Valuing Forest Recreation in Europe: Time and Spatial Considerations

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ABBREVIATIONS

CS	Consumer surplus
GDP	Gross domestic product
GIS	Geographic Information Systems
HA	Hectare
HRS	Hours
IID	Independently and identically distributed
ITCM	Individual travel cost method
KM	Kilometre
MN	Minutes
OLS	Ordinary least square
PPP	Purchasing power parity
RUM	Random utility model
TCM	Travel cost method
UNCED	United Nations Conference on Environment and Development
ZTCM	Zonal travel cost method
YR	Year

EXECUTIVE SUMMARY

Forests produce a wide variety of useful market and non-market goods and services, such as timber, sequestration of carbon, protection of biodiversity and groundwater reservoirs and, especially in the developed world, also popular destinations for recreation. Since the UN Conference on Environment and Development in Rio 1992 and subsequent international and European Agreements, forests in Europe are now managed to a large extent as multi-purpose forestry, where recreation is acknowledged as one of the main contributors to welfare derived from forestry.

The forest resource covers nearly half of land area in Europe and continues to grow by approximately 802.000 ha per year. However, it is becoming increasingly difficult to find land suitable for afforestation, due to a competition for use of land, which drives up the cost of new afforestation activities (Miljøministeriet, 2000; MCPFE & UNECE/FAO, 2003). The emphasis on multi-purpose forestry means that economic appraisals of forest management practices and afforestation projects should take into account the provision of non-market benefits, such as recreation opportunities. It is therefore important for forest managers, planners and politicians to have appropriate economic tools that quantify the non-market benefit implications of how to manage the current forest resource and how and where to establish new forest sites.

This thesis estimates and analyses the values of forest recreation in Europe and considers the spatial and time aspects of valuing existing and new forest sites, given preferences for forest characteristics. The analysis of forest recreation values in Europe is conducted with a meta-analysis, which has not previously been done for Europe and includes exogenous variables on site characteristics, which is also new to meta-analysis. The estimation of total forest recreation values is carried out on state owned forests in a region in Denmark in 1977 and 1997 using a mixed logit specification of the random utility model (RUM) combined with Geographic Information System (GIS). A series of benefit transfers are conducted over time and space and validated against the 'true' values to ascertain the efficiency of transfers under different conditions. Validated benefit transfers over 20 years have not been attempted previously, primarily due to a lack of adequate data. Also the use of the mixed logit specification and GIS is novel in benefit transfer. The findings of the thesis reveal the variance of forest recreation values in Europe and identifies the main influences on

welfare. It also sheds light on the error structure of benefits transfers over time and space and provides policy relevant advice on valuing not yet established forest sites.

FOREST RECREATION BENEFITS IN EUROPE

Forest recreation values in Europe vary considerably. The meta-analysis on forest recreation valuation studies having applied the travel cost methods (TCM) showed that consumer surplus range as much as from €0.66 to €112 per trip with a median of €4.52 per trip (in PPP 2000 values). The meta-analysis, based on 25 studies from nine countries since 1979, ascertains the type of components that influence the value of forest recreation. It is conducted with a step-wise increasing number of variables where level I includes only data available from the studies, level II adds aggregate socio-economic variables and level III further includes site specific characteristics such as diversity of vegetation, fraction of open land, and location. The model selected as the best overall summary was the log of consumer surplus with an overall R^2 of 87%, which is considerably higher than in previous meta-analyses on outdoor recreation.

Main influences on forest recreation values in TCM studies are related both to the specification of the travel cost demand parameters and to the observed behaviour. In terms of influences from model specification, studies carried out by K.G. Willis, surveys conducted in Italy, the use of the individual TCM, as well as the inclusion of opportunity cost of time and the level of costs per kilometre, appeared to increase consumer surplus. This illustrates that modelling assumptions and research designs play a significant role in valuing sites, as has been found previously in the literature (Smith and Kaoru, 1990a; Smith and Kaoru, 1990b). In terms of observed behaviour, the average distance travelled by visitors and site characteristics including large forests and sites with many visits, monotone vegetation and diverse age classes positively influences consumer surplus. The chapter shows that meta-analyses would gain considerably from site attributes being included as additional data in original valuation studies.

