ARTICLE

Efficiency of fire protection programmes in New Zealand

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ABSTRACT

Evidence is presented which indicates that expenditure on measures to protect New Zealand's exotic forests from fire may be excessive, given the value of the forest which can be expected to be saved as a result. The implication of this research is that resource allocation may be optimised by reducing expenditure on exotic forest fire protection programmes.

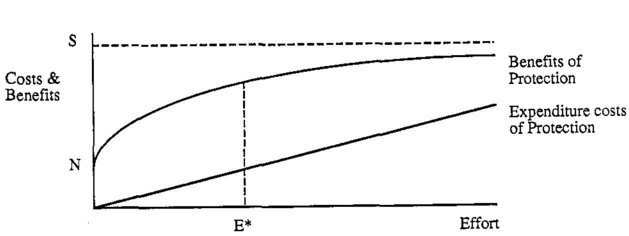
Introduction

This article seeks to assess the effectiveness of fire protection programmes in New Zealand using economic criteria. That is, it presents a comparison of how well the different forest conservancies addressed the problem of finding an appropriate balance between costs sustained through fire damage and expenditure costs incurred by prevention and suppression activities, so as to minimise the total costs incurred.

In practice it is extremely difficult to know how to achieve this balance, especially when there are recreational, aesthetic and other non-commercial benefits at stake. An interesting example of how the problem has been addressed is the US Department of Agriculture's 10 o'clock rule.[2] This required that the fire control authority invest enough protection expenditure to ensure any fire could be extinguished within a specified time limit, namely 10 o'clock the next morning. Thus a "trade off" point between the costs of protection and costs of fire damage was chosen arbitrarily, but erring on the conservative side, owing to potentially large, but unknown, social values.

Given better information about the size and risks involved for any given fire, however, it is possible, in principle, to do better than this arbitrary approach. Expenditure on fire prevention could be allocated in proportion to the size of expected losses caused by fires so as to make sure that proportionately more resources are allocated to areas where the potential harm of a fire is greatest. Similarly the allocation of resources to fire protection activities as a whole should reflect benefits which can be expected from that particular activity relative to other activities to which the funds could be diverted. These concepts can be explained with the aid of a simple diagram.[3] See Fig. 1.

Figure 1: The Optimal Expenditure Level

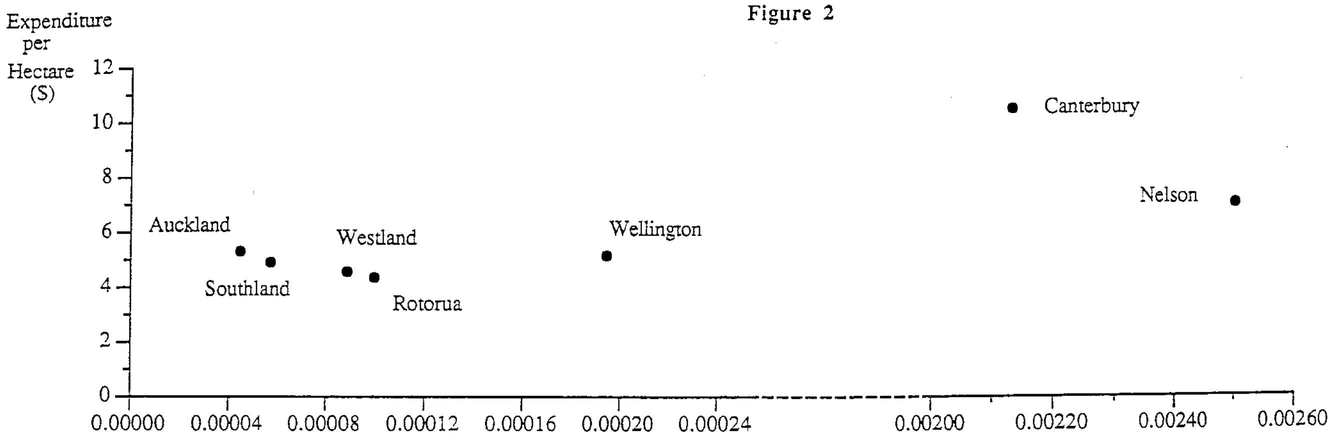


In the graph the total benefits of protection increase with effort at a decreasing rate and approach the total prevention level (S) at very high levels of effort. This schedule intersects the vertical axis at (N), which is the natural protection level, that is, the amount of forest which would not be destroyed even if no effort was made to suppress or prevent fires. Similarly each level of effort is associated with a level of protection expenditure and this relationship is represented as a protection expenditure cost curve. The optimal expenditure level is the level of effort which maximises the difference between total benefits and protection costs, shown here as E*.

