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Methods

Valuing changes in forest biodiversity

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ABSTRACT

The paper attempts to improve current understanding of the economic value of biodiversity. Instead of the prevailing approach of using only one indicator of biodiversity (typically, species richness) we provide evidence that it is possible to value changes in a number of attributes which describe complex characteristics of biodiversity, based on ecological knowledge. The attributes used include structural, species and functional diversity. The empirical application is a choice experiment study conducted in the Białowieża Forest, Poland: our study is therefore also one of the first to cast light on the value of biodiversity protection in Eastern Europe. Interestingly, respondents valued passive protection regimes resulting in preservation of natural ecological processes. In addition, the respondents seemed to be concerned with the means, and not only the results of protection programmes.

1. Introduction

Biodiversity is important on many grounds. Biodiversity plays a critical role in sustainable development and poverty eradication (WSSD, 2002), and is important to human well-being, livelihoods and cultural integrity. Biodiversity is also recognised as underpinning the functioning of ecosystems by maintaining flows of ecosystem services (Hooper et al., 2005), and to play an important role in maintaining ecosystem resilience to exogenous shocks such as extreme weather events (DEFRA, 2007). Biodiversity is also valued in and of itself, as a direct source of utility (rewards from the contemplation or hunting of wildlife), and as something of cultural and spiritual importance (DEFRA, 2007). However, biodiversity is under threat globally, and convincing evidence exists that it is dramatically changing. Biodiversity loss is characterized by a decrease in the abundance and distribution of species, by the fragmentation of habitats, as well as by reductions in habitat quality (MEA, 2005).

There have been many attempts both to conceptualise and value biodiversity in economic terms (Kontoleon et al., 2007). The pace of research has increased since OECD (2001) underlined the necessity for valuation studies and pointed out the range of potential applications of biodiversity values. The Convention on Biological Diversity (CBD) encouraged parties to take economic values into account in the development of incentive measures for biodiversity conservation (CBD, 1998). This was seen as being particularly important for reaching the CBD 2010 targets of halting loss of biodiversity. However, economists face two major problems in assigning values to changes in biodiversity. Firstly, there exists a large range of quantifiable indicators of biodiversity, and it is not obvious which is best to focus on. For example, biodiversity can be described in terms of the number of species or ecosystems, their distributions, and differences in their functional traits (Hooper et al., 2005). Secondly, many of the "best" indicators from an ecologist's perspective may be not understandable to the general public whose values are relevant for cost–benefit analysis.

The aims of this paper are to extend work by Christie et al. (2006) in bringing a number of aspects of biodiversity thought important by ecologists into an economic valuation context, through the use of the choice experiment technique. We extend the list of "biodiversity attributes" considered by Christie et al. (2006), introducing ideas of structural, species and functional diversity. In addition, we are interested in whether how biodiversity protection is brought about matters to people, rather than simply the predicted changes in biodiversity itself. Finally, our study is of interest in that it reports on economic values for biodiversity conservation for Poland: many of Europe's remaining biodiversity hot-spots are found in Eastern Europe, yet very little work exists measuring the economic value of conserving this resource.

1.1. Valuing biodiversity—the challenge

Biodiversity is generally defined as variability among living organisms, and the ecological complexes of which they are part of. This includes diversity within species, between species and between and within ecosystems (CBD, 1992). There are many approaches to

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defining the scale on which biodiversity should be compared: from point diversity (homogenous habitat), through alpha (within habitat) and gamma (landscape scale), to epsilon diversity (regional, large biogeographic areas). Other levels of differentiation involve pattern, beta, and delta diversity (Whittaker, 1977). Species level diversity, or species richness, is the most commonly used indicator for practical purposes (Baumgartner, 2007). It must be noted however that this does not reflect all the information necessary for a full description of biological diversity. What is more, this approach is not necessarily the most useful for assessing human impacts on biodiversity and the implications for ecosystem productivity, functioning and resilience. Last but not least, whilst a species-based assessment of biodiversity might be easily explained to general public, it introduces complications since the human values placed on species need not reflect the significance of that species for ecosystem functioning. There exists a substantial body of literature devoted to the 'cuteness' concept of particular species and the existence of so called 'flagship species' or 'charismatic species' (May, 1995). People simply tend to place higher values on well recognised, high-profile species—usually impressive predators or species linked to local identity (Noss, 1990a). Since economic values are by definition anthropogenic this relationship is understandable, however, it causes estimation of biodiversity values based on the species level to be less useful, because the species highly valued are not necessarily the ones which are the most important for maintaining biodiversity—keystone species.[1]

There have been some attempts to create a concept of "ecologically important" species that could easily be communicated to general public, such as indicator[2] and keystone species, or concepts based on rarity. It is still, however, not clear to what extent the complicated relationships within ecosystems can be meaningfully explained and understood by the general public, who are usually the target of stated preference valuation techniques such as contingent valuation and choice experiments (Barbier, 2007; Christie, 2001; Heal et al., 2005). Indeed, there seem to be no simple ways of communicating the concept of biodiversity and its changes to members of the public, nor an established framework for valuing biological variety. The number of species is considered a good starting point, but this needs to be reinforced with other attributes, such as the existence of natural processes and specific habitats within the ecosystem.

1.2. Previous studies

On first glance, there seem to have been a great many studies estimating the economic value of biodiversity (Pearce, 2007). Following Pearce (2001), it must be noted that what most of these studies valued was biological resources rather than the variety of life (biodiversity). This distinction, made clear by Nunes and Van den Bergh (2001), allows one to categorise studies into those valuing particular biological resources, such as genes, species, habitats or ecosystems existence, and those valuing biological diversity of these resources. We refer the reader to Nijkamp et al. (2008); Christie et al. (2006, 2004); Greensense (2003); Nunes et al. (2003) and Nunes and van den Bergh (2001) for the detailed review of these studies, and summarise the most common approaches below.