PREDICTING CHANGES IN RECREATION VALUES OVER TIME

Assessing future values of forest recreation is highly relevant when planning long-term afforestation projects. In order to test the performance of predicting values over time, two different benefit functions of forest recreation are transferred from 1977 to 1997 and compared with the 'true' value of recreation in 1997. The transfers are conducted over 52 state owned forests in the Copenhagen region of Denmark. In addition, changes in welfare over the same period and forests are quantified. Both the transfers and quantification of welfare in 1977 and 1997 show substantial changes.

The data used is based on two identical national visitor surveys in forests from 1976/77 and 1996/97 (Koch, 1980; Jensen, 2003) and representative national household surveys in 1977 and 1994 (Koch, 1978; Jensen and Koch, 1997). The benefit transfers and valuations of forest recreation are specified with multi-site discrete choice models that link mixed logit specifications of the random utility model (RUM) and a count data model to estimate total value of access per site. The estimation process is combined with Geographic Information Systems (GIS), which together with the mixed logit allows for heterogeneous preferences across the population and captures a larger proportion of site heterogeneity.

Some preferences for forest characteristics in the Copenhagen region in Denmark changed. People have developed a heterogeneous preference with 62% of the population preferring a species rich forest and 76% a dense forest whereas the 1977 sample did not show significant evidence of variance in preferences. Also, the full sample in 1997 appears to prefer tree stands older than 60 years compared to 82% in 1977. Commonalities of taste between the 1977 and 1997 sample include a favourable attitude towards coniferous vegetation (60%-64% of the sample), large forests (albeit at a marginal declining rate), sloped terrain and coastal proximity. The preference for coniferous forests in this region contrasts with findings at the national level, where only 40% prefer coniferous sites (Termansen, 2004b). A probable explanation is the prevalence of broadleaf forests in the metropolitan region, making sites dominated by coniferous vegetation seem more attractive.

The transfers over time compare the efficiency of transferring benefits over 20 years between a functional transfer model that update car-borne forest recreation demand to recent years (transfer type A) and a functional transfer that does not update the demand function to recent years (transfer type B). The non-updated transfer type B produces an error margin across the 52 sites of 434% on average. Updating the transfer model with present demand for recreation (Transfer type A) improves the error margins considerably by a factor of 4 on average. The median transfer error of model A is 4%, ranging from – 74% to 234% of the 'true' value. 32 transfers of model A are found to be within a ± 50%

and 15 transfers within a ± 20% error margin of the 'true' value. The confidence intervals of the two transfer models indicate that the values of 13 forests of transfer type A overlap the confidence interval of the 'true' model whereas only one transfer value of type B overlaps the confidence intervals of the 'true' model. The 14 transfers with overlapping confidence intervals were also the most successful transfers, producing error margins less than ± 24%.

A main contributor to the poor results of the transfer type B and the relatively good results of transfer type A is a pronounced shift in transport mode over the period towards other means of transport than cars when visiting forests. The transfer type B therefore predicts far more car-borne visits in 1997 than was observed (Koch, 1978; Jensen and Koch, 1997) and estimated in this thesis. A related aspect to the shift in transport mode is the higher travel cost parameter in the 1977 RUM, which indicates a preference for longer trips in 1977 than in recent times, despite a relatively higher petrol price in 1977. Transfer model A therefore tends to underestimate urban fringe forests close to Copenhagen by between –9% and –80% and to overestimate the value of remote forests by up to 240%.

