J Bioecon (2010) 12:55–70
DOI 10.1007/s10818-010-9077-6

# Cost benefit analysis of conservation efforts to preserve an endangered species: The Griffon Vulture (*Gyps fulvus*) in Israel

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Published online: 30 March 2010


**Abstract** The major goal of this study was to determine whether protective measures in the case of the Eurasian Griffon Vulture are in accordance with public priorities. To this end we used the Travel Cost (TCM) and Contingent Valuation Methods (CVM) to estimate its value. We also determined the break even point in the allocation of funds targeted to protection at the regional level and performed a cost-benefit analysis of conservation efforts on a national level in Israel. The value of the marginal vulture was found to be approximately 34,000 NIS at Gamla and 316,000 NIS at Hai-Bar Nature Reserves. The economic efficiency of feeding stations was examined from two aspects: At the regional level, the break-even point for a feeding station to be efficient was 0.24 and 2.20 vultures per year for the Hai-Bar and Gamla NRs respectively. At the national level, in most cases, the national project to save vultures, 'Porsim Kanaf' ('Porsim Kanaf' is the national birds of prey conservation project in Israel) passes a Cost-Benefit test based on the valuation results.

**Keywords** Cost–benefit analysis · Israel · Griffon Vulture · Valuation

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**JEL Classification** Q51 · Q57

## 1 Introduction

Using different economic valuation techniques to estimate the value of endangered species is a well documented concept in the literature (Brown 1993; Navrud and Mungatana 1994; Bulte and Van Kooten 1999; Jakobsson and Dragun 2001; Gonzalez-Caban et al. 2003; Kontoleon and Swanson 2003). Those benefits can be contrasted against the protection cost or against alternative uses of the habitat that might risk their existence. The major goal of this study was to determine whether the protective measures and the budget allocated for those measures in the case of the Eurasian Griffon Vulture, *Gyps fulvus*, are in accordance with public priorities.

We envision the contribution of the study in that it measures the value of the marginal individual of an endangered species in order to conduct a Cost-Benefit Analysis of a specific management scenario. Since a policy should be judged at the margin, calculating the average values of endangered species provides the wrong signal for benefit estimation (Bulte and Van Kooten 1999). We used the marginal value in order to compare it to the cost of one management tool, namely operating feeding stations. We also used the value of a marginal individual when we contrasted it to the total effort to conserve vultures. Using the value of an average individual would seem to be more consistent here. However, since the marginal value is smaller than the average, it provides a more conservative estimate which can better serve decision makers, especially when the net benefit is positive anyhow.

The Israeli red list of threatened animals classifies the Griffon Vulture, our case study, as vulnerable (Dolev and Perevolotsky 2002). The population, once abundant, has suffered from a severe decline during the last century. In Israel, although protected by law, the vulture population has declined from over 1,000 breeding pairs in the second half of the nineteenth century (Tristram 1885; Mendelssohn and Leshem 1983), to a present number of less than 100 breeding pairs. This worrisome decline is a result of hunting, abuse usage of pesticides (Mendelssohn 1972; Shlosberg 2001), electrocutions (Lehman et al. 1999) and improved pastoral hygiene which resulted in less available food for vultures (Cramp and Simmons 1980).

The Griffon Vulture is an obligatory carrion feeder which forages over extensive areas (Cramp and Simmons 1980; Mundy et al. 1992). In Israel, its main food source is cattle (Bahat 1995). Since this food source is not always available, several feeding stations have been established. Such feeding stations have proved to be successful in sustaining stable vulture populations particularly in the southern part of Israel, reinforcing their numbers and preventing their decline (Mundy et al. 1992; Bahat et al. 2002).

The benefits of protecting vultures are both ecological and social. Scavengers perform a crucial ecosystem function and provide ecosystem services through their role in the removal of animal carcasses that could otherwise be hazardous both to wildlife and humans. In addition, vultures are spectacular creatures which attract people who enjoy their grandeur and soaring flight.

## 2 Literature review

### 2.1 Feeding stations

One of the conservation efforts employed in the protection of vultures and in preventing their decline is the operating of feeding stations where food quality can be assured, and the availability of food attracts vultures to areas where they once used to frequent (Mundy et al. 1992). A feeding station can also serve as a source of bone-fragments as calcium supply to the breeding parents to compensate for the absence of the main bone-crushers in their foraging areas (Richardson et al. 1986). In the absence of bone fragments, the parents search for various substitutes which are equally hard, such as pieces of metal. As a result, the nestling suffers from rickets, and may die (Houston 1978).

This management tool was first used in South Africa in 1966, where a feeding scheme for the Bearded Vulture, *Gypaetus barbatus*, was conducted (Butchart 1988). In France, the use of feeding stations started in the Pyrenees in 1969 (Terrasse 1985). Right after that, feeding stations were established in other places in Europe and in the United States, as a part of the reintroduction program of the endangered California Condor (Wilbur et al. 1974). The population of the Black Vulture, *Aegypius monachus*, in Greece is recovering as a result of the operation of feeding stations (Vlachos et al. 1999).

