The economic impact of the invasion of Acacia saligna in Israel

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THE ECONOMIC IMPACT OF THE INVASION OF *ACACIA SALIGNA* IN ISRAEL AND THE OPTIMAL MANAGEMENT STRATEGY

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Abstract

The article illustrates the use of alternative, non-market valuation methods to estimate the economic value of damage caused by the invasive plant *Acacia saligna*. We discuss the motivation to perform an economic valuation of bio-invasion in general and then we examine the costs and benefits of conservation management programs that reduce the risk of *A. saligna* invasion at the Nizzanim LTER nature reserve in Israel. The study found that the annual mean willingness to pay (WTP) for containment or eradication of *A. saligna* was $8.41 and $8.83, respectively. The value placed on conserving the nature reserve was then compared to the cost of containment or eradication of the species enabling a standard economic benefit-cost analysis. The result of this analysis showed that, using the most conservative method of valuation of the nature reserve, eradication of the *A. saligna* revealed a net benefit. The net benefit of containment was dependent on which method of containment was used. This research showed the importance of basing conservation decisions on total economic value which includes both use and non-use values. By taking into account only use value policy makers run the risk of undervaluing the environmental good. The successful use of a contingent valuation method (CVM) survey to measure the value of a non-market good such as biodiversity gives policy makers an important tool in deciding how best to use scarce resources for nature protection. The uniqueness of this research was the use of a CVM survey to value management of an invasive plant.

Keywords: *Acacia saligna*, Conservation planning, Non-Market valuation, Benefit-cost analysis.

JEL Classification code: A13, Q51, Q58

1. Introduction

Since the UN Summit in Rio de Janeiro, 1992, where invasive species have come to be regarded as one of the main reasons for the loss of biodiversity (OECD 1996; Keane and Crawley 2002), economic studies have been increasingly used to justify measures to eradicate such species.

In order to create a more sophisticated decision making process, policy-makers need to consider the preferences of the citizens in their community. Because our resources are scarce, policy-makers are asked to make the most efficient choices regarding the allocation of these resources. In this context, if policy-makers decide to invest in the protection of the ecosystem against invasive species, fewer financial resources would be available for other policy areas. On the other hand, such a policy provides a wide range of benefits to society, many of which are not valued by current market prices. Given that most human activities are priced in one way or another, the temptation exists in some decision contexts to downplay or ignore these benefits based on the lack of market prices. The simplistic idea here is that a lack of prices is identical to a lack of value. This is a slightly biased perspective. The microeconomic theory of externalities tells us that many values cannot be incorporated into conventional market transactions. The question then is how to translate such values into monetary terms.

By performing a monetary value assessment of the damage caused by bio-invasions, it allows benefit-cost analysis for policy guidance and hence ranking of alternative prevention, restoration, and amelioration options. Monetary value assessment of the damage caused by bio-invasions has its foundations in welfare economics, because it establishes the concept of a bio-invasion value in terms of the impact on the welfare of human beings.

This paper focuses on the invasion of *Acacia saligna* at the Nizzanim LTER (Long Term Ecosystem Research) nature reserve, located in the southern part of Israel. The introduction of *A. saligna* from Australia into Israel was started by the British at the beginning of the 20th century and continued by the Jewish National Fund's (JNF) forestation department for over 70 years. Due to its rapid growth rate over a broad ecological range, it was chosen either for preventing erosion and Aeolian problems, such as dune mobility, or as a fodder plant in semi-arid and arid regions. Since being planted in Israeli coastal sand dunes, *A. saligna* has spread rapidly at an annual growth rate of 2.92% (Bar (Kutiel) et al. 2004). This has caused significant undesired changes, from the conservation point of view, to the a-biotic and biotic features of the ecosystem (Mehta 2000; Cohen and Bar (Kutiel) 2005) and to the regional biodiversity as a whole. High biodiversity is considered crucial for ecosystem sustainability (Tilman et al. 1996).

This research combines our ecological knowledge of the spread of an invasive plant species with known economic tools in order to answer two fundamental questions: Does the benefit of slowing its spread outweigh the costs? And what is the most cost effective method to control the spread?

In order to assess the non-market benefit of controlling bio-invasions, a contingent value methodology (CVM) study was performed. We analyzed a representative sample of both visitors and non-visitors in the nature reserve and asked for their willingness to pay (WTP) for two conservation management

programs, namely containment of the spread and eradication of the species from the nature reserve. The intention of presenting respondents with these two environmental goods was to test whether the respondents are willing to pay for a higher quality of the environmental good.

The two research questions the paper aims to answer are:

1) Is the value of the coastal sand dune biodiversity higher than the invaded sand dunes?

2) Is the value of the coastal sand dune biodiversity higher than the cost of *A. saligna* eradication?

This paper is divided into the following sections:

Following this introduction, Section 2 describes the study site; Section 3 presents the methodology implemented in this research and includes a brief literature review; Section 4 presents the results of the CVM survey; Section 5 analyzes the costs of the different conservation management programs; Section 6 compares the results of the CVM survey with the cost estimations of the management programs in a benefit-cost analysis; Section 7 summarizes and concludes the paper.

2. The study site

Nizzanim LTER coastal sand dune nature reserve is located on the Israel's southern Mediterranean coast between the cities of Ashdod and Ashkelon. The nature reserve covers an area of 20 square km and is the only large nature reserve along the Mediterranean coast in Israel that contains dunes with various levels of stabilization (Kutiel 2001). The flora and fauna is a mix of desert, psammophile, Mediterranean and generalist species. The non-stabilized and semi-stabilized dunes inhibit psammophile and xeric species, most of which originate from the Sahara and Sinai Peninsula, while the stabilized dunes inhibit mesic Mediterranean species. About 20% of the entire endemic plant species in Israel can be found along the coastal dunes, and most of them are in the Nizzanim LTER nature reserve. Likewise, the only endemic mammal in Israel, the rare and endangered *Meriones sacramenti* found only in the sands of the southern coast of Israel, in the north-western Negev and in northern Sinai, can be found in the semi-stabilized dunes at Nizzanim together with the ground beetle *Scarites striatus*, the ant beetle *Mecynotarsus bison*, the scorpion *Buthacus leptochelys*, and the sand navigator ant *Cataglyphis subulosa*, all having a distribution limited to the shifting dunes of the Middle East (the Levant) (Kutiel 2001; Ramot 2007). Species diversity and the percentage of Mediterranean species increase with increasing dune stabilization. Similarly, desert annuals and psammophiles decrease with sand stabilization (Kutiel et al. 1980; Kutiel et al. 2004a; Perry 2008).