The quantification of changes in welfare over time illustrates the effects of changes in site and travel preferences on recreation valuation. Generally, urban fringe forests have gained in value on average by 280% and values of forests further away from the densely populated areas have decreased by up to 100%. In addition, the case study of Vestskoven, which is a relatively new forest that was established in the 1970s on former agricultural and horticultural land at the outskirts of Copenhagen, showed a dramatic increase in value by nearly 70 times. This alters the ranking of the new forest from one of the least attractive in 1977 to one of the most attractive sites in the region in 1997. Both the gradual afforestation, increasing maturity and diversification of the vegetation in Vestskoven as well as the general change in preference towards urban forests has led to the steep increase in welfare over time.

PREDICTING RECREATION VALUES OVER SPACE

Benefit transfers over space remain the only option to quantify the value of new sites when using revealed preference valuation methods. Using the case study of Vestskoven and the 1997 discrete choice framework of the previous section, we perform and test three different scenarios of spatial benefit transfers where the choice set of policy sites differ between i) a benefit transfer function based on 51 forests; ii) a benefit transfer based on attractiveness and iii) a benefit transfer based on urban fringe forests.

The first scenario clearly shows the importance of having the right variation in the policy site choice set in order to successfully transfer values to study sites. As Vestskoven was planned and managed differently from the remaining forest sites in the region, the variance in the policy site choice set is not sufficient to transfer a value close to the 'true' value. The transfer to Vestskoven therefore exaggerates the 'true' value by as much as 346%, which is the highest error produced across the 52 transfers. For the large majority of forests (36), transfers perform within a ±20% error margin.

The second scenario, which excludes the most attractive or the least attractive sites from the policy site choice set, indicates that excluding the most extreme sites worsen transfer efficiency and reconfirms the importance of appropriate variance in the policy site choice set. The Vestskoven transfer, when excluding the least attractive forests, leads to fairly decent results (31%-36% error) compared to a 330%transfer error when excluding the most attractive sites. The large transfer error of excluding the most attractive sites is attributable to the fact that Vestskoven is today one of the most popular forests, and hence excluding comparable sites from the choice set removes the appropriate variance in the transfer model.

The third scenario, where the choice set of policy sites only includes urban fringe forests, illustrates the importance of designing sampling with a sufficient variety in distances in order to estimate the marginal utility of income. The spatially narrow choice set excludes people who are willing to travel far and thereby prevents the model to detect a trade off in preferences between travelling further to an attractive site or visiting a local non-attractive forest. As a result, all forests in the region are underestimated and the transfer to Vestskoven is close to the average under-prediction (57% below the 'true' value).

CLOSING COMMENTS

This thesis attempts to illustrate the influences on welfare derived from forest recreation over space and time. Revealed preference valuation methods are well known to be sensitive to the specification of demand parameters and the substantial randomness in non-linear functions (Haab and McConnell, 2002). The reason can be found in the connection that the researcher creates between observed market behaviour and values, through strategic research decisions. The meta-analysis shows this clearly through the significant influence of some authors and countries on consumer surplus or the use of the individual TCM approach leading to higher values than when using the zonal TCM.

The discrete choice models are also subject to the same sensitivity in the specification of the demand framework. For instance, we voluntarily omit the opportunity cost of time from the overall travel costs to avoid a purely researcher defined level of time value. Previous travel cost studies have used average wage rates ranging from 0% to 100% of hourly wages. Adding this component would increase the estimated values. Another influence on welfare is the strategic choice of recreation demand modelling, which in this thesis follows the approach of Bockstael, Hanemann and Strand (1986) by linking the site selection and visit frequency in two stages. This can be modelled differently, for instance by using the approach of the Kuhn-Tucker model (Wales and Woodland, 1983; Hanemann, 1978) or the repeated nested logit model (Morey et al., 1993), where the site selection and participation decision are modelled simultaneously. It could be useful to assess the differences between these models on the Danish datasets in future research.

