Resource Equivalency Analysis for Marbled Murrelets
New Carissa Spill, February 1999

May 24, 2005

Prepared by:

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Summary

The New Carissa oil spill killed approximately 262 endangered Marbled Murrelets in February 1999. Resource equivalency analysis (REA) is used to evaluate the direct loss (birds killed) and indirect loss (two generations of lost reproduction) over time. Two types of compensation scenarios are evaluated: (1) acquisition of mature habitat; and (2) protection of habitat with easements of varying lengths. A summary of the final results are provided below in Tables 1 through 3. All figures are converted to 2004 values (present value, or PV) using a 3% discount rate. Details on the inputs, assumptions, and method used are provided later in this report.[1] This report also serves as the reference document for other seabird and shorebird analyses. Complete citations are provided in a separate References section.

Table 1
Total Lost Bird-Years (Debit)

Interim Losses	Lost Bird-Years in PV
Direct Injury	**1,717.54**
1st Generation	1,082.75
+ 2nd Generation	470.93
= Total Indirect Injury	**1,553.68**
Total Direct & Indirect Injury:	**3,271.22**

Table 2
Relative Productivity of Restoration Options

Relative Productivity	Bird-Years/Nest		
Option 1–Acquire Mature Habitat	64.43		
Purchase Easements	**25 Years**	**45 Years**	**Perpetuity**
Option 2A–Protect Immature Habitat–115-Years-Old	12.57	17.60	23.53
Option 2B–Protect Immature Habitat–45-Years-Old	1.59	2.22	2.92

[1]All research and data on the Marbled Murrelets were provided by Mike Szumski, Natural Resource Damage Assessment/Spill Response, US Fish & Wildlife Service, US Department of the Interior, 2600 SE 98th Ave., Suite 100, Portland, OR, 97266-1398.

Table 3
Total Acres to Offset Lost Bird-Years (Credit)

Restoration Options	Compensatory Restoration*		
	Acres of Habitat Required Direct Injury	Acres of Habitat Required Indirect Injury	Total Acres of Habitat Required
Option 1: Acquire Mature Habitat	666.41	602.83	1,269.24
Option 2A: Hold Easements 25 Years	3,415.52	3,089.68	6,505.20
Option 2A: Hold Easements 45 Years	2,440.23	2,207.43	4,647.65
Option 2A: Hold Easements in Perpetuity	1,824.95	1,650.85	3,475.79
Option 2B: Hold Easements 25 Years	27,043.49	24,463.54	51,507.04
Option 2B: Hold Easements 45 Years	19,321.28	17,478.03	36,799.30
Option 2B: Hold Easements in Perpetuity	14,713.05	13,309.42	28,022.47

*Totals are rounded by the computer; hand calculations may not sum to those presented.

Introduction

A natural resource damage assessment determines whether a release or discharge has harmed any natural resources. If it did, the assessment determines what actions or funds, if any, are needed to "restore, replace, or acquire" the equivalent of the injured resources. There are two potential types of loss associated with an injury: (1) loss of baseline condition, which is the loss of resources as compared to their baseline condition (i.e., the condition they would be in now if the contamination was not present); and (2) the interim losses, which are the losses over time for which resources are in a depleted condition and less available to the public. Primary restoration projects (including acquisition) are used to bring resources to baseline condition. Compensatory restoration projects are used to offset the interim loss. When no primary restoration is pursued and natural recovery occurs, then the entire claim is for interim loss.

When the majority of damages are from birds like the endangered Marbled Murrelets, their value can be difficult to quantify in economic terms. Exactly how much are they worth to the public? An alternative approach to economic valuation is resource equivalency analysis (REA) (variation based on Unsworth and Bishop 1994; Jones and Pease 1997). An REA responds to the question, "What, but for the release, would have happened to the injured species?" In this case, what services would the 262 murrelets have provided over their expected lifespans (direct injury), including fledging (indirect injury), if they had not been killed by the oil spill? With REA, the replacement services are quantified in physical units of measure such as *bird-years*.[2] The selected projects are scaled so that the quantity of replacement services equals the quantity of lost services in present value terms. In the end, responsible parties pay for (or implement) restoration projects that are sufficient to cover the public's interim losses. Because the services provided by compensatory restoration are qualitatively equivalent to the services lost due to the release, REA can avoid valuation altogether. When responsible parties are interested in providing a payment rather than an in-kind restoration project, the projects may be costed out for a final settlement.

[2] A *bird- year* refers to all services provided by one bird for one year. This measure of services is specific to the type of bird since different birds provide different services. So, e.g., the replacement services for 20 bird-years could be 20 birds for only one year, one bird over 20 years, or anything in between.

The remainder of this report is presented in three sections. The first section provides information on the injuries to Marbled Murrelets and the assumptions used in the REA. The second section provides an overview of the methodology used to calculate the interim losses to the public using REA, including an analysis of direct lost services, indirect lost services, and characterization of the replacement services provided by the emergency restoration. An overview on how to scale projects and the final results is provided in the third section.

Injuries & Assumptions

Date of Injury: February 8, 1999

Direct and Indirect Injury Assumptions: See Table 4 on the next page

Population Information: See Table 5 on the following page

Compensation Assumptions:

Option 1–Acquire Mature Habitat. The acquisition of suitable nesting habitat will be the primary means of restoration. Stands of Douglas-fir begin to provide suitable habitat for Marbled Murrelets to reproduce at around 150 years of age.

- **Start Date of Compensatory Restoration Project(s):** 2005 at the earliest
- **Years to Restoration:** If occupied, mature habitat is acquired, it could begin producing birds immediately.

Option 2A–Protect Immature Habitat–115-Year-Old Stands. If suitable nesting habitat is not available, conservation easements to delay harvest will be secured on tracts of forested land with 115-year-old stands of Douglas-fir.

- **Start Date of Compensatory Restoration Project(s):** 2005 at the earliest
- **Years to Restoration:** The stands need to be protected for 35 years (2040) before they would be likely to produce murrelets. Once the stands mature, three easement scenarios are considered to protect murrelets: (1) hold 25 years (2065), (2) hold 45 years (2085), and (3) hold in perpetuity.

Option 2B–Protect Immature Habitat–45-Year-Old Stands. If suitable nesting habitat is not available, conservation easements to delay harvest will be secured on tracts of forested land with 45-year-old stands of Douglas-fir.

- **Start Date of Compensatory Restoration Project(s):** 2005 at the earliest
- **Years to Restoration:** The stands need to be protected for 105 years (2110) before they would be likely to produce murrelets. Once the stands have matured, three easement scenarios are considered: (1) hold 25 years (2135), (2) hold 45 years (2155), and (3) hold in perpetuity.