A. saligna was planted at Nizzanim in 1962 in order to stabilize sand dunes and since then the area covered in *Acacia saligna* has increased by 166% at an annual growth rate of 2.92%. If this process continues, it is predicted that within 25 years, all of the nature reserve will be covered by this invasive species (Kutiel et al. 2004b). The *A. saligna* has caused the

stabilization of the dunes and a significant change in the flora and fauna to mostly generalists species (Cohen and Bar (Kutiel) 2005; Manor et al. 2007).

3. Research Methodology

3.1. Theoretical background

In the end, policy makers will have to make a decision on whether or not the damage caused by invasive species such as *A. saligna* justifies the expense of control. Ecologists must be able to express the benefits of the expenditure on management and conservation of ecological resources in terms of goods and services to the public (Richardson and van Wilgen 2004). While the cost of control may be simple to calculate, estimating the cost of biodiversity loss to an ecosystem may be somewhat more challenging.

One way to measure the economic benefits of the prevention of the spread of *A. saligna* would be to measure the damage that the spread does to economic goods (goods that have a market value). For instance, studies of alien plant species in South Africa have shown that these species have a major impact on the water resources of the country (van Wilgen et al. 2001). The impact of invasive species on biodiversity is more difficult to estimate because not only is biodiversity a public good but in addition, the exact economic benefit of biodiversity may be difficult to measure.

A number of methods have been developed to estimate the value of public goods such as nature reserves, parks, open spaces and biodiversity. The most common tools are the contingent valuation method (CVM) and the travel cost method (TCM) (Maille and Mendelsohn 1993; Carson 2000; Hacket 2000; Jakobsson and Dragun 2001; Carson et al. 2003; Becker et al. 2004). A recent review of 60 papers on the economic valuation of biodiversity concluded that the CVM can be an important tool in determining conservation policy as long as the surveys are carefully constructed, the respondents are appropriately informed about the environmental good and factors influencing valuation are understood (Martin-Lopez et al. 2008)

The CVM is a survey method which asks the respondent to express how much he or she is willing to pay for a non-market environmental good or service. This method is used to determine how people value environmental goods and services through direct questioning and the benefits, therefore, are measured directly. The assumption is that individuals have hidden preferences (detected from their behavior), which they will reveal when questioned about their preferences. This is the only method available to estimate non-use or passive use value (sometimes referred to as existence value first mentioned by Krutilla (1967) (Carson 2000; Jakobsson and Dragun 2001; Carson et al. 2003, Boman et al. 2008, Yacob et al. 2009). While most CVM surveys are used to measure the willingness to pay (WTP), some surveys, such as the one performed by Shrestha et al. (2007) in local communities adjacent to the Koshi Tappu Wildflife Reserve in Nepal, measures willingness to accept (WTA) and can be used to measure conservation costs. A CVM survey creates a hypothetical market by proposing possible scenarios that represent different policy actions, usually by governments. At least one scenario

represents status quo or business as usual and then one or more additional options are presented. The respondent is asked to state their preference or their WTP for a specific scenario through a hypothetical market mechanism of price (Carson 2000, Yacob et al. 2009).

Recently CVM has been used to estimate the value of the prevention or mitigation of bio-invasions. In a study by Nishizawa et al. (2006) of the Lake Biwa Japan invasion of alien fish, a WTP was found of residents of the region that equaled approximate current expenditure on alien fish mitigation. It is estimated, however that current efforts will not guarantee the spread of the bio-invasions. Therefore, currently the estimated benefit would not outweigh the cost of restoring the ecosystem. McIntosh et al. (2007) also looked at the WTP for bio-invasions prevention, but made the basic assumption that bio-invasions are inevitable. Under these assumptions, conservation efforts can only lead to a **delaying** of the inevitable invasion of alien species. Their study concluded that even under the assumption that such invasions will eventually happen, there is a positive WTP for delaying the inevitable. Passive value was recommended by Carson et al. (2001) to be taken into account provided a carefull analysis is done in order to elicit the respondents true WTP while caution might be exercised with respect to various biases (to be described later on).

Non-use value (NUV) of an environmental asset is especially important in the valuation process of environmental goods that do not attract a lot of visitors and as such, do not have a large use value. Since anyone can hold NUV, the issue of distribution of values and benefits arises. Unlike many categories of use, holders of NUV need not live in proximity or ever visit the resource in order to receive benefit. They need only information on the continued existence of the resource or the service it provides. In this sense, NUV's are purely public good values because no one can be excluded from holding them. Some studies have shown that the NUV of non-locals is considerable, in some cases higher than values (use and non-use) held by local stakeholders (Chambers and Whitehead 2003; Becker and Freeman 2009). In addition, the benefit of biodiversity conservation may be more pronounced globally than locally, while conservation costs are generally born by local populations making NUV of critical importance in valuation of biodiversity (Shrestha et al. 2007).

Notwithstanding the importance of the above issues, it is our position that while caution must be exercised in estimating and using WTP for NUVs, at the very least, they can provide robust and accurate indications of orders of magnitude. The CVM applied to non-use valuation has been incorporated in major policy frameworks worldwide and subjected to professional scrutiny (Arrow et al. 1993; REMEDE 2008). Properly designed and administered surveys can describe environmental assets accurately and frame the problem so that meaningful responses can be elicited.

3.2. Using CVM to value Nizzanim LTER nature reserve

The basic problem confronted by the research was the difficulty in explaining to the uninformed public the complexity of biodiversity loss so that informed answers could be gleaned. This may be clear-cut when it comes to how much people are willing to pay for recreational services, clean air or drinking water but it is less clear-cut when people are asked how much they are willing to pay for such a general

environmental service as the prevention of biodiversity loss. This is the question that is at the heart of the discussion on the invasion of *A. saligna* at the Nizzanim LTER nature reserve.

> *"Stated preference valuation methods require survey respondents to make well-informed value judgments on the environmental good under investigation. This requires information on unfamiliar goods to be presented to respondents in a meaningful and understandable format." (Christie et al. 2006, p. 305)*

The problem is that the general public does not have a strong understanding of biodiversity and is unaware of its importance to the ecosystem. If the respondents to a CVM survey are unaware of the importance of the good that they are being asked to value, they may not reveal a strong preference and the good may be undervalued (Carson et al. 2001; Christie et al. 2006).

In their review of CVM studies of biodiversity, Martin-Lopez et al (2008) found that WTP for species conservation can be impacted by respondent's attitudes towards specific species. The closer in similarity species are to human beings, the more likely the respondent is to place a high value on species conservation. This human tendency makes landscape valuation a more difficult task. Previous CVM studies of beach landscapes such as Blakemore and Williams' (2008) valuation of Turkish beaches and Yacob et al's (2009) study of marine parks in Madagascar emphasize the tourist (user) aspect of beach landscape preservation and less, the biodiversity conservation aspects of beach conservation.

