Marginal Costs of Managing Endangered Species: The Case of the Red-Cockaded Woodpecker

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Abstract. *This case study of red-cockaded woodpecker management in the Croatan National Forest in North Carolina demonstrates that a schedule of opportunity costs for endangered species management (1) is easy to calculate and (2) can help clarify management and policy alternatives The study also shows that the greatest gains from biological research will come from improved understanding of how the woodpecker chooses new habitat Finally, it shows, in this case, management of endangered species need not impose large costs on society*

Keywords. *Endangered species, red-cockaded woodpecker*

The purpose of this article is to consider management of one endangered species, the red-cockaded woodpecker (RCW), in the Croatan National Forest in North Carolina as an example of a general economics problem for all endangered species The RCW is on the national endangered species list and its management is a contentious issue for USDA Forest Service, which is concerned with conflicts between endangered species and other forest uses and the Interior Department's (USDI) Fish and Wildlife Service, which is concerned with strictly upholding the endangered species law This article shows that even an incomplete analysis based on readily available data can help managers and policymakers understand the relevant tradeoffs It also shows, in this special case, that there is great variation in costs depending on where and how RCW management proceeds This is important information considering the highly speculative, and often inflammatory, statements made by both proponents and opponents of endangered species protection

Previous economics literature on preservation focuses on either maximizing a social welfare function, which includes both development goods and natural assets, or satisfying a safe minimum standard The welfare maximization approach has yet to be successfully applied to an example involving an actual endangered species (*6, 12, 16*) [1] The safe minimum standard literature accepts a normative decision to preserve, provided that costs are within socially acceptable limits, and then searches for the minimum viable population given irreversibility and uncertainty (*2, 3, 4, 5*)

This article takes an intermediate approach Given the normative decision to preserve, the article searches for the least-cost management alternative for preserving any population level, implicitly including the level of the safe minimum standard [2] Miller discusses some conceptual aspects of this approach (*13*) There is an empirical solution arising from this approach for any species and for any set of management alternatives

This article shows how managers and policymakers can use this approach to make cost-effective endangered species decisions at the margin The article shows the critical RCW management variables and suggests where biological research can provide information useful to managers The discussion begins with an introduction to the important characteristics of RCW biology and habitat It continues with development of an economic model that emphasizes the tradeoff between RCW habitat and timber production, the highest valued alternate use of most RCW habitats

Biological Background

The red-cockaded woodpecker inhabits mature pine forests (50-150 years old) in the South It lives in population units called clans, each of which consists of a mated pair and its (up to seven) helpers Clans roost in areas known as colonies and mated pairs nest in cavity trees within these colonies Cavity trees are mature, live pines in which the woodpeckers excavate cavities for nesting The existence of cavities is essential because without them males cannot attract females

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[1]Italicized numbers in parentheses cite sources listed in the References section at the end of this article

[2]The stochastic nature of species populations and the uncertainty surrounding our means for their measurement imply that the safe minimum standard is actually a range in population, not a population level

Apparently, woodpeckers do not select cavity trees for age alone Rather, they choose and excavate trees that contain substantial heartwood (which is positively correlated with age), and, of trees with heartwood, woodpeckers prefer those with red heart fungus (*10*) The fungus softens and destroys heartwood, thereby making excavation easier

Colony sites must include a replacement stock of cavity trees because woodpeckers abandon nests in dead trees Woodpeckers also abandon nests in live trees when the hardwood and sapling pine undergrowth reaches the height of the cavity (*7*) Prescribed burning can control the undergrowth, preventing this cause of abandonment