Valuation studies of biological resources are quite common in the literature. Use values for genetic diversity have been usually estimated utilising market based methods, such as valuing diversity as an input to a production function for pharmaceutical, agricultural and chemical products (e.g. bioprospecting). There have also been numerous studies using stated preference techniques for assessing use and non-use values of particular species, including non-use values (Christie et al., 2006). Valuations of natural areas, such as terrestrial, coastal and wetland habitats, have been conducted using the travel cost method for estimating recreational use values, and utilising stated preference methods, such as contingent valuation (CV) or choice experiments (CE), for non-use values (Jacobsen and Hanley, 2009). Finally, there have been only a few studies valuing ecosystem functions and services (DEFRA, 2007). This is probably the most challenging task for stated preference techniques, because the complexity of the relationships between ecosystem characteristics and level of services provided is very difficult to explain and convey in a short CV or CE survey. For this reason it is more usual to apply other valuation techniques, such as averting behaviour, replacement cost and production function techniques to estimate the value of such services as waste assimilation, flood control or water quality.

Another body of literature focuses on the valuation of biodiversity itself. Two approaches can be identified—studies eliciting WTP for policies aiming to, or resulting in, particular biodiversity changes, and studies trying to value changes in sets of components or indicators, that describe the biological diversity of an area.

Good examples of the first approach are Garrod and Willis (1997) who estimated non-use values for remote upland coniferous forests in the UK, Hanley et al. (2002) who examined public preferences for biodiversity across a range of woodland types, Pouta et al. (2000) and Li et al. (2004) who elicited preferences for the extension of Natura 2000 areas in Finland, and Horne et al. (2005) who examined preferences for management options and resulting expected characteristics of privately owned forests. Even though this approach is relatively straightforward, it has its drawbacks. First of all it might be difficult to predict how a particular program would influence biodiversity. Secondly, a program might consist of many impacts, biodiversity being only one of them. In this case the respondent's willingness to pay (WTP) might be only partly reflecting utility from an improvement of biodiversity, and partly other reasons for implementing the program. Finally some authors (Lehtonen et al., 2003; Pouta et al., 2002) provide evidence that the estimated welfare measures depend on the policy context itself.

Applications of the second approach are scarcer, and can be represented by Christie et al. (2006, 2004) who identified a set of attributes to describe variation in biodiversity in agricultural landscapes in the UK. The attributes involved well recognised species; rare, unfamiliar species; habitat quality and ecosystem functions. The authors argue that the selected set of attributes describes biological diversity well from an ecological perspective, yet also remains meaningful to respondents. This approach offers promise for valuing biodiversity, and is developed in this paper. Since most respondents are not familiar with the term 'biodiversity', the best way is to describe changes in biodiversity is with a set of attributes that are based on sound ecological knowledge and at the same time are understandable to the general public. A set of attributes describing biodiversity might also be site specific, however some general guidelines might be established through a process of empirical testing of different approaches. It seems interesting to test if the approach prevalent in the literature—using the number of species as the only indicator of biodiversity changes—is indeed the only approach which might be comprehensible to respondents, or at least if it is the most important one (for wider disusion of using the number of species as an indicator of biodiversity see some of the recent studies by Baillie et al., 2008; Billeter et al., 2008; Hak et al., 2008; Larsen et al., 2009).

The main purpose of this paper is thus to extend the approach initialized by Christie et al. (2006, 2004) by describing biodiversity using carefully chosen attributes that would be both scientifically sound and meaningful to the respondents. Our approach aimed to describe structural, species and functional diversity and communicate these difficult issues to respondents. We also investigate whether how

[1] A keystone species is one whose presence is vital to the functioning of an ecosystem or food web (Paine, 1995).

[2] An indicator species is any biological species that defines a trait or characteristic of the environment. For example, a species may delineate an ecoregion. Indicator species can be among the most sensitive species in a region, and sometimes act as an early warning (see e.g. Farr, 2002; Lindenmayer et al., 2000; Noss, 1990b; Shrivastava, 2007).

biodiversity improvements are "delivered" matters to people. We extend the econometric modelling approach used by Christie et al. (2006), in that an Error Components Model is used here (in contrast to the conditional logit models reported in Christie et al.): this allows a consideration of the extent and determinants of error variance across respondents. Finally we provide evidence on valuation of biological diversity in an Eastern European country, which is of particular interest since Eastern European sites seem likely to contain relatively rich biodiversity compared to more-developed Western European equivalents. Empirical evidence on biodiversity values in Eastern Europe is currently rather deficient, relative to the body of evidence existing for Western Europe.

2. The study

We used the Choice Experiment method to study the values of biodiversity conservation in the Białowieża Forest, Poland. A stated preference technique was selected in order to estimate use and non-use values of changes in the biodiversity of Białowieża Forest. A Choice Experiment allowed us to estimate separate values for different biodiversity attributes.

2.1. Site selection

65% of biodiversity resources in Poland are located in forests, which cover roughly 30% of the country's land surface (Rykowski, 2005). One of the most recognised and ecologically valuable forests in Poland is the Białowieża Forest, which despite some visible signs of human activity is still commonly considered the last natural lowland forest in temperate Europe. It is especially regarded for its natural dynamics as well as its species richness, and its ecological structures and functions. For these reasons it was selected to be the site of our valuation study.

Some authors (e.g. Faliński, 1992) suggest that the highest priority from a policy perspective should be the protection of all forms of biological variability within the Białowieża Forest, including landscape, habitats and their components, species, as well as biological and ecological processes. Such a policy would allow for long-term observation of flora dynamics, succession and regression, fluctuation, degeneration and regeneration, as well as seasonal changes. Most transformed and actively-managed temperate forests in Poland and elsewhere in Europe do not allow for observations of all the above processes, which makes the Białowieża Forest unique. Almost 40% of currently known species present in Poland (over 11.000) can be found in the Białowieża Forest.[3] It is estimated that many faunal species are still undiscovered (Gutowski and Jaroszewicz, 2001). The forest's habitats are characterized by the presence of a large volume of dead wood, so that many endangered species dependent on this are still present. One of the flagship endangered species that exists here is the European Bison (Żubr). The Białowieża Forest has played an important role in the recovery of this species.