Since a routine supplement of bone fragments at the local feeding station at Gamla Nature Reserve began in 1998, the number of nestlings suffering from rickets declined (Ben-noon et al. 2003).

### 2.2 The value of wildlife protection

Two of the most widely used economic valuation for natural resources and amenities are the Travel Cost Method (TCM) and the Contingent Valuation Method (CVM). TCM is designed to measure in monetary terms the benefits of enjoyment that visitors get from visiting a recreation site. This method derives individuals' willingness to pay WTP for a particular activity at a given site based on their associated trip expenditures (travel costs). The variation in visit frequency among visitors living in different proximity from the site can be used to trace the demand function. From the demand curve the consumer surplus or the net WTP can be calculated.

CVM is a stated preferences method for estimating the economic value of a non-market good. The assumption is that individuals can reveal their true WTP through their behavior in hypothetical markets. By asking people questions, one can reveal the mean WTP of the relevant population and thus the social WTP for the good. The drawback of CVM is that it is based on hypothetical situations. However, TCM cannot deal with non-use values such as bequest and existence values which are a major part of goods such as wildlife.

This is one of the major difficulties in determining the optimal amount of wildlife protection. The good produces benefits associated with particular uses (direct, indirect, or passive) that carry associated values. However, only a portion of these values are reflected in market transactions associated with the good, such as trip and equipment expenditures from wildlife-associated recreation activities. The economic benefit associated with species conservation is often non-marketed. The difference between the benefits an individual person receives from a wildlife-associated activity such as wildlife viewing and his or her opportunity costs of engaging in that activity, represent the net economic benefit, or consumer surplus, he or she derives from the activity.

Studies on the value of wildlife viewing and protection include Brown (1993), Navrud and Mungatana (1994) and Jakobsson and Dragun (2001) to name a few. Most of the studies conducted have dealt with the value of a habitat area, nature reserve, or the value of a representative individual of a given population of an endangered species. However, policy decisions are often made on the margin. Bulte and Van Kooten (1999) argue that the threshold level should dictate if one deals with a marginal analysis or alternatively a moral obligation to save a given species. Other researchers who analyzed the value of the marginal individual are Kontoleon and Swanson (2003) and Gonzalez-Caban et al. (2003) among others.

One way of estimating marginal values is to combine CVM and TCM studies. Gonzalez-Caban et al. (2003) used TCM results of additional trips as a response to increased deer numbers in order to estimate the marginal value of a deer. Other reasons for combining TCM–CVM studies can be explained as calibrating CVM hypothetical responses (e.g., Cameron 1992. If one can break down the CVM results into use and non-use values and if one can compare the use value derived from CVM to the use value derived from TCM, then the non-use value can be regarded as a reliable estimate[1]. Carson et al. (1996) provide a comprehensive review of the literature of such studies.

In our case study we see the benefit of using the marginal value of the species from the following 3 reasons:

i The number of the individuals in the relevant population is above the threshold level.
ii Marginal value is better in the case of several sites (as in this paper) or species. The guideline for policy makers is to invest in species conservation in such a way so that the net marginal value should be equal across sites (or species).
iii Marginal value is smaller than the average and as such provides a lower bound to the benefit estimation. This may serve as a stronger argument for preservation.

## 3 The study sites in Israel

Gamla Nature Reserve is located in the center of the Golan Heights in northern Israel. The reserve contains the highest waterfall in Israel, archaeological sites and the largest Griffon Vulture nesting colony in the country at the beginning of the 21st century. On average, about 100,000 people visit the reserve annually.

[1] The passive-value versus the value obtained through the TCM does not imply on the importance of the former but provides a reliability measure.

Hai-Bar Nature Reserve is located at the south-eastern outskirts of the city of Haifa, in the heart of Mt. Carmel. Hai-Bar is a wildlife preserve which aims to breed and rehabilitate animals that were once common in the Mediterranean area and then release them into the wild. On average, about 45,000 people per year visit this reserve.

## 4 The valuation process

TCM and CVM questionnaires were distributed amongst visitors at both Gamla and Hai-Bar Nature Reserves. CVM questionnaires were also distributed within a representative national level sample-riders on the train line between Haifa and Tel-Aviv. The ride lasts for about an hour and the riders can be considered as a 'captive audience'. The atmosphere during the train ride is quite pleasant so there is no concern that respondents would be distracted by time pressure etc. Train riders are also believed to be a representative sample of the general population which was verified by comparing the mean socio-demographics of both the sample and the general population.

### 4.1 Travel cost

TCM was conducted in order to estimate the use values of the sites as reflected in the travel costs incurred by the visitors. Besides travel cost, we used the following explanatory variables: Membership in a 'green' organization, education and income levels (Ward and Beal 2000).

One hundred and seventy questionnaires were distributed at Gamla from January to June 2003. One hundred and forty three were usable (85%). At Hai-Bar, two hundred and seventy out of the two hundred and ninety six questionnaires were usable (91%). The questionnaires were distributed from November 2003 to April 2004.

