ECONOMIC IMPACT OF MOUNTAIN PINE BEETLE ON OUTDOOR RECREATION*

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This study estimates the economic impact of outdoor recreation as a contributor to total value of forest resources in an area which has been heavily infested by Mountain Pine Beetle. The area of study was the Island Park are in eastern Idaho's Targhee National Forest. Targhee is a popular recreation area west of Yellowstone and Grand Teton National Parks. Recreationists use the area for both destination and non-destination purposes. The recreation opportunities of this area include water sports, hiking and related outdoor activities. It is classed as one of Idaho's major recreation areas.

The Island Park area has been heavily infested with Mountain Pine Beetle since 1960.[1] The major tree species involved is Lodge Pole Pine, which at present levels of forest utilization, provides poles, fence posts, round wood, cord wood and pulp wood. Other resources such as grazing leases, watershed values and outdoor recreation are also important contributors to the area's economy. Recreation resources are directly impacted by the Mountain Pine Beetle, evidenced by the large number of dead trees observed in infested campgrounds. The question uppermost in the minds of the resource managers is to what extent is the Mountain Pine Beetle affecting recreational and other resource values in the Targhee National Forest? Secondly, how do recreationists react to the large number of dead trees in the infested areas?

OBJECTIVES

The purpose of this study is to estimate the economic impact of the Mountain Pine Beetle infestation on recreational resources of the area and project this economic impact future recreational use. Specific objectives were to:

1. Survey recreational users in selected campgrounds in the Targhee National Forest to obtain information on recreational patterns and uses.
2. Develop recreational demand models to estimate the economic impact of Mountain Pine Beetle on recreational use in the Targhee National Forest.

DATA

The basic data used in this study were obtained from interviews with approximately 500 recreational users in six campgrounds in the Targhee National Forest during July and August of 1973. Basis for selection of campgrounds utilized in this study was the degree of evident Mountain Pine Beetle infestation. Three of these campgrounds were defined as infested (over 50 percent of the trees affected by Mountain Pine Beetle), and three as non-infested (10-20 percent of the trees infested). All areas of the Targhee National Forest have some Mountain Pine Beetle infestation.

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[1]Rivas, A., "Economic Evaluation of Mountain Pine Beetle Control on the Targhee National Forest," unpublished paper presented at Western Forest Insect Work Conference, Salt Lake City, Utah.

The interview procedure included visiting the campgrounds in the evening, leaving questionnaires with recreationists, and allowing them to fill them out overnight. Of the 500 questionnaires handed out, 90 percent were returned and 307 were useful in the analysis.

Information obtained from the questionnaires consisted of a profile of the recreational user, a catalog of the activities in which he participated, origin-destination data, and transfer costs of the recreation trip. These included the cost of transportation as well as those directly related to participating in recreational experiences.

Tabulated questionnaires indicated that approximately 86 percent of the recreationists were repeat visitors. Only 14 percent were first-time visitors. Recreation was the major purpose of the trip for the majority (53 percent), and it was a vacation trip for most of them (49 percent). Only 30 percent of these recreationists visited other areas compared to 60 percent who did not. Ninety percent indicated that they planned to return to the area in the future. Most popular activities were fishing, camping, sightseeing, canoeing or rafting, hiking, photography, swimming or water skiing.

Average length of stay in these campgrounds was 6.4 days or 12.8 visitor days. The average group included 7.2 persons. This large average-group size reflects the use of this area by campers such as Boy Scout Troops, church and other organized groups. The average distance traveled to the Targhee National Forest was 550 miles. Residents traveled an average of 517 miles, while nonresidents traveled 617. The estimated average return distance was 527 miles, that for residents being 465 miles and 641 for nonresidents. The average travel time to the area was 50.7 hours. For residents it was 47.2 hours. Nonresidents spent 57.6 hours. Estimated return time was 60 hours, 58.5 for residents and 63.5 for nonresidents.

