Valuation of Biodiversity Effects from Reduced Pesticide Use

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ABSTRACT

This study deals with the effects on biodiversity of pesticide-free buffer zones along field margins. Using choice modeling, the majority of respondents to a survey on pesticide use in the environment are willing to accept an increase in the price of bread if the survival of partridge chicks and the number of wild plants increase. The study identifies the need for further empirical work with respect to methodological validation, price estimation, and the use of survey results in policy analysis. In particular, the environmental effects of pesticide use are complex and, therefore, present difficult challenges when presenting information to lay people. Forty-one percent of respondents changed their responses regarding willingness to pay more for bread when references to pesticide use were introduced in the questionnaire. This indicates that scenarios depicting changes in pesticide use can be difficult to present to lay people in an economically rational and well-defined context. Thus, in the study of valuation related to changes in pesticide use, much attention should be devoted to the design and definition of the context. Furthermore, the effects of providing different background information, e.g., with or without the mention of pesticides, should be tested.

Keywords: Biodiversity Pesticides Benefits Survey design Choice modeling

INTRODUCTION

Externalities caused by the use of pesticides in agriculture have given rise to concern in a large number of countries. In this context, the Organization for Economic Cooperation and Development (OECD) has initiated a Pesticide Working Party, which makes recommendations for monitoring pesticide use and formulation of policy responses to reduce externalities (e.g., OECD 1996). In Denmark, concern over the external effects of an increasing use of pesticides led to the formulation of the 1st Pesticide Action Plan in 1985 aimed at reducing pesticide use by 50% within 10 y (Schou and Streibig 1999). Over the years, the plan has been revised 3 times and, along with the revisions, understanding has grown of the desirability of relating policies explicitly to reducing the adverse effects of pesticide use instead of solely focusing on the amounts used. This led to designation in 1998 of the Bichel Committee, which was given a mandate to investigate the environmental effects achieved by existing pesticide policies and to assess the socioeconomic costs and benefits of a unilateral ban on pesticide use in agriculture. The committee presented some generally accepted estimates of the costs to the farming sector, but did not produce estimates of the benefits of such a ban (Kaergaard et al. 2001).

The recommendations from the economic working group called for further investigation into the possibilities of conducting valuation studies of the effects of changes in the use of pesticides to quantify the benefit components and, thereby, facilitate cost-benefit analysis related to ex ante and ex post policy evaluation. On the basis of this, the Danish Environmental Protection Agency initiated the crossdiscipli-

nary project "Valuing environmental and nature effects of pesticide use." The primary focus of the project was a literature-based discussion of the pros and cons of economic valuation related to pesticide use. Furthermore, an empirical valuation study was designed to quantify the benefits of different types of pesticide-free buffer strips in field margins.

The findings from the pilot study are reported in this paper. The paper begins with a discussion of the use of indicators for biodiversity in valuation studies. This is followed by a description of the pilot study including the selection of valuation method and the scenarios. Next, we present results from the pretests in which the indicators, question formats, and issue of mentioning pesticides were tested, as was the factor causing the biodiversity changes. Subsequently, the results of the survey and statistical estimation of the benefits are presented and conclusions are drawn.

INDICATORS FOR BIODIVERSITY EFFECTS

Following the work of the National Oceanic and Atmospheric Administration panel (Arrow et al. 1993), an extensive body of literature on methodological issues and case studies relating to the economic valuation of biodiversity has emerged (see e.g., Garrod and Willis 1999). Among the methodological issues, selection of valuation method especially has drawn much attention. Economic research on the effects of the indicators (or attributes) used to quantify biodiversity effects and the respondent's perception of the problem has been more modest, although good examples are found in Spash and Hanley (1995) and Nunes and van den Bergh (2001). However, analysis of the perception of the biodiversity indicators is important. For example, 1 of the central recommendations from the National Oceanic and

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Atmospheric Administration panel is that the respondents should understand intuitively and unambiguously the effects subject to valuation.