### 4.2 Estimation using TCM

Travel Cost analysis was applied by using the above mentioned socio-demographic variables as well as the cost of travel, the opportunity cost of time (25% of the net income) (Cesario 1978) and entrance fee to the site. We controlled for multi-site visitation by asking the respondents to fill in how may places they had visited during their trip. Usually, the visit at both sites is the major or only reason for the trip. However, there were cases where we had to split the travel and time value proportionally among the sites visited.

We used a semi-log functional form in order to estimate visitation frequency from ten regions in which the distance between them and the site is increasing by 30 km per region:

$$Log(V_i/pop_i) = \alpha + \beta(TC_i) + \delta(SOC_i) + \varepsilon_i \qquad (1)$$

where: $V_i$ = Visits from region $i$.
$Pop_i$ = Population from region $i$.
$\alpha$ and $\beta$ and $\delta$ are parameters to be estimated.
$TC_i$ = Travel cost from region $i$.
$SOC_i$ = A vector of socio-demographic characteristics.
$\varepsilon$ = is an error term.

If one sets the socio-demographic variables at their respective mean values and adds the product of the mean by the coefficient of each variable to the constant, which leaves us with a semi logarithmic function of only one variable, namely the travel cost. After estimating the functions, we raised the price for each region by increments of 20 NIS until the visits diminished to zero and calculated the implied visits from each region. The last step was to sum the number of visits from each region for every price level. Regressing the visits on implied prices and integrating to find the area beneath the function, resulted in the use value of the site to its visitors. The regression results of the travel frequency as a function of TC and other socio-demographic variables are given in Table 1 for Gamla and Hai-Bar NRs.

We used a zonal TCM approach which resulted in the following demand-functions for Gamla and Hai-Bar NRs as given in Eqs. 1 and 2 respectively. These demand functions were estimated after holding all significant variables at their respective mean level. They are given by:

$$P = TC_G = 4.43 - 1.86Ln(VI_G) \quad R^2 = 0.913 \tag{2}$$

$$P = TC_H = 7.65 - 6.69Ln(VI_H) \quad R^2 = 0.823 \tag{3}$$

where $TC_G$ = Visiting price to Gamla NR
$TC_H$ = Visiting price to Hai-Bar NR
$VI_G$ = Number of visitors to Gamla NR
$VI_H$ = Number of visitors to Hai-Bar NR

Integrating the quasi-demand functions given by (2) and (3) we found the value of the sites as related to viewing vultures. They were 11.76 million NIS and 9.84 million NIS for Gamla and Hai-Bar NRs respectively.

**Table 1** Travel cost regressions: dependent variable: log of travel frequency

| Parameter (variable) | Hai-Bar | Gamla |
|---|---|---|
| Intercept | 0.069* (5.454) | 0.31* (1.115) |
| No. of children | 0.0016* (2.513) | 0.0054* (2.1) |
| Green organization membership | 0.0070 (−2.476)* | 0.0004 (−1.52) |
| Education | 0.0050* (2.515) | 0.04* (2.42) |
| Income | 0.00003* (2.047) | 0.0001* (2.09) |
| Travel cost | −1.86* (−12.639) | −3.60* (−4.63) |
| Adj. R-sq. | 0.77 | 0.50 |
| F | 46.34 | 45.45 |

* Significance at 95% confidence level

### 4.3 Estimation using CVM

We used a payment card (PC) type of CVM questionnaire to estimate the total value of viewing vultures and protecting them. We chose the method of direct interview, as recommended by the NOAA panel (Arrow et al. 1993). While using a dichotomous choice (DC) seems to be the most popular approach and also the most recommended by the NOAA panel, there are studies who question the assumptions under which it turns out to be the most preferred survey method (e.g., Diamond and Hausman 1994). PC estimates have a tendency to yield more conservative estimates than DC models (Ryan et al. 2004; Blaine et al. 2005 among others). Another reason to choose PC over DC is the large number of respondents needed to be surveyed in a DC format. While this could be handled in a one site study, it is much more difficult to handle in a three sites study (Gamla, Hai-Bar and a representative sample of the general population).

CVM questionnaires were distributed to a sample of one hundred and fifty people at each of the two sites and to a sample of the general population, with the assumption that they too attribute non-use values to viewing and protecting vultures, even if they were users while filling out the questionnaire (Shechter et al. 1998). Furthermore, this is indeed the relevant population which is able to value the site because of their affinity for it. We approached people throughout the day at the coffee shop and at the observation deck. Attention was also given to obtaining a representative sample by means of comparison with the most recent census data. This was an ongoing procedure with comparisons of demographics being periodically reviewed and if necessary, adjustment made to the target population. We used the payment card procedure with fifteen payment options marked down on the survey. The response rate was 89, 90 and 84% for Hai-Bar, Gamla and the sample of the general population respectively.

