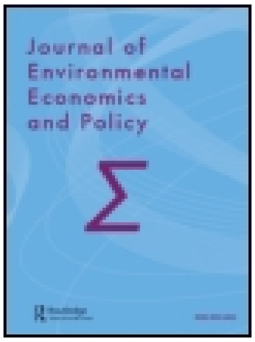

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Valuing trade-offs between local forest uses and environmental services in Tunisia

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ABSTRACT

Successive afforestation programmes undertaken in Tunisia have doubled the forest surface area in the last 50 years. A choice experiment exercise was used to estimate the social welfare associated with a plantation programme in Tunisia. The application dealt with different environmental services, and access of local users to the forest. The results show that having access to the forests for recreational activities has an average willingness to pay of 6.46 Tunisian dinar (TND) per person and year, for five years. In contrast, limiting access to the afforested areas for grazing and other uses decreases the overall welfare by 5.63 TND per person and year. An individual marginal value of 4.29×10^{-5} TND per ton of CO_2 sequestered was obtained. Furthermore, a 1% decrease of dam sedimentation is worth 2.16 TND per person and year. However, results are subject to heterogeneity, particularly regarding rural and urban populations. This paper highlights that preferences for environmental services depend on socio-economic attributes, the welfare of local users could lower due to restricted access to the forest. It was found that population heterogeneity influenced the valuation results and is to be considered in policy designs based on this type of studies.

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Valuation; forest valuation; choice experiment

1. Introduction

Successive afforestation programmes were undertaken in Tunisia since the mid-twentieth century. As a result, the forest area in the country attained 1.2 million ha by 2010 (DGF 2010), which doubled the forest surface area the country had in 1962 (Auclair 2001). The last afforestation programme running from 2007 to 2011 aimed at increasing the forest area by 150,000 ha, with an estimated total cost of 150 million Tunisian dinar (TND) (MARH 2007), with 1 euro = 1.80 TND in 2008. During the period 2001–2010, forest investments constituted around 0.6% of all public investments used in Tunisia's development programmes (Ministry of Agriculture 2013).

It was expected that the new forests would increase the social welfare by providing additional environmental services, while on the other hand it could also result in increased costs related to the risk of forest fires and a land temporary access prohibition of local communities to protect young forest plantations. From an economic perspective, an afforestation programme would be desirable if the expected social benefits outweighed the expected social costs. Furthermore, it would be of interest to explore how the costs and benefits are distributed amongst the Tunisian population. The latter

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information would help decision makers understand how an afforestation programme would impact the redistribution of welfare.

Some studies have attempted to estimate the value of different forest services in Tunisia (Cesaro et al. 1998; Daly-Hassen and Ben Mansoura 2005; Daly-Hassen et al. 2012; Masiero, Pettenella, and Secco, 2016). Cesaro et al. (1998) used different methods to estimate benefits related to forestry and soil conservation projects in two watershed areas. The methods were benefit transfer for recreation, costs of reducing carbon emissions for carbon sequestration, and avoided loss of production for valuing reduced dam sedimentation and flooding risk. Also, Daly-Hassen and Ben Mansoura (2005) applied similar methods to assess recreation, soil erosion and carbon sequestration. The authors reported that, according to their estimates, the benefits accounted for less than half of those obtained from grazing and other non-wood products collected by local inhabitants. A third study focused on the generation of environmental benefits in Barbara watershed (World Bank 2010). The authors used market prices to estimate the value of carbon sequestration, and replacement costs for the provision of fresh water. More recently, Masiero, Pettenella, and Secco (2016) used the market price method to estimate values of wood, non-wood forest products, and carbon for Mediterranean countries.

The diversity of valuation methods applied makes the comparison of results difficult, even within the same study. Furthermore, in most cases the heterogeneity of preferences among different population groups was not explored; for instance, rural and urban populations may not share the same preferences with regard to the afforestation of the countryside. The spatial heterogeneity topic has been examined in different valuation studies, including forestry or forest related goods, and it is often regarded as of particular interest for policy making (see, for instance, Bateman 2002; Voces González, Díaz Balteiro, and López-Peredo Martínez 2010; Termansen, McCleanb, and Søndergaard Jensen 2013; Elberg Nielsen, Hedemark Lundhede, and Bredahl Jacobsen 2016).

Thus, the aim of this paper is twofold. First, to provide an estimation of the value and relative importance of a fairly large number of ecosystem services and impacts generated by a Tunisian afforestation programme – more specifically, biodiversity, carbon sequestration, erosion prevention, recreation – and risk of forest fires and limitation of access rights, as will be detailed later, using the same method, choice experiment (CE). The second aim is to explore whether there is a significant heterogeneity, particularly between the rural population where the afforestation is implemented and the urban inhabitants: non-market benefits can be perceived differently by the rural population, who may bear a burden from changes in their rights of access to the countryside.

The rest of the paper is organised as follows. Section 2 provides some background information on Tunisian forestry and a description of forest environmental services and other forest attributes. Section 3 describes the methodology and presents the survey application, questionnaire, and interviews. Section 4 summarises the main results of the study. Finally, Section 5 discusses the findings and highlights the main conclusions.

2. Background

In 2000, forest land in Tunisia covered a surface area of 1.1 million ha, which represents 7% of the country surface area (DGF 2010). Most forested area is under public ownership, while only a small fraction representing about 5% is privately owned. The main forest species are Aleppo pine (53%), cork oak (10%), acacia species (7%) and eucalypt species (6%). Forests are mainly located in the North and West of the country: 42% in the North-West, 26% in the North-East, 27% in the Centre-West, and 5% in the rest of the country (DGF 2010). The most important programmes of forest plantations were implemented between 1990 and 2010. In fact, the surface area of forest and shrubs has increased by 17,800 ha per year on average between 1990 and 2000, according to forest inventories (DGF 2010 and DGF 1995). This extension of forest area is located in the North-West (38%), Centre-West (27%), North-East (17%), South-West (8%), South-East (7%) and Centre-East (3%). In the South, and despite affecting a limited surface area in absolute terms, forest plantations have contributed to multiply by six the initial surface area existing in 1990. During the last decade (between 2000 and 2010), a surface area of nearly 185,000 ha was planted with forest and pastoral tree species (FAO 2010).

