These changes need to be modeled effectively.

Forest disturbances such as fires and invasive species impact forest health and utility. The way in which these disturbances impact forests through time has a random component but the paths are knowable. Because we can know the trajectories of recovery we can plan the best paths of recovery. It is possible to incorporate the trajectories and the random components into decision making.

The impact of these choices is extraordinary. After the removal of old-growth forests it can take centuries to recover aesthetic values. The case of Jasper National Park should be a sobering one. But, at least those forests can recover. In some places the impact of fire, insects or harvesting can damage soils making it impossible for the forests to recover. The application of certainty equivalent discounting makes these losses vastly more pronounced.

Certainty equivalent discounting profoundly changes the relationship between current policy choices and the future. With certainty equivalent discounting the future plays a much larger role in current decision making. Future benefits are worth a great deal more in today's terms. It seems likely that social evolution will also play a role.

While there are large fields of research into the complexion of future societies this work is rarely explicitly incorporated into current cost benefit analysis. Yet, as can be seen, there is every reason to believe that incorporating those effects can completely tilt the balance of how forests should managed.

Finally, much of this should be fairly common sense. The challenge is to quantify these effects and incorporate them into policy models. Quantifying these effects is an effort that requires data and careful analysis. Luckily our access to data models is just getting greater and greater. It seems that one should be optimistic about the future.

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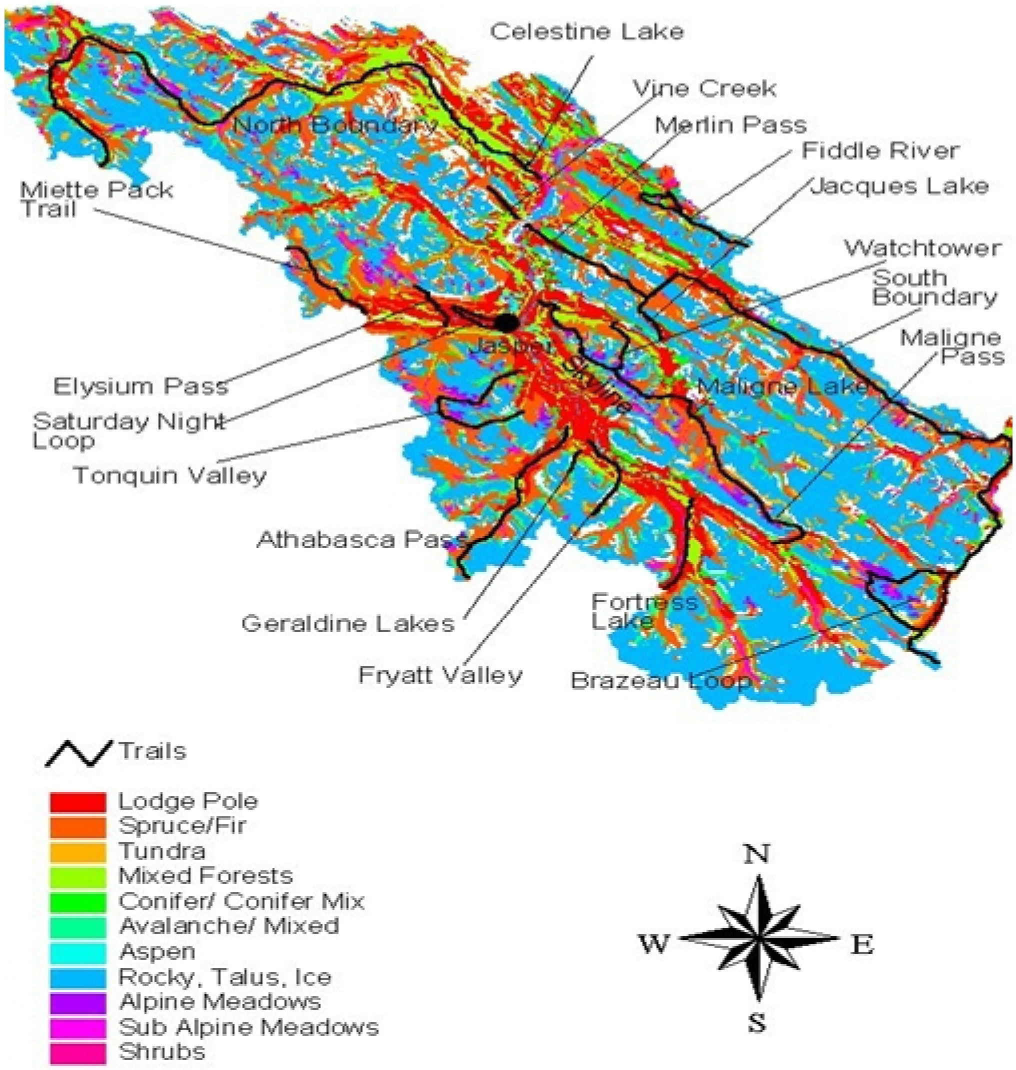
Appendix A



A.1 Trails of Jasper National Park taken from Figure 3.2 in Mc Donald (2000).