Table 4
Injury, Life History & Demographic Parameters

Parameter	REA Value	Reference
Species	Marbled Murrelet	Morgue database
# killed (carcasses in hand)	28	Morgue database
# injured (rehabilitated birds)	0	Rehabilitation records
Estimated direct mortality (includes injured birds)	262	Morgue database; Ford *et al.* 2001
Confidence in mortality estimate	High	Ford *et al.* 2001
Age Distribution	18.7% 0-1 year old 10.4% 1-2 years old 7.9% 2-3 years old 6.9% 3-4 years old 6.4% 4-5 years old 6.0% 5-6 years old 5.6% 6-7 years old 5.2% 7-8 years old 4.8% 8-9 years old 4.5% 9-10 years old 4.2% 10-11 years old 3.9% 11-12 years old 3.6% 12-13 years old 3.3% 13-14 years old 3.1% 14-15 years old 2.9% 15-16 years old 2.6% 16-17 years old	OSPR General Bird REA 2002; Perry *et al.* 2004
Average life span	17 years (max 25 years)	Beissinger & Nur 1997; Cam *et al.* 2003; D. Lank pers. comm 2003.
Age of first breeding	3 years	Nelson 1997; Bradley 2002; Burger 2002
Expected years of breeding	14 years	Average lifespan – age of first breeding
Percentage of adult females that breed	82.5%	Beissinger & Perry 2003; Cam *et al.* 2003; McShane *et al.* 2004
# eggs/nest	1	Burger 2002; Nelson 1997
Nesting success (% of nests that successfully fledge a chick)	40% (32.4% to 46% Zone 3) 0.4 fledglings/pair	K. Nelson pers. comm 2003; McShane *et al.* 2004
Fecundity	0.11 females/adult female 0.042 females/adult female	Perry *et al.* 2004; Beissinger & Nur 1997; Bradley 2002; K. Nelson pers. comm 2003
year 0-1 survival	0.62	Beissinger & Nur 1997; Cam *et al.* 2003
year 1-2 survival	0.72	Beissinger & Nur 1997; Cam *et al.* 2003
year 2-3 survival	0.82	Beissinger & Nur 1997; Cam *et al.* 2003
years 3+ survival	0.82	Cam *et al.* 2003

Source: Mike Szumski, Natural Resource Damage Assessment/Spill Response, US Fish & Wildlife Service, US Department of the Interior, 2600 SE 98th Ave., Suite 100, Portland, OR, 97266-1398, May 4, 2005.

Table 5
Marbled Murrelet Population Information

% of Total Population[3]	Age [4]	Age Distribution of 262 Birds*	Annual Survival Rate[5]
18.7%	0–1	18.7% x 262=48.994	56%
10.4%	1–2	10.4% x 262=27.248, etc.	76%
7.9%	2–3	20.698	87%
6.9%	3–4	18.078	93%
6.40%	4–5	16.768	
6.00%	5–6	15.72	
5.60%	6–7	14.672	
5.20%	7–8	13.624	
4.80%	8–9	12.576	
4.50%	9–10	11.79	
4.20%	10–11	11.004	
3.90%	11–12	10.218	
3.60%	12–13	9.432	
3.30%	13–14	8.646	
3.10%	14-15	8.122	
2.90%	15-16	7.598	
2.60%	16-17	6.812	
100%		262	

*Totals are rounded by the computer; hand calculations may not sum to those presented.

[3]OSPR General Bird REA (2002); Perry *et al.* (2004).

[4]Beissinger and Nur (1997); Cam *et al.* (2003); D. Lank (personal communication 2003)

[5]Beissinger and Nur (1997); Cam *et al.* (2003)

Relative Productivity for Options 1, 2A and 2B: Data from Nelson (2003) collected for the natural resource trustees and from Conroy et al. (2002) indicate that each active nest requires approximately 25 acres of suitable nesting habitat. Only 40% of the nests will successfully fledge a chick (Nelson pers. comm. 2003). Therefore, 25 acres of suitable nesting habitat would be expected to produce 0.40 fledglings per year (i.e., fledge-years, assuming that nesting habitat is utilized every nesting season at the same rate).

Economic Assumptions: Discount Rate – 3%

Figures presented in current value have no discounting; the number presented is the actual number expected to occur in the year it appears. In contrast, present value means that it has been converted to 2004 values such that the number presented reflects its value today. Services provided in the future are discounted at an appropriate rate of discount to reflect the social rate of time preference, the rate at which society is willing to substitute between present and future consumption of natural resources. The real rate of interest and the government borrowing rate are recommended in the economics literature as the best measures of the social rate of time preference. Empirical evidence supports a 3% discount rate (e.g., Freeman 1993; NOAA 1999). Federal rulemakings also support a 3% discount rate for lost natural resource use valuation (61 FR 453; 61 FR 20584). The annual discount factor may be calculated as $(1+r)^{P-t}$, where r is the discount rate, P is the present time period, and t is the time period of lost services. In 2004, for example, the discount factor is 1.0, because any number raised to the zero power equals 1.0 ($1.03^{(2004-2004=0)} = 1.0$).

REA Methods

Calculating Interim Loss: Direct Lost Bird-Years

The first step in REA is to quantitatively identify lost bird-years from the oil spill. In this case, 262 Marbled Murrelets were killed by the oil spill on February 8, 1999. Lost-bird years are calculated in current value on an annual basis at the midpoint of the year as shown in Figure 1 and described in Table 6. Using the age distribution, survival rates, and calculation method described above, Table 7 provides the number of lost birds per year (direct bird-years) by age class in current value. Table 7 also identifies the subset expected to reproduce, starting with age class (3-4). Table 8 provides the present value of the direct injury by multiplying the current value by the discount factor.

Figure 1
First Year After Spill

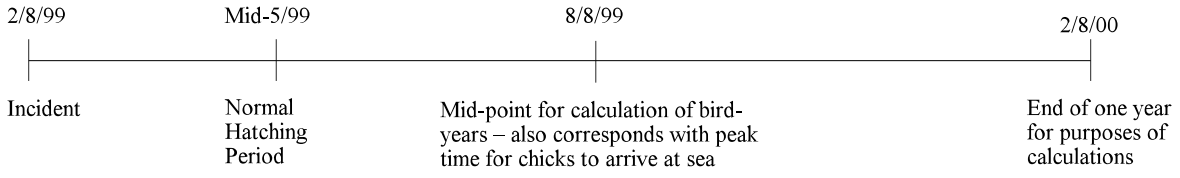


Table 6
Sample Calculations
Direct Lost Bird-Years Age Class (0-1)

2/8/99 (denoted as incident) = 18.7% of Murrelet population is age class (0-1) x 262 killed murrelets = 48.994 birds lost in age class (0-1)

2/8/00 (denoted as 2000) = 76% survival rate from age class (1-2) x 48.994 birds = 37.235 birds in age class (1-2), so the midpoint* of birds "but for" the spill in the 1st year (8/8/99) = 43.115 birds age class (1-2) "but for" the spill

8/8/01 (denoted as 2001) = 87% survival rate x 43.115 birds (mid-year) = 37.510 birds lost in age class (2-3) "but for" the spill

8/8/02 (denoted as 2002) = 93% survival rate x 37.510 birds (mid-year) = 34.884 birds lost in age class (3-4) "but for" the spill, etc.