The most important market products are cork and wood – their overall direct forest contribution to the gross domestic product (GDP) accounted for 0.02% in 2010 (Daly-Hassen et al. 2012). However, some products, like firewood, grazing, or forest fruits, are consumed locally without being transacted in a market. Furthermore, Tunisian forests provide other valuable services that generate welfare, but are not accounted in the country's GDP. Such provision is one of the purposes of the public forest management policy.

Afforestation programmes are paid from public funds, with the exception of some public–private partnership contracts. In the 1960s, the afforestation was mainly driven by the need of increased wood production. However, the low productivity of Tunisian forests has made this objective less prominent, and the official management priorities have been shifting from timber production to environmental protection, other non-wood forest goods production (cork, fruits, mushrooms, and alike) and recreation, especially in the 2000s (DGF/FAO 2005).

Afforestation programmes aim at improving soil protection, carbon sequestration, biodiversity, recreation, and forage production. Nevertheless, their implementation conveys a risk of forest fires, and implies restrictions on the access to local forest uses for the first 5 or 10 years (such as grazing, and the collection of firewood and non-wood forest products), to increase the survival probabilities of the young plantation. These ecosystem services and negative impacts are shortly described in the following paragraphs.

Soil erosion is considered an important environmental problem in Tunisia. It was estimated that erosion processes affected about 3 million ha in 2003 (MARH 2007). In this respect, dense forest cover can significantly contribute to mitigate the problem. Soil erosion on forested land is almost negligible, with an annual soil loss of 0.01–1.5 tons/ha (FAO 1994; Hadri and Tschinkel 1976), while on agricultural land the annual soil loss can ascend up to 24.6 tons/ha (Hadri and Tschinkel 1976).

Concerning carbon sequestration, forests help to reduce the quantity of carbon dioxide (CO_2) in the atmosphere. It was estimated that the total net emission of CO_2 in Tunisia for 2008 was 25.5 million tons, which is approximately 2.5 tons/habitant (ANME 2010). On the other hand, the average amount of CO_2 sequestered per ha of forest area was around 2.5 tons per year (DGF 2005), which approximately offsets the annual emissions of CO_2 per inhabitant.

Forest ecosystems are considered key habitats for some fauna and flora. There is evidence that larger forest areas tend to have more species diversity. For instance, Arrhenius proposed an equation in exponential form of the number of species in relation to the size of forest area that can be applied to plants and animals (Rosenzweig 2007). From this equation, it is estimated that the afforestation programme (150,000 ha) would increase the number of species by 2%.

In addition, there is an increased demand for recreational services in Tunisian forest. For example, the number of visitors to different parks has increased from 93,000 visitors in 1998 (Daly and Ben Mansoura 2005) to 110,000 visitors in 2014 (DGF personal communication), despite the administrative authorisation required.

Forest local communities living within or up to 5 km in the vicinity of forest areas, represent 7% of the total Tunisian population (750,000 people) (FAO/DGF 2012). Local inhabitants are officially designated as 'forest users', with some legal use rights, like the collection of deadwood and brushwood, grazing in permitted areas and non-commercial use of other forest products. Many rely on forest resources to fulfil most of their daily basic needs. Nearly, one-third of their income comes from the use of forest resources (grazing livestock, fuel wood and fruits collection, charcoal and honey production) and forest employment (FAO/DGF 2012). Forage provided by forests and woodlands constitute the most important income benefit, followed by remunerations from forest employment. Grazing, however, is restricted for the first 5–10 years together with other uses, to protect the young plantation, causing a temporary decrease of the benefits for the neighbouring population (most new plantations take place in grazing land). For the purpose of this paper, the rural population is composed by people not living in cities, and includes the local forest communities. While the urban population (7.5 million in 2014, according to official statistics) can be interested directly in recreation, the rural population (3.5 million) is probably more concerned with the reduction of erosion and the direct use of forest goods.

Forest fires are a permanent threat for the forest stands. Nevertheless, the burnt surface areas are in continuous reduction, which can partly be explained by efficient firefighting measures. About 300,000 ha were burnt between 1900 and 1950, and 50,000 ha during the last 50 years (DGF, Internal database). Based on this trend, the burnt area would attain 2% of the planted surface area in the next 50 years, although the percentage could decrease if more resources are devoted to fire prevention and abatement.

3. Methodology

3.1. Choice experiment

CE is a valuation technique that is increasingly used to estimate the value of ecosystem services. CE is a survey-based valuation method that belongs to the group of stated preference methods (Hensher, Rose, and Greene 2005). This method conforms with the economic notion that the value placed on a good is a reflection of its characteristics or attributes (Lancaster 1966), which permits the estimation of the value of changes in these characteristics.

In the CE approach, goods are described as a collection of attributes. By varying the attribute levels, different good bundles (alternatives) are created. Survey respondents face different alternatives, usually with one of them representing the current state (BAU or business as usual) and the rest indicating possible scenarios with different levels of attributes. Typically, each alternative is appended with a monetary attribute, which represents an amount that would have to be allocated for the selected scenario. Alternatives, including BAU, that are presented to the respondent simultaneously, constitute a so called choice set. In the survey, respondents are asked to choose the most preferred alternative. Thus, when individuals make their choice, they implicitly reflect the trade-offs between the levels of the attributes in the different alternatives presented in a choice set, including the monetary cost attached to the alternative. In this study, each choice set was composed of BAU and two afforestation alternatives.

CE is based on the random utility maximisation (RUM) model (McFadden 1974). Under RUM, the indirect utility function for each respondent can be expressed as follows:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{1}$$

where U_{ij} is the utility of individual i for choosing alternative j, V_{ij} is the deterministic component of the utility, and ε_{ij} is a stochastic component that represents influences on individual choices that are not observed by the researcher but are known to the individual.

The probability P that any particular respondent prefers alternative j to any other alternative k in the choice set equals the probability that the utility of this alternative exceeds the level of utility associated with other alternatives (Louviere, Hensher, and Joffre 2000), i.e.

$$P_j = P\left(U_j > U_k\right) = P\left(V_{ij} + \varepsilon_j > V_{ik} + \varepsilon_k\right) = P\left(V_{ij} + \varepsilon_j - V_{ik} + \varepsilon_k\right) > 0; \forall j \neq k \varepsilon C \tag{2}$$

where C is a set of all possible alternatives.