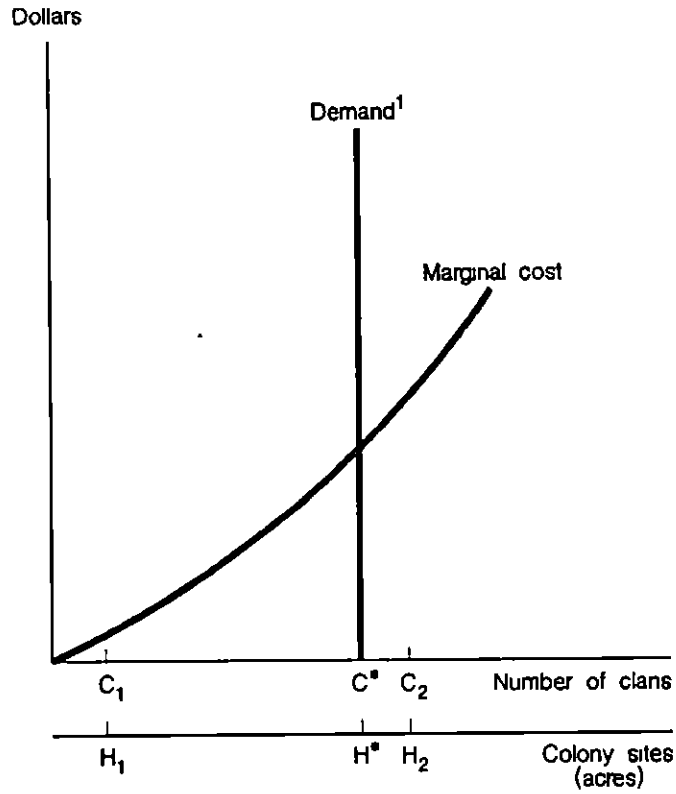
The land area for each colony site ranges from 7 to 90 acres Clans defend territories ranging from 100 to 250 acres around colony sites, and they forage on live pines of all ages within this territory

Economic Analysis

This analysis assumes an exogenous demand That is, a public law requires endangered species management The law imposes the demand for RCW management The analysis itself is composed of a search for the management alternative that satisfies this demand at the least marginal cost [3] The most important costs for RCW management are the implicit costs of foregone timber opportunities Neither the Forest Service nor the Fish and Wildlife Service makes claims for other competitive uses on RCW habitat in the Croatan National Forest The costs associated with prescribed burning to maintain understory height below cavity level are also the costs of the more basic stewardship responsibility of the Forest Service for all national forestlands, commercial or otherwise There are no incremental direct RCW management costs The cost management unit is the clan Therefore, the marginal cost function measures the timber opportunity cost per clan or the cost per colony site No change in timber management is necessary in woodpecker-foraging territories because foraging and timber management are naturally compatible

The Croatan National Forest manages its important timber species, loblolly and longleaf pine, on 70-year rotations in accordance with multiple use-sustained yield criteria and the National Forest Management Act of 1976 [4] RCW biologists recommend average ages

Figure 1
Endangered species modeling



1/ Demand is externally set by a law which requires protection of all known populations of the endangered species.

of 95 years for longleaf and 75 for loblolly, although there are woodpeckers nesting in Croatan loblolly stands as young as 46 years (*10*) The costs of delayed harvests imposed by the biological recommendations are not constraining everywhere in the Croatan because not all timberstands in the forest are commercially productive The noncommercial stands tend to be biologically mature and RCW preservation can occur on these without conflict with timber management The marginal cost function, in this noncommercial case, runs along the horizontal axis in figure 1

Where the timberstands are commercial, either of two alternate approaches may extend timber management rotations for woodpecker management (A) permanent cessation of all timber harvesting on currently occupied colony sites or (B) extended rotations and harvests on a sequence of timberstands recruited as colony sites

[3]Where the law is not indicative of marginal social valuation, then the approach in this article says nothing about social optimality This analysis only shows the least expensive manner of accomplishing any given level of endangered species protection

[4]The Forest Service prescribes these long rotations regardless of the presence or absence of other resource values on these lands Rotations for the same species grown on private lands tend to be closer to 40-45 years The literature on this difference is extensive and rotation differences of this magnitude make a large financial difference (See (*9*), ch 2, and the citations in that chapter) Forest Service rotations are relevant for this article where laws and management practices other than those specifically designed for endangered species management are held constant