This thesis also shows that recreational welfare depends to a large extent on the characteristics of sites, the ease of access and substitution possibilities. It is therefore more than necessary that original studies start to include detailed information on site characteristics for use in benefit transfers and meta-analyses.

The performance of benefit transfers over space and time clearly indicates that we cannot completely do without original valuation studies, especially when we wish to value sites that are atypical and/or when determinants of welfare, such as recreation patterns, change substantially over time.

KURZFASSUNG

Wälder produzieren verschiedene nützliche Güter und (Dienst)leistungen innerhalb und außerhalb des Marktes, z.B. Nutzholz, die Kohlenstoffbindung oder den Schutz der Biodiversität und der Grundwasserreservoirs. In den entwickelten Ländern sind sie außerdem ein beliebtes Naherholungsziel. Die Wälder in Europa werden seit der *UN Conference on Environment and Development* in Rio (1992) und den anschließenden internationalen und europäischen Vereinbarungen zum großen Teil als Forstwirtschaft mit mehreren Zwecken geführt, in denen die Erholung als einer der hauptsächlichen, von der Fortwirtschaft abgeleiteten, Faktoren für die Wohlfahrt gilt.

Wälder bedecken annähernd die Hälfte der Fläche Europas und ihre Fläche nimmt kontinuierlich mit etwas 802.000ha pro Jahr zu. Aufgrund der steigenden Kosten im Rahmen des Wettbewerbs um die Nutzung der Flächen, wird es allerdings zunehmend schwerer, geeignete Aufforstungsgebiete zu finden (*Miljøministeriet, 2000; MCPFE & UNECE/FAO, 2003*). Die Betonung des Mehrzwecks der Fortwirtschaft bedeutet, dass der erbrachte Nutzen außerhalb des Marktes in die ökonomische Bewertung der Forstpraktiken und Aufforstungsprojekte einbezogen werden sollten, wie z.B. die Möglichkeiten der Erholung. Es ist daher für Förster, Planer und Politiker wichtig, angemessene ökonomische Werkzeuge zu haben, um die Implikationen des Nutzens quantifizieren zu können, d.h. wie die Wälder als Ressource geführt bzw. wo neue Wälder entstehen sollten.

Diese Doktorarbeit bewertet und analysiert den Wert der Wälder als Erholungsgebiete (Walderholung) in Europa und berücksichtigt dabei Aspekte von Raum und Zeit für die Bewertung bestehender und neuer Wälder. Die Analyse der Werte, die der Walderholung in Europa beigemessen werden, wird mittels einer Meta-Analyse durchgeführt. Für Europa existieren bisher weder Meta-Analysen für diesen Bereich, noch wurden in bisherigen Analysen dieser Art exogene Variablen der Waldcharakteristika berücksichtigt. Die Bewertung der rekreativen Werte wird für staatliche Wälder in einer Region in Dänemark für 1977 und 1997 durchgeführt; dabei wird eine *mixed logit specification* des *random utility model (RUM)* mit einem Geografischen Informations System (GIS) kombiniert. Es werden eine Serie von *benefit transfers* über Raum und Zeit durchgeführt und an den ‚wahren' Werten validiert, um die Effizienz der Transfers unter verschiedenen Bedingungen zu prüfen. Hauptsächlich wegen des Fehlens adäquater Daten wurden solche *benefit transfers* über einen Zeitraum von 20 Jahren bisher nicht in Studien

berechnet. Neu in der Berechnung von *benefit transfer* ist außerdem die Benutzung der *mixed logit specification* und des GIS. Die Ergebnisse dieser Doktorarbeit zeigen deutlich die Varianz der Walderholungswerte in Europa und identifizieren die hauptsächlichen Einflüsse auf die Wohlfahrt. Sie beleuchten außerdem die Fehlerstruktur der *benefit transfers* über Zeit und Raum und liefern relevante Einsichten über die Bewertung von neu zu planenden Wäldern.