2.2. Development of the questionnaire

The authors identified biodiversity attributes based on ecological knowledge and research results, collected from the study site over the last 50 years (Faliński, 1991, 1996; Gutowski et al., 2004; Gutowski and Jaroszewicz, 2001; Rykowski, 2005). A careful process of pretesting allowed for the valuation study to incorporate this information into the valuation of changes in forest biodiversity.

To describe possible changes in biodiversity of the site the most important aspects of forest biodiversity were identified in cooperation with biologists and ecologists, whilst drawing on (Christie et al., 2006, 2004). The list of attributes considered included familiar species of wildlife (rare and common), unfamiliar species of wildlife (rare and common), quality of habitat, ecosystem processes, ecosystem resilience, habitat for endangered and protected plant and animal species, forest stand structure, landscape diversity, amount of dead wood, and others. Our approach consisted in trying to find the most important biodiversity attributes from an ecological perspective and then testing understanding of these with respondents, thus extending the way in which the respondents think about biodiversity rather than eliciting willingness to pay for the most well-known attributes to respondents, which need not necessarily correspond to those of ecological importance.

Through this careful process of pretesting and focus groups, candidate attributes were merged and finally narrowed down to three most important ones and, additionally, a cost attribute. The selected attributes represented potential changes in forest biodiversity and at the same time were understandable to the respondents.

The first attribute—natural ecological processes—represented natural dynamics of the Białowieża Forest. The dynamics of these natural processes allows for unique scientific observations of biodiversity changes in the Białowieża Forest and their meaning for ecosystem functioning and resilience. According to specialists, and as explained in the questionnaire, the improvement in this attribute could be achieved by passive protection of a given percentage of the total area of the forest. A passive protection would mean leaving the ecosystem without any human intervention, such as cutting and removing selected trees, recreating selected biotopes or influencing animal populations in any way, even if this resulted in (natural) changes in ecosystems. The three levels set for this attribute were: status quo—16%, partial improvement—30%, and substantial improvement—60% of the area to be passively protected.

Rare species of fauna and flora represented the second attribute. It was highlighted in the questionnaire that this attribute represents not only known, but also yet-unknown species. Examples of both flagship and lesser-known species were given together with information on their reliance on active protection activities, such as controlling animal species populations, feeding or reproduction programmes. A short general explanation of the importance of different species to the ecosystem was also provided. The design levels of this attribute were: status quo—a decline threatening total extinction of some species; partial improvement—actions to maintain the current populations and improvement of their quality, and substantial improvement—maintaining and expanding current populations.

Ecosystem components was the attribute characterizing the existence of biotopes and ecological niches, such as dead wood, natural ponds, streams, and forest clearings. It was explained in the questionnaire that improvements in this attribute could be achieved by active protection of these components. This attribute could be important for respondents both for the existence of the components alone, as well as being a proxy for improved well-being of species inhabiting the forest. The possible levels of this attribute were: status quo—an absence of some components and decreases in the quality of existing ones, minor improvement—regeneration of deteriorated components on 10% of the area, partial improvement—on 30%, and substantial improvement—on 60% of the area.

In all cases, the biodiversity attribute levels, including the status quo, were based on the present state of the Białowieża Forest and possible changes of management regime which are currently being considered by policymakers and environmentalists. The final attribute was monetary, representing an increase in a compulsory tax to be paid for the following 10 years.

The questionnaire was administered face-to-face to a representative sample of adult Poles. It consisted of general information about

[3] The area of Białowieża Forest is roughly 62,000 ha, what accounts for only 0.02% of the territory of Poland.

the Białowieża Forest, its current situation and problems, a detailed description of attributes, their possible levels and their meaning for ecosystem health, socio-demographic and environmental attitude questions. The survey was accompanied by a set of auxiliary cards with diagrams and pictures shown to respondents, as illustrative of the problems discussed and to enable better understanding of possible policy options. A copy of the survey materials is available from the first-named author.

2.3. The experimental design

The experimental design we used was a L^{MA} factorial design (Louviere et al., 2006). The first (constant, status quo) alternative was added to every choice set (there was no variation in the attribute levels for this alternative). The second alternative was labelled 'extension of the national park' while the third was labelled 'other form of protection'. The attributes were assumed to be generic across alternatives (no alternative specific parameters were included in the utility function, except for the constant) with dummy coded attribute levels. Additionally, we used a blocking variable to limit the number of choice sets faced by each person. Each respondent was presented with four choice sets, each of three alternatives. The purpose of labelling alternatives was to test if the respondents are in fact indifferent to how biodiversity protection was achieved, as found by some studies (Christie et al., 2006), and not by the others (Lehtonen et al., 2003; Pouta et al., 2002). Currently, national park status applies to roughly 16% of the area of the Białowieża, despite a 20-year struggle by NGOs and environmental organizations to extend it to the entire area of the forest. It might seem reasonable that some of the respondents would like to see the national park extended. It was explained in the questionnaire, however, that 'extension of national park' and 'other forms of protection' are in every respect the same with regard to their implications for biodiversity, and that all differences between the two alternatives are illustrated by the attribute levels given in the choice tasks. Focus groups and pretesting confirmed that this issue was understood by the respondents.

Finally an additional 'opt out' alternative was provided, which was described as 'I don't want to pay anything at all'. Selecting this alternative, together with other attitude questions, allowed for protest response identification. An example of the choice card is given in Appendix A.