The WTP question was presented in three scenarios, adopting the method used by Loomis (1987) at Mono Lake and by Kontoleon and Swanson (2003) with the Giant Panda. In these studies, respondents were presented with three levels of the environmental attribute they were asked to value. The reasons for varying the environmental attribute in the questionnaires are first, to test for the presence of scope issue (or embedding) in CVM. The second is to get the observations from which a demand function (or marginal benefit function) can be traced. Scope effect is the impact of changing the magnitude or quantity of the non-market good. Concern over scope analysis started after the NOAA—Panel report (Arrow et al. 1993) which mentioned that scope test should be required in order to assess whether a CV study complies with the neo-classical economic theory. This, in addition to the influential paper of Kahneman and Knetsch (1992), sparked an empirical debate in which some studies found scope sensitivity (e.g., Smith et al. 1999) while others have not (e.g. Hammit and Graham 1999). In this study, we demonstrate how scope sensitivity was found in each site no matter if the sequence of questions was in direction of increasing the number of vultures (Hai-Bar) or decreasing it (Gamla). Respondents were shown three levels of the vulture population density (Appendix A).

Since at Gamla NR seeing vultures in the sky is a common sight, respondents were asked about their WTP *to prevent* their decline, going from the first high level of population density to the second one and from the second level to the third one. At

Hai-Bar NR and within the sample of the general population, on the other hand, where vultures are not a common sight, respondents were asked about their WTP to increase their numbers in the sky[2], going from the first low level to the second one, and from the second level to the third one.

The number of soaring vultures represents the actual population density at the site. At Gamla, five soaring vultures in the picture represent ninety five vultures on site (the current situation) and two vultures represents 38 vultures. At Hai-Bar, two soaring vultures in the picture represents five vultures on site (the current situation) while seven vultures in the picture represents 18 vultures on site.

This was done according to the data of daily observations which was gathered over a period of 5 years, and the calculation of the average daily number of vultures in the reserves, according to that data. The staff in both reserves was also interviewed to verify this number in each one of them.

After the WTP question, a number of reasons were enumerated and respondents were asked to circle the ones which were relevant to them when answering the WTP question. The different reasons were meant to deal with two issues, namely, division of the total value into use and non-use and exclusion of protest bids from the survey (Bateman et al. 2002) as well as split zero responses between legitimate and protest bids. The number of protest bids was 14, 17 and 21 for Gamla, Hai-Bar and the general population samples respectively[3].

In addition, the WTP bid function was estimated with the following controlled variables: income, education, age, gender, number of children and membership in a 'green' organization. Part of them conform to the economic theory (income, education and membership in green organization) while others can be a basis for prediction and policy (i.e., the importance of children, age and gender).

It should be noted that the payment options were expressed as annual payments so the estimates are expected to be higher than they would be if respondents were asked to make a one-time payment (Bateman et al. 2002, p. 134). The payment card estimate yield a response of the maximum WTP amount listed on the card. However, it might be that the given respondent is actually willing to pay any amount between the stated one and the next higher one. Therefore, the estimation is based on a random maximum WTP; a usual OLS is not appropriate in this case. This should be dealt with one of the following ways: Either we use the mid-point between the reported payment and the next payment option as the reported maximum WTP, or estimate the function by maximum likelihood (ML) procedure. Cameron and Huppert (1989) have shown that as the interval gets smaller, so does the difference between the OLS and ML. We reported only the OLS results which are very similar to the ML estimates since we had fifteen payment options on the card. This is also consistent with Ryan et al. (2004) who have done their analysis on health care provision.

[2] It should be noted that in both cases the relevant question is WTP and not willingness to accept (WTA). The difference in the direction of change (less in Gamla and more in Hai-Bar) is based on the current property rights in the different sites. Therefore, the anomaly presented by Kahneman et al. (1991) should not be of concern here.

[3] We continued our surveys until we obtained the desired number of respondents, thus excluding no responses from our analysis. Since some no respondents may indicate zero WTP, our WTP estimates may be biased upward (See Halstead et al. 1992 for a discussion on the issue).

**Table 2** CVM questionnaire: WTP in the three samples (NIS per year)

| | Gamla | Hai-Bar | General pop. |
|---|---|---|---|
| Mean WTP1 | 50.72 | 41.61 | 36.77 |
| Median | 50.0 | 20.0 | 20.0 |
| Standard deviation | 48.17 | 39.82 | 36.7 |
| Mean WTP2 | 66.93 | 45.19 | 37.48 |
| Median | 50.0 | 20.0 | 20.0 |
| Standard deviation | 61.45 | 42.79 | 36.5 |
| Total WTP | 117.65 | 86.8 | 74.25 |