***The midpoint provides average bird-services for the year instead of overvaluing at the beginning of the year or undervaluing at the end of the year.

Calculating Interim Loss: Indirect Lost Bird-Years

In addition to the direct injury to the Marbled Murrelets, two generations of lost fledglings are considered measurable based on breeding rates using a variation of an approach developed in the North Cape damage assessment case (Sperduto et al.: 1999). As shown in Table 4:

- Statistically, approximately 93% of Marbled Murrelet adults survive for one more year;
- The sex ratio of the population is assumed to be 1:1;
- 82.5% of the female adult population > 3 years old that survives is expected to reproduce;
- The breeding pairs are assumed to have one nesting attempt per year (eggs begin to hatch around mid-May), though Burger (2002) states that there is evidence for re-laying and believes that 1.05 nesting attempts may be more valid);
- 0.40 fledglings are produced per nest with the fledging occurring 27-40 days after hatching (mid-June to early July);
- 56% of the fledglings are expected to survive one year; and
- Each bird that survives one year has a 76% chance of surviving to the end of the second year; each bird that survives the second year has an 87% chance of surviving to the end of the third year; each bird that survives the third year has an 93% chance of survival each year thereafter for a total of 17 years of life.

There are four basic steps for measuring indirect lost bird-years:

Step 1: Identify how many adults would have reproduced "but for" the New Carissa oil spill.
Step 2: Calculate how many of the adults would have actually reproduced.
Step 3: Multiply the number of reproducing females by the average number of fledglings per nest to estimate the total number of first generation lost fledglings.
Step 4: Repeating the previous three steps, calculate each generation of lost fledglings based on the previous generation of lost fledglings.

Table 7
Direct Injury–Numbers of Marbled Murrelets by Age Class
& Outlined Subset Expected to Reproduce

	Age Class																Total Direct	Reproducing
Year	(0-1)	(1-2)	(2-3)	(3-4)	(4-5)	(5-6)	(6-7)	(7-8)	(8-9)	(9-10)	(10-11)	(11-12)	(12-13)	(13-14)	(14-15)	(15-16)	(16-17)	Bird-Years**	Subset
Incident	48.994	27.248	20.698	18.078	16.768	15.720	14.672	13.624	12.576	11.790	11.004	10.218	9.432	8.646	8.122	7.598	6.812	262.000	165.060
2000	0.000	43.115	25.477	19.974	17.445	16.181	15.170	14.158	13.147	12.136	11.377	10.619	9.860	9.102	8.343	7.838	7.332	241.274	172.683
2001	0.000	0.000	37.510	23.693	18.575	16.224	15.048	14.108	13.167	12.227	11.286	10.581	9.876	9.170	8.465	7.759	7.289	214.980	177.470
2002	0.000	0.000	0.000	34.884	22.035	17.275	15.088	13.995	13.120	12.246	11.371	10.496	9.840	9.184	8.528	7.872	7.216	193.152	193.152
2003	0.000	0.000	0.000	0.000	32.442	20.493	16.066	14.032	13.015	12.202	11.388	10.575	9.762	9.151	8.541	7.931	7.321	172.920	172.920
2004	0.000	0.000	0.000	0.000	0.000	30.171	19.058	14.941	13.050	12.104	11.348	10.591	9.835	9.078	8.511	7.943	7.376	154.007	154.007
2005	0.000	0.000	0.000	0.000	0.000	0.000	28.059	17.724	13.895	12.136	11.257	10.553	9.850	9.146	8.443	7.915	7.387	136.367	136.367
2006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	26.095	16.483	12.923	11.287	10.469	9.815	9.160	8.506	7.852	7.361	119.951	119.951
2007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	24.268	15.329	12.018	10.497	9.736	9.128	8.519	7.911	7.302	104.709	104.709
2008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	22.570	14.256	11.177	9.762	9.055	8.489	7.923	7.357	90.588	90.588
2009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	20.990	13.258	10.394	9.079	8.421	7.895	7.368	77.405	77.405
2010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	19.521	12.330	9.667	8.443	7.831	7.342	65.134	65.134
2011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	18.154	11.467	8.990	7.852	7.283	53.747	53.747
2012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	16.883	10.665	8.361	7.303	43.211	43.211
2013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.701	9.918	7.776	33.395	33.395
2014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	14.602	9.224	23.826	23.826
2015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	13.580	13.580	13.580

*This table shows the estimated number of birds that should have progressed through the age classes described in Table 5 "but for" the spill. For example, an estimated 48.994 Marbled Murrelets in age class (0-1) were killed by the oil spill. In 2000, 43.115 of the 48.994 statistically should have been alive in age class (1-2); 37.510 of the 48.994 murrelets should have been alive in 2001 in age class (2-3); in 2002, 34.884 of the 8.646 should have been alive in age class (3-4), etc. **Totals are rounded by the computer; hand calculations may not sum to those presented.