The task of explaining to respondents the importance of protecting the sand dunes at the Nizzanim LTER nature reserve from the biological invasion of *A. saligna* within the framework of a survey was particularly challenging. The biodiversity loss is that of thinly dispersed flora and fauna thriving on sand dunes, which are being replaced by a dense cover of a non-native species of plant. For respondents, unaware of the importance of preventing the loss of native species, it was exigent to comprehend the impact of *A. saligna* on the nature reserve.

If, despite this difficulty, a positive value were found for the WTP to conserve the biodiversity of the coastal dune nature reserve, this would confirm the usefulness of the CVM method as a means to estimate the cost of biodiversity loss and damage to the coastal sand dune nature reserve in Israel from the invasion of the *A. saligna*.

Carson et al. (2001) emphasize the importance of conformity with economic theory as a confirmation of the validity of contingent value methodology. The expectation is that the results of a CVM study will conform to the predictions of economic theory. Two tests for conformity with economic predictions are suggested: (1) the number of respondents who are willing to pay for an environmental good should fall as the price increases and (2) the respondents should be willing to pay more for a higher quality or larger amount of the environmental good. In this study we took into account this issue by considering two conservation management programs which should yield different WTP.

Finally, the issue of the payment question format has sparked a great deal of interest. Open ended questions have fallen out of use in recent CVM studies. The two remaining options are payment card

(PC) and dichotomies choice (DC). While the first one asks the respondent to circle the highest WTP from a series of numbers on the card, the DC procedure asks respondents to answer only yes or no to a given bid. The bid itself changes for different sub-samples. Relating probability of "voting yes" to the bid allows the researcher to estimate the probability function and from there, the mean and median WTP as well as socio-demographic characteristics impacts on the WTP.

We used a payment card (PC) type of CVM questionnaire to estimate the total value of the conservation management programs. While the dichotomous choice option (DC) seems to be the most popular approach and the one recommended by the NOAA panel (Arrow et al. 1993), there are studies which question the assumptions by which dichotomous choice is indicated as the preferred survey method (Diamond and Housman 1994). Specifically, the assumption that people are more familiar with a situation in which a price is given and they have to "vote" to purchase by saying "yes" or "no" may be true in the United States but may prove less effective in the Middle East. PC estimates also have a tendency to yield more conservative estimates than DC models and as such provide a common platform for agreement in case of conflict between different stakeholders (Ryan et al. 2004; Blaine et al. 2005).

Recently choice modeling (CM) is being used more often to estimate the value of specific attributes (e.g., Fleischer and Sternberg, 2006). However, CM, in spite its potential cost effectiveness nature, is more suitable for a multi-policy case (due to its multi attribute analysis) while our case involves a single policy analysis.

3.3. Survey Design

The survey design consisted of the collection of background information, focus groups, questionnaire development, and pretesting. The first phase of the survey design involved meetings with stakeholder groups and an extensive literature review. Two focus groups were then held in different locations to assess the public's level of knowledge of the issue. The focus groups were also used to test specific survey materials, such as passages of text, photographs and maps. The respondents from the first focus group had a difficult time valuing the environmental good. This led the researchers to adjust the introductory explanation about the environmental good. After adjusting the explanation in the first section of the survey, the second focus group respondents had no problem responding to the valuation questions.

The survey design process continued with the drafting of the survey materials. This introduced respondents to the bio-invasion issues and ways that these problems can be managed. It also included color photos of the site. These pictures showed the current situation and hypothetical scenarios, respondents were asked to pay for later on in the survey. Peers and selected stakeholders reviewed drafts of the survey materials and provided important feedback.

The final phase of survey design involved extensive pretesting of the survey instrument. First, several cognitive interviews were conducted with respondents in a face-to face setting. Besides administration of the survey, these interviews included extensive debriefing sessions to uncover any potential

problems. In all pretesting interviews a behavioral coding technique was used to identify any problematic survey questions (Presser and Blair 1994).

3.4. Survey Implementation

There were two groups of respondents from which an overall response rate of 80% was achieved. One group consisted of 113 visitors to the Nizzanim LTER nature reserve. The second group consisted of 291 respondents from all over Israel. The purpose of surveying these two groups was to compare the answers of users and non-users. Due to incomplete surveys (52) and "protest" answers (51) , 103 surveys were removed from the data leaving 301 surveys for analysis.

3.5. Survey description

The interviews were carried out face-to-face and lasted an average of 20 minutes. The survey began with a set of questions about various current issues, and respondents' recreational activities. Respondents were then asked a series of questions relating to their understanding of the importance of bio-invasion. The interviewer asked the contingent valuation (CV) question after reiterating the management plan to respondents and reading additional text that set up the CV scenario. Following the CV question, respondents were asked questions aimed at assessing their level of understanding of the CV scenario and their reasons for their payment (or reasons for zero bidding). Owing to their sensitive nature, demographic questions were asked at the end of the interview. These variables included: gender, age, country of origin, family status (married or not), number of kids, place of residence (distance in km from nature reserve), and membership in green organization, education and income.

The willingness to pay (WTP) question was elicited in a payment card format in which a given respondent had 30 options to circle a number between 0 and 150 New Israeli Shekels (NIS) ($US 0 to $US 33). This range was based on previous analysis with the focus groups and was used for both WTP questions. Following the payment questions, the respondents were asked to circle one or more of their reasons for payments. This was done with the intention of capturing both a split in use and non-use values and also to distinguish between legitimate zeros bids and protest bids which were excluded from the final analysis. Fonta et al. (2010) emphasize the importance of removing sample bias by appropriately distinguishing legitimate zero bids from protest bids. We split the zeros into protest bids and legitimate based on the follow up question presented following the payment question for those who answered zero. This was done in order to reveal their motivation for not paying.

4. Results of the CVM survey

4.1. Respondents' demographics

Selected socioeconomic characteristics of the survey respondents are presented in Table 1 alongside results obtained regarding the overall population in Israel (Israeli Government CBS 2007). Differences between the survey sample and the general population were then corrected through the use of weighting techniques (Loomis 1996).

4.2. WTP distribution and motives

As explained earlier, we asked two WTP questions, one regarding the containment of the bio-invasion and the second about eradication of the bio-invasion. Frequency for both questions is presented in Table 2. Mean WTP for use and non-use motives for visitors and non-visitors for the two conservation management programs are presented in Table 3.