Neither alternative is a perfect preservation solution Nevertheless, these are the solutions that focus current management discussion The first alternative fails to consider the 4-9 percent annual rate of mortality among occupied cavity trees and makes no provision for their future replacement [5] The understory is unlikely to provide replacement trees because pines tend to grow in even-aged stands with large gaps between the older age classes The second alternative assumes that clans easily relocate when their colony sites are harvested, although there is no empirical evidence supporting this assumption Thus, in the short run, the second alternative provides uncertain results In the long run, however, we can expect that biologists will learn more about colony establishment and the second alternative may become more attractive

Alternative A: Preserving Existing Colonies in Perpetuity

Current woodpecker management in the Croatan corresponds to this alternative Forgone net timber receipts V_1 can be calculated according to the familiar Faustmann equation modified to include revenues from a sequence of harvests Q(t), including both thinnings and final harvests which vary in diameter and, therefore, value, increasing relative stumpage prices p(t), costs c(t) from a sequence of inputs, and the number of acres A comprising the known colony site

$$V_1 = A[(\sum_{t=0}^{T} p(t)Q(t)e^{-rt} - \sum_{t=0}^{T} c(t)e^{-rt})]/(1-e^{-rT}) \quad (1)$$

Equation (1) describes the present value of an infinite series of rotations beginning now Table 1 describes the empirical data used to estimate this value

Further modification is necessary to include the value of currently standing timber on an existing colony site The present value of standing timber is equal to

$$V_2 = A[(\sum_{t=0}^{T-a} p(t)Q(t)e^{-rt} - \sum_{t=0}^{T-a} c(t)e^{-rt})], \quad (2)$$

where the revenues and costs generated by the current stand are calculated from the present (t=0) to the time of their final harvest (t=T–a, where T=70 years and a=the current stand age)

The combined value of the standing timber V_2 plus the value of all future rotations V_1 equals the total value of the colony site V_3 where

$$V_3 = [V_2] + [V_1 e^{-r(T-a)}] \quad (3)$$

The discount term is $e^{-r(T-a)}$ because the perpetuity rent V_1 is not forthcoming until after the current timberstand is harvested V_3 is the final measure for management alternative A, the timber opportunity associated with permanent removal of the existing colony site from timber production

Alternative B: Rotating Recruitment Stands

The cost of implementing management alternative B equals the difference between net timber revenues from current 70-year rotations and net revenues from the extended rotations necessary for recruitment stands of potential cavity trees Its calculation depends on two important assumptions, one having to do with the length of RCW habitation in recruitment stands and the other having to do with current stand age structures and harvest scheduling

Biological evidence suggests that woodpeckers mate in their second year and inhabit colony sites until their eighth year when they die The sites then can be harvested and descendants of the mated pairs may relocate to adjacent recruitment stands (*11*) This assumption, together with Lennartz's recommendation of stands averaging 75 years for loblolly and 95 years for longleaf, recommends sequences of 13 loblolly sites (that is, the oldest between 72 and 78 years where 13 equals 78 years divided by 6 years per mated pair occupancy) and 17 longleaf sites (98 years divided by 6 years) In addition, we can assume that each colony site is 11 7 acres, the average size of current RCW colonies in the Croatan, and that the various loblolly and longleaf sites in the Croatan have sufficient adjacent acreage to allow the necessary sequences of recruitment stands [6] Conversion from 70-year rotations to extended rotations poses no immediate stand age problems because the Croatan has an excess of mature and noncommercial timberstands that can fill the RCW management gap until current commercial stands reach ages 75 and 95 for loblolly and longleaf, respectively

[5]With an average of 1 5 cavity trees per colony in the Croatan and an annual mortality rate of 4 9 percent, all existing cavity trees will be dead in 17-38 years Clearly, an alternative to preservation of existing stands must be found and implemented soon

[6]Forest Survey data show that sufficient acreage exists within each site index, but they provide no indication regarding its locational distribution The 200-acre foraging areas recommended for the Croatan National Forest are not constraining That is, 11 7 acres for each of 13 loblolly or 17 longleaf stands implies 152 1 or 198 9 acres per colony, respectively, less than the 200 acre constraint