The average total cost of the trip for the sample was $188. Residents generally spent $188, nonresidents $191. The average amount spent in Idaho was $78.20, residents spending $80.40 and nonresidents $73.90.

Differences in average mileage traveled, travel time, and average costs of recreating between residents and nonresidents were not very large. Reasons for this were related to the fact that many residents visiting the area come from western and northern Idaho, 500 to 800+ highway miles. A second reason was that when out-of-state people indicated that the major purpose of their trip was to visit some other area, mileage charged to their Targhee visit was computed from the last stop prior to their next destination. This was done to allocate travel costs in a reasonable manner between destination and non-destination recreation. A third factor was that most out-of-state recreationists using the area come from Utah (approximately a 300-mile trip).

METHODOLOGY

Procedures used to evaluate economic impact logically compare two situations. The first step would be to hypothesize what the situation in the Targhee National Forest would be without the Mountain Pine Beetle, and compare this with the existing situation. That difference measures the economic impact of the Mountain Pine Beetle on outdoor recreation. Equation (1) below indicates a simplified model:

$$(1) \quad R \text{ w/o mbp} - R \text{ w/mbp} = E.I.$$

where: R w/o mpb = economic value of recreation without the presence of the Mountain Pine Beetle,

R w/mpb = economic value of recreation with Mountain Pine Beetle infestation, and

E.I. = Economic Impact of the Mountain Pine Beetle.

The evaluation procedure relied upon separation of campgrounds to compare those infested with those not infested. Where the economic impact of recreation was estimated, it was done by interviewing recreationists camping in infested and non-infested campgrounds.

The evaluation technique involved developing a statistical demand model to estimate the number of visitor days of outdoor recreation as a function of round trip mileage, estimated travel time and cost per visitor day.[2] Given such an equation, it became possible to determine transfer costs and consumer surplus per person, per recreation trip.

The general form of demand curves developed are shown in equation (2) below:

[2]For a more detailed discussion see Clawson, M. and Knetsch, J.L., Economics of Outdoor Recreation". Resources for the Future, John's Hopkins Press, 1966, and Nawis, F., "The Oregon Big Game Resource: An Economic Evaluation". Unpublished Ph.D. Thesis, Oregon State University, Corvallis, Oregon, 1972.

(2) $Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon$

where: Y = number of visitor days,

X_1 = round trip mileage

X_2 = estimated travel time

X_3 = cost/visitor day

$\alpha+\beta$ = constants, and

ϵ = error term.

The above general model utilized a multiple regression least squares analysis. Usual assumptions of the estimating technique were made.

ANALYSIS

The demand equations developed in the analysis are shown in Table 1. R^2 statistics in the three equations varied from 0.43 to 0.56. Parameters were all significantly different from zero at the 5 percent level. The estimated economic values are shown in Table 2. Demand relationships were estimated for: 1) all campgrounds, 2) campgrounds heavily infested with Mountain Pine Beetle and 3) campgrounds which were lightly infested. For purposes of convenience, the terms "infested" and "non-infested" were used to describe 2) and 3). This table indicates average group sizes, number of visitor days, cost per visitor day, total cost per trip, average consumer surplus per visitor day and total consumer surplus per trip. The average consumer surplus per visitor day was obtained by interpreting the equation between average cost per visitor day and intercept of the estimated curve and the vertical axis of the graph. Consumer surplus was defined as that benefit which consumers receive but do not pay for. It can be interpreted as a net resource value for publicly-owned properties if one assumes that marginal utility equals marginal cost at each point on the curve above the cost per visitor day, and that the government is a discriminating monopolist.