A survey of relevant case studies shows large variation in the type of indicators used, as well as the methodologies for deriving and presenting indicators of changes in biodiversity. Three basic approaches to constructing and presenting biodiversity indicators can be generalized: A qualitative approach; a formal statistical approach; and a simple statistical meta-analysis. An example of the 1st is found in Macmillan et al. (2001) where the effects of changes in land use are described based on expert statements (foresters and woodland experts) using graphics, manipulated photos, and text. Kealy et al. (1999) exemplified the formal statistical approach by valuing biodiversity effects of changing habitat characteristics. Here, changes to the number of birds and bird species are used to approximate biodiversity changes. The number of birds and bird species are estimated using a formal model based on observations in the field. The expected survival rate of the bird species is based on the probability of observing a given number of birds and bird species, in a given period of time, under conditions of well-specified habitat characteristics.

An example of the 3rd approach is found in Foster and Mourato (2002) who studied changes in the use of pesticides in the United Kingdom. The study aims to estimate the trade-off between farmland birds and expected cases of human illnesses resulting from different strategies to reduce the use of pesticides. Here the biodiversity effects are described by the number of farmland bird species, a well-established indicator in the United Kingdom, and the differences between the various pesticide strategies are predicted using meta-analysis on existing data.

In this study, a mix of the 2nd and 3rd approaches is used. The basis for the scenarios and the resulting biodiversity effects is a study by Hald and Lund (1994) investigating the effects on flora and insects of different types of field margin management. The study is supplemented with simple models of the interaction between the floristic and insect data and the survival rate for partridge chicks. This approach was chosen because both social and natural science expertises were represented in the project, enabling a multidisciplinary discussion of how to develop the scenarios and attributes.

STUDY DESIGN

Scenarios

The starting point of the analysis is to develop a number of attributes used to quantify the biodiversity effects of different types of field margin management. Field margins are defined here as the first 6 m in from the edge of a cropped field. This is chosen to secure correspondence to the study by Hald and Lund (1994) used for establishing the set of ecological attributes for the effects relating to the provision of nature goods (Hald 2002). The scenarios used in the study are

1. Conventional cereal cropping (reference scenario),
2. No pesticide use in the field margin,
3. No pesticide use and undersowing of herbs in the field margin, and
4. No pesticide use and undersowing of herbs in the field margin in combination with a reduction in pesticide application (50% reduction in herbicide use, no insecticides used and full use of fungicides) and a 50% cut in fertilizer use in the midfield.

Based on the scenario descriptions, the economic costs to farmers of the different management types are analyzed in Schou (2002). The set of ecological attributes directly relates to the parameters used in the field trials by Hald and Lund (1994) comprising 1) the number of wild plants, 2) the number of wild plant species, 3) the amount of bird forage (insects), and 4) mortality of partridge chicks. The mortality of partridge chicks is modeled based on results from Potts (1986) showing the relationship between forage and mortality. For all estimates, the uncertainty is shown in terms of 85% confidence intervals. The methodology is explained further in Hald (2002). In Table 1, the chosen ecological attributes are summarized for each type of field margin management. Note that all figures refer to the total field area.

Compared with scenario 1 (the reference scenario), establishment of pesticide-free field margins in scenario 2 leads to relatively small effects on the ecological attributes and primarily increases the number of wild plants. In scenario 3, the amount of bird forage increases to the extent that mortality of partridge chicks is reduced from 40% to 30%. Thus, changing from scenario 2 to 3 implies substitution from wild plants to birds. This is because the undersowing of herbs in scenario 3 increases the total number of plants but decreases the number of wild plants. In scenario 4, a strong impact on all of the attributes is seen because this scenario represents the least intensive of the agricultural management alternatives.

The economic costs are calculated as the loss of economic rent. Hereafter, the increase in the retail price of 1 standard loaf of bread that compensates for the costs is calculated based on the average cost-share of cereals (flour) when producing bread. The compensatory price of bread is used as the payment vehicle, because we expect relative ease for the respondents in relating this to their budgetary constraints, bread being a commonly purchased good. With an average price for 1 loaf of bread of 15 in the reference scenario, the compensatory increase in the price ranges from 5% to 34% in the scenarios. In the focus group interviews, the price of 1 kg of wheat flour was tested as an alternative to the price of 1 loaf of bread. The results from the focus group interviews are described in detail later on in the paper.