**Table 3** CVM regression estimates: dependent variable: WTP (NIS)

| | Coefficient (t-value) | | | | | |
|---|---|---|---|---|---|---|
| | WTP1 Gamla | WTP2 Gamla | WTP1 Hai-Bar | WTP2 Hai-Bar | WTP1 general population | WTP2 general population |
| Constant | 38.860* | 25.975 | 19.039 | 69.887* | 64.839* | 57.676* |
| | (2.086) | (1.523) | (1.421) | (2.467) | (2.495) | (2.182) |
| Gender | 6.80 | 7.059 | −7.488* | −7.639* | −2.555 | −8.661* |
| | (1.402) | (1.599) | (−1.974) | (−1.951) | (−1.352) | (−2.049) |
| Age | 17.356* | 16.924* | 11.963* | 13.373* | 5.012 | 4.848 |
| | (3.507) | (2.412) | (2.627) | (2.779) | (1.387) | (1.114) |
| No. of children | −6.031 | −4.560* | −2.254 | 1.743 | −5.304 | −2.159 |
| | (−1.472) | (−1.806) | (−1.454) | (1.352) | (−1.341) | (−1.476) |
| Green organization | 5.141 (1.48) | 10.633 (1.708) | 3.134 (1.334) | 12.399 (1.261) | 17.535* (2.165) | 21.814* (2.291) |
| Education | 1.939 | 1.266 | 2.979 | 5.531* | 21.852* | 21.578* |
| | (1.392) | (1.182) | (1.548) | (1.964) | (3.544) | (3.07) |
| Income | 5.729 | 5.896 | 6.353* | 3.443 | 2.854 | 0.402* |
| | (1.27) | (1.56) | (2.109) | (1.584) | (1.624) | (2.079) |
| Adj. R-sq. | 0.42 | 0.40 | 0.44 | 0.56 | 0.58 | 0.70 |
| N | 150 | 150 | 150 | 150 | 150 | 150 |

* Significance at 95% confidence level

## 4.4 CVM results

Descriptive statistics are shown in Table 2 while regression results are presented in Table 3. The coefficients of the variables in the WTP functions show in most cases the expected signs although not all are significant at the 95% confidence level. For example, *age* was found to be a significant variable at both sites but not in the general population. On the other hand, *membership in 'green'* organizations was found to be significant only in the general population sample. Another interesting point to note is

**Table 4** CVM questionnaire—use and non-use values (NIS per year)

| | Gamla | Hai-Bar | General pop. |
|---|---|---|---|
| Use value per respondent (NIS) | 22.00 | 20.22 | 18.26 |
| Use value for site (milNIS) | 2.68 | 1.0 | 40.01 |
| Non use value per respondent (NIS) | | | |
| Existence value | 54.12 | 32.98 | 26.28 |
| Option value* | 3.41 | 6.94 | 8.53 |
| Bequest value | 31.30 | 24.82 | 17.15 |
| Total non use value per respondent (NIS) (% of non-use value from total value) | 88.83 (80.1%) | 64.74 (76.2%) | 51.96 (74%) |
| Total non use value for site (mil. NIS) | 8.26 | 2.91 | 93.55 |
| Total WTP per respondent NIS | 117.65 | 86.7 | 74.25 |
| Relevant population (number of households) | 92,700 | 45,000 | 1.8 million households |
| Total value of vultures to visitors at each site and for general population | 10.94 mil. NIS | 3.91 mil. NIS | 133.6 mil. NIS |

* Option value can also be considered as part of the use value

the *education* and *income* coefficients. Although having the expected sign, in almost every equation they were not significant. Their absolute value is also relatively small, indicating that they do not have much impact on the WTP. It seems that the only influential variables are *age* and *membership in 'green' organization.*

The breakdown of the total value into its use and non use components is shown in Table 4. We asked respondents to associate their WTP to use and non-use values (Option, Bequest and Existence). The breakdown is presented also in Table 4. As can be seen—and also expected—about 75% of the value is associated with non-use motives. The total average and marginal values of vultures at the sites are given in Table 5. As can be seen from the table, the total WTP for the site is 118 NIS and 87 NIS for the average visitor at Gamla and Hai-Bar NRs respectively. If we multiply this value by the number of visitors at the sites, we can derive the total value which is 10.94 million NIS and 3.91 million NIS for Gamla and Hai-Bar NRs respectively.

The marginal benefit function can be derived by plotting a line through the two mean points of the change in the number of vultures in the two scenarios. For example, at Gamla, an average respondent is willing to pay 51 NIS to prevent a decline of 60% in the number of vultures (three in the picture or 57 in reality). That means, 0.894 NIS on average per additional vulture for a vulture population ranging from 57 to 95 individuals. After completing this analysis, linear line equations that pass through these mean points were estimated. These equations represent the marginal

**Table 5** Total, average and marginal values of vultures (NIS per year)

| | Gamla | Hai-Bar | General population |
|---|---|---|---|
| Scenario 1 | Avoid drop from 5 to 2 | From 0 to 2 | From 0 to 2 |
| WTP1 per capita | 51 | 42 | 37 |
| Scenario 2 | Avoid drop from 2 to 0 | From 2 to 7 | From 2 to 5 |
| WTP2 per capita | 67 | 45 | 38 |
| Total WTP | 118 | 87 | 75 |
| No. of vultures on site | 95 | 5 | 350 |
| Annual no. of visitors | 92,700 | 45,000 | 1.8 M. households |
| Total value of site | 10.94 M. | 3.91 M. | 135 M. |
| Total value of average vulture | 115,000 | 783,000 | 385,714 |
| WTP per marginal vulture per capita | 0.37 | 7.03 | 0.13 |
| Total social value of marginal vulture | 34,438 | 316,440 | 244,800 |
| Net social value of marginal vulture | 27,742 | 293,846 | 212,348 |

benefit function and are presented in Eqs. 4 and 5 for Gamla and Hai-Bar NRs respectively[4].