Table 8
Direct Injury–Numbers of Marbled Murrelets in Present Value

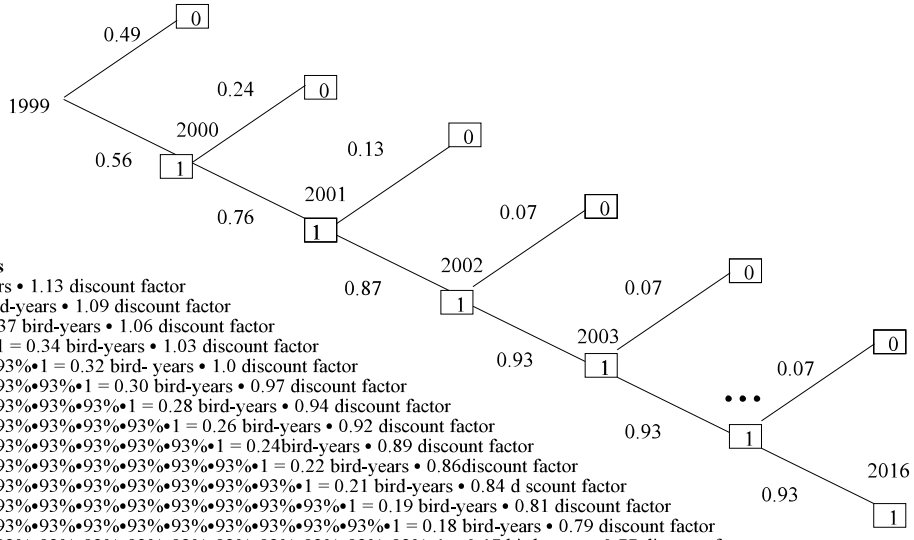
Year	Time Period	Discount Factor		Total Bird-Years*		Total Bird-Years in Present Value**
2000	-4	1.13		241.274		271.557
2001	-3	1.09		214.980		234.914
2002	-2	1.06		193.152		204.915
2003	-1	1.03		172.920		178.108
2004	0	1.00		154.007		154.007
2005	1	0.97		136.367		132.395
2006	2	0.94		119.951		113.065
2007	3	0.92		104.709		95.823
2008	4	0.89	x	90.588	=	80.486
2009	5	0.86		77.405		66.770
2010	6	0.84		65.134		54.549
2011	7	0.81		53.747		43.701
2012	8	0.79		43.211		34.111
2013	9	0.77		33.395		25.595
2014	10	0.74		23.826		17.729
2015	11	0.72		13.580		9.811
				1,738.248		**1,717.537**

*Total direct bird-years from Table 7. As shown in Figure 1, the start year of 2000 is actually the mid-point of lost bird-years from the incident in 1999 to 2000.

**When compounding from the past to the present value, numbers get larger because of the larger discount factor; when discounting from the future to the present value, numbers get smaller. The totals are rounded by the computer; hand calculations may not sum to those presented.

Figure 2 shows the expected value of each lost fledgling in terms of lost bird-years, adjusted to present value. Table 9 reflects the information shown in Table 7 and Figure 2. As already noted, reproduction starts at age class (3-4). Based on the number of lost reproducing birds by age class identified in Table 7, Table 9 first shows the total number of adults expected to reproduce by age class and year. The total adults of reproducing age are then divided in half to represent the reproducing pairs, and are then multiplied by the estimated female reproduction rate of 82.5%. The expected number of fledglings is estimated by multiplying the number of reproducing females by the expected 0.4 fledglings per nest. The estimated number of fledglings is then multiplied by the bird-years per fledgling in present value for 1999 to 2000 (i.e., 4.267), which is calculated by multiplying the bird-years by the relevant discount factor and summing, as shown in Figure 2. For each subsequent year shown, the total estimated bird-years are discounted by an additional 3% (i.e., 4.267 x 0.97 = 4.139, 4.139 x 0.97=4.015). The final results are lost indirect bird-years for the first generation of Marbled Murrelets that should have provided services "but for" the New Carissa oil spill.

Figure 2
Expected Value of Having One Marbled Murrelet Survive Through its 17-Year Lifespan (Would Have Fledged in 1999 and Died in 2016)



Expected Value in Bird-Years
2000: 56%•1 = 0.56 bird-years • 1.13 discount factor
+ 2001: 56%•76%•1 = 0.43 bird-years • 1.09 discount factor
+ 2002: 56%•76%•87%•1 = 0.37 bird-years • 1.06 discount factor
+ 2003: 56%•76%•87%•93%•1 = 0.34 bird-years • 1.03 discount factor
+ 2004: 56%•76%•87%•93%•93%•1 = 0.32 bird- years • 1.0 discount factor
+ 2005: 56%•76%•87%•93%•93%•93%•1 = 0.30 bird-years • 0.97 discount factor
+ 2006: 56%•76%•87%•93%•93%•93%•93%•1 = 0.28 bird-years • 0.94 discount factor
+ 2007: 56%•76%•87%•93%•93%•93%•93%•93%•1 = 0.26 bird-years • 0.92 discount factor
+ 2008: 56%•76%•87%•93%•93%•93%•93%•93%•93%•1 = 0.24bird-years • 0.89 discount factor
+ 2009: 56%•76%•87%•93%•93%•93%•93%•93%•93%•93%•1 = 0.22 bird-years • 0.86discount factor
+ 2010: 56%•76%•87%•93%•93%•93%•93%•93%•93%•93%•93%•1 = 0.21 bird-years • 0.84 d scount factor
+ 2011: 56%•76%•87%•93%•93%•93%•93%•93%•93%•93%•93%•93%•1 = 0.19 bird-years • 0.81 discount factor
+ 2012: 56%•76%•87%•93%•93%•93%•93%•93%•93%•93%•93%•93%•93%•1 = 0.18 bird-years • 0.79 discount factor
+ 2013: 56%•76%•87%•93%•93%•93%•93%•93%•93%•93%•93%•93%•93%•93%•1 = 0.17 bird-years • 0.77 discount factor
+ 2014: 56%•76%•87%•93%•93%•93%•93%•93%•93%•93%•93%•93%•93%•93%•93%•1 = 0.16 b rd-years • 0.74 discount factor
+ 2015: 56%•76%•87%•93%•93%•93%•93%•93%•93%•93%•93%•93%•93%•93% •93%•1= 0.14 bird-years • 0.72 discount factor
+ 2016: 56%•76%•87%•93%•93%•93%•93%•93%•93%•93%•93%•93%•93%•93% •93%•93%•1= 0.13 bird-years • 0.70 discount factor

= **4.494 Total Bird-Years in Current Value ; 4.267 Total Bird-Years in Present Value**

Table 9
Indirect Injury–1st Generation

Year	Total # Birds–Reproduction Age*		# Reproducing Females		# 1st Generation Fledglings		Bird-Years/ Fledgling in PV		Lost 1st Gen Indirect Bird-Years in PV***
Incident	165.060		68.087		27.235		4.267**		116.211
2000	172.683		71.232		28.493		4.139		117.931
2001	177.470		73.206		29.283		4.015		117.564
2002	193.152		79.675		31.870		3.894		124.114
2003	172.920		71.330		28.532		3.778		107.780
2004	154.007		63.528		25.411		3.664		93.112
2005	136.367		56.251		22.501		3.554		79.973
2006	119.951		49.480		19.792		3.448		68.236
2007	104.709	÷2 x	43.192		17.277		3.344		57.778
2008	90.588	0.825=	37.368	x0.40=	14.947	x	3.244	=	48.487
2009	77.405		31.930		12.772		3.147		40.188
2010	65.134		26.868		10.747		3.052		32.802
2011	53.747		22.171		8.868		2.961		26.255
2012	43.211		17.825		7.130		2.872		20.476
2013	33.395		13.775		5.510		2.786		15.349
2014	23.826		9.828		3.931		2.702		10.623
2015	13.580		5.602		2.241		2.621		5.873
Total	1,797.206								**1,082.752**

*Subset total of reproducing birds, as identified in Table 7.