3. Results

Face-to-face surveys were conducted in June 2007 on a nationwide representative quota sample of adult Poles by a professional surveying company. A total of 400 surveys were collected resulting in 1600 choice observations. Protest responses were identified as those where the respondent (1) selected the 'don't want to pay at all' option and (2) showed typical protesting attitude in the debriefing questions[4] and (3) stated that the changes in the forest biological diversity were important to him/her. A total of 387 out of 1600 such observations were removed from the sample.

For the statistical analysis of the data we used an Error Components Multinomial Logit Model with heteroscedascity of the error terms, in order to allow for the error variances to vary within or between choosers or choice occasions, and to include individual preference heterogeneity in the model.[5] The Error Components approach is an extension of the multinomial (conditional) logit model, allowing for a possibility of introducing alternative- or individual-specific random effects, thus relaxing the IIA assumption and introducing preference heterogeneity into the model (Greene, 2007). In the general form of the model, individual *i*s utility function resulting from choosing alternative *j* in choice situation *t* may be formalized as:

$$U_{jit} = \boldsymbol{\beta}'\mathbf{x}_{jit} + \varepsilon_{jit} + \sum_{m=1}^{M} d_{jm}\theta_m \exp(\boldsymbol{\gamma}'_m\mathbf{h}_i)E_{im} \tag{1}$$

where $\boldsymbol{\beta}$ is the parameter vector, $\mathbf{x}_{jit}$ is the individual- and alternative specific vector of characteristics of the choice and ε_{jit} is the individual specific random term, assumed to be identical and independently distributed with an extreme value distribution (as in the case of basic MNL model). The remaining expression represents the 'error components': E_{im} is the individual- and alternative specific random error component (that accounts for choice situation invariant variation that is unobserved and not accounted for by the other model components) assumed to be standard normally distributed ($E_{im}\sim N[0,1]$), d_{jm} takes the value of 1 if error component appears in the utility function for alternative j and 0 otherwise, and the expression $\theta_m \exp({}_m\mathbf{h}_i)$ is the standard deviation of the error component made explicit, where heterogeneity of the variance is a product of choice invariant characteristics of the respondent ($\mathbf{h}_i$) and appropriate parameter vector ($\boldsymbol{\gamma}_m$). Under the assumptions the probability that individual i chooses the alternative j of the available J alternatives in the choice set becomes:

$$\Pr(\forall_{q\neq j}\ U_{jit} > U_{qit}) = \frac{\exp\left(\boldsymbol{\beta}'\mathbf{x}_{jit} + \varepsilon_{jit} + \sum_{m=1}^{M} d_{jm}\theta_m \exp(\boldsymbol{\gamma}'_m\mathbf{h}_i)E_{im}\right)}{\sum_{q=1}^{J_i} \exp\left(\boldsymbol{\beta}'\mathbf{x}_{qit} + \varepsilon_{qit} + \sum_{m=1}^{M} d_{qm}\theta_m \exp(\boldsymbol{\gamma}'_m\mathbf{h}_i)E_{im}\right)} \tag{2}$$

Estimation results are summarized in Table 1. The explanatory variables are dummies representing possible improvements in the levels of the attributes, thus allowing for nonlinear marginal utilities. The variables represent partial and substantial improvement in the protection of the natural processes, improvement in the rare species of fauna and flora,[6] and minor, partial, and substantial improvement in the quality of ecosystem components. Park is a dummy representing the alternative specific constant for the labelled alternative 'extension of the national park' and Cost is the monetary variable measured in Polish Zlotys. There were two error components introduced into the model, E_{SP}—which is common for the alternatives 'status quo' and 'park' and E_{PO}—common for the alternatives 'park' and 'other form of protection'. Heterogeneity of the variances of the error components was introduced by including the following socio-demographic dummy variables: *visit*—equal to 1 if the respondent intended to visit the Bialowieża Forest in the future, influence—1 if the respondent believed that the Bialowieża Forest has an influence on his environment, edu—1 if the respondent had higher education, and city—if the respondent lived in a city of 100,000 citizens or more.[7,8]

[4] Such as: 'polluters should pay', 'I'm against any additional taxes', 'I don't believe the money would be used as stated' etc.

[5] A number of other model specifications were tried, such as: Multinomial Logit, Nested Logit, Covariance Heterogeneity, Heteroscedastic Extreme Value, Random Parameters Logit and Multinomial Probit, each with many possible functional forms. These alternative approaches were compared using Vuong test (Vuong, 1989) and Clarke's distribution free test (Clarke, 2003; 2007). Where necessary tests were corrected for different numbers of estimated coefficients using Schwarz's Bayesian information criterion (Schwarz, 1978).

[6] Because there was no statistical difference between 'partial' and 'substantial' improvement in the Rare Species attribute the improvement is represented jointly.

[7] Individual heterogeneity of variance of error component was found statistically significant in the case of only the second error component, E_{PO}.

[8] The parameters of these variables are difficult to interpret. They allow, however, for the respondents with similar socio-demographic characteristics to have similar variances of the error terms (and thus influence e.g. standard errors of implicit prices) as well as allow for some level of correlation between alternatives for similar respondents.

Table 1
The error components multinomial logit model.