Table 1—Abbreviated cost-revenue stream used in the calculation of perpetuality rents[1]

$$V_2 = A[(\sum_{t=0}^{T} p(t)Q(t)e^{-rt} - \sum_{t=0}^{T} c(t)e^{-rt})]/(1-e^{-rT})]$$

Year[2]	Treatment[2]	Output (Q(t)), by Site Index (SI)[3]					Costs (c(t))	Revenues[4,5]
		SI 70	80	90	100	110		
Loblolly pine								
								Dollars
0	Site preparation	—	—	—	—	—	130/acre	0
0	Fertilizer	—	—	—	—	—	30/acre	0
1-T[6]	Annual management	—	—	—	—	—	2/acre/year	0
30	Commercial thinning (cordwood)	0 98	4 03	6 63	11 10	13 44	6/cord	7 75/cord
50	Commercial thinning (cordwood)	11 55	15 62	22 00	29 44	33 57	6/cord	7 75/cord
70[7]	Harvest (sawtimber)	22 55	29 50	36 60	44 95	53 10	10/Mbf[10]	148 00/Mbf
78[8]	Harvest (sawtimber)	23 65	30 60	37 95	46 10	54 70	10/Mbf	148 00/Mbf
Longleaf pine								
		SI 50	60	70	80			
0	Site preparation	—	—	—	—		130/acre	0
0	Fertilizer	—	—	—	—		30/acre	0
1 T[6]	Annual management	—	—	—	—		2/acre/year	7 75/cord
40	Commercial thinning (cordwood)	0	0	1 47	4 84		6/cord	7 75/cord
60	Commercial thinning (cordwood)	0	4 09	9 74	15 24		6/cord	7 75/cord
80[9]	Commercial thinning (cordwood)	0	7 50	14 71	25 05		6/cord	7 75/cord
70[7]	Harvest (sawtimber)	5 40	12 35	20 40	28 30		10/Mbf	148 00/Mbf
98[8]	Harvest (sawtimber)	9 60	18 50	27 35	36 55		10/Mbf	148 00/Mbf

[1]See text for discussion of formula r = 4 percent, 7 percent, or 10 percent
[2]Various sources Asheville Office, National Forests of North Carolina
[3]Source USDA (1929, revised 1976)
[4]Source for prices Norris (1979-81)
[5]Price sensitivity tested by assuming constant prices and rising relative prices, in separate runs
[6]T denotes the final year of the rotation Thus, T=70 for 70-year rotation, T=78 for loblolly extended rotations and T=98 for longleaf extended rotations
[7]Projected cut under current rotation
[8]Projected cut under extended rotation
[9]Commercial thinnings in the 80th year occur only under the longleaf extended rotation management alternative
[10]Mbf=Thousand board feet

This completes the preparatory background necessary for modeling rotating recruitment stands We can make the assumption that all recruitment stands grow from currently unmanaged standing timber The existence of standing timber raises net timber values and depreciates the economic justification for RCW management It is a conservative assumption with respect to promoting RCW management

The present value of the perpetual net revenue stream from one colony site is

$$V_4 = V_1(T) - (V_1(T_R), \tag{4}$$

where V_1 remains as defined previously, T is the mandated 70-year Forest Service rotation, and T_R is the RCW rotation For a sequence of 6-year inhabited sites, opportunity costs totaling V_4 occur every 6 years on each 200-acre RCW habitat The discounted total costs for maintaining one RCW clan in perpetuity are

$$V_5 = V_4(e^{-6r} + e^{-12r} + \qquad + e^{-T_R r}) \tag{5}$$

The present value of the perpetual net revenue stream from 11 7 acres of loblolly pine on a 70-year rotation is

$$V_1(T) = [11\ 7/1-e^{-70r})][(p(70)Q(70)-c(70) + (p(30)Q(30)-c(30))e^{-30r} + (p(50)Q(50)-c(50))e^{-50r}], \tag{6}$$

for stands currently 70 years old Initial-year site preparation and fertilization costs enter as final harvest costs for the previous rotation[7] Annual management costs are compounded, summed, and entered at year 30 and year 50 (Recall from table 1 that thinning occurs at ages 30 and 50 for loblolly) Similarly, the present value of the perpetual net revenue stream from 11 7 acres of loblolly on 78-year rotation is

$$V_1(T_R) = [11\ 7(1-e^{-78r})][(p(78)Q(78)-c(78))e^{-8r} + (p(30)Q(30)-c(30))e^{-38r} + (p(50)Q(50)-c(50))e^{-58r}] \tag{7}$$