Table 1. EQUATIONS USED TO ESTIMATE THE DEMAND FOR OUTDOOR RECREATION IN THE TARGHEE NATIONAL FOREST, 1973

1. All campgrounds: $N = 180$, $R^2 = 0.499$, $F = 58.54$

$$Y^n = 13.732 + 0.005X_1^* + 0.632X_2^* + 1.142X_3^*\ ^{1/}$$

(1.0617) (0.0012) (0.0140) (0.2701)

2. Infested campgrounds: $N = 113$, $R^2 = 0.435$, $F = 28.00$

$$Y^n = 13.920 + 0.004X_1^* + 0.732X_2^* - 1.083X_3^*\ ^{1/}$$

(1.2592) (0.0017) (0.2125) (0.3703)

3. Non-infested campgrounds: $N = 68$, $R^2 = 0.564$, $F = 27.60$

$$Y^n = 12{,}869 + 0.006X_1^* + 0.555X_2^* - 1.083X_3^*\ ^{1/}$$

(1.9803) (0.0018) 0.2027) (0.4224)

[1] Y^n = number of visitor days per trip
X_1 = round trip mileage
X_2 = hours traveled to recreation in area, and
X_3 = cost per visitor day

*coefficient significant at the 5 percent level, and estimates of the standard errors of the coefficients are given in parentheses.

Table 2. ESTIMATED ECONOMIC VALUES FOR OUTDOOR RECREATION IN SELECTED CAMPGROUNDS IN THE TARGHEE NATIONAL FOREST, 1973

Campground Categories	Average Visitor Days Per Person	Average Cost Per Visitor Day	Average Consumer Surplus Per Visitor Day
All	2.5	$2.95	$15.60
Infested	2.1	2.85	15.50
Non-infested	3.3	3.10	17.90

There were differences between estimates of value derived for the three demand equations. The average number of visitor days per person per trip was 2.5 for all campgrounds, 2.1 per infested campgrounds and 3.3 for the non-infested campgrounds. Average group size was 7.2 persons for all campgrounds, 8.1 for infested campgrounds and 5.8 for non-infested campgrounds. Average cost per visitor day was $2.95 per day in all campgrounds, $2.85 for visitor day in infested ones and $3.10 per day in non-infested ones. Consumer surplus values were $15.60 per visitor day in all campgrounds, $15.50 per visitor day in infested campgrounds and $17.90 per visitor day in non-infested ones.

Results indicate a difference in recreationist responses to infested and non-infested campgrounds. Presumably, this response measures the desirability of recreating in campgrounds without large numbers of dead trees. The demand curves measure recreationists' response to the environment by the length of stay, and by amount of money spent.

ESTIMATION OF LOSSES

Losses were determined by calculating differences between estimated average consumer surplus and recreation costs for infested and non-infested campgrounds. Average consumer surplus values were estimated by holding other variables in the estimating equations at average levels, recreation costs being the estimated average cost per visitor day. The method used to develop loss values is indicated in Table 3. The calculation subtracted consumer surplus value of infested campgrounds from that estimated for non-infested campgrounds ($17.90 - $15.50 = $2.40/visitor day). A similar calculation was made for the cost per visitor day expenditures ($3.10 - $2.85 = $0.25/visitor day). These residuals were then summed to determine the total value (marginal value per visitor day) of $2.65 per visitor day. This value was an estimate of the economic cost of Mountain Pine Beetle infestation in terms of its impact on recreational values.

Table 3. ESTIMATED LOSSES OF RECREATIONAL VALUES RESULTING FROM MOUNTAIN PINE BEETLE INFESTATION IN THE TARGHEE NATIONAL FOREST

Item	Number of Visitor Days	Expenditure/ Visitor Day	Consumer Surplus/ Visitor Day
Non-infested campgrounds	19.4	$3.10	$17.90
Infested campgrounds	16.8	2.85	15.50
Net difference	2.6	.25	2.40

The values generated above were aggregated to determine the magnitude of total losses caused by Mountain Pine Beetle in the Targhee National Forest. This was done first for the campgrounds which were studied, then for all campgrounds in the forest. Finally, it was done for all forest campgrounds assuming average level of infestation currently existing there.