The analysis reveals that the use values of the mean WTP for visitors to the nature reserve for both conservation management programs are higher (Q1-$2.23 and Q2-$2.82) than the use values for the general population (Q1-$1.69 and Q2-$1.72). The difference suggests that visitors to the nature reserve are more likely to see the value of protecting the biodiversity of the nature reserve in terms of use value as opposed to non-use value.

Further analysis revealed that the mean WTP (use and non-use values) for visitors to the Nizzanim LTER nature reserve was higher for Question 2 (eradication) ($8.22) than for Question 1 (containment) ($6.72). The t-test confirmed the results as significant. On the other hand, we found no significant difference between the mean WTP for the general population for Questions 1 and 2. This could indicate that for the visitors in Nizzanim LTER nature reserve, there is a significant added value to eradicating the invasive plant over simple containment.

It is important to note that although the Nizzanim LTER nature reserve is a recreational site and although a quarter of the surveys were implemented in and around the nature reserve, the majority of the value of the mean amount of WTP to conserve and protect the nature reserve is due to non-use value.

In addition to discovering the economic value of the resource, the purpose of asking two "willingness to pay" questions was to test conformity with economic theory. According to Carson et al. (2001), the respondents should be willing to pay more for a higher quality or larger amount of the environmental good. Question 2 was meant to indicate a higher intensity of control used on the *A. saligna* than Question 1. The higher intensity would not only stop the spread of the invasive species (the result of Question 1) but would improve the situation by eliminating the invasive species and rehabilitating the nature reserve.

Figure 1 demonstrates that as the hypothetical price for control of the spread of *A. saligna* in Nizzanim LTER nature reserve increases, the number of respondents willing to pay for the environmental good decreases.

The CVM survey asked respondents their WTP for two different environmental goods:

> *"On the assumption that a closed public fund was established in order to finance actions that would prevent the spread of the Acacia saligna at the Nizzanim Nature Reserve and to rehabilitate the beach, choose the maximum amount of money in shekels that you would be willing to pay as an annual donation to such a fund:*

1. *In order to preserve the present situation I am willing to contribute from my pocket once a year:*
2. *In order to improve the situation, eliminate the Blue Acacia on the Nitzanim Beach and rehabilitate the nature reserve, I am willing to contribute from my pocket once a year:"*

The intention of presenting respondents with these two environmental goods, prevention of further spread of the invasive species and elimination of the invasive species, was to test whether the respondents are willing to pay for a higher quality of the environmental good. The results of this research show that the average contribution that respondents (visitors and non-visitors) were willing to pay for eliminating the *A. saligna* from Nizzanim LTER nature reserve ($8.83) was higher than the average contribution that the respondents were willing to pay for the conservation of the current situation or stopping further spread of the *A. saligna* ($8.41). However, paired t-tests did not confirm this difference to be statistically significant. Respondents may be stating WTP without regard for the amount or scope of the environmental good being offered. On the other hand, a larger mean difference was found for the WTP of visitors to the site to eradicate the species as compared to just containment. This gives some support to the idea that at least among visitors to the site, the difference between containment and eradication was clear. The implication that they were willing to pay more for the better environmental good is consistent with economic theory according to the test suggested by Carson et al. (2003).

4.3 Econometric evaluation of the CVM responses

When analyzing PC WTP data, certain assumptions must be made about the respondent's true WTP. One procedure assumes that the midpoint between the lowest and highest point in the selected range is representative (Cameron 1987). The approach has the advantage of enabling the computation of WTP directly from the data without needing to specify the functional form of the utility function or the appropriate regression model (i.e. probit or logit). The disadvantage of this approach is that it offers little information on the factors that influence WTP. For this reason, we also ran a regression of WTP on the attitudinal, behavioral and socio-economic-demographic explanatory variables. The underlying assumption is that the true WTP is uncertain and that the uncertainty is bounded by the low and high values in the selected range on the payment card. We used an ordered probit procedure (Cameron and Huppert 1989).

A full description of the variables used in the econometric estimation is given in Table 4, while results for the different regressions are presented in Tables 5 and 6. These include both non-parametric (midpoint estimate) as well as parametric (ordered probit). The estimation was done for both questions and for both samples.

One of the main advantages of using the ordered probit when the dependent variable lies within a given range, as it does in the PC technique, is that parameter estimates can be interpreted in a straightforward manner similar to ordinary least squares.

Applying the model to the estimation of the mean WTP based on the weighted average of the respective explanatory variables multiplied by their associated coefficients, we obtain by (1):

$$(1) \quad WTP_{PC} = (B_0 + \sum_{J=1}^{m} B_j X_j)$$

Where B_0 is the intercept, B_j is the parameter estimate on the j_{th} explanatory variable whose mean is denoted X_j and *m* is the number of explaining variables in the regression.

4.4. Estimating the value of the benefits due to the conservation management programs

In order to estimate the value of the site, two things needed to be determined: the number of beneficiaries and the type of value. To generalize the results, we use two types of beneficiaries, namely, entire households in Israel (2,087,000 households in 2008) and the number of visitors to the site (57,000 households). With respect to value types, we take into account both total and use only values. Table 7 presents valuation options of the Nizzanim LTER nature reserve based on the WTP of visitors and non-visitors, use value and total value (use and non-use values) for both conservation management programs. Clearly valuing the nature reserve based only on visitors WTP is a much more conservative approach to valuation of the environmental good and therefore this is the approach chosen for the final benefit-cost evaluation.

5. Cost of conservation management programs

Cost estimates for the containment and eradication of the spread of *A. saligna* at the Nizzanim LTER nature reserve were derived from an interview with Oded Cohen a PhD candidate at Ben-Gurion University on January 14th, 2007. The relevant treatments were narrowed down to the following five:

A. Cutting & clearing, spraying of stumps & sprouts
B. Cutting & burning, spraying of stumps & sprouts
C. Cutting & clearing, solar sterilization based on natural irrigation
D. Uprooting, solar sterilization based on natural irrigation
E. Uprooting, spraying stumps & sprouts

Each step of the various containment and eradication treatments were examined and cost estimations were derived from market prices. Table 8 presents the costs per acre of the individual steps that were included in at least one of the proposed treatments.

Table 9 presents the total cost of each treatment based on an aggregation of the costs of the steps included in each proposed treatment.