[7]Again, this is debatable Forest Service timber management practice It is also poor economics if these are only the costs of generating the next commercial timberstand (See (9), ch 2) This article accepts this Forest Service practice on the grounds that the article is restricted to examining only management prescriptions specifically designed for endangered species

Subtracting equation 7 from equation 5 provides the loblolly opportunity cost for providing a single RCW colony site

Incorporating the 6-year sequence of 13 sites yields the discounted total loblolly opportunity costs for maintaining an RCW clan in perpetuity

$$V_5 = V(70)(1+e^{-6r}+ \quad +e^{-72r}) - V(78)(e^{-8r}+e^{-14r}+ \quad +e^{-80r}) \qquad (8)$$

Analogous expressions describe longleaf opportunity costs for maintaining RCW clans in perpetuity

Empirical Results

Table 1 shows our harvest projections, prices, and costs, and their sources One modification and two sensitivity analyses are especially important First, Hopkins provides data on the stocking of current stands (*8*) An additional generous assumption that all future stands will be fully stocked raises our timber opportunity perhaps as much as 50 percent

The analysis may be sensitive to increases in relative stumpage prices over time and to various costs of capital Real sawtimber stumpage prices are increasing at a 3-percent annual rate and cordwood prices are increasing at a 1 5-percent annual rate (*5*) Some evidence, however, suggests that these rates may decline early in the next century (*1*) Other evidence suggests that competing environmental amenity values may also be increasing in real value (*15*) Therefore, it is appropriate to examine real annual rates of 0, 1:5, and 3 0 percent for sawtimber and 0, 0 75, and 1 5 percent for cordwood Finally, the Forest Service uses a 4-percent discount rate but only on appeal from the general Federal agency rate of 10 percent We might test for both, as well as for the intermediate rate of 7 percent The social opportunity cost of funds probably falls within this range

A First Order of Results

Table 2 shows the range of results for management alternative A, preserving existing colonies in perpetuity For example, for constant stumpage prices and a 4-percent discount rate, the costs of preserving the 52 existing colony sites in perpetuity range from $255 to $56,529 per site These one-time-only costs are equivalent to streams of annual rents ranging from $10 to $2,261 per site Table 2 also shows that these perpetual preservation costs are inversely proportional to changes in the discount rate and directly proportional to changes in rates of sawtimber and cordwood price increases

Table 2—Costs of preserving existing colony sites

Price changes[1]	Discount rate 4 percent	7 percent	10 percent
	Dollars per colony		
0, 0			
Present value	255-56,529	81-35,798	24-24,015
Annual rent	10-2,261	6-2,505	2-2,402
0 015, 0 0075			
Present value	722-74,453	303-44,762	224 29,828
Annual rent	29-2,978	21-3,133	22-2,984
0 03, 0 015			
Present value	1,537-100,862	512-56,025	349-36,912
Annual rent	61-4,034	36-3,922	35-3,691

[1]The first number is the rate of sawtimber stumpage price change and the second is the rate of cordwood price change

Table 3 shows the range of results for management alternative B, rotating recruitment stands It is strictly comparable with table 2, except that its results refer to the opportunity costs of extending current timber rotations and providing recruitment stands The range of costs in each cell of the two tables directly relates to the acreage in the colony site, the site productivity for timber, species (loblolly sites tend to be higher valued), and the age and stocking of the current timberstand The rankings of individual colony sites change somewhat within the cells of table 2 because younger current stands are more affected by the relative price change, but all stands are equally affected by discounting