**From Figure 2.

***The totals are rounded by the computer; hand calculations may not sum to those presented.

Table 10
Number of 1st Generation Marbled Murrelets & Subset Expected to Reproduce a 2nd Generation

1st Generation by Age Class--Subset Available to Reproduce a 2nd Generation																	
Year	**(0-1)**	**(1-2)**	**(2-3)**	**(3-4)**	**(4-5)**	**(5-6)**	**(6-7)**	**(7-8)**	**(8-9)**	**(9-10)**	**(10-11)**	**(11-12)**	**(12-13)**	**(13-14)**	**(14-15)**	**(15-16)**	**(16-17)**	**Subset Total**
1999	27.235	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	28.493	15.252	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	29.283	15.956	11.591	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	31.870	16.398	12.126	10.084	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	10.084
2003	28.532	17.847	12.463	10.550	9.378	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	19.928
2004	25.411	15.978	13.564	10.842	9.812	8.722	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	29.376
2005	22.501	14.230	12.143	11.801	10.084	9.125	8.111	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	39.120
2006	19.792	12.600	10.815	10.565	10.975	9.378	8.486	7.544	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	46.946
2007	17.277	11.083	9.576	9.409	9.825	10.206	8.721	7.892	7.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	53.069
2008	14.947	9.675	8.423	8.331	8.750	9.137	9.492	8.111	7.340	6.524	0.000	0.000	0.000	0.000	0.000	0.000	0.000	57.686
2009	12.772	8.370	7.353	7.328	7.748	8.138	8.498	8.827	7.543	6.826	6.068	0.000	0.000	0.000	0.000	0.000	0.000	60.976
2010	10.747	7.152	6.361	6.397	6.815	7.206	7.568	7.903	8.210	7.015	6.348	5.643	0.000	0.000	0.000	0.000	0.000	63.105
2011	8.868	6.018	5.436	5.534	5.949	6.338	6.701	7.038	7.350	7.635	6.524	5.904	5.248	0.000	0.000	0.000	0.000	64.222
2012	7.130	4.966	4.574	4.729	5.147	5.533	5.895	6.232	6.546	6.835	7.100	6.067	5.490	4.881	0.000	0.000	0.000	64.456
2013	5.510	3.993	3.774	3.979	4.398	4.787	5.146	5.482	5.796	6.088	6.357	6.603	5.643	5.106	4.539	0.000	0.000	63.923
2014	3.931	3.086	3.034	3.284	3.701	4.090	4.452	4.785	5.098	5.390	5.661	5.912	6.141	5.248	4.749	4.221	0.000	62.732
2015	2.241	2.202	2.345	2.640	3.054	3.442	3.804	4.140	4.450	4.741	5.013	5.265	5.498	5.711	4.880	4.416	3.926	60.981
2016	0.000	1.255	1.673	2.040	2.455	2.840	3.201	3.538	3.850	4.139	4.410	4.662	4.897	5.113	5.311	4.539	4.107	55.101
2017	0.000	0.000	0.954	1.456	1.897	2.283	2.641	2.977	3.290	3.581	3.849	4.101	4.336	4.554	4.755	4.940	4.221	48.880
2018	0.000	0.000	0.000	0.830	1.354	1.765	2.123	2.456	2.768	3.060	3.330	3.580	3.814	4.032	4.235	4.422	4.594	42.363
2019	0.000	0.000	0.000	0.000	0.772	1.259	1.641	1.975	2.284	2.575	2.845	3.097	3.329	3.547	3.750	3.939	4.113	35.125
2020	0.000	0.000	0.000	0.000	0.000	0.718	1.171	1.526	1.837	2.124	2.394	2.646	2.880	3.096	3.299	3.487	3.663	28.842
2021	0.000	0.000	0.000	0.000	0.000	0.000	0.667	1.089	1.419	1.708	1.976	2.227	2.461	2.679	2.879	3.068	3.243	23.416
2022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.621	1.013	1.320	1.588	1.837	2.071	2.289	2.491	2.678	2.853	18.761
2023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.577	0.942	1.228	1.477	1.709	1.926	2.129	2.317	2.490	14.794
2024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.537	0.876	1.142	1.374	1.589	1.791	1.980	2.155	11.443
2025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.499	0.815	1.062	1.278	1.478	1.666	1.841	8.638
2026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.464	0.758	0.987	1.188	1.375	1.549	6.321
2027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.432	0.705	0.918	1.105	1.278	4.438
2028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.402	0.655	0.854	1.028	2.939
2029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.373	0.609	0.794	1.777
2030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.347	0.567	0.914
2031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.323	0.323
Total:																		**1,000.681**

Table 11
Indirect Injury–2nd Generation

Year	Total # Birds–Reproduction Age*		# Reproducing Females		# 2nd Generation Fledglings		Bird-Years/ Fledgling in PV		Lost 2nd Gen Indirect Bird-Years in PV***
Incident	0.000		0.000		0.000		0.000		0.000
2000	0.000		0.000		0.000		0.000		0.000
2001	0.000		0.000		0.000		0.000		0.000
2002	10.084		4.160		1.664		3.894**		6.480
2003	19.928		8.220		3.288		3.778		12.421
2004	29.376		12.118		4.847		3.664		17.761
2005	39.120		16.137		6.455		3.554		22.942
2006	46.946		19.365		7.746		3.448		26.706
2007	53.069		21.891		8.756		3.344		29.283
2008	57.686		23.795		9.518		3.244		30.876
2009	60.976		25.153		10.061		3.147		31.658
2010	63.105		26.031		10.412		3.052		31.780
2011	64.222		26.492		10.597		2.961		31.373
2012	64.456		26.588		10.635		2.872		30.542
2013	63.923		26.368		10.547		2.786		29.381
2014	62.732		25.877		10.351		2.702		27.969
2015	60.981	÷2 x	25.155		10.062		2.621		26.372
2016	55.101	0.825=	22.729	x0.40=	9.092	x	2.542	=	23.115
2017	48.880		20.163		8.065		2.466		19.890
2018	42.363		17.475		6.990		2.392		16.721
2019	35.125		14.489		5.796		2.320		13.448
2020	28.842		11.897		4.759		2.251		10.711
2021	23.416		9.659		3.864		2.183		8.435
2022	18.761		7.739		3.096		2.118		6.556
2023	14.794		6.103		2.441		2.054		5.014
2024	11.443		4.720		1.888		1.993		3.762
2025	8.638		3.563		1.425		1.933		2.755
2026	6.321		2.607		1.043		1.875		1.955
2027	4.438		1.831		0.732		1.819		1.332
2028	2.939		1.212		0.485		1.764		0.855
2029	1.777		0.733		0.293		1.711		0.502
2030	0.914		0.377		0.151		1.660		0.250
2031	0.323		0.133		0.053		1.610		0.086
Total	1,000.681								**470.932**

*Subset total from Table 10.