Table 10 presents a summary of the total costs for treating the invaded area for both containment and eradication. The total costs per acre of each eradication treatment range from $1,590 per acre for Treatment A to $774 per acre for Treatment E. It is estimated that currently the invasion of *A. saligna* is in an area of approximately 250 acres out of a total of about 5,000 acres for the whole nature reserve

(Cohen and Bar (Kutiel) 2004). In order to completely eliminate the *A. saligna* from the Nizzanim LTER nature reserve, a one-time investment would have to be made of between $193,000 and $397,000 depending on which method of treatment is chosen.

The current rate of invasion is approximately 25 acres per year. The expectation is that within 25 years the Nizzanim LTER nature reserve will be completely invaded by *A. saligna.* To contain the spread of the invasive species, maintaining the current area of invasion, 25 acres of the invasive species would need to be eradicated annually in order to achieve containment. In order to be able to compare the benefits of conservation management programs which were calculated on a one-time basis (eradication) with the costs of annual conservation management programs (containment), the total costs for containment in Table 10 were calculated by estimating the present value for each treatment over a 20 year period at 5% interest.

6. Benefit-cost analysis

In order to exercise caution in the benefit-cost analysis, we chose to compare the total benefits of the two conservation management programs derived from the mean use value and the mean total value for visitors only to the nature reserve (57,000 households), with the costs of containment and elimination of the invasive species at the reserve.

As presented in Table 7, the total benefit of containment of the invasive species to the visitors to the nature reserve based on mean use value only is estimated at $127,000, while the total benefit of eradication of the invasive species is estimated at $161,000. Comparing these economic benefits to the total economic costs of the various treatments, for containment and eradication, leads to the immediate conclusion that, in the case of use value, the benefits do not outweigh the costs.

On the other hand, comparing the total economic benefit derived from both use and non-use values of visitors in the nature reserve to the total economic costs of the various management treatments, leads to a very different conclusion. Table 7 presents the total value of containment of the invasive plant for visitors to be $406,000 and the total value of eradication of the invasive plant for visitors to be $468,000. The economic benefit of eradication of the invasive plant outweighs the economic costs for all proposed treatments. The net economic benefit for containment of the invasive plant is less straightforward as the costs of the more expensive treatments, A and B, are greater than the economic benefit from containment. Treatment C almost breaks even, while the benefit for containment is greater than the costs for the less expensive treatments D and E.

It is our conclusion that if policy makers take into account both use and non-use values of managing the invasive Acacia, they can easily justify a one-time expenditure of between $193,000 to $397,000 in order to eradicate the plant. Policy makers must be more cautious however, when weighing containment strategies. Some treatments are more expensive than others and only the use of the less expensive methods of treatment (which may possibly be less effective) produces a positive net benefit.

Table 11 presents the results of the benefit-cost analysis. Benefit is derived from the use value and from the total value (which includes both use and non-use) for visitors to the nature reserve. The range of costs for each treatment for containment and elimination are presented below the benefits. Annual containment costs have been translated into present value using a rate of 5% and a period of 20 years in order to make the total benefits comparable to total costs. Finally, costs are deducted from benefits in order to achieve net benefits.

7. Summary and conclusions

The aim of this research was to estimate the economic value of the damage caused by the invasion of Acacia saligna at the Nizzanim LTER nature reserve in Israel. Management of this invasion through containment or eradication is a non-market good. To determine the value of the non-market good, a CVM survey was implemented among a sample of visitors to the site and the general Israeli public. While CVM has been used to value a diverse set of environmental goods, such as the conservation of specific species, natural resources and landscapes, the uniqueness of this research was the use of a CVM survey to value management of an invasive plant.

The CVM survey asked respondents their WTP for two different environmental goods, containment of the spread and eradication of the species from the nature reserve. The intention of presenting respondents with these two environmental goods was to test whether the respondents are willing to pay for a higher quality of the environmental good. The results of this research show that the mean contribution that respondents were willing to pay for eliminating the *A. saligna* from the Nizzanim LTER nature reserve ($8.83) was higher than the mean contribution that the respondents were willing to pay for the conservation of the current situation or stopping further spread of the *A. saligna* ($8.41). However, this difference was not found to be statistically significant. The concern is that the respondents are stating WTP without regard for the amount or scope of the environmental good being offered. The issue of scope continues to concern CVM studies, for example, Boman et al.'s (2008) study of valuation of biodiversity in Sweden found that higher levels of biodiversity did not necessarily elicit a higher WTP. In our study, a larger mean difference was found in the WTP of visitors to the site to eradicate the species as compared to just containment. This gives some support to the idea that at least among visitors to the site, the difference between containment and eradication was clear. The implication that they were willing to pay more for the better environmental good is consistent with economic theory.

In addition to these two basic tests of conformity to economic theory, regression analysis indicates two predictors of WTP, consistent with the results of previous CVM studies, income level and membership in environmental organizations. The regression analysis revealed that a higher level of income and membership in environmental organizations were positively correlated with a higher WTP.

Our study reveals that for both those who visited Nizzanim LTER nature reserve and those who did not, the NUV or existence value of containment or eradication of the invading species is greater than

the use value. This seems to indicate that the Israeli public, both visitors and non-visitors in the nature reserve, recognize the value of conserving the nature reserve for its own sake and not simply for its utility to human beings. This is even more significant considering the fact that the invasion added more greenery and nice blooming trees to the site so that the respondents were choosing the environmental good over aesthetics. The inclusion of non-use value in the valuation of management of the invasive plant is critical in order not to undervalue this environmental good.

When the estimated total economic values based on use value alone for containment and eradication of the invasion were compared to the cost of management, the benefit-cost analysis revealed negative net benefits for the two conservation management programs. However, when the estimated total economic values based on total value (which includes use and non-use values) for containment and eradication of the invasion were compared to the cost of management, the benefit-cost analysis revealed positive net benefits for the eradication of the invasive species. In the case of containment, the benefit-cost analysis based on both use and non-use values revealed both positive and negative net benefits depending on the type of treatment used.

This study reveals the importance of CVM tool for policy makers. In the example of Nizzanim LTER nature reserve, by taking into consideration use value only in the valuation of the management of the bio-invasion, policy makers could be undervaluing the environmental good and possibly cancelling an economically sound conservation management program. CVM is the only tool available to policy makers which will allow them to take into consideration the total economic value of the environmental good and not allow undervaluation to misguide their conservation policy decisions.