Variable	Coefficient	Standard Error	*p*-value
Natural ecological processes (1-level improvement)	0.648957	0.12047168	0.0000
Natural ecological processes (2-level improvement)	0.829424	0.16563363	0.0000
Rare species (improvement)	0.468667	0.12203158	0.0001
Ecosystem components (1-level improvement)	0.597792	0.15514383	0.0001
Ecosystem components (2-level improvement)	0.632682	0.14518121	0.0000
Ecosystem components (3-level improvement)	0.841666	0.18705936	0.0000
Park (alternative specific constant)[a]	0.716243	0.12708347	0.0000
Cost	−0.0417313	0.00394792	0.0000
Standard deviations of latent random effects (θ)			
E_{SP}	1.57151	0.15837530	0.0000
E_{PO}	6.74596	1.66519361	0.0001
Heterogeneity in variances of latent random effects (γ)			
Visit (E_{PO})	−0.570907	0.22744505	0.0121
Influence (E_{PO})	−0.77398	0.22545476	0.0006
City (E_{PO})	−0.825597	0.22361625	0.0002
Edu (E_{PO})	−0.546768	0.30523973	0.0732

Number of observations 1213.
Log likelihood function −1061.759.
Chi squared 541.7158.
Degrees of freedom 14.
Pr(χ^2>critical value) = 0.0000000.
[a] ASC *park* was representing particular way of implementing the change—providing the changes in the form of national park extension.

All the choice variable parameters are significant at the 1% level and are of expected signs. The direct interpretation of the coefficients is difficult due to an unidentifiable scale parameter, however, their relative values represent marginal effects on the probability of choosing a particular alternative, if it is included as a choice option. That is, variations in natural ecological processes, rare species and ecosystem components all have significant effects on respondents' choices, and thus on their utility. To make comparisons between the biodiversity attributes easier, we estimated implicit prices of the attributes, implementing the approach suggested in Louviere et al. (2006). WTP values for each level of the attributes were calculated, with reference to the status quo level of each attribute. The results, given in EUR,[9] are summarized in Table 2. Standard errors were calculated using the Delta method (Oehlert, 1992).

The results in Table 2 allow us to draw some conclusions. First of all, willingness to pay for preserving natural processes (4.32 and 5.52 EUR/household/year for partial and substantial improvements respectively) was close to the willingness to pay for better protection of ecosystem components (3.98, 4.21 and 5.60 EUR respectively) and higher than willingness to pay for better protection of endangered species (3.12 EUR). This indicates, that the respondents placed, on average, higher value on the passive protection of ecosystem processes than the active protection of endangered species. In addition, the alternative specific constant representing a particular way of implementing environmental change (extending the national park) turned out to be a significant explanatory variable. As noted before, currently the national park covers roughly only 16% of the Białowieża Forest area and there is an ongoing debate whether the park should be extended to the whole area of the forest. The variable park represents additional utility the respondents get if the protection plan is implemented through the extension of the national park, independently from changes in all the other attributes. The monetary equivalent of this utility was 4.77 EUR/household/year.

[9] The values in EUR were calculated using the following exchange rate: 1 EUR≈3.6 PLN (2007).

Table 2
Implicit price estimates (EUR).

Variable	Implicit price	Standard Error	*p*-value
Natural ecological processes (1-level improvement)	4.32	0.825952	0.0000
Natural ecological processes (2-level improvement)	5.52	1.024932	0.0000
Rare species (improvement)	3.12	0.824432	0.0002
Ecosystem components (1-level improvement)	3.98	1.054462	0.0002
Ecosystem components (2-level improvement)	4.21	0.960714	0.0000
Ecosystem components (3-level improvement)	5.60	1.076968	0.0000
Park (alternative specific constant)	4.77	0.781302	0.0000

Wald Statistic 287.14050.
Pr(χ^2>critical value) = 0.0000000.

Finally, we applied the approach provided by Hanemann (1982) to estimate welfare measures in our case of an Error Components model with heteroscedascity. Letting V_j^0 and V_j^1 be the value of the utility function (for the alternative j) for the status quo and the improved state of the public good (new level of the attributes) respectively, and β_1 be the parameter of the monetary attribute in the utility function, the compensating variation associated with the change becomes:

$$CV = -\frac{1}{\beta_1}(E[\max_j U^1] - E[\max_j U^0]) \quad (3)$$

This allowed us, by conducting repeated draws from error components distributions, to estimate the compensating variation for a change in protection policy in the Bialowieża Forest. If all the attributes were improved to their maximum levels used in the study from the status quo, and if the changes were implemented by extending the national park to entire area of the forest, then the predicted change in mean welfare per household per year in Poland is equivalent to 19.82 EUR (with the 95% confidence interval of 17.49–22.14 EUR).

4. Discussion

Our results show that mean willingness to pay for the program of improving the biodiversity level in the Białowieża Forest was close to 20 EUR/household/year for a 'maximum' improvement in all the biodiversity attributes. This result is difficult to compare with other studies, both because the site is unique and has little if any substitutes in Europe, and because the approach and attributes used were particular to this case study. Some comparison can be attempted with respect to some of the implicit prices, however. Both this study and Christie et al. (2006) included attributes for rare species and for ecosystem processes, although how these were described and the context within which they were evaluated clearly both differ substantially (farmland in England compared with a forest in Poland). The Christie et al. implicit prices were around 245 EUR (Northumberland) and 149 EUR (Cambridgeshire) for recovery of rare, unfamiliar species. In our study, the implicit prices are much smaller: a mean of 11.23 EUR. Similarly, the Christie et al. implicit prices for "all" ecosystem process restoration were much higher, at 54 EUR in Cambridgeshire (the implicit price for Northumberland was insignificantly different from zero). This value for Cambridgeshire is much higher than the value for a 2-level improvement in ecosystem processes obtained in the present study.

These comparisons, as well as the absolute value or welfare measure per household in Poland, illustrate that potentially very valuable biodiversity resources in Europe will have relatively low economic conservation values, when only the population of a single transitioning country (Poland) is taken into account. One may expect that this is a result of differences in relative wealth of respondents between the Eastern and Western Europe, rather than differences in consumers' preferences. This result has important implications in terms of how Europe should allocate its funds to conserving its biodiversity in a manner which reflects benefits and costs: although conservation costs (opportunity costs) may also be lower in Eastern Europe than in the West.