Depending on the assumption of the distribution of (2), different regression models can be estimated, usually by means of a maximum-likelihood approximation (Louviere, Hensher, and Joffre 2000). The multinomial logit model is one of the commonly applied specifications used in CE exercises (Hensher, Rose, and Greene 2005; Kaval et al. 2016). A limitation of this model is that the selection from the choice sets must comply with the independence of irrelevant alternatives (IIA) assumption (Louviere, Hensher, and Joffre 2000). This assumption states that the relative probabilities of two alternatives being selected are not affected by the presence or absence of other alternatives in the choice set. There are various statistical tests that can be applied to test the IIA assumption. Its compliance can be tested following, for example, Hausman and McFadden (1984). If a violation of the IIA assumption is observed, other statistical models can be applied, e.g. a nested logit model, a latent class model, or a random parameter logit model (Train 2003).

A random parameter or mixed logit model is a multinomial logit probability derivation. It is based on random coefficients, generalizing the conditional logit model by the introduction of unobserved preference heterogeneity through the parameters (Train 1998). The latent class approach probabilistically assigns individuals to classes, where preferences are heterogeneous across classes, but homogeneous within each class. A nested logit uses a hierarchical structure with different levels when modelling the reported choices, as explained in more detail below. All three models overcome the IIA problem, and cope with the type of heterogeneity discussed in this study a bit differently (Greene and Hensher 2003) – while the random parameter model does it by assuming a continuous distribution of the parameters, and the latent class model uses discrete classes to reach this objective, the nested logit model relies on the interactions among attributes and characteristics to capture the observed heterogeneity, adding the unobserved one to the error term.

In this study, a multinomial logit model was initially applied to detect the relationships between the attribute levels and the probability of choosing a particular alternative. The Hausman and McFadden (1984) test rejected the IIA assumption at the 0.1% significance level. To overcome the problem, the study focused on the alternative models. The one yielding the best statistical Akaike and Bayesian information criterion values in this particular study was the nested logit model.

A nested logit model is appropriate when the set of alternatives faced by a decision maker can be partitioned into subsets, called nests, where, for any two alternatives that are in the same nest, the ratio of probabilities is independent of the attributes or existence of all other alternatives, i.e. IIA holds within each nest. On the other hand, the ratio of probabilities for any two alternatives in different nests can depend on the attributes of other alternatives in the two nests, i.e. IIA does not hold in general for alternatives in different nests. For example, in this study it was assumed that respondents would consider the different afforestation alternatives as similar (see Figure 1); therefore, they could be placed into the same nest (IIA holds among them). Furthermore, the no afforestation alternative (BAU) was considered as different, with IIA not holding between this and the rest of the alternatives in the choice set. With this structure, there are only two choice alternatives at each level and the issue of 'irrelevant alternatives' is no longer a problem.

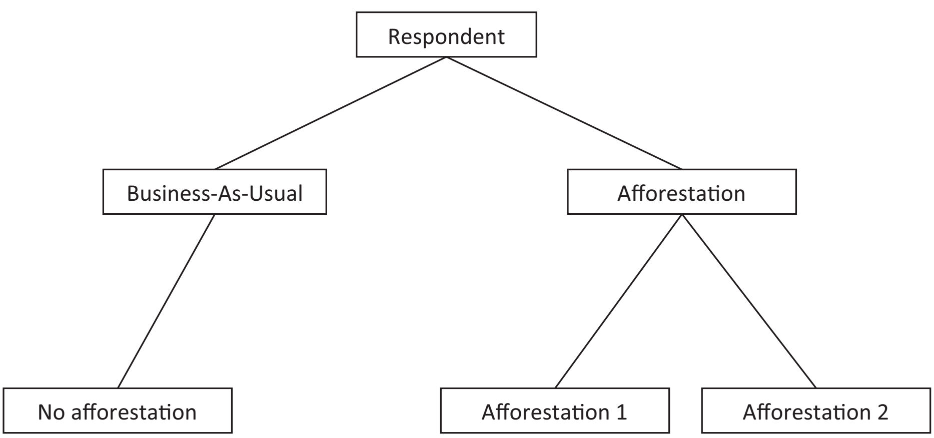

Figure 1. Structure of the used nested logit model.

Following the structure shown in Figure 1, it was further assumed that the selection of the preferred alternative was performed in two steps. In the first step (upper level), respondents choose whether they would support an increase in the forest area (afforestation) or rather to continue with BAU. In the second step (lower level), conditional on supporting the afforestation programme, the choice is between the two afforestation alternatives presented in the choice set.

The utility function associated with the upper-level choice was assumed to be dependent on the respondent's socio-economic characteristics, like age, gender, place of residence, income level, which can interact with the attributes, as detailed in Section 4. The utility function for the upper level can be written as

$$U(\mathrm{BAU}) = \beta_{\mathrm{GENDER}} \cdot \mathrm{GENDER} + \beta_{\mathrm{AGE}} \cdot \mathrm{AGE} + \beta_{\mathrm{SUPP}} \cdot \mathrm{SUPPORT} + \beta_{\mathrm{INCO_LOW}} \cdot \mathrm{INCOME\_LOW} + \beta_{\mathrm{NW}} \cdot \mathrm{NW} + \beta_{\mathrm{URB}} \cdot \mathrm{URBAN}, \tag{3}$$

where U(BAU) denotes the utility obtained from BAU, and the β parameters express, in this instance, the impact of some socio-economic variables on the utility.

At the lower level, the utility associated with each of the afforestation alternatives was assumed to be influenced by the attributes and their corresponding levels. Thus, the utility for option j is given by

$$U_j = \beta_{\mathrm{BIOD}} \cdot \mathrm{BIODIVERSITY} + \beta_{\mathrm{CARBON}} \cdot \mathrm{CARBON} + \beta_{\mathrm{FIRE}} \cdot \mathrm{FIRE} + \beta_{\mathrm{ERO}} \cdot \mathrm{EROSION} + \beta_{\mathrm{RECR}} \cdot \mathrm{RECREATION} + \beta_{\mathrm{ACCESS}} \cdot \mathrm{ACCESS} + \beta_{\mathrm{PAY}} \cdot \mathrm{PAYMENT}. \tag{4}$$

Louviere, Hensher, and Joffre (2000) show that if price is one of the included attributes, estimates of consumers' surplus associated with the changes in the levels of another attribute can be derived from the estimated regression model. This is based on the interpretation of the parameter of price as the marginal utility of income. For example, the implicit value (willingness to pay) for attribute a in a linear additive specification is calculated as

$$p_a = -\beta_a / \beta_{\mathrm{PAYMENT}}, \tag{5}$$

where β_{PAYMENT} is the parameter estimate of the price variable (in this case PAYMENT), and β_a is the parameter estimate for the attribute a. For non-linear specifications, see, e.g., Riera et al. (2012), and Mogas, Riera, and Bennett (2006) in a forestry application study.