DER NUTZEN VON WALDERHOLUNG IN EUROPA

Die Walderholungswerte in Europa variieren signifikant. Die Meta-Analyse über Studien mit der Reisekostenmethode (TCM) zeigt, dass die Konsumentenrente pro Fahrt in einem Bereich von €0.66 bis €112 liegt. Der Median befindet sich bei €4.52 pro Fahrt (in PPP 2000 Preisen).

Die Meta-Analyse basiert auf 25 Studien aus neun Ländern (seit 1979) und prüft, welche Komponenten die Walderholungswerte beeinflussen. Die Anzahl der einbezogenen Variablen wurde schrittweise erhöht: Die erste Ebene beinhaltet nur die Informationen aus den Studien, auf der zweiten Ebene werden aggregierte sozioökonomische Daten hinzugefügt und die dritten Ebene bezieht außerdem waldspezifische Charakteristika mit ein, z.B. die Diversität der Vegetation, der Anteil offener Flächen oder der Standort. Das beste in dieser Arbeit verwendete Modell lag mit R^2 von 87% deutlich höher als in vorhergehenden Meta-Analysen.

Die hauptsächlichen Einflüsse auf die Walderholungswerte in TCM-Studien sind sowohl mit der Spezifikation der Reisekostennachfrageparameter als auch mit dem beobachteten Verhaltens verbunden. In Bezug auf den Einfluss der Modellspezifikationen zeigt sich, dass mehrere dieser Faktoren einen Einfluss auf die Konsumentenrente haben. Sowohl die Studien von K.G. Willis, die Surveys aus Italien, die Benutzung der individuellen TCM, sowie der Einbezug der Opportunitätskosten über Zeit und die Höhe der Kosten pro Kilometer erhöhen die Konsumentenrente. Damit zeigt sich, dass die Modellannahmen und das Forschungsdesign eine bedeutsame Rolle in der Bewertung von Wäldern spielen, wie auch in der Literatur dargestellt (Smith and Kaoru, 1990a; Smith and Kaoru, 1990b). Die Konsumentenrente wird in Bezug auf das beobachtete Verhalten positiv von der mittleren Reisedistanz und den Charakteristika der Standorte beeinflusst, wie z.B. große Wälder und Wälder mit vielen Besuchen, monotone Vegetation und diverse

Altersgruppen. Dieses Kapitel zeigt, das Meta-Analysen durch zusätzlich zu den Originalstudien einbezogene Daten zur Waldcharakteristik deutlich verbessert würden.

VORHERSAGE DER VERÄNDERUNG VON ERHOLUNGSWERTEN ÜBER ZEIT

Die Bewertung von zukünftigen Walderholungswerten ist für die langfristige Planung von Aufforstungsprojekten höchst relevant. Um das Verhalten der Vorhersagewerten über Zeit zu testen, werden zwei unterschiedliche Walderholungs-Funktionen von 1977 nach 1997 transferiert und mit den 'wahren' Werten von 1997 verglichen. Die Transfers werden über 52 staatliche Wälder in der Region um Kopenhagen in Dänemark durchgeführt. Zusätzlich werden die Veränderungen in der Wohlfahrt über die selbe Periode und die selben Wälder quantifiziert. Sowohl die Transfers als auch die Quantifizierungen der Wohlfahrt zwischen 1977 und 1997 zeigen substantielle Veränderungen.

Die verwendeten Daten basieren auf zwei identischen nationalen Besucherbefragungen in Wäldern von 1976/77 und 1996/97 (Koch, 1980; Jensen, 2003) und repräsentativen nationalen Haushaltsbefragungen von 1977 und 1994 (Koch, 1978; Jensen and Koch, 1997). Sowohl die *benefit transfers* als auch die Bewertung der Walderholung sind mit *multi-site discrete choice models* spezifiziert. Diese Modelle verbinden *mixed logit* Spezifikationen des *random utility model* (RUM) und ein *count data model*, um den Gesamtwert der Zugänge pro Standort zu ermitteln. Diese Berechungen werden mit einem GIS kombiniert, welches im Zusammenhang mit dem *mixed logit* ermöglicht, sowohl heterogene Präferenzen über die Bevölkerung festzustellen als auch einen größeren Anteil von Standortheterogenitäten zu erfassen.