Some biodiversity valuation studies have reported insufficient sensitivity of respondents' willingness to pay to the scope of environmental change considered (e.g. Heberlein et al., 2005; Veisten et al., 2004). In our study we observed that the difference between the implicit prices of partial and substantial improvements in the rare species attribute was not statistically significant. However, it is worth remembering that the difference between these attributes was the expansion of current populations, in addition to maintaining and increasing their quality, as represented by partial improvement. It thus appears that an expansion of current populations was not associated with significantly larger utility for respondents. Despite this, the implicit prices of both areas of passive protection of natural ecological processes and the amount of ecosystem components to be actively protected are increasing with the scope of the good.[10,11] We believe that this provides evidence that scope sensitivity can indeed be achieved in biodiversity valuation studies.

Insight is also provided by a comparison of the implicit prices of the attributes, which reflect their relative importance for the respondents. It is interesting to find that the improvement in the area of protection of natural processes was found one of the most important. Since the unmanaged character of this forest is widely recognised, this result may be unique to the study site. Nonetheless it illustrates that consumers can indeed appreciate natural processes happening without human interference. Moreover, the result shows that implementing passive protection regimes can be understood and highly valued by the general public. The implicit price of the improvement of conditions for rare species was found to be lower than the implicit price of improvements in natural processes, and lower than the value of improvements in ecosystem components. This result clearly illustrates that species alone are not necessarily a good proxy for measuring preferences towards biodiversity. This result remains robust even in the light of the findings of Jacobsen et al. (2008) who found higher willingness to pay if species were 'iconised', i.e. described using their names. In our study we both 'iconised' the species to be protected, giving examples of flagship species (e.g. the Polish Bison) and lesser-known species, as well as explaining that protection would involve all rare species (well-known, less-known and unknown).

Methodologically, we applied a wide range of econometric modelling approaches and used a formal testing procedure to discriminate among them to find the model that would best explain respondents' choices. The model which turned out to be the best was the error components multinominal logit model with heterogeneity of error components variances. This is an interesting result in itself because it demonstrates that allowing for different variances within error components may outperform other choice modelling approaches. In particular, this result is achieved by allowing the error variances to be non-constant within and between choosers or choice occasions (Louviere and Swait, forthcoming) whilst also accounting for preference heterogeneity (Colombo et al., 2007; Colombo and Hanley, 2007).

Finally, the alternative specific constant representing how environmental changes were provided (whether by an extension of national park status or not) turned out to be a significant variable. It appears that the respondents had preferences for extending the national park per se, irrespectively of what the extension would really mean.[12,13] This is in line with the results of Jacobsen and Thorsen (2008).

5. Conclusions

Our study has implications for future research and policy making, as well as implications for forest management. We avoided describing biodiversity change in terms of changes in species richness alone, or simply in terms of iconic species. Instead, our approach consisted of describing complex changes in biodiversity using a carefully selected set of attributes taken from ecologists, in the spirit of Christie et al. (2006), but then tuned to what the general public could appreciate. Our approach also avoided eliciting preferences over different management regimes that could lead to variable outcomes (in other words, the main object of value here was predicted outcomes, not management outcomes). As explained above, a management-action focussed approach is prone to difficulties in conveying the possible results of each policy with any certainty, and makes separation of different components of preferences for biodiversity impossible.

These results provide valuable information for designing future policies of managing the Białowieża Forest. They are also of interest given the lack of evidence regarding biodiversity valuation in Eastern European countries (Bartczak et al., 2008; Żylicz, 2000). The relative implicit prices of the attributes used here provide insights that might be useful in designing policy in a range of settings. Interestingly, it was found that respondents may strongly prefer protection of natural ecological processes, at least for some environmentally valuable areas, and are willing to pay for passive protection regimes. What is more, improvements in the protection of rare species and iconic species were not found to be the most important aspects of biodiversity conservation for the general public. This provides an illustration of the potential inadequacy of the more usual approach of using species richness alone as an indicator of biodiversity values.

Finally, our results also show that people may be concerned with the way in which an environmental change is provided, even if alternative approaches may result in similar environmental results. We found that the respondents were concerned not only with achieving a certain biodiversity outcome but also with how this might be achieved. In other words, the means of protection itself might be an important constituent of the perceived value of an environmental policy.

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[10] It was also observed that the marginal utility of increasing levels of environmental improvements is decreasing. This is in line with economic theory and may be explained by the status quo reference level which was described as slow deterioration of environmental conditions.

[11] However, due to high standard errors of the estimates this evidence is rather weak.

[12] It is worth noting that national parks in Poland have varying management regimes and protection goals; thus 'extending the national park' is not associated with any specific set of actions or outcomes.

[13] It should be clearly stated that qualitative analysis conducted via focus groups and verbal protocols did not show up any particular attributes associated with the extension of the national park. It was strongly highlighted in the questionnaire that both alternative ways of protection would essentially mean the same changes to the environment in terms of the attributes used in the design.

Appendix A. Example of the choice card

	Option A: Status quo	Option B: Extension of the National Park	Option C: Other form of protection
Natural ecological processes	No change—protection of natural ecological processes at 16% of the forest area	No change—protection of natural ecological processes at 16% of the forest area	No change—protection of natural ecological processes at 16% of the forest area
Rare species of fauna and flora	No change—decline threatening extinction	Substantial improvement—better condition of current standings and their expansion	Partial improvement—maintaining and better condition of current standings
Ecosystem components	No change—lack of some components and decrease in quality of the existing ones	Minor improvement—regeneration of deteriorated components on 10% of the forest area	Partial improvement—regeneration of deteriorated components on 30% of the forest area
Cost—your tax increase (yearly)	0 zł	50 zł	10 zł
Choice	□	□	□

References

Baillie, J.E.M., Collen, B., Amin, R., Akcakaya, H.R., Butchart, S.H.M., Brummitt, N., Meagher, T.R., Ram, M., Hilton-Taylor, C., Mace, G.M., 2008. Toward monitoring global biodiversity. Conservation Letters 1 (1), 18–26.