3.2. Questionnaire

The questionnaire scenario was inspired on the XIth National Development Plan (2007–2011), an afforestation programme prepared by the Tunisian forest administration (MARH 2007). The questionnaire explained that the Tunisian administration was considering the afforestation of 150,000 ha of marginal agricultural land within the following five years. Following the Plan main purposes, the questionnaire was not focusing on the commercial wood production of the new native forests, but on other benefits, like reducing soil erosion, increasing carbon sequestration, enhancing biodiversity, and recreation. However, the implementation of the afforestation programme would restrict, for a certain period, the access to the afforested area. This would mostly affect the neighbouring population, limiting their use of forests for grazing and collection of fuel wood and other products. Additionally, the afforestation would convey a risk of forest fire. The first part of the questionnaire described these attributes. In addition, it was indicated that payments would be compulsory from next year and will be spread over 5 years for all Tunisian residents as a green tax.

The central part contained the choice questions. Table 1 summarises the choice set attributes included. Quantitative attributes erosion, CO_2, biodiversity and fire had three levels – the BAU level

Table 1. Attributes and levels of the choice exercise.

Attribute	Description	BAU (without programme)	With afforestation programme (intermediate situation and whole programme)
BIODIVERSITY	Increase of fauna and flora species by *x*%	0%	1%, 2%
CARBON	Carbon sequestered as produced by xxx residents per year	0	75,000, 150,000
FIRE	Percentage of planted area affected by forest fires in 50 years' time	0%	1%, 2%
EROSION	Reduction of negative impacts of erosion by x%	0%	4%, 8%
RECREATION	Possibility or not for allowing recreation activities in the planted forest areas	No	Yes, No
ACCESS	Possibility or not to access to the planted forest areas for grazing and other uses	No	Yes, No
PAYMENT	The required payment per person per year during 5 years for the afforestation programme	0 TND	10 TND, 20 TND, 30 TND, 40 TND

and two more – while Payment had four in addition to the zero payment for the BAU option. Qualitative attribute recreation and access to forest uses had two levels, reflecting whether the activities were allowed. The payment levels, expressed in local TND currency, were determined after a pilot study in which different amounts of willingness to pay were tested.

Each combination of attribute levels constitutes an alternative. Excluding the BAU levels there were 256 ($2^6 \times 4$) possible combinations. In order to make the survey easier to implement, a main-effects fractional factorial orthogonal design allowing for two-way interactions (Hensher, Rose, and Greene 2005) was implemented, reducing to 64 the number of alternatives to be included in the questionnaire. JMP software (SAS Institute Inc., Cary, NC, 1989–2007) was used to obtain the design, including the assignation of alternatives to each choice set. Figure 2 reproduces a choice set example with the BAU option and two afforestation alternatives (options A and B). Four different choice sets were presented to each respondent, yielding eight questionnaire versions. The final part of the questionnaire contained some debriefing and socioeconomic questions.

Table 2 shows the socioeconomic variables finally included in the model estimation.

3.3. Survey

Different versions of the questionnaire were tested in focus groups (resource persons, individuals) and a pilot survey (general population), in preparation for the final questionnaire. The main survey was implemented in Tunisia during 2008. Interviews were conducted face to face, with a typical duration of 25 min. Residents of 20 years of age or above were considered. The sample included a total of 558 individuals.

The sample followed a mixture of randomness selection and representative quotas of age brackets, gender, occupation, region/sub-region and territory of residence to attain representativeness. The interviewers visited rural and urban areas in different regions of the country, and attempted to fill the number of questionnaire by category combining random walks with quotas. Specifically, 63% of the sample was from urban areas, and 37% from rural areas. Regionally, 21% resided in Great Tunis, 14% in the North East, 15% in the North West, 21% in the Centre East, 14% in the Centre West, 8% in the South East, and 7% in the South West. Urban dwellers are more concentrated in the Great Tunis region (32%) and the East of the country (North East (13%), Centre East (26%), and South East (10%)). Rural dwellers, on the other hand, are mainly located in the North and the Centre of the country (North East (16% of the rural dwellers), North West (21%), Centre East (19%), and Centre west (26%)). Table 3 shows the correspondence between sample and population figures for different variables.

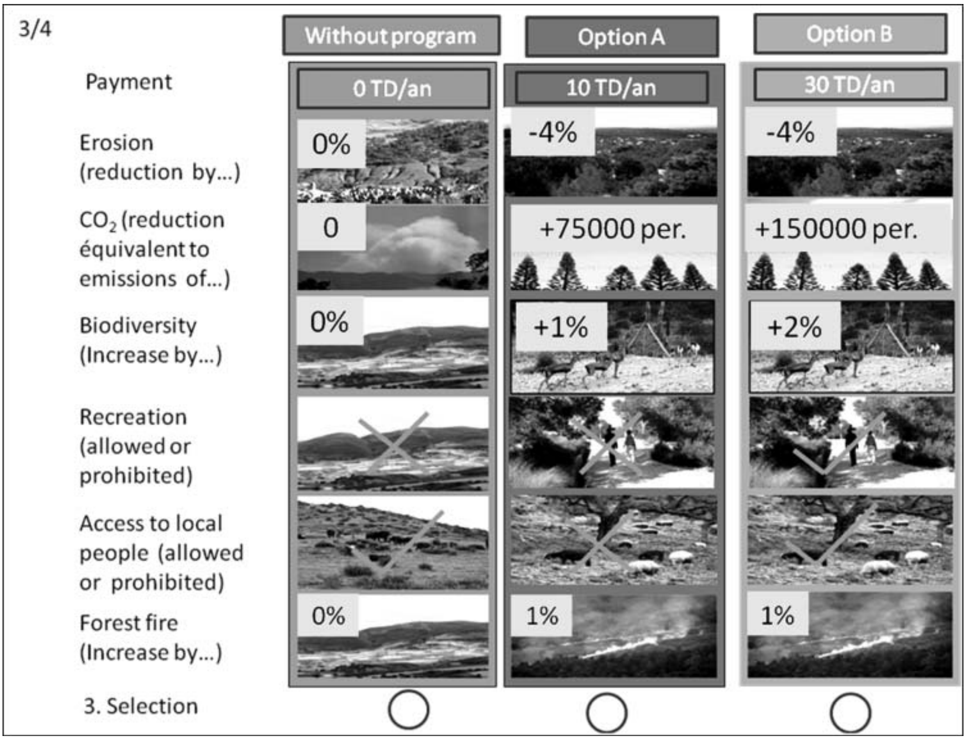

Figure 2. Choice set example from one of the questionnaires.