**From the Bird-Years/Fledgling in PV column (starting in 2002) in Table 9.

***Totals are rounded by the computer; hand calculations may not sum to those presented.

Total Lost Bird-Years

Direct and indirect interim losses are additive for a total debit of approximately **3,271.22 bird-years**, as shown in Table 12.

Table 12
Total Lost Bird-Years (Debit)

	1,717.537	direct loss (see Table 8)
+	1,082.752	indirect loss – 1st generation (see Table 9)
+	470.932	indirect loss – 2nd generation (see Table 11)
=	**3,271.22**	total lost bird-years in present value*

*Totals are rounded by the computer; hand calculations may not sum to those presented.

Calculating the Relative Productivity of Compensatory Restoration

The second step in REA is to quantitatively characterize the replacement services provided by compensatory restoration. At each point in time, replacement services are described as a proportional equivalent of baseline called *relative productivity*. Relative productivity describes the net services provided by a compensatory restoration option relative to the baseline productivity of the injured habitat or species. In this analysis, three compensatory restoration options are considered:

(1) Suitable nesting habitat is acquired (stands with 150+ year-old Douglas-fir);
(2A) If suitable nesting habitat is not available, conservation easements to delay harvest will be secured on tracts of forested land with 115-year-old stands of Douglas-fir.
(2B) If suitable nesting habitat is not available, conservation easements to delay harvest will be secured on tracts of forested land with 45-year-old stands of Douglas-fir.

For options 2A and 2B, three easement scenarios are considered: (1) hold 25 years, (2) hold 45 years, and (3) hold in perpetuity.

As discussed earlier, one nest on 25 acres of mature habitat is assumed to produce 0.40 Marbled Murrelets per year. How many acres need to be acquired or protected to return 100% of lost bird-years?

Option 1–Acquire Mature Habitat. If occupied stands of 150+ year old Douglas-fir are acquired, the habitat could begin producing birds immediately. A project that starts in 2005 can start producing bird-years by 2006. Using the same population data as described above, one nest used in the 2005/2006 reproduction season can produce a total of 1.991 present value bird-years over their lifespan, as explained in Tables 13 and 14. The acquired forest would provide habitat for Marbled Murrelets in perpetuity, so the total per nest restored on 25 acres would be **64.4** bird-years.[6]

[6] Perpetuity calculation: $1 \div [1.03^{(2005-2004)} * 0.03] * 1.991$ bird-years = 64.433 bird-years

Table 13
Sample Calculations for Relative Productivity of Option 1

2006:	0.4 birds-years/nest + (0.4 bird-years/nest*56% survival rate to year 1) ÷ 2 (midpoint of 2005/2006) = 0.312 bird-years * 0.94 discount factor = 0.294 bird-years
2007:	0.312 bird-years from 2006 * 76% survival rate to year 2 = 0.237 * 0.92 = 0.217 bird-years
2008:	0.237 bird-years from 2007 * 87% survival rate to year 3 = 0.206 * 0.89 = 0.183 bird-years
2009:	0.206 bird-years from 2008 * 93% adult survival rate = 0.192 * 0.86 = 0.165 bird-years, etc.

Table 14
Option 1: Relative Productivity of Restoring One Nest in 2005/2006
(Bird-Years Per Nest)

Year	Discount Factor		Bird-Years/Nest		Discounted Bird-Years/Nest**
2006	0.94		0.312*		0.294
2007	0.92		0.237		0.217
2008	0.89		0.206		0.183
2009	0.86		0.192		0.165
2010	0.84		0.178		0.149
2011	0.81		0.166		0.135
2012	0.79		0.154		0.122
2013	0.77		0.144		0.110
2014	0.74	x	0.133	=	0.099
2015	0.72		0.124		0.090
2016	0.70		0.115		0.081
2017	0.68		0.107		0.073
2018	0.66		0.100		0.066
2019	0.64		0.093		0.060
2020	0.62		0.086		0.054
2021	0.61		0.080		0.049
2022	0.59		0.075		0.044
			Total Restored Services:		**1.991**

*Results from Table 11.

**Totals are rounded by the computer; hand calculations may not sum to those presented.

Option 2A–Protect Immature Habitat–115-Year-Old Stands. If suitable nesting habitat is not available, conservation easements to delay harvest will be secured on tracts of forested land with 115-year-old stands of Douglas-fir. The stands need to be protected for 35 years before they would be likely to produce murrelets. A project that starts in 2005 would require protection until 2040, and start producing bird-years in 2041. As shown in Table 15, one nest can produce a total of **0.71** present value bird-years for the 2040/2041 nesting season over the lifespan of the birds using the same population data described above. The stands continue to produce bird-years per nest each year, which need to be discounted to present value and aggregated. The relative productivity of the three easement scenarios are:

(1) Hold 25 years–12.572 bird-years per nest (see Table 16);
(2) Hold 45 years–17.596 bird-years per nest (see Table 17); and
(3) Hold in perpetuity–23.529 bird-years per nest.[7]

Table 15
Option 2A: Relative Productivity of Restoring One Nest in 2040/2041
(Bird-Years Per Nest)

Year	Discount Factor		Bird-Years/Nest		Discounted Bird-Years/Nest**
2041	0.33		0.312*		0.105
2042	0.33		0.237		0.077
2043	0.32		0.206		0.065
2044	0.31		0.192		0.059
2045	0.30		0.178		0.053
2046	0.29		0.166		0.048
2047	0.28		0.154		0.043
2048	0.27		0.144		0.039
2049	0.26	x	0.133	=	0.035
2050	0.26		0.124		0.032
2051	0.25		0.115		0.029
2052	0.24		0.107		0.026
2053	0.23		0.100		0.023
2054	0.23		0.093		0.021
2055	0.22		0.086		0.019
2056	0.22		0.080		0.017
2057	0.21		0.075		0.016
			Total Restored Services:		**0.708**

*Results from Table 11 x 0.33 discount factor = 0.105
**Totals are rounded by the computer; hand calculations may not sum to those presented.