In the case of campgrounds studied, estimated losses relfected the existing situation with regard to infestation levels. Loss estimates were based on U.S. Forest Service estimates of recreational use in these campgrounds. This estimated use was 124,783 visitor days.

Estimated losses were $330,675, based on the average loss per visitor day of $2.65, estimated from demand equations developed previously. This value can be allocated as follows: $31,195 in reduced expenditures and $299,480 of consumer surplus value, Table 4.

Table 4. ESTIMATED POTENTIAL ECONOMIC LOSSES IN OUTDOOR RECREATION VALUES ASSUMING THAT THE CAMPGROUNDS STUDIED WERE INFESTED WITH MOUNTAIN PINE BEETLE

Item	Value
All campgrounds studied (124,783 visitor days)	
1. No infestation	
a. Expenditures	$ 386,827
b. Consumer Surplus	2,233,616
Total	$2,620,443
2. Infestation	
a. Expenditures	$ 355,632
b. Consumer surplus	1,934,136
Total	$2,289,768
3. Economic Losses	
a. Expenditures	$ 31,195
b. Consumer Surplus	299,480
Total	$330,675

Additional data on campgrounds use were available from U.S. Forest Service records. These indicated the total number of visitor days of use in all campgrounds in the forest. The record covers the years 1967 to 1970, the average use for this period being 202,650 visitor days annually. In making loss projections, it was assumed that the level or degree of infestation would be the same as that observed in campgrounds previously studied. (This assumed an infestation level of 0 to 30 percent in the non-infested campgrounds and 40 to 70 percent of the trees in infested campgrounds).

The first projection was made by assuming that all 19 campgrounds in the forest were infested. Economic losses were calculated as shown in Table 5. Total losses were $537,023, determined as follows: a) expenditure losses were $0.25/visitor day x 202,650 visitor days = $50,663; and b) consumer surplus or net resource benefit losses were $2.40 x 202,650 visitor days = $486.360.

Table 5. ESTIMATED POTENTIAL ECONOMIC LOSSES IN OUTDOOR RECREATION VALUES ASSUMING THAT ALL CAMPGROUNDS IN THE TARGHEE NATIONAL FOREST WERE INFESTED BY MOUNTIN PINE BEETLE

Item	Value
Total campground use (202,650 visitor days)	
1. No infestation	
a. Expenditures	$ 628,215
b. Consumer Surplus	3,627,435
Total	$4,255,650
2. Infestation	
a. Expenditures	$ 577,552
b. Consumer Surplus	3,141,075
Total	$3,718,627
3. Economic losses	
a. Expenditures	$ 50,663
b. Consumer Surplus	486,360
Total	$537,023

A second estimate was made, assuming that only half the campgrounds would be infested at any one time. This relationship was assumed because there were no empirical data available to verify a greater or smaller level of campground infestation. The assumption introduced an aspect of marginality into the analysis in a gross way. Loss values estimated were half the value of those for the previous estimate, Table 6. The calculations were: a) ($0.25/visitor day x 202,650 visitor days)/2 = $25,332 loss of expenditures; and b) ($2.40/visitor day x 202,650 visitor days)/2 = $243,180 loss of consumer surplus. These values sum to $268,512 in terms of annual economic losses of recreation values in the Targhee National Forest.

Table 6. ESTIMATED POTENTIAL ECONOMIC LOSSES IN OUTDOOR RECREATION VALUES ASSUMING THAT HALF OF ALL THE CAMPGROUNDS IN THE TARGHEE NATIONAL FOREST WOULD BE INFESTED BY MOUNTAIN PINE BEETLE AT ANY ONE TIME

Item	Value
Number of visitor days 101,325	
1. No infestation	
a. Expenditures	$ 314,108
b. Consumer Surplus	1,813,718
Total	$2,127,826
2. Infestation	
a. Expenditures	$ 288,776
b. Consumer Surplus	1,570,538
Total	$1,859,314
3. Economic losses	
a. Expenditures	$ 25,332
b. Consumer Surplus	243,180
Total	$268,512

INVESTMENT IN CONTROL PROGRAM

If a recreational management agency is interested in developing a control program, an obvious question is how much money can the agency justify spending on control measures, given the estimated losses caused by Mountain Pine Beetle? This question can be defined in terms of how present losses are evaluated in terms of future losses.