Valuation by choice modeling

Hypothetical methods such as the contingent valuation method are the most commonly used methods for valuation of nonmarket public goods, in Denmark as well as internationally. Hypothetical methods imply that the respondents are asked to reveal their hypothetical willingness to pay by answering, for example, open-ended or referendum format questions, or to make choices between hypothetical alternatives.

Choice modeling techniques are hypothetical methods that, in recent years, have been used widely. The strength of these methods is the potential to present different attributes, including the payment attribute, in terms of alternative scenarios, described within choice sets. The respondents are asked to trade off between the attributes and indicate their most preferred alternative in each choice set. Therefore, this method offers some advantages when valuing more complicated environmental issues, such as biodiversity changes, as the biodiversity changes are presented in a market-like situation as choices between the scenarios. Thus, for issues that relate to many nonuse and unfamiliar goods, the method

Table 1. Average effects and range[a] on selected ecological attributes resulting from introduction of scenarios for pesticide-free field margins (min; average; max). Note: All effects refer to the total field area

	Scenario 1 (reference)	Scenario 2	Scenario 3	Scenario 4
No. of wild plants (per m²)	4; 26; 48	7; 43; 79	6; 36; 65	15; 84; 168
No. of wild plant species (per m²)	5; 7; 9	6; 8; 10	6; 8; 10	8; 11; 14
Amount of bird forage (insects, g/m²)	68; 153; 338	72; 162; 366	79; 183; 418	109; 259; 505
Mortality of partridge chicks (%)	40	40	30	10
Avg. economic rent (DKr/ha)	1,540	1,440	1,370	990

[a] Range corresponds to the 85% confidence interval.

seems to offer advantages compared with, for instance, contingent valuation, although the former method's statistical analyses pose greater challenges.

Using choice modeling methods, the researchers formulate realistic scenarios or alternatives that are characterized by a few well-chosen indicators—also called attributes—that should be familiar to the respondents. To achieve an appropriate and not overly complex framing of the survey, the number of attributes should be kept as low as possible, but still convey enough information so that the respondents can construct preferences for the environmental goods as for ordinary marketed goods. Examples of attributes are the number of wild plants and animals per hectare that can be described as purely wild plants, wild animals, or by their names, e.g., orchids or poppies and roe deer, hares, or partridges. The costs can be expressed using various payment vehicles—e.g., yearly income tax payments, voluntary donations to a designated fund, or increases in commodity prices—all related to the activities causing the changes in biodiversity (e.g., agriculture).

The results are analyzed by estimating random utility functions. Using the indicators relating to ecological effects and the economic costs as attributes in choice sets, 2 different sets of questionnaires were designed and tested in the focus group interviews. The 1st represented data on all the ecological indicators, including average and minimum values as well as the compensatory increase in the price of 1 loaf of bread. The 2nd questionnaire was a reduced version of the 1st, but representing average values of just 2 ecological indicators (number of wild plant species and mortality of partridges) and the increase in the price of 1 loaf.

The survey is divided into 2 parts. The 1st part aims to reveal the respondents' general attitudes toward agriculture and environment and serves 3 purposes. First, the National Oceanic and Atmospheric Administration panel states that it is very important to the validity of economic valuation of biodiversity that all possible alternatives in a given case are presented. Therefore, respondents are asked initially if they would like Danish agriculture to convert fully to organic farming and whether they find agriculture today environmentally safe. Second, 3 questions were aimed at revealing the respondents' general attitudes toward national spending on the environment and disclosing respondents' opinions on which groups in society should carry the economic burden of improving biodiversity. The answers are compared with the ranking of the 4 scenarios to check for internal consistency.

Thirdly, the questions are intended to give some idea about what the respondents are valuing—existence value or recreational value.

The 2nd part presents the empirical basis of the valuation study, where the respondents are asked to rank the 4 scenarios based on their preferences for the levels of the presented attributes. After having consulted the survey institute GALLUP, we decided to present each scenario on individual choice cards. The 4 choice cards were handed out to the respondents and they were asked to rank the cards so that the 1 where the ecological effects best match the costs is number 1 and so on.

