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Spatially explicit demand for afforestation

Julian Sagebiel [a,*], Klaus Glenk [b], Jürgen Meyerhoff [c,d]

[a] Institute for Ecological Economy Research, Potsdamer Str. 105, 10785 Berlin, Germany
[b] Scotland's Rural College (SRUC), Land Economy, Environment & Society Group, Peter Wilson Building, Kings Buildings, West Mains Road, Edinburgh EH9 3JG, United Kingdom
[c] Technische Universität Berlin, Institute for Landscape and Environmental Planning, Straße des 17. Juni 145, 10623 Berlin, Germany
[d] Kiel Institute for the World Economy, Kiellinie 66, 24105 Kiel, Germany

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ABSTRACT

Afforestation is a stated goal in European Union policy and several member states have already implemented schemes to extend forest cover. However, little is known about the magnitude of non-market benefits of afforestation and how these benefits spatially differ. In this article, we propose a novel method to spatially explicitly predict marginal willingness to pay for afforestation. The approach is illustrated with data from a discrete choice experiment on local land use changes in Germany. GIS data on the respondent's place of residence allows inferring their current endowment with forest, which enters the utility specification of each respondent's status quo alternative. Marginal willingness to pay estimates therefore represent the value of changes in local forest cover relative to the observed status quo. This relationship can be utilized to predict willingness to pay at the county level. We find that marginal willingness to pay decreases as the current endowment with forest increases. The estimated optimal share of forest based on the average respondent's preferences is between 50 and 60%. The associated county level predictions of marginal and total willingness to pay can be used to inform national, regional and local policies that aim to increase forest cover.

1. Introduction

Forests provide important ecosystem services, including biomass, recreation and climate regulation. This is reflected in the new EU Forest Strategy, which emphasizes the need for multi-functional forest management to safeguard the demand for ecosystem service provision (EC, 2013). The area of forest cover has increased in Europe over the past decades (FAO, 2010) but further extending forest cover remains part of national forest strategies within the EU. Afforestation can facilitate transitions to a bio-based economy, is a cost-effective means to contribute to climate change mitigation (e.g. Valatin and Price, 2014), and can result in synergies with efforts to achieve national biodiversity conservation targets. Additionally, forests are widely used for recreational activities. The German Forest Strategy 2020 recommends the extension of forest area where afforestation can make a positive contribution to climate change mitigation, nature and landscape (BMELV, 2011). The Forest Strategy emphasizes that afforestation should take place "where possible", depending on "regional possibilities" (BMELV, 2011, p. 23). This implies a need for an understanding of how costs and benefits of increasing forest cover vary across the country to enable policy makers to develop efficient and regionally targeted policies based on the strategic objectives.

Some costs and benefits may be more readily observable by drawing on market information. This includes the opportunity costs of farmers who provide agricultural land for afforestation or the potential values of carbon sequestration (Yemshanov et al., 2005). However, non-market benefits to the local population arising, for example, from increased recreational possibilities and landscape aesthetics may represent a considerable share of overall costs and benefits, which are often ignored. These additional values can be critical to determine whether an afforestation program is financially viable or whether multiple purposes (e.g. recreation, biodiversity) of afforestation can be achieved simultaneously (Gimona and van der Horst, 2007). Many studies also emphasize the importance of spatial heterogeneity in costs and benefits of afforestation for policy planning purposes (Broch et al., 2013; Gimona and van der Horst, 2007; Plantinga and Wu, 2003).

The environmental benefits of afforestation are well understood (Plantinga and Wu, 2003). However, in contrast to the benefits from changes of forest management (see, for example Giergiczny et al. (2015) or the studies used in two recent meta-analyses by Hjerpe et al. (2015) and Barrio and Loureiro (2010)) only a few studies have investigated the non-market benefits of afforestation with stated preferences methods. Colombo and Hanley (2008) investigated marginal willingness to pay (MWTP) for increases in mixed and broadleaved woodland and found values of around 0.6 € for a 1% increase. Upton et

* Corresponding author.
E-mail addresses: julian.sagebiel@ioew.de (J. Sagebiel), klaus.glenk@sruc.ac.uk (K. Glenk), juergen.meyerhoff@tu-berlin.de (J. Meyerhoff).

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al. (2012) estimated MWTP for increases in forest area in Ireland, which is characterized by low forest cover. One important finding was that the location, i.e. where the afforestation takes place, impacts MWTP. In a case study in the Basque Country in Spain, de Ayala et al. (2015) find that respondents are on average willing to pay one Euro per year for a 1% increase in native forest area. In a case study on the Venice hinterland in Italy, Vecchiato and Tempesta (2013) report that people, on average, are willing to pay up to 50 Euro per year and household for an afforestation program, which leads to a forest share of 75% of the landscape. They emphasize that a landscape solely covered by forest is suboptimal. Further, they identify distance decay effects, i.e. the farther people live away from the hinterland, where the afforestation should take place, the lower is their MWTP.

The present study adds to the scant body of literature on non-market benefits of afforestation programs by providing insights into MWTP of private households for local afforestation in Germany. The aim is to derive spatially explicit estimates for the demand for increased forest cover across Germany. The approach taken makes use of stated preference data from a discrete choice experiment (DCE) study on local land use changes in Germany. The DCE was part of a cost-benefit analysis within a research project on climate change and land use interactions and included increases and decreases in forest share as one of the attributes. The remaining attributes were used to describe other land uses of interest and biodiversity outcomes. In this paper, we focus on the forest share attribute to examine the spatial distribution of willingness to pay for changes in forest cover and propose a novel method to derive spatially explicit MWTP values.