Comparing the results in table 3 with those in table 2 yields unsurprising conclusions Management alternative B represents a land-intensive means of preservation requiring almost 20 times more land than alternative A Although timber harvest revenues are permanently forgone under alternative A, the loss amounts to little more than the value of the standing timber Revenues from future rotations are so highly discounted as to make them of little significance Under alternative B, 70-year harvest revenues are forgone every 6 years on 13 loblolly or 17 longleaf land units, each 11 7 acres in size While this loss is partially relieved by revenues from the 78-year or 98-year harvests, the discounted compensation cannot offset the large difference in the required acreage

Final Results

Some woodpecker colony sites are on timberland that is not now fully managed for timber Therefore, some RCW protection occurs without a timber opportunity cost, which means that some RCW management costs

Table 3—Costs of rotating recruitment sites of extended ages

	Discount rate		
Price changes[1]	4 percent	7 percent	10 percent
	Dollars per colony		
0, 0			
Present value	11,824-118,349	13,632-98,193	12,553-93,769
Annual rent	473-4,734	954 6,874	1,255-9,377
0 015, 0 0075			
Present value	8,966 131,342	14,249-107,895	13,607 94,600
Annual rent	359-5,254	997 7,553	1,361-9,460
0 03, 0 015			
Present value	1,076 145,404	13,972-118,519	14,598-99,666
Annual rent	43-5,816	978-8,296	1,460-9,967

[1]The first number is the rate of sawtimber stumpage price change, and the second is the rate of cordwood price change

are not as great as tables 2 and 3 indicate Various generous timber cost estimates have been identified throughout the paper, but the most pervasive overestimation stems from our disregard of the expensive costs of access to timber management sites (including building the roads themselves)

For example, in 1982, timber managers harvested only 2 8 million board feet (MMbf), or 14 percent of the mature timber in the Croatan If managers' judgments were financially rational, then only this 14 percent was commercial and the remaining 86 percent, in fact; had no timber opportunity cost This 86 percent of timber sites was available for RCW management at zero opportunity cost

Consider how this alters our cost estimates for preserving 52 RCW habitat sites under either management alternative Assume the least-cost ordered ranking of sites is correct and assume our generous timber opportunity costs estimates are correct for the more valuable 14 percent of all sites

Under alternative A the best 22 timber sites fall on longleaf site indices 70 and 80 and loblolly site indices 100 and 110 These sites provide nearly 3 MMbf, annually, or more than a sufficient volume to satisfy the 1982 harvest level for the Croatan There are no forgone timber opportunities on the remaining 30 RCW colony sites The large number of low-quality timber sites with RCW colonies suggests that low-quality sites were left undisturbed by timber managers before RCW protection became an issue and that timber managers displayed the economically rational tendency to harvest good sites first Of the 22 sites with valuable timber opportunities, 6 have timber stands currently over age 85 Timber managers apparently found these sites unprofitable for timber even before recent discoveries of the woodpecker and requirements for its protection Subtracting these 6 sites leaves 16 RCW sites on which the Croatan must forgo a viable timber option Table 4 is the marginal cost schedule for these remaining 16 sites under each price and discount rate scenario It leads us to the observation that the total perpetuity cost for preserving the 52 existing sites (at a 4-percent discount rate and zero rate of stumpage price increase) is $220,422 The annual payment associated with this level of protection is $8,817 (More than one-fourth of the cost is for one highly productive loblolly site which is near harvest age now)

There are 54 200-acre preservation units on longleaf site index 50 and loblolly site index 70 These each satisfy the alternative B requirement for rotating recruitment stands in perpetuity They are the poorest sites and the least likely ever to become commercially viable for timber None are currently viable for commercial timber production and preserving 52 of them, one for each existing colony, requires no timber opportunity forgone

Conclusions

The cost of preserving the 52 *existing* RCW colonies is relatively small There is no cost for the 52 *recruitment* colonies Indeed, the costs of timber opportunities forgone are probably lesser problems of RCW management than is the uncertainty clouding the efficiency of either preservation alternative