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Table 1: Socioeconomic Characteristics of Survey Respondents

National Data from CBS Vs. Survey Data for Israel					
Demographics		**National**	**Total Surveyed**	**Visitors**	**Non-Visitors**
Gender	Male	49.39%	55.48%	49.44%	58.02%
	Female	50.61%	44.52%	50.56%	41.98%
Origin	Israel	71.90%	85.71%	84.27%	86.32%
	Abroad	28.10%	14.29%	15.73%	13.68%
Age	18-25	19.34%	32.23%	40.45%	28.77%
	26-35	22.42%	27.57%	22.47%	29.72%
	36-45	17.19%	22.26%	23.60%	21.70%
	46-55	16.07%	11.30%	6.74%	13.21%
	Over 55	24.97%	2.99%	2.25%	3.30%
Family	Not Married	42.96%	45.18%	53.93%	41.51%
	Married	57.04%	54.82%	46.07%	58.49%
Average Persons Per Household		3.35	3.04	2.84	3.12
Education	Not attend school	2.20%	0.00%	0.00%	0.00%
	Elementary or High School	33.30%	35.55%	35.96%	35.38%
	Vocational School	16.90%	17.61%	15.73%	18.40%
	University or Yeshiva	47.20%	42.52%	44.94%	41.51%
Income	Under Average	65.00%	64.45%	62.92%	65.09%
	Above Average	35.00%	35.55%	37.08%	34.91%

Table 2: WTP frequency

Question 1 - Containment		**Frequency**		
Bid in NIS	**Converted to US$**	**Visitors**	**Non-Visitors**	**Total**
0.00	0.00	17	37	54
5.00-30.00	1.10-6.60	40	96	136
35.00-60.00	7.70-13.20	16	33	49
65.00-90.00	13.30-19.80	1	6	7
95.00-120.00	20.90-26.40	9	30	39
125.00-150.00	27.50-33.00	6	10	16
Question 2 - Eradication		**Frequency**		
Bid in NIS	**Converted to US$**	**Visitors**	**Non-Visitors**	**Total**
0.00	0.00	17	32	49
5.00-30.00	1.10-6.60	36	100	136
35.00-60.00	7.70-13.20	19	32	51
65.00-90.00	13.30-19.80	0	12	12
95.00-120.00	20.90-26.40	7	27	34
125.00-150.00	27.50-33.00	10	9	19

Table 3: Mean WTP (use and non-use) for the two conservation management programs

WTP in US$	Q1-Containment	Q2-Eradication
Mean WTP visitors	**$6.72**	**$8.22**
Use value	$2.23	$2.82
Non-use value	$4.49	$5.40
Mean WTP Non-visitors	**$7.07**	**$7.28**
Use value	$1.69	$1.72
Non-use value	$5.38	$5.56

Table 4: Variables used in the econometric estimation

Demographic Variables	Description	Survey Variables	Regression Variables
Gender	What gender is the respondent?	Male	0
		Female	1
Age	In which age range does the respondent fall?	18-25	21.5
		26-35	30.5
		36-45	40.5
		46-55	50.5
		56-65	60.5
		Over 65	75.5
Country of birth	What is the respondent's country of birth?	Israel	1
		Other	0
Family status	Is the respondent, single, married, divorced or a widow?	Single	1
		Divorced	2
		Widow	3
		Married	4
Number of children	How many children does the respondent have?	1,2,3…	1,2,3…
Town of Residence	In what town or city does the respondent live? Each town was translated into a distance in km from the Nizzanim LTER nature reserve	Jerusalem	72
		Tel Aviv	40
		Haifa	150
		…	…
Membership in environmental organization	Is the respondent a member of an environmental organization?	No	0
		Yes	1
Level of education	What level of education has the respondent achieved?	Elementary	1
		High School	2
		Vocational	3
		University	4
Level of Income	In what level of income does the respondent place him or herself?	Under average	1
		Average	2
		Above average	3
		Far above average	3

Table 5: Regression results – general population

	Q.1		Q.2	
Variable	OLS	Ordered probit	OLS	Ordered probit
Gender	9.126 (6.249)	0.329 (0.148)*	11.263 (5.867)*	0.386 (0.148)*
Age	0.429 (0.361)	0.007 (0.009)	0.163 (0.339)	-0.001 (0.009)
Country of birth	3.589 (10.724)	-0.048 (0.251)	6.522 (10.068)	0.021 (0.251)
Family status	-1.279 (2.869)	-0.065 (0.068)	-2.774 (2.694)	-0.093 (0.067)
Number of children	-3.723 (9.237)	-0.039 (0.214)	-7.287 (8.671)	-0.113 (0.214)
Town of residence	-0.029 (0.053)	-0.001 (0.001)	-0.004 (0.049)	-0.0002 (0.001)
Membership in green organization	26.347 (12.319)*	0.705 (0.29)*	36.649 (11.565)*	0.968 (0.292)*
Education	-0.682 (3.559)	-0.014 (0.084)	-0.325 (3.341)	-0.030 (0.084)
Income	8.820 (4.651)*	0.243 (0.111)*	10.495 (4.366)*	0.294 (0.111)*
Constant	19.188 (22.204)	3.120 (0.651)*	12.976 (20.846)	3.076 (0.651)*
R^2 or Pseudo R^2	0.176	0.37	0.224	0.89
Log Likelihood		-493.668		-529.757

Standard error in parenthesis

* Indices significance at 10% level.

Table 6: Regression results – visitors

	Q.1 - Containment		Q.2 - Eradication	
Variable	OLS	Ordered probit	OLS	Ordered probit
Gender	6.926 (9.160)	0.221 (0.229)	19.494 (10.852)	0.451 (0.230)*
Age	-0.298 (0.572)	-0.003 (0.014)	-0.581 (0.678)	-0.134 (0.014)
Country of birth	-14.646 (13.459)	0.008 (0.350)	-23.805 (15.994)	-0.274 (0.342)
Family status	-4.698 (4.560)	-0.138 (0.114)	-4.017 (5.402)	-0.058 (0.114)
Number of children	-19.002 (22.987)	-0.439 (0.561)	-21.587 (27.232)	-0.296 (0.560)
Town of residence	-0.445 (0.153)*	-0.118 (0.004)*	-0.549 (0.181)*	-0.010 (0.004)*
Membership in green organization	2.429 (15.487)	0.334 (0.382)	-4.881 (1.347)*	0.118 (0.381)
Education	6.378 (6.296)	0.125 (0.158)	5.751 (7.458)	0.110 (0.158)
Income	11.831 (7.213)*	0.369 (0.184)*	13.140 (98.544)*	0.260 (0.181)*
Constant	60.367 (34.646)*	1.465 (0.878)*	76.665 (41.044)*	2.120 (0.941)*
R^2 or Pseudo R^2	0.433	0.365	0.165	0.276
Log Likelihood		-197.611		-203.662

Standard error in parenthesis

* Indices significance at 10% level.