The survey and the general questionnaire were introduced by the following text:

Changing agricultural production methods in field margins will improve the conditions for nature in the agricultural landscape. Wild plants and birds will benefit, but at the same time the farmer is presented with an economic loss. In this survey, we will ask you to state your preferences for 4 types of agricultural production methods. The results will be used in a research project aimed at revealing the trade-off the Danish public makes between nature and economy. First, we would like to request that you reveal the extent to which you agree with the following statements (Table 2).

The choice exercise was introduced by the following text:

On the 4 cards you see the effects of 4 different types of farming. For each type, the effects on nature are shown in terms of wild plant species and birds. Furthermore, the costs of realizing the nature effects are shown by the increase in the basic price of wheat flour at 8 DKK/kg, which would correspond to the economic loss. We ask you to rank the 4 cards so that the card where you find the nature effects best match the costs is ranked as number 1 and the card where you find the nature effects poorest match the costs is ranked as number 4.

The choice cards were designed to represent the scenarios in the choice modeling exercise.

Pretests and survey

Considering the many-sided externalities of pesticide use and the uncertainty associated with measuring these quantitatively, the issue of how to measure the effects from reduced pesticide use and how to present these to the respondents is

Table 2. General qualitative background questions used in the preference study

	Agree strongly	Agree	Disagree	Disagree strongly	Don't know
1. Agricultural production today is environmentally safe					
2. Agriculture should fully convert to organic farming methods					
3. Too many resources are used today on nature and the environment compared with other sectors (e.g., health sector, education)					
4. The price is important to my choice of food items					
5. The farmer should pay for the costs of improvements in nature					
6. The agricultural landscape is important in Danish nature					
7. The agricultural landscape is of no importance for my nature experiences					

central. With reference to the sociological and psychological research on risk perception, the study of pesticides appears to incur serious pitfalls. In a study by Sparks and Shepherd (1994), pesticides are found to be rated very high as a hazard when compared with other hazards. Pesticides are grouped together with other unwanted production process byproducts as technological hazards. During recent decades, it may even be the case that pesticides have become stigmatized, implying that an individual's evaluation of the hazards involved may not be influenced, even where the benefits involved are documented as high (Slovic 1999).

From an economic point of view, the benefits of a given change in biodiversity derive from the change in opportunities with regard to consumption of the relevant goods. This implies that a given change in biodiversity, all else being equal, should result in the same benefits independently of how the change is established. Based on these considerations, we decided to present the ranking exercise to the focus groups initially without mention of pesticides. After the participants had carried out the ranking exercise, prevention of the use of pesticides in the buffer strips was presented as the cause of the biodiversity change and the implications of this new information for the ranking were discussed.

Besides aiming to look deeper into the importance of mentioning the pesticide issue to the respondents, the aim of the focus group interviews was to identify whether the framing and wording of the choice cards as well as the background information were sufficient. Firstly, respondents were asked to comment on this in open, roundtable discussion without detailed guiding questions, but motivated by the moderator. This information was used to elicit the degree of complexity the respondents can cope with, i.e., the information on the public good, the wording and the choice opportunities, as well as the number of attributes. Next, they were asked 3 questions in sequence on how the valuation

would work if many attributes were presented: How the valuation would work if real scientific uncertainty is presented; whether it matters if the respondent is informed about the cause of the biodiversity effects (in casu changed pesticide use); and, finally, how they would respond to different ways of presenting the information.

The questionnaire was tested on 2 focus groups. Both groups represented a mixture regarding residential status (present and while growing up), educational background, job situation, age, and gender. The results of the focus group interviews are summarized in Table 3.

In general, the respondents wanted more written information to explain the importance of field margins as a habitat for wild flora and fauna. Related to this, some of the respondents questioned the scaling of the choice sets, i.e., they asked how much nature they would receive for the costs. This question appeared partly because the expression of some of the attributes (bird fodder in grams) was unfamiliar to them and partly because they wanted information on the number of plants, birds, and animals at a national scale, or descriptions of whether these species are threatened by extinction. Furthermore, some of the respondents in 1 of the groups found it easier to make the ranking of the choice set when they were told explicitly that the reference scenario represented ordinary, conventional agricultural practice.