$$\text{Marginal benefit for Gamla}: MB_G = 2.11 - 0.0183(VU_G) \tag{4}$$

$$\text{Marginal benefit for Hai-Bar}: MB_H = 9.767 - 0.547(VU_U) \tag{5}$$

As can be seen from both equations, the marginal benefit is decreasing with an increase in the number of vultures. In order to calculate the total benefit of the site, we can integrate (4) and (5) to get (6) and (7) as follows:

$$\text{Total benefit for Gamla}: TB_G = 2.11(VU_G) - 0.00915(VU_G)^2 \tag{6}$$

$$\text{Total benefit for Hai-Bar}: TB_H = 9.76(VU_H) - 0.2735(VU_H)^2 \tag{7}$$

The above analysis results in a total value of 10.84 million NIS and 3.16 million NIS for Gamla and Hai-Bar NRs respectively.

## 5 Break-even point, cost-benefit, and other policy implications

### 5.1 Cost of feeding stations

In order to decide if resources should be devoted to help the vulture population not to diminish, we should compare the estimated benefits with the costs of establishing and operating feeding stations. The information was taken from the financial reports of the Israel Nature and National Parks Authorities (Hatzofe 2003). The annual operating

[4] It is important to note, that the process here involves averaging values of vultures that are relatively different from one another. Therefore, it can be thought of actually as a step function on one extreme and as a linear line on the other.

**Table 6** Breakeven point under different scenarios (number of vultures)

| Site | Payment | | | |
|---|---|---|---|---|
| | Mean | | Median | |
| | Total value | Use value only | Total value | Use value only |
| Gamla | 2.63 | 10.74 | 3.09 | 12.62 |
| Hai-Bar | 0.26 | 1.02 | 0.57 | 2.23 |

cost of a feeding station (amortized fixed costs plus variable costs) is estimated to be 73,000 NIS per year.

## 5.2 Break even analysis

Since it is impossible at the current ecological knowledge to know how many vultures a given feeding station can save, we determine the number of additional vultures a feeding station would need to produce in order for it to be cost-covering. As seen from Table 5, we can estimate the value of the marginal vulture. In order to compare benefits to costs, we need to subtract the travel cost from the use-value of a given visitor so that we can get the consumer surplus only. This was done by subtracting the mean travel cost to Gamla and Hai-Bar NRs from the mean WTP part which is associated with the use-value. The net social value of the marginal vulture is given in the last line of Table 6[5]. Dividing the annual cost of feeding stations by the net social value, gives us the break-even point. Table 6 presents the break- even point under four scenarios. It includes total and use value only for the mean and median willingness to pay. As can be seen from the table for Gamla NR, the break- even point ranges from 2.63 to 12.62 vultures annually. At Hai-Bar, it ranges from 0.26 to 2.23 vultures.

## 5.3 Cost-benefit

There is one case in which cost-benefit analysis can be implemented; this is the case of the entire vulture population increase due to the total investment through the national project ‘Porsim Kanaf’. During the first 5 years of the project, the number of breeding couples increased from 70 to 140 (Bahat et al. 2002). The total budget of the project was estimated to be 3.7 million NIS. This is equivalent to a cost of 26,000 NIS per additional vulture. Based on that, we can extrapolate the net marginal benefit for the four scenarios shown in Table 5 in order to generate a cost-benefit ratio for each scenario[6] (Table 7).

[5] Non-use values were taken in full, since there is no need to get to the site. The use value for the general population was weighted by the number of visits at Gamla and Hai-Bar NRs in order to allocate the travel cost to the mean respondent.

[6] We performed the analysis in annual terms. These kinds of policies can have an instantaneous impact and as such don’t carry the dynamic path of different benefits and costs over time. Hence, annual figures seem to represent better the situation.

**Table 7** Benefit-cost ratio (BCR) under the different scenarios

| Site | BCR | | | |
|---|---|---|---|---|
| | Mean | | Median | |
| | Total value | Use value only | Total value | Use value only |
| Gamla | 1.07 | 0.28 | 0.92 | 0.23 |
| Hai-Bar | 11.30 | 2.86 | 5.20 | 1.32 |
| General population | 8.17 | 2.45 | 4.40 | 1.32 |

As can be seen from the table, only at Gamla and only if the median respondent or the direct use values are included in the analysis is the ratio smaller than 1.

## 6 Policy and conclusions

Valuing endangered species usually requires decisions to be made on the margin. This study uses TCM and CVM in order to estimate the value of the marginal individual—in this case the Griffon Vulture in Israel. A cost-benefit analysis was carried out both on the regional level with respect to feeding stations as one means of preservation effort and a total effort of preserving vultures on a national level. This was done by comparing the cost of one of the conservation measures, namely, feeding stations, to the estimated value of the marginal vulture derived from the two valuation methods. Two important results emerge from the research:

1. The general financial expenditures directed to protect vultures passes a national cost-benefit test.
2. Feeding stations are economically viable when saving at least between 0.23 and 2.12 vultures annually, depending on the site.