Table 7: Value of Nizzanim LTER Nature Reserve

In thousand US $	**Q.1 -Containment**		**Q.2- Eradication**	
Value type (US $)	**Use ($2.23)**	**Total ($7.12)**	**Use ($2.82)**	**Total ($8.22)**
Visitors only (57,000 households)	127	406	161	468
Overall population (2,087,000 households)	4,646	14,858	5,886	17,153

Table 8: Costs of steps in proposed treatments

Steps	Production input	Cost per unit	No. of units	Total cost
Cutting	Person workday	$44	12	$528
Clearing	Shredding per ton	$44	8	$352
Burning	Fire truck per hour	$44	4	$176
	Bulldozer per hour	$36	4	$143
Uprooting	Bulldozer per hour	$36	4	$143
Defoliation	Herbicide (stumps & sprouts) per acre	$58	1	$58
	Herbicide (sprouts) per acre	$44	1	$44
	Annual repeat treatment	$40	PV - 20 years 5% interest	$494
Solar sterilization	Person workday	$44	2	$88
	Polyethylene Sheets per acre	$246	1	$246
Misc/Unexpected	10% of total costs per treatment per acre	~10%	1	Varies per treatment

Table 9: Costs of proposed treatments of the *A. saligna* bio-invasion per acre

In US$			**Treatments:**				
			A	**B**	**C**	**D**	**E**
Steps:	**Requirements**	**Cost per acre**	Cutting & clearing, defoliation of stumps &sprouts	Cutting & burning, defoliation of stumps &sprouts	Cutting & burning, solar sterilization based on natural irrigation	Uprooting, solar sterilization based on natural irrigation	Uprooting, defoliation of stumps & sprouts
Cutting	Work days	528	528	528	528		
Clearing	Branch Shredder rental & transport	352	352				
Burning	Fire Truck and Fireman	176		176	176	176	
	Bulldozer rental	143		143	143	143	
Uprooting	Bulldozer rental	143				143	143
Defoliation	Herbicide (stumps and sprouts)	58	58				58
	Herbicide (sprouts)	44		44			
	Annual repeat treatment (NPV 20 years 5%)	494	494	494			494
Solar sterilization	Work days	88			88	88	
	Polyethylene sheets	246			246	246	
Miscellaneous & unexpected			158	158	132	87	79
Total Cost of Program per acre			**1,590**	**1,543**	**1,313**	**884**	**774**

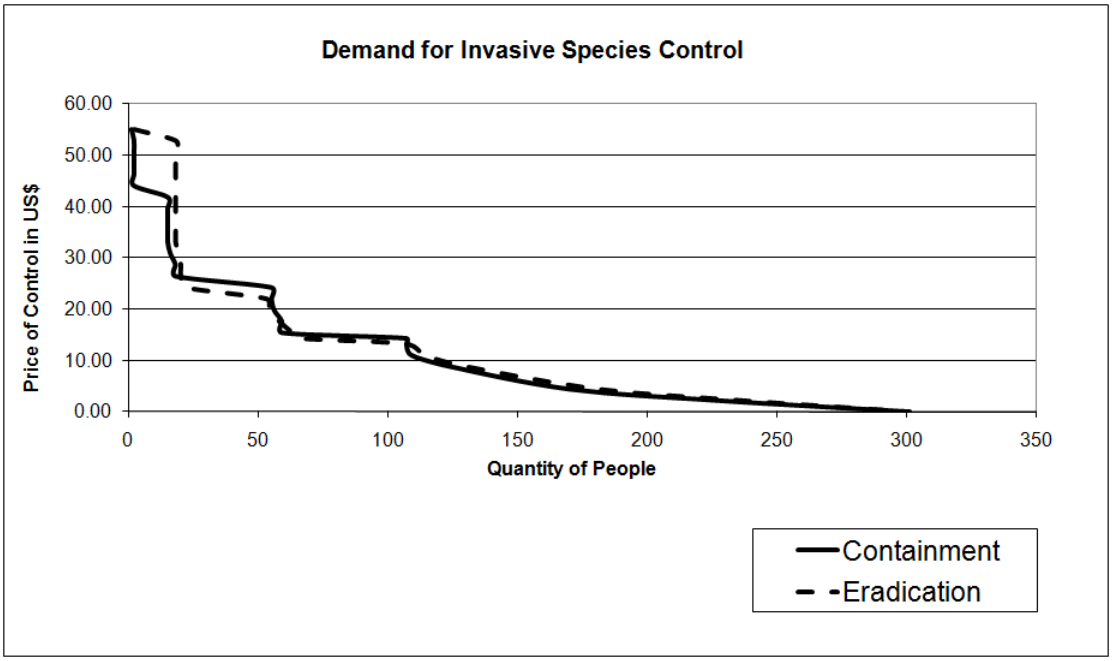
Table 10: Summary of total costs of treatments for both conservation management programs

Treatments ***(costs in US $)***		**Containment (PV of annual)**	**Eradication (one time)**
A	Cutting & clearing, defoliation of stumps and sprouts	495,368	397,496
B	Cutting & burning, defoliation of stumps & sprouts	480,700	385,726
C	Cutting & burning, solar sterilization based on natural irrigation	409,197	328,350
D	Uprooting, solar sterilization based on natural irrigation	275,539	221,100
E	Uprooting, defoliation of stumps & sprouts	241,076	193,446

Table 11: Benefit-cost analysis of the two conservation management programs for visitors to the nature reserve

In US $	**Containment**		**Eradication**	
	Use-Value	**Total Value**	**Use-Value**	**Total Value**
Benefit	2.23	7.12	2.82	8.22
No. of annual visitors to nature reserve (households)	57,000	57,000	57,000	57,000
Total Benefit	127,110	405,840	160,740	468,540
Cost				
Treatment	**Total Cost**	**Total Cost**	**Total Cost**	**Total Cost**
A - Cutting & clearing, defoliation of stumps and sprouts	495,368	495,368	397,496	397,496
B - Cutting & burning, defoliation of stumps & sprouts	480,700	480,700	385,726	385,726
C - Cutting & burning, solar sterilization based on natural irrigation	409,197	409,197	328,350	328,350
D - Uprooting, solar sterilization based on natural irrigation	275,539	275,539	221,100	221,100
E - Uprooting, defoliation of stumps & sprouts	241,076	241,076	193,446	193,446
Net Benefit (Benefit - Cost)				
Treatment	**Net Benefit**	**Net Benefit**	**Net Benefit**	**Net Benefit**
A - Cutting & clearing, defoliation of stumps and sprouts	-368,258	-89,528	-236,756	71,044
B - Cutting & burning, defoliation of stumps & sprouts	-353,590	-74,860	-224,986	82,814
C - Cutting & burning, solar sterilization based on natural irrigation	-282,087	-3,357	-167,610	140,190
D - Uprooting, solar sterilization based on natural irrigation	-148,429	130,301	-60,360	247,440
E - Uprooting, defoliation of stumps & sprouts	-113,966	164,764	-32,706	275,094