Based on these results, the final choice cards were designed as shown in the Appendix 1. Four important changes in the presentation of the parameters were made. The number of attributes was reduced to the number of wild plants and the survival of partridge chicks, and the lower bounds on the attributes were omitted. The payment vehicle was changed to the price of wheat bread instead of flour, as initially intended; last, it was decided not to include any information on pesticide use in the introductory text. The main reason for omitting mention of pesticides was that the participants

Table 3. Summary of the focus group results

Issue	The Copenhagen group	The Roskilde group
Introducing risk	The respondents were aware of this information, used it in their ranking, and found it trustworthy.	None of the respondents actually used this information, and found it superfluous. Consequently, it was not considered trustworthy.
Introducing pesticides	Some of the respondents thought that the change in biodiversity was caused by changes in pesticide application, and hence the additional information did not change their attitudes and ranking. However, some of the respondents answered that the information would change their ranking towards more ideological answers. They did not take other effects (groundwater protection, health, etc.) into consideration, but displayed a general attitude toward pesticides.	Some of the respondents thought that the change in biodiversity was caused by changes in pesticide application, and hence the additional information did not change their attitudes and ranking. Most of the respondents, however, thought that the additional information would change their ranking selection.
Alternative presentation formats 1. Should examples of wild plants and animals be presented? 2. Will illustrations by pictograms or graphs improve the presentation of each of the alternatives?	The respondents found that the text was difficult to understand due to the complexity in the text, and pictograms could help. Some of the respondents found it relatively easy to understand, interpret, and rank the choices.	The respondents found that the text was difficult to understand due to the complexity in the text, and graphs could help. None of the respondents found it easy to understand, interpret, and rank the choices.

revealed that this information led them toward more ideological answers. Thereby, the focus on the trade-off between biodiversity and consumption of other goods would have been lost. Instead the differences in biodiversity between the scenarios were ascribed to "environmentally friendly changes in agricultural production methods".

RESULTS

The data collection was carried out on 266 respondents by a professional interview firm as part of their omnibus survey. The survey is stratified to be representative of the Danish population +16 with respect to central variables such as gender, age, and household income, etc. Out of the 266 respondents, 246 responded (i.e., the response rate was more than 90%).

Table 4 shows the distribution of the respondents' answers to the ranking exercise in terms of the number of times the

individual scenario was given each possible ranking. Current agricultural practice was given 1st priority 30 times (12%) and the lowest priority 134 times (55%). Scenario 3, involving no pesticide use and undersowing with herbs in the field margin, was prioritized 1st the majority of times (25%). It is notable that the answers are distributed broadly among the choice options, indicating that the respondents performed the actual trade-offs and that the options rendered a relevant range of options for respondents to state their preferences.

Subsequent to the ranking exercise, the effect of mentioning pesticide use as the cause of the biodiversity changes was tested. Respondents were posed the following question:

The nature effects previously shown to you are caused by reduced pesticide use in field margins. If the use of pesticides totally was stopped in agricultural cereal production, the same nature effects as described in scenario 4 would be obtained, but

Table 4. Results of the ranking exercise

Scenario/no. of scores	1st Priority	2nd Priority	3rd Priority	4th Priority
Scenario 1 (reference)	29	21	55	134
Scenario 2	65	91	78	5
Scenario 3	83	99	49	8
Scenario 4	62	28	57	92
The ranking only partly completed	0	4	4	6

the price of bread would increase by an extra 18%. Are you willing to pay an additional price on bread of 52% to avoid pesticide use in Danish cereal production?

The statement has no specific scientific basis but serves to provide information to test if respondent's preferences are affected by mentioning the word pesticides, all else equal. Forty-one percent of the respondents answered yes, 50% answered no, and the remaining 9% answered don't know, indicating a high degree of dependency of the ranking on the information given. This could indicate that pesticides, in themselves, are considered a problematic input (i.e., stigmatized). An alternative explanation is that the respondents attach extra goods to the scenarios, such as improved groundwater protection. This should be seen in the context that 99% of total Danish drinking water supply comes from only mechanically treated groundwater and that pesticide pollution is considered an important threats to this source.