Dividing the total value into its use and non-use components values is of importance as well. This was demonstrated in the cost-benefit calculations if one needs to be as conservative as possible.

One shortcoming of the stated WTP which is common to many studies is the lack of respondents to capture the ecological benefits of preserving species. It is less felt in this study because vultures can be considered as Mega-Fauna kind of species. However, it might deserve special attention in less 'popular' species. As such, the estimated values are somehow downward biased.

Finally, it is of major importance to create a solid data base of threshold levels for different endangered species that indicate the net benefits to be gained from increasing the respective species' populations. Once these levels have been estimated, decisions can be made on the margin, and therefore, public resources can be allocated more efficiently. However, caution should be exercised with respect to the WTP values since in many cases there are other eco-system services provided by the species, which respondents are not aware of. The estimated values may represent underestimates of the actual value of the species.

**Acknowledgements** The research was funded by the Ministry of Environmental Protection in Israel. Our thanks go first and foremost to them. We also would like to thank the staff at Gamla and Hai-Bar nature reserve for their cooperation and to Eyal Bartov for the pictures. Two anonymous referees provided helpful comments.

## Appendix A: 3 stage scenarios in each of the questionnaires

### Gamla questionnaire:

**Stage 1**

**Stage 2**

**Stage 3**

Photographs: Eyal bartov

### Hai-Bar questionnaire:

**Stage 1**

**Stage 2**

**Stage 3**

Photographs: Eyal bartov

## References

Arrow, K., Solow, R., Portney P. R., Leamer, E., Radner, R., & Shuman, H. (1993). Report of the NOAA Panel on Contingent Valuation. *Federal Register, 58*, 4601–4614.

Bahat, O. (1995). *Physiological adaptations and foraging ecology of an obligatory carrion eater—the Griffon Vulture (Gyps fulvus).* Ph.D. Dissertation, Tel-Aviv University, Tel-Aviv.

Bahat, O., Hatzofe, O., Perevolotsky, A. (2002). *'Porsim Kanaf'—protecting the vultures and raptors. A report for the first five years, 1996-2001.* Israel Nature and Parks Authority, The Society for the protection of Nature in Israel and Israel Electric Company (in Hebrew).

Bateman, I. J., Carson, R. T., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Peaece, D. W., Sugden, R., & Swanson, J. (2002). *Economic valuation in stated preference techniques: A manual*. Cheltnham: Edward Elgar publishing.

Ben-noon, G., Eshed, O., Court, L., Hatzofe, O., & Bahat, O. (2003). Calcium provision to Griffon Vulture chicks as part of a management scheme implemented at Gamla Nature Reserve. In Abstract of Presentations, 6th World Conference on Birds of Prey and Owls, Budapest, Hungary, May 2003.

Blaine, T. W., Lichtkoppler, F. R., Jonesand, K. R., & Zondag, R. H. (2005). An assessment of household willingness to pay for curbside recycling: A comparison of payment card and referendum approaches. *Journal of Environmental Management, 76*(1), 15–22.

Brown, G., Jr. (1993). The viewing value of elephants. In E. B. Barbier (Ed.), *Economics and ecology.* (pp. 146–155). London: Chapman and Hall publishing.

Bulte, E., & Van Kooten, G. C. (1999). Marginal valuation of charismatic species: Implications for conservation. *Environmental and Resource Economics, 14*(1), 119–130.

Butchart, D. (1988). Give a bird a bone. *African Wildlife, 42*, 316–322.

Cameron, T. A. (1992). Combining contingent valuation and travel cost data for the valuation of non-market good. *Land Economics, 68*(3), 302–317.

Cameron, T. A., & Huppert, D. D. (1989). OLS vs. ML estimation of non market resource values with payment card interval data. *Journal of Environmental Economics and Management, 17*(3), 230–246.

Carson, R. T., Flores, N. E., Martin, K. M., & Wright, J. L. (1996). Contingent valuation and revealed preference methodologies: Comparing the estimates for quasi-public goods. *Land Economics, 72*, 80–99.

Cesario, F. J. (1978). Value of time in recreation benefits studies. *Land Economics, 52*(1), 32–41.

Cramp, S., & Simmons, K. E. L. (Eds.). (1980). *Handbook of the birds of Europe, the Middle East and north Africa: The birds of the Western Palearctic. Vol. 2: Hawks to bustards*. Oxford: Oxford University Press.

Diamond, P. A., & Hausman, J. A. (1994). Contingent valuation: Is some number better than no number? *Journal of Economic Perspectives, 8*(1), 45–64.

Dolev, A., & Perevolotsky, A. (Eds.) (2002). *Endangered species in Israel, Red List of Threatened Animals, vertebrates.* Israel: Nature and Parks Authority and the Society for the Preservation of Nature (in Hebrew).