Figure 1: Demand curve for invasive species control



Appendix 1

Willingness to Pay Survey of the Protection of the Nizzanim Nature Reserve

Greetings,

Background to the Survey:

Israeli beaches, which are an integral part of Israel's landscape, are slowly disappearing. In another 20 years, the rate of growth of building and development in the coastal area will leave the State of Israel, out of the current 200 square kilometers, only 45 square kilometers of natural beaches. The Nizzanim Nature Reserve is among the last beaches in Israel, which are preserved in their natural state. At the Nizzanim Nature Reserve, it is still possible to observe natural habitats, special native plants and animals like gerbils, lizards, antelope, foxes and plants that are characteristic of the beach. Today there is a new danger to the Nizzanim Nature Reserve – the spread of an invasive species, the Blue Acacia tree.

The Spread of the Blue Acacia Tree:

The Blue Acacia tree was imported to Israel from Australia at the beginning of the last century by the British in order to reforest and stabilize lands. In the 1960's, the Jewish National Fund used the Blue Acacia tree in order to stabilize sand dunes at the Nizzanim Nature Reserve. The Blue Acacia tree is known around the world as an invasive species, a species which when imported to an foreign environment, quickly adapts to the new environment and due to the absence of natural enemies, spreads rapidly and in a relatively short time replaces the native species in the area. The Acacia is spreading at the Nizzanim Nature Reserve, replacing native species at the rate of 3% a year.

What is an Invasive Species?:

An invasive species is a species that comes from another land. The process of the spread of an invasive species limits the habitats of native species in Israel and therefore threatens their continued survival. Because of our special climatic conditions, the State of Israel is blessed with an especially high level of biodiversity, including many species that are not found anywhere else in the world. The spread of invasive species endangers the continued existence of native species, turning the natural landscape into a monotonous landscape and possibly causing the collapse of entire ecosystems. At the Nizzanim Nature Reserve, we are witnessing the spread of an invasive species, the Blue Acacia tree, that enables the entrance of plants and animals that characterize an damaged ecosystem and not a natural one that is characteristic of the sand park.

Prevention of the Spread of the Blue Acacia

There are methods the prevent the spread of the Blue Acacia tree and even to totally eradicate the species at the Nizzanim Nature Reserve. It is difficult to control the Acacia once it has taken over the area. It is relatively easier to take care of the problem at the earlier stages of the invasion but expensive resources are necessary. Policy makers are interested in knowing whether or not the public benefit of

investing in control of the Blue Acacia is worth the cost? You are asked to help policy makers by filling out the following survey that tries to reveal the public willingness to support actions that will save the sand dunes and the native species at the Nizzanim Nature Reserve.

In order to estimate the amount of benefit to the public of preventing the spread of the Blue Acacia tree and the restoration of the Nizzanim Nature Reserve, we would like you to answer the following questions. While answering, please consider your financial limitations and the fact that you may have other environmental and social goals that are at least as important to you.

Before you are three pictures of the Nizzanim landscape:

A) Picture A is of the Nizzanim Nature Reserve area where the Blue Acacia has not spread and the native habitat's still dominate the beach.

B) Picture B is of the Nizzanim Nature Reserve area under the current circumstances where the Blue Acacia has spread over about 30% of the natural sand dunes.

C) Picture C is of the Nizzanim Nature Reserve area in another 20 years when the Blue Acacia will have spread over 90% of the sand dunes and the native species will no longer dominate the beach.

Under the assumption that a designated public fund is created for the purpose of financing programs to prevent the spread of the Blue Acacia tree on the Nizzanim Nature Reserve and the restoration of the beach, what is the maximum amount of money in shekels that you would be willing to pay as an contribution to this fund:

1) In order to preserve the present situation, I would be willing to contribute from my own pocket once a year in NIS:

0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00 45.00 50.00
55.00 60.00 65.00 70.00 75.00 80.00 85.00 90.00 95.00 100.00 105.00 110.00 115.00
120.00 125.00 130.00 135.00 140.00 145.00 150.00

Another sum_____ Not enough information_____

2) In order to improve the present situation, eliminate the Blue Acacia tree at the Nizzanim Nature Reserve and restore the reserve, I would be wiling to contribute from my own pocket once a year in NIS:

0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00 45.00 50.00
55.00 60.00 65.00 70.00 75.00 80.00 85.00 90.00 95.00 100.00 105.00 110.00 115.00
120.00 125.00 130.00 135.00 140.00 145.00 150.00

Another sum_____ Not enough information_____

Please choose the best explanation for why you answered as you did:

A) I identify in general with the goal of environmental protection and nature in Israel and it is important to me that the Nizzanim Nature Reserve remains a special place.

B) I am a frequent visitor at the Nizzanim Nature Reserve and want to protect the natural landscape of the beach.

C) I do not see a real difference between the Blue Acacia tree and other trees, therefore I am not ready to spend money in order to prevent its spread.

D) Protecting plants and natural animal habitats is not important enough to me in order to spend money on this.

E) I am willing to pay money to prevent the spread of the Blue Acacia tree and to restore the Nizzanim Nature Reserve in order to guarantee that my children and my children's children the opportunity to enjoy the natural landscape of the beach in the future.

F) It is not my responsibility to pay from my own pocket for the prevention of the spread of the Blue Acacia and for the restoration of the Nizzanim Nature Reserve.

G) The value of nature is impossible to estimate in terms of money (priceless) therefore I am not willing to set a price for the prevention of the spread of the Blue Acacia and restoration of the Nizzanim Nature Reserve.

H) I would like to guarantee for myself the option to enjoy in the future the natural landscape of the Nizzanim Nature Reserve.

I) Other_____
_____

Finally, we would appreciate it if you could give us the following personal details:

1) Male/Female_____

2) Age a. 18-25 b. 26-35 c. 36-45 d. 46-55 e. 56-65 f. over 65

3) Place of birth:_____

4) Family status:_____

5) Number of children;_____

6) City or town of residence:_____

7) Membership in an environmental organization (if yes, please indicate the name of the organization:_____

8) Education: a. elementary b. high school c. technical college d. university

9) Income (the average monthly income for a family in Israel is 10,000 NIS and for an individual is 7,000 NIS):
a. below average b. average c. above average d. very much above average

Thank you for your cooperation