Present value of all future losses needs to be determined. This can be done by assuming that estimated losses are an opportunity cost and by discounting the at an appropriate rate. The rate used in this analysis was 7 percent. To develop these capitalized values, the formula was: $V = \frac{L}{r}$

where: V = Capitalized value,
L = aggregate annual economic losses, and
r = discount rate of 7.0 percent

The present value of economic losses for each example discussed above are shown in Table 7. Total capitalized value for each example was: $4,723,922 for the campgrounds studied, $7,671,757 for potential loss due to infestation of all Targhee campgrounds, and a $3,835,857 value for loss of half of the campgrounds (or visitor-day use in the Targhee National Forest).

Table 7. PRESENT VALUES OF ECONOMIC LOSSES IN OUTDOOR RECREATION VALUES IN THE TARGHEE NATIONAL FOREST

Item	Capitalized Values
1. Infested campgrounds, 124,783 visitor days	
a. Expenditures	$ 445,643
b. Consumer Surplus	4,278,286
Total	$4,723,922
2. All campgrounds potential losses, 202,650 visitor days	
a. Expenditures	$ 723,757
b. Consumer Surplus	6,948,000
Total	$7,671,757
3. Half of all campgrounds, potential losses 101,325 visitor days	
a. Expenditures	$ 361,857
b. Consumer Surplus	3,474,000
Total	$3,835,857

Capitalized values represent present value of recreational losses resulting from beetle infestation in the national forest. These values can also be used to determine upper limits on the amount of investment which could be justified for a pest management control program. The difficulty is that a decision maker needs to know what his potential losses may be before he can determine the amount of investment he should be using, or if he should be concerned with a control program at all.

SUMMARY

This study used demand models to estimate the economic impact of Mountain Pine Beetles on recreational use in the Targhee National Forest. The procedure estimated the demand for

both infested and non-infested campgrounds and compared consumer surplus and transfer cost estimates derived from models. These estimates were then used to simulate various infestation conditions, to determine the magnitude of average annual losses from beetle infestation. Losses were then capitalized to determine total value of damages. This value was interpreted as the upper limit for investment in control measures for the Targhee's Mountain Pine Beetle pest control program.

Several concerns should be recognized when using transfer costs as a surrogate for prices in estimating consumer surplus values for outdoor recreation. First, an adjustment was made to account for nondestination use, because in some cases hours and mileage traveled were incidental to a Targhee visit. A second factor affecting the estimation of consumer surplus was that data used for this study were obtained during the summer of 1973, a period of rapidly rising gasoline prices. These price increases had the effect of dramatically raising the average cost per visitor day compared to earlier years. A third factor that the consumer surplus values estimated were point estimates. These point estimates are assumed to have wide and unknown bounds, and computation of them is difficult if not impossible.

Results of this paper imply that measurement of economic impact is possible, and that the loss estimates developed in this analysis may be compared to losses of other resources in the national forest. More research is needed to develop models for other resources to obtain loss values related to Mountain Pine Beetle damage.

REFERENCES

[1] Clawson, M. and Knetsch, J.L. "Economics of Outdoor Recreation," *Resources for the Future,* John's Hopkins Press, 1966.

[2] Nawis, F. "The Oregon Big Game Resource: An Economic Evaluation," Unpublished Ph.D. Thesis, Oregon State University, Corvallis, Oregon, 1972.

[3] Rivas, A. "Economic Evaluation of Mounatin Pine Beetle Control on the Targhee National Forest," Paper presented at Western Forest Insect Work Conference, Salt Lake City, Utah.