Gonzalez-Caban, A, Loomis, J. B., Griffin, D., Wu, E., McCulum, D., McKeever, J., & Freeman, D. (2003). Economic value of big game habitat production from natural and prescribed fire. Research Paper PSW-RP-249. USDA Forest Service, Pacific South West Research Station.

Halstead, J. M., Luloff, A. E., & Stevens, T. H. (1992). Protest bidders in contingent valuation. *Agricultural and Resource Economic Review, 21*(2), 160–169.

Hammit, J. K., & Graham, J. D. (1999). Willingness to pay for health protection: Inadequate sensitivity to probability? *Journal of Risk and Uncertainty, 8*, 33–62.

Hatzofe, O. (2003). Financial report. Israel Nature and Parks Authority. Inner document (in Hebrew).

Houston, D. C. (1978). The effect of food quality on breeding strategy in Griffon Vultures. *Journal of Zoology, 186*, 175–184.

Jakobsson, K. M., & Dragun, A. K. (2001). The worth of a Possum: Valuing species with the contingent valuation method. *Environmental and Resource Economics, 19*, 211–227.

Kahneman, D., & Knetsch, J. L. (1992). Valuing public goods: The purchase of moral satisfaction. *Journal of Environmental Economics and Management, 22*(1), 57–70.

Kahneman, D., Knetch, J. L., & Thaler, R. H. (1991). Anomalies: The endownment effect, loss aversion, and status quo bias. *Journal of Economic Perspectives, 5*(1), 193–206.

Kontoleon, A., & Swanson, T. (2003). The WTP for property rights for the Giant Panda: Can a charismatic species be an instrument for conservation of natural habitat? *Land Economics, 79*, 483–499.

Lehman, R. N., Ansel, A. R., Garret, M. G., Miller, A. D., & Olendorff, R. R. (1999). Suggested practices for Raptor protection on power lines: The American story. In M. Ferrer & G. F. E. Janss (Eds.), *Birds and power lines* (pp. 125–144). Madrid: Quercus.

Loomis, J. B. (1987). Balancing public trust resources of Mono Lake and Los Angeles' water right: An economic approach. *Water Resource Research, 23*(4), 1149–1456.

Mendelssohn, H. (1972). The impact of pesticieds on bird life in Israel. *ICBP Bulletin, 11*, 75–104.

Mendelssohn, H., & Leshem, Y. (1983). The status and conservation of vultures in Israel. In S. R. Wilbur & J. A. Jackson (Eds.), *Vulture biology and management* (pp. 86–98). Berkeley: University of California Press.

Mundy, P., Butchart, D., Ledger, J., & Piper, S. (1992). *The vultures of Africa*. Randburg, South Africa: Accorn books and Russel Friedman books.

Navrud, S., & Mungatana, E. D. (1994). Environmental valuation in developing countries: The recreational value of wildlife viewing. *Ecological Economics, 11*(1), 135–151.

Richardson, P. R. K., Mundy, P. J., & Plug, I. (1986). Bone crushing carnivores and their significance to osteodystrophy in Griffon Vulture chicks. *Journal of Zoology, Series A, 210*(15), 23–43.

Ryan, M., Scott, D. A., & Donaldson, C. (2004). Valuing health care using willingness to pay: A comparison of the payment card and dichotomous choice. *Journal of Health Economics, 23*(2), 237–258.

Shechter, M., Reiser, B., & Zaitzev, N. (1998). Measuring passive use value. *Environmental and Resource Economics, 12*(3), 457–478.

Shlosberg, A. (2001). Toxicological risks of raptors in Israel. In A. Shlosberg & O. Bahat (Eds.), *Proceedings on an International Workshop on the Risk of Toxicoses from Pesticides and Pollutants in Raptors and Wildlife in Israel—The Present Situation and Recommendations for the Future* (pp. 8–30). Jerusalem Biblical Zoo, Israel, SPNI, Tel-Aviv.

Smith, V. K., Zhang, X., & Palmquist, R. B. (1999). Marine debris beach quality and non-market values. *Environmental and Resource Economics, 10*(2), 223–247.

Terrasse, J. F. (1985). The effects of artificial feeding on Griffon, Bearded and Egyptian Vultures in the Pyrenees. In I. Newton & R. D. Chancellor (Eds.), *Conservation studies on raptors.* (pp. 429–430). Norwich: Pastom Press.

Tristram, H. B. (1885). *The fauna and flora of Palestine*. London: Palestine Exploration Fund.

Vlachos, C. G., Bakaloudis, D. E., & Holloway, G. J. (1999). Population trends of Black Vulture, *Aegypius monachus*, in Dadia Forest, north eastern Greece following the establishment of a feeding station. *Bird Conservation International, 9*(1), 113–118.

Ward, F., & Beal, D. (2000). *Valuing nature with travel cost models*. Cheltenham, UK: E. Elgar Publishing.

Wilbur, U. S., Sanford, R., Carrier, W. D., & Borneman, J. C. (1974). Supplemental feeding program for California Condor. *Journal of Wildlife Management, 38*(1), 343–346.