Two features distinguish this work from earlier studies on forest-related land use changes. The first aspect concerns the incorporation of the actual status quo of forest share each respondent faces in the status quo alternative. We argue that the assumption of constant marginal utility implied by a linear specification of the utility function may be inappropriate if the land use type is frequently used for recreational activities, which is the case for forest areas: a greater level of current supply implies a greater availability of areas that can act as substitutes to the expanded area of a land use type. This would be expected to have a negative effect on the marginal value placed upon additional units of the land use type. Additionally, a varied portfolio of land use types may be preferred over landscapes in which a single land use dominates (van Zanten et al., 2014; Vecchiato and Tempesta, 2013). In this case, an increase in a single land use type would yield additional benefits only up to a threshold, where MWTP equals zero, thus representing the land use type's optimal share. Beyond the threshold, marginal benefits of additional supply are negative. One example of evidence for aversion against monotone (closed or open) landscapes is provided by Schmitz et al. (2003), who used a DCE to value multi-functionality of landscapes in Hessia, Germany. One of their attributes referred to landscape appearance. The study found that landscapes with moderate forest shares were preferred to landscapes with very high or very low shares of forest.

The second differentiating aspect of this study is the use of the estimated MWTP function, which depends on the status quo and other spatial variables, to predict MWTP at the county level. We thus derive a map displaying MWTP values based on individual predictions aggregated at the county level. Here, our approach contributes to the ongoing discussion on how to incorporate spatial elements in DCEs. Early approaches assume that MWTP is a function of the distance to the site that is to be valued (Schaafsma et al., 2013, 2012). However, this approach is not meaningful in the context of this study, which aims to value local land use changes where all respondents have the same distance to the valued good at hand. Further developments make use of geostatistical methods such as spatial autocorrelation to identify local and global hotspots (Campbell et al., 2008; Johnston and Ramachandran, 2013; Meyerhoff, 2013) and spatial interpolation to create smooth maps with spatially comprehensive MWTP values (Campbell et al., 2009; Czajkowski et al., 2016; Johnston et al., 2015). These approaches rely on 'individual-specific' estimates of MWTP, which introduces new sources of uncertainty. In contrast, the approach presented here relies on predictions and does not require further assumptions on the distribution of MWTP. It is, thus, computationally less intensive and can be applied with simpler models such as the conditional logit model.

Table 1
Attributes and levels of the choice experiment.

Attribute (label)	Levels
Share of forest (ShFor)	As today, decrease by 10%, increase by 10%
Field size (FiSiz)	As today, half the size, twice the size
Biodiversity in agrarian landscapes (Biodiv)	As today, slight increase (85 points), considerable increase (105 points)
Share of maize on arable land (ShMai)	As today, max. 30% of fields, max. 70% of fields
Share of grassland on agricultural fields (ShGra)	As today, 25%, 50%
Annual contribution to fund (price)	0, 10, 25, 50, 80, 110, 160€

2. Study design and survey data

This study employs data from a survey administered to 1233 randomly selected German adults that were recruited from an online panel of a German market research company between March and April 2013. In addition to the DCE, the survey included questions on socio-demographics, attitudes and perceptions of land use and land use induced climate change as well as on recreational activities. Respondents indicated their place of residence on an embedded Google maps interface from which we could extract WGS84 coordinates to infer their exact place of residence.

Respondents were informed that the objective of the survey is to learn more about people's views regarding the landscape in their surroundings, which is characterized by a number of attributes. Subsequently, six attributes were introduced. These attributes were (i) share of forest in the landscape, (ii) the average size of fields and forests, (iii) agro-biodiversity, (iv) the share of maize on arable land, (v) the share of grassland on agricultural land and (vi) an annual contribution to a local landscape fund (Table 1). Each attribute had three levels. Two levels described changes compared to the current situation that would occur within a 15 km radius of their place of residence, while the remaining level referred to the status quo ("as today"). The attribute *share of forest* was described as the forest share of total land cover within the 15 km radius. The first level was a 10% decrease in forest share, and the second level a 10% increase. Respondents were informed that decreases and increases in forest share were associated with corresponding increases and decreases in agricultural land cover. The second attribute *field size* referred to the average size of individual forest and field plots. A large field size means that, on average, individual forest areas and fields within the 15 km radius of the respondent's place of residence are large, implying a more monotonic landscape. A small field size implies a more fragmented, mosaic-like landscape. The third attribute was biodiversity of agrarian landscapes (agro-biodiversity) within the 15 km radius. As biodiversity is generally difficult to measure, we used a bird species indicator (Hoffmann et al., 2007) as a proxy. The indicator describes, for different landscapes, the extent to which native birds find an adequate habitat. The indicator is normalized for the year 1970, where its value is set to 100 points. Currently, the indicator in German agrarian landscapes takes a value of 65 points (BMUB, 2015), which we used as the status quo level.[1] The other attribute levels indicated a slight increase to 85 points and a considerable increase to 105 points, i.e. a condition slightly better than in 1970. The attribute *share of maize* describes the share of arable land within the 15 km radius

[1] New data that became available only after the survey was conducted showed that the bird indicator on agricultural landscapes has further decreased to 56 points (BMUB, 2015).