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An Economic Analysis of a Simple Structural Method to Reduce Road-Kills of Royal Terns at Bridges

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Royal terns (S*terna maxima*) in Florida are listed as a "species of special concern" by the Florida Committee on Rare and Endangered Plants and Animals (Egensteiner et al., 1996). These birds live along the Atlantic and Gulf coasts of Florida throughout the year (Egensteiner et al., 1996); their winter range along the Atlantic Coast of the United States is from North Carolina south through Florida (Clapp et al., 1983), with the Florida population augmented by terns migrating from breeding colonies farther north.

Collisions with vehicles cause many marine bird road-kills at some coastal roads and bridges in Florida (Skoog, 1982; Smith et al., 1994; Bard et al., 2002b). General methods to reduce wildlife resource road-kills have included reduced speed limits, physical barriers, and public education (Bertwistle, 1999; Brown et al., 1999; Evink, 1999). We examine herein the benefit-costs from a multi-year trial of a simple hazard reduction method applied to a bridge in east-central Florida.

Sebastian Inlet State Park is approximately 324.5 ha and is located in Melbourne Beach, Florida, at the juncture of Brevard and Indian River counties. The park is divided north to south by approximately 5.0 km of State Road A-1-A including a 13.1-m high, two-lane bridge over the inlet. A daily road-kill survey was started in 1989 consisting of slowly searching the road and bridge surfaces for dead wildlife (Smith et al., 1994; Bard et al., 2002a). During 1994,122, 3-m long, 5.1-cm diameter metal poles were fastened vertically 3.7-m apart from each other on both sides of the bridge at a cost of $5,900 (Bard et al., 2002a). The purpose of the poles was to reduce the number of collisions between vehicles and marine birds by influencing them to fly well over bridge traffic (Bard et al., 2002a).

The road-kill data used in the benefit-cost analysis came from years when the bridge had no poles or the full complement of poles. Ninety-seven terns were road-killed from 1989 to 1993, before the installation of the bridge poles, and 26 were killed from 1995 to 1999, after the installation of the poles (Bard et al., 2002a). The years 1994 and 2000 were not included in our analysis because the poles were installed during 1994 and because they were damaged by hurricanes in 2000.

Determination of monetary values for rare species is not straight-forward or precise. For example, the values of endangered or threatened species were deemed "incalculable" in a U.S. Supreme Court case law (Tennessee Valley Authority vs. Hill, 1978). Still, conservative monetary values for rare species can be estimated through means such as the minimal statutory financial penalties assessed as mitigation for illegal kills (Bodenchuk et al., 2002; Engeman et al., 2002, in press). Minimum monetary values (penalties) in Florida are clearly specified by statutes and administrative codes (Florida Statutes 370.021(5)d-f; Florida Administrative Code 39-27.002 and 39-27.011). Various federal laws (e.g., Migratory Bird Treaty Act) also apply that usually impose larger values. State and federal values are normally applied simultaneously.

At the time of the bridge pole installations in 1994, and to date, the Wildlife Code of the State of Florida (Chapter 39, F.A.C.) specifies up to a $500 fine for "take" applicable to all wildlife in section 39-4.001 F.A.C. Likewise, the U.S. Migratory Bird Treaty Act (16 U.S.C. 703-711) specifies up to a $2,000 fine for "take" of any migratory bird. Our benefit-costs analysis used these values.