The econometric analysis is based on a random utility model in which each respondent's response is assumed to reflect an indirect utility function as stated in Equation 1.

By means of the probabilities of a choice between the alternatives, the utility can be described as a function of the attributes. As the attributes and costs vary systematically between the choices, implicit prices for the attributes can be estimated.

The method can be described formally by the following utility function. An individual i utility from a good j (U_{ij}) can be described as a function of a deterministic part (v) and a stochastic element (γ) as follows:

$$U_{ij} = v(Z_j, S_i) + \gamma \qquad (1)$$

where Z represents characteristics of the good (e.g., biodiversity attributes) and S characteristics of the individual (e.g., gender, income, etc.; see Adamowicz et al. 1994; Bateman et al. 2002).

The utility function is specified linear

$$v(Z_j, S_i) = b_1 P + b_2 H + b_3 B \qquad (2)$$

where P is the price of bread, H is the survival rate of partridge chicks, and B is the number of wild plants.

A priori it is expected that $b_1 < 0$, $b_2 > 0$, and $b_3 > 0$. From Equation 2, the marginal substitution rate between the survival rate of partridge chicks and the price of bread is found to be

$$\Delta H = \frac{b_1}{b_3} \Delta P \qquad (3)$$

and the substitution rates between the other attributes can be deducted in the same way.

Due to the fact that the results reported here derive from a pilot study where focus has been on the design of the valuation study, parameters b_j are specified as constant across respondents. Also, initially, we used the most-preferred alternative method, which is based on the assumption that the alternative preferred by respondent i is characterized by

$$V(X, Z) + e > V(X, Z) + e, \ m \neq n \qquad (4)$$

Because e is a stochastic variable, Equation 4 represents the probability of respondent i choosing option m instead of option n. Assuming that the stochastic element follows a Weibull distribution, Equation 4 can be rewritten as

$$Pr(U > U, \ m \neq n) = (exp[V] + exp[V]) exp[V] \qquad (5)$$

where $Pr()$ is the probability for option m being preferred to option n.

The parameters are estimated using the maximum likelihood method and, using the above specification of the indirect utility function, the likelihood function is given as

$$LnL = \sum_i \sum_j y_{ij}(V_{ij} - \ln \sum_{ij} exp[V_{ij}]) \qquad (6)$$

Note that, using this specification, the level of the attributes is fixed. From Table 5 it is seen that the coefficients fulfill the a priori expectations that $b_1 < 0$, $b_2 > 0$ and $b_3 > 0$, and that the estimates of the main effects are significant.

The willingness to pay (WTP) can be estimated using the estimated parameters in Table 5. The WTP for an increase in the survival rate of partridge chicks of 1% is $0.81/3.12 = 0.26$ DKr per loaf of bread purchased by the household. The WTP for an increase of 1 wild plant/m^2 is $0.17/3.12 = 0.05$ DKr per loaf of bread purchased by the household. The yearly purchase in the period 2001 to 2003 was approximately 210 loafs of bread per household. This implies that the estimated WTP per household is 55 DKr/y for an increase in the survival rate of partridge chicks of 1% and, similarly, the estimated WTP is 11 DKr/y per household for an increase of 1 wild plant/m^2. The number of households in Denmark is approximately 2.5 million, and a rough estimate for the net present value of the pesticide reductions in buffer zones can be obtained by comparisons of the total costs and the benefits for all Danish households. This cost-benefit assessment has not been part of the reported study and is not described here, however, the results can be used for such cost-benefit assessments.

A number of estimations have been carried out using the most-preferred alternative method, including different combinations of background variables for the respondents, such as age, location, education, and occupation, and with different specifications relating to the increase in costs. As seen in Table 5, only the gender variable is insignificant. Moreover, the estimated parameters in Table 5 show that the WTP increases with the age of the respondents and, as expected, individuals with high-income jobs have the highest WTP. Although the variable gender is insignificant, there is a tendency that the female has a higher WTP than the male. Other analyses of WTP for environmental programs reach the same results of gender differences being statistically insignificant (Loomis 2000). The estimated parameter for the education is negative. This can be explained only by the presence of multicollinarity, which is the case when, for example, 2 or more explanatory variables are correlated highly and, result in bias in the estimated b coefficient. The presence of multicollinearity can be explained by the design of the study where most attention has been paid to the presentation of attributes representing the real biological research results. As mentioned, the study is a pilot study with only 260 respondents; we must emphasize that the estimation results should be interpreted with caution.