[7]Because the restoration takes place so far into the future, the restored bird-years are measured in fractions. When these fractions enter standard perpetuity formulas, the results are incorrect (multiplying by a fraction results in a smaller number). Using a base year of 2004, the maximum discount factor for a 3% discount rate is 33.3 (1/0.03). When the discounting is conducted by hand rather than formula, year-after-year, rounding errors are minimized when the 33.3 maximum is achieved by year 2238. As such, the analysis for estimating the restored bird-years for easements held in perpetuity is estimated by applying standard discounting methods through 2238.

Table 16
Relative Productivity of Option 2A: 25-Year Easement
(Bird-Years Per Nest)

Year	Time Period	Indirect Lost Bird-Years*
2041	37	0.708
2042	38	0.686
2043	39	0.666
2044	40	0.646
2045	41	0.626
2046	42	0.608
2047	43	0.589
2048	44	0.572
2049	45	0.555
2050	46	0.538
2051	47	0.522
2052	48	0.506
2053	49	0.491
2054	50	0.476
2055	51	0.462
2056	52	0.448
2057	53	0.435
2058	54	0.422
2059	55	0.409
2060	56	0.397
2061	57	0.385
2062	58	0.373
2063	59	0.362
2064	60	0.351
2065	61	0.341
Total		**12.572**

* From Table 15, 0.708 declines 3% annually to reflect the declining present value of bird-years over the time of the easement. Totals are rounded by the computer; hand calculations may not sum to those presented.

Table 17
Relative Productivity of Option 2A: 45-Year Easement
(Bird-Years Per Nest)

Year	Time Period	Indirect Lost Bird-Years*
2041	37	0.708
2042	38	0.686
2043	39	0.666
2044	40	0.646
2045	41	0.626
2046	42	0.608
2047	43	0.589
2048	44	0.572
2049	45	0.555
2050	46	0.538
2051	47	0.522
2052	48	0.506
2053	49	0.491
2054	50	0.476
2055	51	0.462
2056	52	0.448
2057	53	0.435
2058	54	0.422
2059	55	0.409
2060	56	0.397
2061	57	0.385
2062	58	0.373
2063	59	0.362
2064	60	0.351
2065	61	0.341
2066	62	0.330
2067	63	0.320
2068	64	0.311
2069	65	0.302
2070	66	0.293
2071	67	0.284
2072	68	0.275
2073	69	0.267
2074	70	0.259
2075	71	0.251
2076	72	0.244
2077	73	0.236
2078	74	0.229
2079	75	0.222
2080	76	0.216
2081	77	0.209
2082	78	0.203
2083	79	0.197
2084	80	0.191
2085	81	0.185
Total		**17.596**

* From Table 15, 0.708 declines 3% annually to reflect the declining present value of bird-years over the time of the easement. Totals are rounded by the computer; hand calculations may not sum to those presented.

Option 2B–Protect Immature Habitat– 45-Year-Old Stands. If suitable nesting habitat is not

available, conservation easements to delay harvest will be secured on tracts of forested land with 45-year-old stands of Douglas-fir. The stands need to be protected for 105 years before they would be likely to produce murrelets. A project that starts in 2005 would require protection until 2110, and start producing bird-years in 2111. As shown in Table 18, one nest can produce a total of **0.089** present value bird-years for the 2110/2111 nesting season over the lifespan of the birds using the same population data described above. The stands continue to produce bird-years per nest each year, which need to be discounted to present value and aggregated. The relative productivity of the three easement scenarios are:

(1) Hold 25 years–1.588 bird-years per nest (see Table 19);
(2) Hold 45 years–2.222 bird-years per nest (see Table 20); and
(3) Hold in perpetuity–2.918 bird-years per nest (see footnote 7).

Table 18
Option 2B: Relative Productivity of Restoring One Nest in 2110/2111
(Bird-Years Per Nest)

Year	Discount Factor		Bird-Years/Nest		Discounted Bird-Years/Nest**
2111	0.04		0.312*		0.013
2112	0.04		0.237		0.010
2113	0.04		0.206		0.008
2114	0.04		0.192		0.007
2115	0.04		0.178		0.007
2116	0.04		0.166		0.006
2117	0.04		0.154		0.005
2118	0.03		0.144		0.005
2119	0.03	x	0.133	=	0.004
2120	0.03		0.124		0.004
2121	0.03		0.115		0.004
2122	0.03		0.107		0.003
2123	0.03		0.100		0.003
2124	0.03		0.093		0.003
2125	0.03		0.086		0.002
2126	0.03		0.080		0.002
2127	0.03		0.075		0.002
			Total Restored Services:		**0.089**

*Results from Table 11 x 0.04 discount factor = 0.013

**Totals are rounded by the computer; hand calculations may not sum to those presented.

Table 19
Relative Productivity of Option 2B: 25-Year Easement
(Bird-Years Per Nest)

Year	Time Period	Indirect Lost Bird-Years*
2111	107	0.089
2112	108	0.087
2113	109	0.084
2114	110	0.082
2115	111	0.079
2116	112	0.077
2117	113	0.074
2118	114	0.072
2119	115	0.070
2120	116	0.068
2121	117	0.066
2122	118	0.064
2123	119	0.062
2124	120	0.060
2125	121	0.058
2126	122	0.057
2127	123	0.055
2128	124	0.053
2129	125	0.052
2130	126	0.050
2131	127	0.049
2132	128	0.047
2133	129	0.046
2134	130	0.044
2135	131	0.043
Total		**1.588**

* From Table 18, 0.089 declines 3% annually to reflect the declining present value of bird-years over the time of the easement. Totals are rounded by the computer; hand calculations may not sum to those presented.

Table 20
Relative Productivity of Option 2B: 45-Year Easement
(Bird-Years Per Nest)

Year	Time Period	Indirect Lost Bird-Years*
2111	107	0.089
2112	108	0.087
2113	109	0.084
2114	110	0.082
2115	111	0.079
2116	112	0.077
2117	113	0.074
2118	114	0.072
2119	115	0.070
2120	116	0.068
2121	117	0.066
2122	118	0.064
2123	119	0.062
2124	120	0.060
2125	121	0.058
2126	122	0.057
2127	123	0.055
2128	124	0.053
2129	125	0.052
2130	126	0.050
2131	127	0.049
2132	128	0.047
2133	129	0.046
2134	130	0.044
2135	131	0.043
2136	132	0.042
2137	133	0.040
2138	134	0.039
2139	135	0.038
2140	136	0.037
2141	137	0.036
2142	138	0.035
2143	139	0.034
2144	140	0.033
2145	141	0.032
2146	142	0.031
2147	143	0.030
2148	144	0.029
2149	145	0.028
2150	146	0.027
2151	147	0.026
2152	148	0.026
2153	149	0.025
2154	150	0.024
2155	151	0.023
Total		**2.222**

* From Table 18, 0.089 declines 3% annually to reflect the declining present value of bird-years over the time of the easement. Totals are rounded by the computer; hand calculations may not sum to those presented.