In the case of NZ exotic forests the values are primarily commercial ones, so the total benefits of protection can be approximated by calculating the value of the resource which was saved. At the time of writing the NZFS had a series of data showing the damages incurred by each conservancy over the period 1975-1984 and expenditure levels over the period 1975-1982. A problem apparent from the framework described in figure 1 is that while the data record the total damage incurred at each level of expenditure, we are interested in the damage incurred net of the natural protection level, that is, the damage averted as a direct result of protection programmes. Thus only if the natural protection levels are similar can the damage data of two forests be meaningfully compared. For example, a comparison of the damage sustained in Westland over a given period with that of Canterbury would not be particularly meaningful, given the vast differences in climate, unless, of course, it was Canterbury (the drier region) that achieved the lower damage.

Various conservancies were thus assessed on the basis of the percentage of exotic forest area burned. If one conservancy achieves a lower damage and expenditure per hectare than a second conservancy, and is at least no better than the second with respect to the suitability of the environment to fire protection programmes, then this (the former) conservancy can be regarded as more cost effective. The following graph shows the expenditure on protection plotted against the damage levels for each conservancy using data made available by the NZFS in 1986.

Figure 2



Source: N.Z.F.S. unpuplished data

It can be seen that Canterbury and Nelson had both higher damage and expenditure levels than the other five conservancies and were therefore less cost-effective. Similarly Wellington was less cost-effective than Westland, Southland and Rotorua. To explain this difference in performance may require specialist forestry and engineering knowledge although, from the previous discussion, it may be stated that the high damage is either a consequence of a relatively low natural protection level, a poor protection programme or both. In the case of Canterbury and Nelson it is reasonable to suppose that the poor results are due to the climatic conditions. The reason for Wellington's poor performance is less obvious. Possible explanations range from the high population to the poor shooting skills of the Air Force who have a target range near one of the forests!

Optimal Resource Allocation

In order to discriminate between the effectiveness of the protection programmes in the other four conservancies – Rotorua, Southland, Westland and Auckland – we must put a value on the forest so that additional losses between conservancies can be directly compared with the reduction in expenditure. Thus, following the framework in figure 1, the aim is to determine whether the extra expenditure in, for example, Southland over Westland, can be justified in terms of a reduction in damage sufficient to cover the cost of that extra effort. Clearly this depends on the value of the timber destroyed. The average value of one hectare of exotic forest in New Zealand has been estimated at close to $6000.[4] Fire damages were thus expressed as the average annual percentage damage (in hectares) multiplied by the estimated average net present value per hectare.[5]

It should be noted that by using prices to determine values there is an implicit assumption that the prices of timber and capital for protection purposes reflect their actual marginal social cost. This would be an unreasonable assumption if we were dealing with native forests, however, because of the inability of market prices to reflect the social benefits of native forests. Secondly, it has been assumed that prices have not changed after the fire in question (for example the reduced supply may raise the price of the remaining timber) so that the value of the damage accurately reflects the difference in values before and after the fire.[6]

Results and Interpretation

By summing both the protection costs and damage costs a figure is obtained which measures the total cost of the particular level of fire protection effort in the different conservancies. Table 1, below, presents the results of summing protection and damage costs for each conservancy.

Table 1

(A comparison of efficiency between conservancies)

	(1) Annual Average Damage* (Hectares)	(2) Average Total Area (Hectares)	(3) Damage as a % of Total Area	(4) Average Annual Expenditure** ($/Hectare)	(5) Average Annual Damage*** ($/Hectare)	(6) Average Annual Total Cost ($/Hectare)	(7) Rank
Auckland	2.9	65,364	4.4×10^{-5}	5.26	0.27	5.56	4
Rotorua	19.3	194,858	9.9×10^{-5}	4.32	0.59	4.91	1
Wellington	10.8	55,678	1.9×10^{-4}	5.13	1.16	6.29	5
Nelson	115.7	46,217	2.5×10^{-3}	7.02	15.02	22.04	6
Westland	1.3	14,790	8.8×10^{-5}	4.56	0.53	5.09	2
Canterbury	60.4	28,290	2.1×10^{-3}	10.44	12.81	23.25	7
Southland	2.8	49,212	5.7×10^{-5}	4.85	0.34	5.19	3

Source: N.Z.F.S. unpublished data.
* Damages are averaged over the period 1975-1984.
** Expenditure is averaged over the period 1975-1982.
*** Based on the value of $6000 per hectare.

Of particular interest is the comparison between Auckland, Rotorua, Southland and Westland in column 5. This shows the annual average exotic forest losses in each conservancy between 1975 and 1984, divided by the average total area of exotic forest over the same period (shown in column 2) multiplied by $6000, the proxy for the value of the timber. Thus, for example, Auckland on average suffered an annual loss of 27 cents per hectare through fire damage. With the exception of Canterbury and Nelson these values seem very small in comparison to the expenditure per hectare figures in column 4. Column 6 represents an estimate of the average total cost of fire protection operations over the years by summing columns 4 and 5. Under some fairly strict assumptions the difference between damage costs in column 5 can be interpreted as the additional benefits of different protection expenditure levels. Thus from column 4 we see that Auckland spent more on protecting its forests than Southland and, in column 5, this resulted in less damage than in Southland. As shown in column 6, however, the damage prevented did not cover the cost of the additional expenditure, and thus it is assigned a lower rank in column 7.