The sample also followed the proportion of economically active population. In 2004, Tunisia had a population of 6.2 million aged 20 or more years; the active population represented half of them. Interviews were conducted in Arabic.

4. Results

4.1. Descriptive analysis

Out of the 558 persons contacted, 21 did not complete the questionnaire. Additionally, 14 individuals refused the exercise or said not to be confident enough with their answers. Finally, 76 protested the payment scenario, because they considered it was the Government who should cover the cost with its current budget. Thus, 447 valid and completed interviews were obtained, which corresponds to 1788 choice sets.

The introductory part of the questionnaire inquired about the perception of afforestation programmes in general. Over 87% of respondents favoured some types of afforestation programmes,

Table 2. Dummy variables considered in the model.

Variable	Description	Levels
GENDER	Respondent's gender	Male = 1; female = −1
AGE	Respondent's age	in years
SUPPORT	Degree of a respondent's support towards the proposed afforestation programme	Scores from 1 to 5 (where Not at all = 1; Very much = 5)
URBAN	Respondent lives in urban or rural area	urban area = 1; rural area = 0
INCLOW	Respondent's net monthly income is lower than 200 TND	Yes = 1; No = 0
NW	Respondent lives in the north-western part of Tunisia, where the proposed afforestation would take place	Yes = 1; No = 0

Table 3. Socio-economic characteristics of the survey respondents.

Variable	Sample	Tunisia average
Age		
20–39	48%	54%
40–59	39%	31%
>60 years	13%	15%
Gender (in % of female resp.)	50.5%	51%
Location of residence		
Urban	63%	65%
Rural	37%	35%
Education		
No finished formal education (illiterate)	21%	23%
Elementary school	26%	37%
Secondary school	31%	32%
Higher education	22%	8%

Source: Institut National de la Statistique (2004).

with less than 2% feeling that afforesting could be disadvantageous. Nearly, 11% of respondents were indifferent or indecisive.

However, when dealing with the proposed specific and costly afforestation programme, the BAU (no afforestation) option was chosen by 41% of the respondents, when taking into account the payment requested – the rest opted for one of the offered afforestation alternatives. To better understand the selection of the BAU option, respondents were asked about the reason for not choosing a payment alternative. Some argued that they preferred to spend their money on other activities, while others claimed income-related reasons such as poverty, unemployment, or retirement (68% of them reported to have no income), or did not give a concrete answer.

4.2. Regression analysis

Table 4 reports the results of the nested logit model estimations. The attribute signs are in accordance with expectations and statistically significant at the 5% level. The results for the lower level utility function indicate that the selection of a given afforestation programme depended on the levels of biodiversity, carbon sequestration, erosion, forest fires, accessibility and recreation opportunities, and the payment amount. In particular, the positive coefficients for biodiversity, carbon sequestration and erosion protection indicate that respondents were more likely to select the afforestation alternatives when more plant and animal species, more carbon sequestration, and more erosion protection were provided. Also, the positive sign of the access and recreation coefficients indicate that those alternatives were more likely to be selected where access for wood collection and grazing, and recreation, was granted. On the other hand, respondents considered as less desirable the alternatives where forest fires affected larger areas, and the requested payment was higher. Finally, the negative sign of the interaction between biodiversity and lower level education (BIODIVERSITY x EDUCATION_LOW) indicates that illiterate respondents and those with no more than a primary school degree would obtain less utility from an increased number of animal and plant species than the rest of the respondents.

Furthermore, when choosing between BAU and the afforestation alternatives (upper level of the nested model), the following variables had a significant influence: respondent's gender, age, income level, and place of residence, as well as those who expressed support for an afforestation programme. It implies that men, younger respondents, respondents who expressed support for an afforestation programme, respondents with higher income levels (above 200 TND/month), and those living in urban areas or in the north-western part of Tunisia, were less likely to select the BAU option.

Table 4. Results of the nested logit model.

Attribute	Coefficient	Standard error	*p*-value
Attributes in the lower level utility functions			
BIODIVERSITY	0.413	0.144	0.004
CARBON	0.479×10^{-5}	0.119×10^{-5}	0.000
EROSION	0.098	0.025	0.000
FIRE	−0.326	0.112	0.003
RECREATION	0.293	0.043	0.000
ACCESS	0.256	0.079	0.001
PAYMENT	−0.045	0.006	0.000
BIODIVERSITY x EDUCATION_LOW	−0.606	0.153	0.000
Attributes of upper-level utility function			
GENDER	−0.516	0.107	0.000
AGE	0.035	0.003	0.000
SUPPORT	−0.434	0.053	0.000
INCOME_LOW	0.889	0.151	0.000
NW	−0.671	0.151	0.000
URBAN	−0.335	0.108	0.002
Instrumental variable parameters			
BAU		1.000 (fixed parameter)	
AFFORESTATION	0.458	0.100	0.000
Log L		−1730.825	
Adjusted pseudo R^2		0.117	
Number of observations		1788	

Note: *** denotes significance at 0.1% level. ** denotes significance at 1% level. * denotes significance at 5% level.

Overall, the significance of the instrumental variable parameters suggests that the specified model structure was appropriate.

The results reported in Table 4 suggest the presence of significant heterogeneity of preferences among the Tunisian population with regard to the proposed afforestation programme. The significant negative coefficient of NW indicates that residents in the north-western part of the country, where most of the afforestation takes place, were more likely to favour afforestation than the rest of Tunisians, probably because they are the ones benefiting the most from the programme. Heterogeneity of preferences can also be observed between the urban and rural population, with the former being less likely to select the BAU option when compared to rural residents.