Barbier, E.B., 2007. Valuing ecosystem services as productive inputs. Economic Policy 22 (49), 179–229.

Bartczak, A., Lindhjem, H., Navrud, S., Zandersen, M., Żylicz, T., 2008. Valuing forest recreation on the national level in a transition economy: the case of Poland. Forest Policy and Economics 10 (7–8), 467–472.

Baumgartner, S., 2007. Why the measurement of species diversity requires prior value judgements. Kontoleon, A., Pascual, U., Swanson, T. (Eds.), Biodiversity economics: principles, methods and applications. Cambridge University Press, Cambridge.

Billeter, R., Liira, J., Bailey, D., Bugter, R., Arens, P., Augenstein, I., Aviron, S., Baudry, J., Bukacek, R., Burel, F., Cerny, M., Blust, G.D., Cock, R.D., Diekötter, T., Dietz, H., Dirksen, J., Dormann, C., Durka, W., Frenzel, M., Hamersky, R., Hendrickx, F., Herzog, F., Klotz, S., Koolstra, B., Lausch, A., Coeur, D.L., Maelfait, J.P., Opdam, P., Roubalova, M., Schermann, A., Schermann, N., Schmidt, T., Schweiger, O., Smulders, M.J.M., Speelmans, M., Simova, P., Verboom, J., Wingerden, K.R.E.V., Zobel, M, Edwards, P.J., 2008. Indicators for biodiversity in agricultural landscapes: a pan-European study. Journal of Applied Ecology 45 (1), 141–150.

CBD, 1992. Convention on Biological Diversity. Rio de Janeiro, Brazil.

CBD, 1998. Decision IV/10, Measures for implementing the convention on biological diversity. Convention on Biological Diversity, Bratislava.

Christie, M., 2001. A comparison of alternative contingent valuation elicitation treatments for the evaluation of complex environmental policy. Journal of Environmental Management 62, 255–269.

Christie, M., Warren, J., Hanley, N., Murphy, K., Wright, R., Hyde, T., Lyons, N., 2004. Developing measures for valuing changes in biodiversity, Final report. DEFRA, London.

Christie, M., Hanley, N., Warren, J., Murphy, K., Wright, R., Hyde, T., 2006. Valuing the diversity of biodiversity. Ecological Economics 58 (2), 304–317.

Clarke, K.A., 2003. Nonparametric model discrimination in international relations. The Journal of Conflict Resolution 47 (1), 72–93.

Clarke, K.A., 2007. A simple distribution-free test for nonnested model selection. Political Analysis 15 (3), 347–363.

Colombo, S., and Hanley, N. (2007). Modelling preference heterogeneity in stated choice data for environmental goods: a comparison of random parameter, covariance heterogeneity and latent class logit models. In: *European Association of Environmental and Resource Economists 15th Annual Conference*, Thessaloniki, Greece.

Colombo, S., Calatrava-Requena, J., Hanley, N., 2007. Testing choice experiment for benefit transfer with preference heterogeneity. American Journal of Agricultural Economics 89 (1), 135–151.

DEFRA, 2007. An Introductory Guide to Valuing Ecosystem Services. Department of the Environment, Food and Rural Affair, London. available from www.defra.gov.uk.

Faliński, J.B., 1991. La dynamique du paysage interpreter par la dynamique de la vegetation. Colloques Phytosociologiques 17, 425–457.

Faliński, J. B., 1992. Cele Ochrony Przyrody w Puszczy Białowieskiej i Możliwości ich Osiągnięcia. In: Chrońmy Przyrodę Ojczystą, Warszawa, 16–41.

Faliński, J. B., 1996. Białowieski Park Narodowy (1921–1996). Próba 75 lat i zadania na przyszłość w służbie nauki i kultury. Phytocenosis, 8.

Farr, D., 2002. Indicator species. El-Sharaawi, A.H., Piegorsch, W.W. (Eds.), Encyclopedia of Environmetrics. John Wiley & Sons, Ltd, pp. 1043–1044.

Garrod, G.D., Willis, K.G., 1997. The non-use benefits of enhancing forest biodiversity: a contingent ranking study. Ecological Economics 21 (1), 45–61.

Greene, W.H., 2007. Econometric Analysis, 6. Prentice Hall, Upper Saddle River, NJ.

Greensense, 2003. Biodiversity. An Applied Integrated Environmental Impact Assessment Framework for the European Union, European Commission, Brussels.

Gutowski, J.M., Jaroszewicz, B., 2001. Katalog Fauny Puszczy Białowieskiej. Instytut Badawczy Leśnictwa, Warszawa.

Gutowski, J.M., Bobiec, A., Pawlaczyk, P., Zub, K., 2004. Drugie życie drzewa. WWF Poland, Warszawa—Hajnówka.

Hak, T., Moldan, B., Dahl, A.L., 2008. Sustainability Indicators: A Scientific Assessment. Island Press, Washington, D.C.

Hanemann, M.W., 1982. Applied Welfare Analysis with Qualitative Response Models. University of California, Berkeley.

Hanley, N., Willis, K., Powe, N., Anderson, M., 2002. Valuing the Benefits of Biodiversity in Forests. Centre for Research in Environmental Appraisal & Management, University of Newcastle. Phase, 2.

Heberlein, T.A., Wilson, M.A., Bishop, R.C., Schaeffer, N.C., 2005. Rethinking the scope test as a criterion for validity in contingent valuation. Journal of Environmental Economics and Management 50 (1), 1–22.

Heal, G., Barbier, E., et al., 2005. Valuing Ecosystem Services: Towards Better Environmental Decision-making. Washington DC, National Academies Press.