The benefit-cost analysis (BCA) of structural modification involves estimating the monetary value of the benefits, measured in terns saved by reduced road-kills at bridge sites, versus the costs of making structural (i.e., erecting poles) modifications. The BCA follows the framework outlined in Loomis and Walsh (1997), Boardman et al. (1996), Nas (1996), Zerbe and Dively (1994) and Loomis (1993). Avoided loss of a tern is considered a benefit; hence, if structural modification prevents the loss of one tern, the benefit of that management effort is the dollar value of the tern saved divided by the cost of the effort. Net annual benefits were calculated using the equation:

$$\text{Net Annual Benefits} = [(X_{pre} - X_{post}) \times V) - C]$$

where X_{pre} is the average annual number of tern road-kills between 1989 – 1993 (before pole installation), X_{post} is the average annual number of tern road kills between 1995-1999 (after pole installation), V is the current dollar value of a tern (i.e., $500 or $2,000), and C is the average annual cost of installing and maintaining the poles. The costs for the structural modifications to the bridge were incurred in the first year and subsequent maintenance and depreciation costs were zero. Thus, C = $5,900 at year one, but averaged $0 additional costs in the subsequent four years, resulting in C = $1,180/yr for the five year period. The benefit cost ratios (BCRs) for the structural modification were calculated as:

$$BCR = \frac{\text{Benefits}}{\text{Costs}} = \frac{\text{\$ value of tern saved}}{\text{\$ cost of structural modification}}$$

TABLE 1. Net benefits and benefit-cost ratios (BCRs) of conservation efforts to protect royal terns from road-kill hazards at a Florida bridge.

	Net Benefits		BCRs	
1995-1999	$ 500	$ 2,000	$500	$2,000
Annual Average	$ 5,920	$ 27,220	6.02	24.07
Total period	$34,320	$140,820	6.02	24.07

Because all costs were incurred in the first year, we also calculated the cumulative rate of return each year for the structural modifications. The cumulative value of terns is the sum of the average value of terns saved per year. The return on an investment is normally measured as the percentage rate of return rather than as the dollar amount of gain or loss. We expressed the sum of the current net value of terns saved (current year's cumulative value minus the current year's costs) as a percentage of the prior year's investment value (Gitman and Madura, 2001). The cumulative rate of return identifies the return to the structural modifications measured by the cumulative value of terns saved.

Using the $500 per tern value, the average loss values before and after the structural modification program were $48,500 and $13,000. The corresponding values using the $2,000 per tern value were $194,000 and $52,000. The initial expenditure of $5,900 to erect the poles provided protection for 5 years (1995-1999), as well as portions of 1994 and 2000. The five full years of protection cost an average of $1,180/yr. The average number of road-killed royal terns during this same period was 5.2 terns/yr, which was 14.2 terns/yr less than the average of 19.4 terns/yr for the 5 years before erection of the poles. Using the conservative $500/bird value represents an average net annual benefit of $5,920, while use of the $2,000/bird value results in a net annual benefit of $27,220. Table 1 shows the net benefits and BCRs of the structural modification program. The BCRs of the program under the $500 tern value indicate that the annual benefits accrued to the structural modification program, in terms of terns lost, were six times greater than the costs. Assuming the $2,000 value, the BCRs indicate that the average annual benefits of the program were an impressive 24 times higher than the cost.

The average of 14.2 terns/year saved with a value of $500 per tern produced an average annual savings of $7,100. Over the 5 year period, the structural modifications provided a cumulative annual rate of return on the initial $5,900 investment that increased from 20 % after year 1 to 502 % after five years (Table 2).

Our benefit cost analysis yielded straight-forward results demonstrating the value of a simple, low-cost method for conserving royal terns (and consequently other shore birds) from the hazards presented by bridge traffic. Our economic analysis considered only the direct benefits of saving terns, without considering indirect benefits such as wildlife viewing, ecological values, and inter-species relationships. The economic aspects of this conservation method suggest that it should be used more frequently to protect this and probably other *species of special concern.*

TABLE 2. Cumulative annual rate of return on the initial cost for structural modifications to protect royal terns from road-kill hazards at a Florida bridge.

		Return on initial structural modification	
Number of years	Yearly cost	Net value of terns saved	Cumulative rate of return
1	$5,900	$ 1,200	20%
2	$ 0	$ 8,300	141%
3	$ 0	$15,400	261%
4	$ 0	$22,500	381%
5	$ 0	$29,600	502%

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