To further analyse it, two separate models for the urban and rural population were estimated. They followed the same structure and contained the same variables than the general one reported in Table 4, with the logical exception of the URBAN variable. The comparison of the urban and rural model estimates (Table 5) reveals significant differences in the preferences between the two population groups with regard to carbon sequestration, erosion prevention and fire occurrence. In the urban model, the three variables are significant, which indicates that these attributes influenced the selection of the afforestation alternatives.

4.3. Marginal values and trade-offs

Table 6 reports the welfare estimates for the afforestation programme attributes. The marginal value for biodiversity indicates that, on average, individuals are willing to pay 9.09 TND per year, during five years, to increase in 1% the amount of fauna and flora species. An individual marginal value of 0.11 TND was obtained for the sequestration of the annual quantity of carbon emitted by one thousand persons (2469 tons of CO_2) or 4.29 10^{-5} TND per ton of CO_2 sequestered. Furthermore, to prevent erosion that would result in a 1% decrease of water dam capacities due to sedimentation is worth 2.16 TND per person and year, during five years. Having access to the afforested areas for recreation has an average annual value of 6.46 TND per person, while the value is 5.63 TND per

Table 5. Results of the nested logit models for the urban and rural population.

Attribute	Urban population	Rural population
Attributes in the lower level utility functions		
BIODIVERSITY	0.293 [0.145] *	1.182 [0.390] **
CARBON	0.605×10^{-5} [0.148×10^{-5}] ***	0.202×10^{-5} [0.208×10^{-5}]
EROSION	0.115 [0.030] ***	0.055 [0.044]
FIRE	−0.271 [0.132] *	−0.364 [0.214]
RECREATION	0.329 [0.052] ***	0.210 [0.077] **
ACCESS	0.231 [0.095] *	0.307 [0.143] *
PAYMENT	−0.044 [0.007] ***	−0.046 [0.012] ***
BIODIVERSITY x EDUCATION_LOW	−0.478 [0.161] **	−1.426 [0.397] ***
Attributes in the upper-level utility function		
GENDER	−0.355 [0.136] *	−0.803 [0.178] ***
AGE	0.032 [0.004] ***	0.036 [0.006] ***
SUPPORT	−0.444 [0.068] ***	−0.493 [0.086] ***
INCOME_LOW	0.807 [0.177] ***	0.985 [0.325] **
NW	−0.643 [0.200] **	−0.679 [0.236] **
Instrumental variable parameters		
BAU	1.000 (fixed parameter)	1.000 (fixed parameter)
AFFORESTATION	0.527 [0.130] ***	0.418 [0.161] **
Log L	−1118.453	−604.174
Adjusted pseudo R^2	0.122	0.120
Number of observations	1124	664

Note: Standard errors in square brackets. *** denotes significance at 0.1% level. ** denotes significance at 1% level. * denotes significance at 5% level.

year and person for granting access for grazing and other uses. Finally, the wellbeing per person would decrease by 7.18 TND on average if the area of Tunisian planted forests affected by fires would be of 1% for the next 50 years. Considering that the plantation programme of 150,000, the expression of these marginal values in TND per ha and year, during 5 years, would be: 827 TND/ha for biodiversity conservation, 786 TND for erosion prevention, 750 TND/ha for carbon sequestration, 294 TND/ha for recreation, −258 TND/ha for prohibiting access and −653 TND/ha for the reduction of forest fires.

The trade-offs among non-monetary attributes can also be obtained from the ratio of the coefficients of the variables involved. For instance, limiting the access to the new forests offsets a decrease of erosion by an additional 2.61%. This result shows the relative importance of the access for local users compared, for example, to erosion, which is one of the main explicit concerns of Tunisian forest development programmes.

Table 6. Willingness to pay (based on the delta procedure).

	Willingness to pay*			
		95% confidence interval		
Attribute	Mean	Lower interval level	Upper interval level	Units
BIODIVERSITY	9.09	2.80	15.38	Increasing the number of species by 1%
CARBON	0.11	0.05	0.16	Carbon sequestered as produced by 1000 residents per year
EROSION	2.16	1.20	3.12	Reduction of negative impacts of erosion by 1%
FOREST FIRES	−7.18	−11.67	−2.69	Planted area affected by forest fires by 1% in 50 years' time
RECREATION	6.46	4.37	8.55	Allowing recreation activities in the planted forest
ACCESS	5.63	2.12	9.14	Access to the planted forest for grazing and other forest uses

*Annual values per individual during 5 years, in 2008 TND.

5. Discussion and conclusions

The comparison between the values obtained here and those from previous studies is not straightforward, and has to be taken with caution given the differences in objectives and methods applied. Furthermore, in this study, the values are expressed in TND per person and year during 5 years, while in the available ones they are usually expressed in TND per ha, either as one-time payment or as a perpetuity. In general, however, the estimated values seem to be higher than the ones obtained by previous studies. The CE method accounts for use and non-use values, while other methods based on market prices and travel cost only capture user values. This could partly explain why the values obtained in this study are relatively higher than those obtained by other authors, except to some extent for recreation – a typical user value.

For example, translated into euros, the Tunisian population value a reduction of 1 ton of carbon at 162 euros per year in 2008 values during five years, according to the results, while it was estimated at 25 euros by Daly-Hassen and Ben Mansoura (2005) using a shadow price approach based on the benefits from reduced carbon emissions. On the other hand, the value here obtained for allowing recreation activities, 3.61 euros per person and year, during five years, is similar to the one obtained by a previous study by Aouididi (1996) using the Travel Cost Method: 3.41 euros, when expressed in 2008 values. Considering the entire Tunisian population, the value for the increase in biodiversity is 13.86 M euro per year, for five years, while it was estimated at 0.18 M per year, indefinitely, by Daly-Hassen and Ben Mansoura (2005) after using a cost-based method (cost of forest conservation and guarding). Similarly, the value of watershed protection is valued at 13.12 M euro per year while it was estimated to be 0.71 M per year using the damage cost avoided method (avoided losses to watershed capacity and agricultural yield). The large difference in value, even when accounting for the different annual reference (five years vs. perpetuity), highlights the discrepancy between using cost approaches or a welfare assessment, like with the CE methodology.