Hooper, D.U., Chapin, F.S., Ewel, J.J., Hector, A., Inchausti, P., Lavorel, S., Lawton, J.H., Lodge, D.M., Loreau, M., Naeem, S., Schmid, B., Setala, H., Symstad, A.J., Vandermeer, J., Wardle, D.A., 2005. Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecological Monographs 75 (1), 3–35.

Horne, P., Boxall, P.C., Adamowicz, W.L., 2005. Multiple-use management of forest recreation sites: a spatially explicit choice experiment. Forest Ecology and Management 207 (1–2), 189–199.

Jacobsen, J.B., Hanley, N., 2009. Are there income effects on global willingness to pay for biodiversity conservation? Environmental and Resource Economics 43 (2), 137–160.

Jacobsen, J. B., and Thorsen, B. J., 2008. Where to put a national park and what to put in it? An a priori study of the willingness-to-pay for coming national parks. University of Copenhagen, Copenhagen, working paper, available from the authors.

Jacobsen, J.B., Boiesen, J.H., Thorsen, B.J., Strange, N., 2008. What's in a name? The use of quantitative measures versus 'iconised' species when valuing biodiversity. Environmental and Resource Economics 39 (3), 247–263.

Kontoleon, A., Pascual, U., Swanson, T., 2007. Introduction. Kontoleon, A., Pascual, U., Swanson, T. (Eds.), Biodiversity Economics: Principles, Methods and Applications. Cambridge University Press, Cambridge.

Larsen, F.W., Bladt, J., Rahbek, C., 2009. Indicator taxa revisited: useful for conservation planning? Diversity and Distributions 15 (1), 70–79.

Lehtonen, E., Kuuluvainen, J., Pouta, E., Rekola, M., Li, C.-Z., 2003. Non-market benefits of forest conservation in Southern Finland. Environmental Science & Policy 6 (3), 195–204.

Li, C.-Z., Kuuluvainen, J., Pouta, E., Rekola, M., Tahvonen, O., 2004. Using choice experiments to value the *Natura 2000* nature conservation programs in Finland. Environmental and Resource Economics 29 (3), 361–374.

Lindenmayer, D.B., Margules, C.R., Botkin, D.B., 2000. Indicators of biodiversity for ecologically sustainable forest management. Conservation Biology 14 (4), 941–950.

Louviere, J. J., and Swait, J. D., forthcoming. Alleviating the constant stochastic variance assumption in decision research: theory, measurement and experimental test. Marketing Science.

Louviere, J.J., Hensher, D.A., Swait, J.D., 2006. Stated Choice Methods: Analysis and Applications. Cambridge University Press, Cambridge.

May, R.M., 1995. Conceptual aspects of the quantification of the extent of biological diversity. Hawksworth, D.L. (Ed.), Biodiversity: Measurement and Estimation. Chapman and Hall, London, pp. 13–20.

MEA, 2005. Ecosystems and human well-being: synthesis. Millenium Ecosystem Assessment, Island Press, Washington, DC.

Nijkamp, P., Vindigni, G., Nunes, P.A.L.D., 2008. Economic valuation of biodiversity: a comparative study. Ecological Economics 67 (2), 217–231.

Noss, R.F., 1990a. Can we maintain biological and ecological integrity. Conservation Biology 4 (3), 241–243.

Noss, R.F., 1990b. Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology 4 (4), 355–364.

Nunes, P.A.L.D., Van den Bergh, J.C.J.M., 2001. Economic valuation of biodiversity: sense or nonsense? Ecological Economics 39 (2), 203–222.
Nunes, P.A.L.D., Van den Bergh, J.C.J.M., Nijkamp, P., 2003. The Ecological Economics of Biodiversity: Methods and Policy Applications. Edward Elgar Publishing Ltd.
OECD. (2001). Valuation of biodiversity benefits: selected studies. Paris.
Oehlert, G.W., 1992. A note on the delta method. The American Statistician 46 (1), 27–29.
Paine, R.T., 1995. A conversation on refining the concept of keystone species. Conservation Biology 9 (4), 962–964.
Pearce, D., 2001. Valuing biological diversity: issues and overview. In: Valuation of Biodiversity Benefits: Selected studies, OECD, Paris.
Pearce, D.W., 2007. Do we really care about biodiversity? Kontoleon, A., Pascual, U., Swanson, T. (Eds.), Do We Really Care About Biodiversity? Cambridge University Press, Cambridge.
Pouta, E., Rekola, M., Kuuluvainen, J., Tahvonen, O., Li, Chuang-Zin, 2000. Contingent valuation of the *Natura 2000* nature conservation programme in Finland. Forestry 73 (2), 119–128.
Pouta, E., Rekola, M., Kuuluvainen, J., Li, C.-Z., Tahvonen, O., 2002. Willingness to pay in different policy-planning methods: insights into respondents' decision-making processes. Ecological Economics 40 (2), 295–311.
Rykowski, K., 2005. O Gospodarce Leśnej w Leśnych Kompleksach Promocyjnych. Sękocin Las, Warszawa.
Schwarz, G., 1978. Estimating the dimension of a model. The Annals of Statistics 6 (2), 461–464.
Shrivastava, R., 2007. Indicator species. Robbins, P. (Ed.), Encyclopedia of Environment and Society. Sage Publications, Thousand Oaks.
Veisten, K., Fredrik Hoen, H., Navrud, S., Strand, J., 2004. Scope insensitivity in contingent valuation of complex environmental amenities. Journal of Environmental Management 73 (4), 317–331.
Vuong, Q.H., 1989. Likelihood ratio tests for model selection and non-nested hypotheses. Econometrica 57 (2), 307–333.
Whittaker, R.H., 1977. Evolution of species diversity in land communities. Evolutionary Biology 10, 1–67.
WSSD. (2002). World Summit on Sustainable Development. Johannesburg.
Żylicz, T., 2000. Costing Nature in a Transition Economy. Case Studies in Poland. Edward Elgar Publishing, Chelthenham.