The rankings between Rotorua, Westland, Auckland and Southland show that in no instance was a higher expenditure justified in terms of a reduction in the damage sustained. That is, the higher the expenditure on protection the lower the total costs. This arises because of the low value of the forest and the small damage incurred relative to the protection expenditure levels and suggests that efficient resource allocation would be attained by lower expenditures. The high relative efficiency of Rotorua over Auckland, Southland and Westland cannot be entirely attributed to a high natural protection because Fire Weather Index (FWI) readings of the NZFS show Rotorua to be relatively hazardous. Its success might be attributed to technological superiority in some form, such as economies of scale, but the damages sustained were relatively high. At least part, if not most, of Rotorua's relative success was because, by chance or design, a relatively high damage was combined with relatively low protection expenditure.

These results imply that the recent policy toward fire protection has been economically inefficient, either as a result of overestimating the marginal benefits of protection, inadequate controls on the allocation of funds, or both. Improvements in efficiency may therefore be realised as a result of reduced levels of expenditure on fire protection operations. While this would increase the average damage sustained, it is suggested that the increased damage would cost less than the extra expenditure used to prevent it. Auckland, for example, on average over the last ten years relative to Rotorua, has spent approximately $63,000 in order to save $21,000 worth of forests – a "loss" of $42,000 per year.[7] To further emphasise the point, the data above show that the expenditure undertaken in Auckland was higher than the individual total loss figure of Rotorua, Southland and Westland. Thus even if Auckland had sustained no fire damage it would still have achieved a higher total cost than these other conservancies.

Clearly commercial values are not the only values to consider from society's point of view. Other values associated with fire prevention should also be considered; for example, risk to life, aesthetic loss, fauna damage and the like. When these are considered to be significant the preceding analysis is not irrelevant however. To the contrary, it enables decision makers to put a cost on these aesthetic social benefits and also compare them with the costs of other environmental projects undertaken by the NZFS. Similarly there are likely to be hidden economic benefits such as regional development projects, low-cost logging and land stabilisation which can be incorporated in a similar fashion. It would seem unlikely, however, that these hidden benefits would be able to explain the large divergence in efficiency levels between different conservancies.

It is interesting, also, to compare the relative performance of the same conservancy over different time periods. Repeating the calculations described for table 1 but using damages over the period 1967-1974 and expenditure over the period 1965-1974 yielded similar results (not presented here). Rotorua's average expenditure level has gradually increased over the last 20 years and the overall efficiency declined. Conversely, Auckland's expenditure has declined and this resulted in a more efficient operation.[8]

The discovery that efficiency gains may be made by reducing the level of fire protection effort is important because it is a result which is neither intuitive nor obvious from casual observation. Clearly, however, these results are tentative and may be improved upon by a more in-depth study and use of more recent data. The strength of the results, in the large divergence between the high cost of protection and the apparent small returns on that protection, seems to indicate that such a study is warranted.

This article, then, has briefly discussed the economic merits of having more or less protection for exotic forests. It has been argued that the benefits of protection may have been overestimated, or that the allocation of expenditure toward protection may have been inadequately controlled, in a number of NZFS conservancies. In other words the value of the forests saved by protection policies has not justified the historical levels of protection expenditure.

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Footnotes

1. Economics Department, University of New England, Australia. Thanks to G. Harris, M. Treadgold and A. Dasgupta for their advice and support.

2. See, for example, Gorte and Gorte 1979, and Baumgartner and Simard 1982.

3. See also Cooper and Ashley-Jones 1987.

4. Cooper and Ashley-Jones 1986 pp 5-6, based on Report of the Director-General of Forests 1985, appendix 8, pp 52, 60. Note that all values in this article are expressed in constant 1983 prices.

5. Although the valuation of forestry has been a difficult and sensitive issue it can be shown that obtaining the analysis is quite insensitive to variations in the values used. See Robertson 1986.

6. It has also been assumed that the cost of extinguishing a fire, over and above the pre-suppression and prevention expenditure, is negligible. Between 1982 and 1986 the cost of fire fighting averaged approximately 2.65% of the total protection expenditure in New Zealand exotic forests. Cooper and Ashley-Jones 1987, table 2, p 15.

7. See table 1. Compared to Rotorua, Auckland sustained 5.4 x 10^{-5}% less damage. The value of the assets is \$6000 x 65,364 ha, 5.4 x 10^{-5}% of this is approximately \$21,000. Similarly the difference in protection cost per hectare is \$0.94, which, multiplied by the total area, yields approximately \$61,000 of additional expenditure.

8. For discussion of the results over this earlier decade see Robertson 1986.

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