A similar CE application was performed in Spain in 2007 (Mavsar and Riera 2007; Mavsar and Farreras 2009). The Tunisian and Spanish studies used almost identical attributes (except for biodiversity), way to express the attribute units, and annual payment format, making them suitable for comparison. Table 7 reflects the values from both applications in euro of the base year, corrected by purchasing power parity. All values are higher for Spain, which may reflect the differences in priorities with respect to the environment, as well as socioeconomic differences between the two populations. However, the estimates for erosion, forest fires, and recreation, are relatively similar, which might be taken as a sign of consistency of the CE applications. Values for the access to the new forests differ more significantly. Nevertheless, they reflect different uses, with the Tunisian variable being of more specific interest to the neighbouring communities, and the Spanish one more related to recreation. The largest difference is with the value of sequestering a tone of CO_2, which differs in one order or magnitude.

Results also revealed some significant spatial differences. On average, the Tunisian urban population was found to consider carbon sequestration as a good, whereas the rural society tended to be

Table 7. Comparison of willingness-to-pay results.

Attribute	Willingness to pay*		Units
	Tunisia**	Spain***	
BIODIVERSITY	7.07	–	Increasing the number of species by 1%
CARBON	3.34×10^{-5}	41.6×10^{-5}	Sequestration of 1 t of CO_2
EROSION	1.68	3.81	Reduction of negative impacts of erosion by 1%
FOREST FIRES	−5.58	−8.85	Increase of burned forest area by 1%
RECREATION	5.02	7.31	Allowing recreation activities in the planted forest
ACCESS	4.38	13.34	Access for forest uses (mostly grazing in Tunisia, and mostly mushroom picking in Spain)

*Annual values per individual during 5 years, in 2008 euro.
**Values in euro, adjusted from TND to Spanish euro according to the purchasing power parity for GDP of the two countries.
***Values from Mavsar and Riera (2007) and Mavsar and Farreras (2009), adjusted for inflation to 2008.

indifferent. Likewise, urban respondents were more likely to select an alternative with higher levels of erosion prevention, and a lower fire risk, keeping the rest of the attributes equal. In contrast, rural respondents seemed to be indifferent to the levels of carbon sequestration, erosion prevention and forest fires. This may denote a current change in environmental perceptions that is not as vigorous in non-urban regions.

By their nature, different attributes have different time horizons. Payments were due in the first five years, coinciding with the main cost of planting. Grazing was to be temporarily banned to allow sprouts to grow into trees– which typically takes no more than 10 years – as explained in the questionnaire. Biodiversity, carbon sequestration, risk of fire, erosion prevention, and recreational enjoyment vary as the forest matures, and last for the duration of the forest life. The long lasting effects make these attributes both of use and non-use value to the respondents. As far as the new forests survive the surveyed individuals, they would be paying for their own enjoyment and for the one of future generations, and consequently, this altruism would be included in their preferences when stated the choices between alternatives.

When moving from the valuation application to an evaluation exercise, a proper cost–benefit analysis, or alike, should be considered, which is beyond the scope of this paper. However, a rough estimate suggests that a forestry programme of that type could yield a positive net social benefit. Evaluated at the highest levels of the attributes considered in the CE application, the total benefits of the programme would be around 29 million euros per year, during five years, while if only erosion control and carbon sequestration are considered, the figure would reduce to around 21.3 million euro. This and other benefits are to be compared against a plantation cost of 16.6 million euros per year, during the five years of the programme, and any other relevant costs. Again, to draw firm conclusions, this ought to be the subjected to a proper evaluation exercise, which is suggested as further research.

Since the exercise took place, the forest plan implementation set by the administration has not been as successful as intended. The annual rhythm of afforestation has slowed from 18,000 ha in 2001–2010 to 7500 ha in 2011–2015 (Daly-Hassen 2016). To a great extent, the slowness is due to problems with the administration and the economic policies, especially after the 2011 revolution. A weaker forest administration authority has led to a less effective territorial planning and management. Furthermore, there has been a lack of incentive policies for afforestation on private land. If this is to be overcome by the development and implementation of a national plan of afforestation and territorial development plans, together with attractive financing mechanism for private owners, the results of this study could be of practical interest to the authorities. They could be used to detail the location, type of species to be planted, and the forestry management scheme to be implemented, paying particular attention to access from the locals, and the compensatory amounts for the incentives, e.g. due to grazing prohibition in afforested areas – if the maximisation of the overall social welfare is to be considered.

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References

Aouididi, A. 1996. *Evaluation économique du parc national de l'Ichkeul*. Tunis: Ministère de l'Environnement et de l'Aménagement du Territoire.

Auclair, L. 2001. "Population et désertification en Tunisie au cours du XXe siècle." In *Régulations démographiques et environnement, actes des 6èmes journées démographiques de l'ORSTOM*, edited by L. Auclair, P. Gubry, M. Picouet, F. Sandron, 237–245. Paris: Paris (FRA), IRD, CEPED.

Agence Nationale pour la Maîtrise de l'Energie (ANME). 2010. K*it sur les changements climatiques et l'énergie*, Vol. 45. Tunis: ANME.

Bateman, I. 2002. "Applying Geographical Information Systems (GIS) to Environmental and Resource Economics." *Environmental and Resource Economics* 22 (1–2): 219–269.

Cesaro, L., V. Cistulli, M. Merlo, and D. Pettenella. 1998. "A Step-wise Procedure to Costs and Benefits Analysis (CBA) of Forestry and Soil Conservation Investments in the Mediterranean Watersheds." In *Future Forest Policies in Europe – Balancing Economic and Ecological Demands,* edited by I. Tikkanen, P. Pajari, 149–167. EFI Proceedings, Vol. 22. Joensuu: European Forest Institute.

Daly-Hassen, H. 2016. *Tunisia Case Study in FAO (Food and Agriculture Organization), The State of the World's Forests*. Rome: SOFO, FAO.

Daly-Hassen, H., and A. Mansoura Ben. 2005. "Case of Tunisia." In *Valuing Mediterranean Forests: Towards Total Economic Value*, edited by M. Merlo and L. Croitoru, 105–122. Wallingford: CABI Publishing.

Daly-Hassen, H., L. Croirtoru, K. Tounsi, A. Aloui, and S. Jebari. 2012. *Evaluation économique des biens et services des forêts tunisiennes* [Economic valuation of Tunisian forest goods and services], Vol. 87. Tunis: DGF/FAO.