Finally, a summary note is in order regarding the application of marginal cost analysis for endangered species management in general Outlining the costs associated with the anticipated preservation of discrete biological units provides resource managers with the total cost information necessary for choices among management alternatives with various associated risks of extinction Furthermore, marginal cost estimates determine the relative costs of preserving various potential individual habitat sites and provide a way of evaluating alternate means of meeting an exogenous preservation constraint

Limitations do exist, however This analysis shows the costs of providing *habitat* for the species This may or may not result in preservation of the species or even its individual members Preservation of the individual occurs when the individual's niche requirements are met throughout its natural lifespan Preservation of the species requires not only preservation of the individual, but also preservation of a sufficient number of individuals such that adequate

Table 4—Marginal costs of preserving individual existing colony sites where timber management is a viable option

Case number	Species	Site index	Area	Age (years)	Discount rate and rate of price change scenarios[1]								
					r = 4 percent			r = 7 percent			r = 10 percent		
					0 0	0 015 0 0075	0 03 0 015	0 0	0 015 0 0075	0 03 0 015	0 0	0 015 0 0075	0 03 0 015
47	Longleaf	70	7	52	$ 3,264	5,218	8,374	1,598	2,346	3,363	884	1,294	1,831
16	Longleaf	70	7	59	4,434	6,355	9,545	2,739	3,482	4,434	1,930	2,410	2,983
31	Longleaf	70	7	64	5,495	7,309	10,531	3,974	4,585	5,373	3,277	3,699	4,173
52	Longleaf	80	7	52	5,566	8,405	13,187	2,812	3,979	5,561	1,583	2,226	3,070
15	Longleaf	70	7	67	6,241	7,947	11,194	4,951	5,375	6,015	4,475	4,762	5,080
49	Longleaf	70	7	69	6,791	8,403	11,670	5,726	6,008	6,478	5,498	5,627	5,780
30	Longleaf	70	15	64	11,776	15,662	22,566	8,515	9,824	11,513	7,021	9,927	8,942
6	Loblolly	100	7	52	12,906	18,770	27,785	6,816	9,350	12,761	3,896	5,311	7,170
10	Longleaf	80	15	54	12,985	19,263	29,274	6,998	9,538	12,908	4,213	5,687	7,568
8	Longleaf	80	15	56	14,130	20,360	30,347	8,116	10,662	13,975	5,215	6,769	8,697
11	Longleaf	70	15	74	15,177	18,515	25,539	13,192	13,853	14,403	13,053	13,102	13,203
12	Longleaf	70	15	74	15,177	18,515	25,539	13,192	13,853	14,403	13,053	13,102	13,203
13	Longleaf	70	15	74	15,177	18,515	25,539	13,192	13,853	14,403	13,053	13,102	13,203
50	Longleaf	70	15	74	15,177	18,515	25,539	13,192	13,853	14,403	13,053	13,102	13,203
9	Longleaf	90	15	52	19,597	28,920	43,420	10,221	14,150	19,446	5,818	8,004	10,875
46	Loblolly	110	15	57	56,529	74,452	100,862	35,798	44,762	56,025	24,015	29,823	36,912
Total cost					220,422	295,124	420,911	151,032	179,473	215,464	120,037	135,947	155,893

[1]Rate of price change First entry for sawtimber, second entry for cordwood

genetic diversity is maintained throughout the geographic range of the species Uncertainty here is compounded We know neither the specific habitat requirements of the individual nor the population level or distribution which must be sustained to provide the necessary genetic stock These problems may be resolved with further biological research on the colony site and on the safe minimum standard for population preservation The same marginal cost analysis demonstrated in this paper could then be applied with superior confidence

The importance of this analysis is that (1) it provides evidence that RCW management costs society less than much of the political discussion would have us believe, and (2) it demonstrates a mechanism for arraying costs and management choices in a manner that makes resource tradeoffs clear The low-cost result causes us to ponder whether the costs of activities to protect other endangered species may be less than often anticipated. Application of this method and these results should help focus scientific research for the RCW, and for other endangered species as well, on topics having large impacts on either management costs or species survival The method and results beg clearer analysis of endangered species problems in general

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