In comparison, Bjørner et al. (2004) carried out a contingent ranking study to estimate the value of biodiversity and health effects related to changes in the use of pesticides by the Danish agricultural sector. The population of birds living and breeding on arable land is used as an indicator of biodiversity, and allergy is included as a health attribute. With respect to biodiversity, a fairly high annual WTP is found corresponding to 213 to 230 DKr per household for a 1% increase in the population of birds. Compared to the present study, where the WTP is estimated at 55 DKr/y, the WTP is higher, but this difference can be explained by the fact that

Table 5. Results from the econometric analysis. Ordered logit model using LIMDEP ver. 6

Variable	Coefficient	Standard error	t Value	p	Mean of x
Gender	−0.202	0.127	−1.584	0.113	1.515
Age	0.012	0.004	3.048	0.002	46.402
Education	−0.096	0.039	−2.496	0.013	4.641
Job	0.065	0.020	3.236	0.001	6.313
Price	−3.118	0.160	−19.490	0.000	16.396
Wild plants	0.166	0.011	15.285	0.000	50.980
Partridges	0.805	0.039	20.595	0.000	68.547

the estimated WTP in Bjørner et al. (2004) covers the increase for birds on arable land in general, and the present study only covers the WTP for an increase in the survival of partridges.

CONCLUSION

This study reports the findings of a pilot study on Danish consumers' willingness to pay for increased biodiversity resulting from changes in the use of pesticides. Different approaches to establishing the relationship between scenarios/policy options and biodiversity effects are discussed and 3 basic approaches are identified: Qualitative approach, formal statistical approach, and simple statistical metaanalysis. All of these provide meaningful input to valuation studies; however, we find that, if it is possible to establish a quantitative relationship, both cross-disciplinary acceptance and usefulness in actual policy use will be promoted when reporting the results.

Results from the benefit study can be used in 2 ways. First, they can be used to indicate that the Danish population's preferences are positive for management that increases the survival rate of partridges, as well as the number of wild plants in arable fields. Secondly, the results can be used in welfare economic cost-benefit evaluations of different pesticide regulations and, hereby, as an input to choose between the regulations. One of the uncertainties in the study, however, is how reduced pesticide applications increase the survival rate of partridge chickens as well as wild plants/m². Ranges for the effects on wild flora are estimated, and these indicate that the effects both on wild flora and partridges are dependent on other causes other than pesticide applications, for example, crop rotation and fertilizer use. These issues also need to be addressed when designing actual policies.

The valuation study is based on choice modeling because this method has advantages when valuing complicated environmental issues such as biodiversity changes. The testing of the survey material showed that respondents were not comfortable with use of information on biodiversity indicator variability (presented as minimum estimates), but that the indicators wild plants and the survival rate of partridge chicks were interpreted easily. Moreover, 41% of the respondents increased the stated willingness to pay when pesticides were introduced in the questionnaire. This might indicate that pesticides, in themselves, are considered a problematic issue (i.e., stigmatized). An alternative explanation is that the respondents attach extra benefits to the scenarios, such as improved groundwater protection. Regardless of the explan-

ation, the results indicate that scenarios relating to changes in pesticide use can be difficult to present to lay people in an economically rational context.

This led to the conclusion that, when performing valuation studies related to changes in the use of pesticides, a great deal of consideration should be devoted to the context and design of the study. Furthermore, the effects of providing different background information, for example, with and without the mentioning of pesticides, should be tested.

The results indicate that the willingness to pay for improvements of biodiversity is positive and, more particular, that the willingness to pay for a 1% increase in the survival of partridge chicks is approximately 55 DKr/household/y. The estimated willingness to pay is less for an increase of 1 wild plant/m²; namely 11 DKr/y/household. The parameters of the willingness to pay are significant on a 10% level; however, the results are indicative only because of the low number of respondents in the study.

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