DGF (Direction Générale des Forêts). 1995. *Résultats du premier inventaire forestier national en Tunisie* [Results of the first forest inventory in Tunisia]. Tunis: DGF.

DGF (Direction Générale des Forêts). 2005. *Afforestation Clean Development Mechanism (CDM) Projects in Tunisia* [Afforestation clean development mechanism (CDM) projects in Tunisia]. Tunis: DGF.

DGF (Direction Générale des Forêts). 2010. *Résultats du deuxième inventaire forestier et pastoral national* [Results of the second national forest and pastoral inventory]. Tunis: DGF.

DGF (Direction Générale des Forêts), FAO (Food and Agriculture Organization). 2005. *Analyse du processus et formulation du Programme Forestier National, Tunisie*. Tunis: Examen de la Situation Actuelle.

Elberg Nielsen, A.S., T. Hedemark Lundhede, and J. Bredahl Jacobsen. 2016. "Local Consequences of National Policies – A Spatial Analysis of Preferences for Forest Access Reduction." *Forest Policy and Economics* 73: 68–77.

FAO (Food and Agriculture Organization). 1994. *Introduction à la gestion conservatoire de l'eau, de la biomasse et de la fertilité des sols (GCES)* [Introduction to the conservative management of water, biomass and soil fertility]. Vol. 70, 243. Bulletin pédagogique de la FAO. Rome: FAO.

FAO (Food and Agriculture Organization). 2010. *Forest Resources Assessment 2010*. National report in French. Rome: FAO.

FAO (Food and Agriculture Organization), DGF. 2012. *Etude sur la caractérisation de la population forestière, elaboré par Tounsi, K., Ben Mimoun, A* [Study on the characterization of the forest population, conducted by Tounsi, K and Ben Mimoun, A]. Tunis: FAO.

Greene, W.H., and D.A. Hensher. 2003. "A Latent Class Model for Discrete Choice Analysis: Contrasts with Mixed Logit." *Transportation Research B* 37: 681–698.

Hadri, H., and H. Tschinkel. 1976. *Hydrologie de trois petits bassins versants caractérisés par une utilisation différente du sol* [Hydrology of three small watersheds characterized by different land uses]. Tunis: INRF.

Hausman, J.A., and D. McFadden. 1984. "Specification Tests for the Multinomial Logit Model." *Econometrica: Journal of the Econometric Society* 52 (5): 1219–1240.

Hensher, D.A., J.M. Rose, and W.H. Greene. 2005. *Applied Choice Analysis: A Primer*. Cambridge: Cambridge University Press.

INS (Institut National de la Statistique). 2004. *General census of population and housing*. Tunis, Tunisia: INS.

Kaval, P., L. Madureira, P.A. Mahieu, J. Meyerhoff, R. Mavsar, P. Riera, and B. Rulleau. 2016. "Stated Preference Guidelines," In *Valuation of Forest Ecosystem Services. A Practical Guide*, edited by P. Riera, G. Signorello. Oklahoma: Books2Read. Chapter 1.

Louviere, J., D.A. Hensher, D. Joffre. 2000. *Stated Choice Methods. Analysis and Application.* Cambridge: Cambridge University Press.

Lancaster, K., 1966. "A New Approach to Consumer Theory." *Journal Policy Economy* 74 (2): 132–157.

MARH (Ministry of Agriculture and Water Resources). 2007. *The 11th Plan of Economic and Social Development*, 76. Sector of Agriculture and Fisheries, in Arabic. Tunis: MARH.

Masiero, M., D.M. Pettenella, and L. Secco. 2016. "From Failure to Value: Economic Valuation for a Selected Set of Products and Services from Mediterranean Forests." *Forest Systems* 25 (1): e051. http://dx.doi.org/10.5424/fs/2016251-08160

Mavsar, R. and V. Farreras. 2009. "A Choice Modeling Approach to Value a Fire Prevention Program in Catalonia (Spain)." Proceedings of the Third International Symposium on Fire Economics, Planning, and Policy: Common

Problems and Approaches, Gen. Tech. Rep. PSW-GTR-227 (English). Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, 137–150.
Mavsar, R., and P. Riera. 2007. *Valoración Económica de las Principales Externalidades de los Bosques Mediterráneos Españoles: Informe final*. España: Ministerio de Medio Ambiente.
McFadden, D. 1974. "Conditional Logit Analysis of Qualitative Choice Behavior." In *Frontiers of Econometrics*, edited by P. Zarembka, New York, NY: Academic Press.
Ministry of Agriculture. 2013. *Economic Budget for the year 2013: Agriculture and Fisheries*, in Arabic. Tunis, Tunisia: Ministry of Agriculture.
Mogas, J., P. Riera, and J. Bennett. 2006. "A Comparison of Contingent Valuation and Choice Modeling with Second-Order Interactions." *Journal of Forest Economics* 12 (1): 5–30.
Riera, P., G. Signorello, M. Thiene, P.A. Mahieu, S. Navrud, P. Kaval, and B. Rulleau et al., 2012. "Non-Market Valuation Good Practice Guidelines Proposal for Forest Goods and Services." *Journal of Forest Economics* 18 (4): 259–270.
Rosenzweig, M.L. 2007. La biodiversité en équation. *Les dossiers de la Recherche* 28: 20–24.
Termansen, M., C.J. McCleanb, F. Søndergaard Jensen. 2013. "Modelling and Mapping Spatial Heterogeneity in Forest Recreation Services." *Ecological Economics* 92: 48–57.
Train, K. 1998. "Recreation Demand Models with Taste Variation." *Land Economics* 74 (2): 230–239.
Train, K. 2003. *Discrete Choice Methods with Simulation*. New York, NY: Cambridge University Press.
Voces González., L. Díaz Balteiro, and E. López-Peredo Martínez. 2010. "Spatial Valuation of Recreation Activities in Forest Systems: Application to Province of Segovia (Spain)." *Forest Systems* 19 (1): 36–50.
World Bank. 2010. *La génération des bénéfices environnementaux pour améliorer la gestion des bassins versants en Tunisie, rapport no 50192 – tn* [The generation of environmental benefits to improve the management of watersheds in Tunisia. Report 50192 – tn]. Washington, DC: World Bank.