Scaling & Results

The third step in REA is to identify the project scale that will equate the total discounted quantity of replacement services to the total discounted quantity of lost services. The result is a credit just equal to the debit to compensate the public for the Marbled Murrelet injury from the New Carissa oil spill.
The project scale for this analysis is calculated by dividing the total discounted value of direct lost services in bird-years (1,717.54 bird-years) by the total discounted value of relative productivity for each compensatory restoration. This calculation ensures that the selected compensatory restoration project will provide a *credit* just equal to the *debit* for direct injury. The same process is completed for the indirect injuries to the 1st and 2nd generations. These final results are shown in Tables 21 through 23.

Table 21
Final Results for Option 1*

Option 1

Direct Injury	1,717.54	bird-years			
÷Relative Productivity	64.43	bird-years/nest			
= Credit	26.66	nests	x 25 acres/nest =	666.41	acres
Indirect Injury--1st Gen	1,082.75	bird-years			
÷Relative Productivity	64.43	bird-years/nest			
= Credit	16.80	nests	x 25 acres/nest =	420.11	acres
Indirect Injury--2nd Gen	470.93	bird-years			
÷Relative Productivity	64.43	bird-years/nest			
= Credit	7.31	nests	x 25 acres/nest =	182.72	acres
Total credit:	**50.77**	**total nests**	x 25 acres/nest =	**1,269.24**	**total acres**

*Totals are rounded by the computer; hand calculations may not sum to those presented.

Table 22
Final Results for Option 2A

Option 2A--Hold Easements 25 Years

Direct Injury	1,717.54	bird-years			
÷Relative Productivity	12.57	bird-years/nest			
= Credit	136.62	nests	x 25 acres/nest =	3,415.52	acres
Indirect Injury--1st Gen	1,082.75	bird-years			
÷Relative Productivity	12.57	bird-years/nest			
= Credit	86.13	nests	x 25 acres/nest =	2,153.18	acres
Indirect Injury--2nd Gen	470.93	bird-years			
÷Relative Productivity	12.57	bird-years/nest			
= Credit	37.46	nests	x 25 acres/nest =	936.50	acres
Total credit:	**260.21**	**total nests**	x 25 acres/nest =	**6,505.20**	**total acres**

Option 2A--Hold Easements 45 Years

Direct Injury	1,717.54	bird-years			
÷Relative Productivity	17.60	bird-years/nest			
= Credit	97.61	nests	x 25 acres/nest =	2,440.23	acres
Indirect Injury--1st Gen	1,082.75	bird-years			
÷Relative Productivity	17.60	bird-years/nest			
= Credit	61.53	nests	x 25 acres/nest =	1,538.34	acres
Indirect Injury--2nd Gen	470.93	bird-years			
÷Relative Productivity	17.60	bird-years/nest			
= Credit	26.76	nests	x 25 acres/nest =	669.09	acres
Total credit:	**185.91**	**total nests**	x 25 acres/nest =	**4,647.65**	**total acres**

Option 2A--Hold Easements in Perpetuity

Direct Injury	1,717.54	bird-years			
÷Relative Productivity	23.53	bird-years/nest			
= Credit	73.00	nests	x 25 acres/nest =	1,824.95	acres
Indirect Injury--1st Gen	1,082.75	bird-years			
÷Relative Productivity	23.53	bird-years/nest			
= Credit	46.02	nests	x 25 acres/nest =	1,150.46	acres
Indirect Injury--2nd Gen	470.93	bird-years			
÷Relative Productivity	23.53	bird-years/nest			
= Credit	20.02	nests	x 25 acres/nest =	500.38	acres
Total credit:	**139.03**	**total nests**	x 25 acres/nest =	**3,475.79**	**total acres**

*Totals are rounded by the computer; hand calculations may not sum to those presented.

Table 23
Final Results for Option 2B

Option 2B--Hold Easements 25 Years

Direct Injury	1,717.54	bird-years			
÷Relative Productivity	1.59	bird-years/nest			
= Credit	1,081.74	nests	x 25 acres/nest =	27,043.49	acres
Indirect Injury--1st Gen	1,082.75	bird-years			
÷Relative Productivity	1.59	bird-years/nest			
= Credit	681.94	nests	x 25 acres/nest =	17,048.49	acres
Indirect Injury--2nd Gen	470.93	bird-years			
÷Relative Productivity	1.59	bird-years/nest			
= Credit	296.60	nests	x 25 acres/nest =	7,415.06	acres
Total credit:	**2,060.28**	**total nests**	x 25 acres/nest =	**51,507.04**	**total acres**

Option 2B--Hold Easements 45 Years

Direct Injury	1,717.54	bird-years			
÷Relative Productivity	2.22	bird-years/nest			
= Credit	772.85	nests	x 25 acres/nest =	19,321.28	acres
Indirect Injury--1st Gen	1,082.75	bird-years			
÷Relative Productivity	2.22	bird-years/nest			
= Credit	487.21	nests	x 25 acres/nest =	12,180.32	acres
Indirect Injury--2nd Gen	470.93	bird-years			
÷Relative Productivity	2.22	bird-years/nest			
= Credit	211.91	nests	x 25 acres/nest =	5,297.70	acres
Total credit:	**1,471.97**	**total nests**	x 25 acres/nest =	**36,799.30**	**total acres**

Option 2B--Hold Easements in Perpetuity

Direct Injury	1,717.54	bird-years			
÷Relative Productivity	2.92	bird-years/nest			
= Credit	588.52	nests	x 25 acres/nest =	14,713.05	acres
Indirect Injury--1st Gen	1,082.75	bird-years			
÷Relative Productivity	2.92	bird-years/nest			
= Credit	371.01	nests	x 25 acres/nest =	9,275.25	acres
Indirect Injury--2nd Gen	470.93	bird-years			
÷Relative Productivity	2.92	bird-years/nest			
= Credit	161.37	nests	x 25 acres/nest =	4,034.17	acres
Total credit:	**1,120.90**	**total nests**	x 25 acres/nest =	**28,022.47**	**total acres**

*Totals are rounded by the computer; hand calculations may not sum to those presented.