Einige Präferenzen in Bezug auf Waldcharakteristika in der Region um Kopenhagen haben sich geändert. Seit 1977 entwickelten sich heterogene Präferenzen in der Bevölkerung; so nahm die Vorliebe für Wälder mit vielen Spezies auf 62% ab bzw. die Bevorzugung von dichtem Wald auf 76%. Im Vergleich mit 82% (1977) scheint darüber hinaus die gesamte Stichprobe im Jahre 1997 Bäume, die 60 Jahre oder älter sind, zu bevorzugen. Zwischen den beiden Zeitpunkten gleichgeblieben sind die Präferenzen für Nadelwald (60%-64% der Stichprobe), große Wälder (bei einer marginal abnehmenden Rate), hügeligem Terrain und Küstennähe. Die Präferenz für Nadelwälder widerspricht Ergebnissen auf nationaler Ebene, bei denen diese nur von 40% bevorzugt werden

(Termansen, 2004b). Eine mögliche Erklärung hierfür ist die Dominanz von Laubwäldern in der Hauptstadtregion, die die selteneren Nadelwälder attraktiver erscheinen lässt.

Die Transfers über Zeit vergleichen die Effizienz verschiedener Nutzen-Funktionen über einen Zeitraum von 20 Jahren. Dieser Vergleich findet statt zwischen einem Modell, in dem die Nachfrage der durch die Benutzung von Autos erzeugten Walderholung aktualisiert ist (Transfer Typ A) und einem Modell, in dem die Nachfragefunktion nicht aktualisiert ist (Transfer Typ B). Der nicht-aktualisierte Transfer produziert einen durchschnittlichen Fehler über die 52 Wälder von 434%. Durch die Aktualisierung des Transfermodells (Typ A) wird der Fehler im Mittel um den Faktor 4 reduziert. Der Median des Fehlers von Modell A beträgt 4%, und erstreckt sich von –74% bis 234% der 'wahren' Werte. Die Fehler innerhalb des Modells A liegen bei 32 von den insgesamt 52 durchgeführten Transfers im Vergleich zu den 'wahren' Werten in einem Bereich von ± 50%; 15 Transfers liegen in einem Bereich von ± 20%. Außerdem zeigt sich, dass sich die Konfidenzintervalle von 13 Wäldern im Modell A mit den Konfidenzintervallen des 'wahren' Modells überlappen, aber für das Modell B gilt dies nur für einen Wald. Diese 14 Wälder haben zudem die erfolgreichsten Transfers mit Fehlern, die mit nur ± 24% am geringsten ausfallen.

Ein Hauptfaktor für die schlechten Ergebnisse des Modells B und die relativ guten Resultate des Modells A ist eine signifikante Veränderung der benutzten Transportmittel (zugunsten anderer Verkehrsmittel als dem Auto) über den untersuchten Zeitraum. Das Transfer Modell B hat daher viel mehr Auto-abhängige Besuche für 1997 vorhergesagt, als tatsächlich beobachtet (Koch, 1978; Jensen and Koch, 1997) und in dieser Arbeit berechnet. Ein damit verwandter Aspekt sind die höheren Transportkosten-Koeffizienten in dem 1997 RUM, die eine Präferenz für längere Fahrten indizieren, obwohl die Benzinkosten 1977 relativ höher waren. Das Modell A tendiert deshalb zu einer Unterschätzung der Wälder in den Randgebieten Kopenhagens um –9% bis –80% und gleichzeitig dazu, die Werte der entfernteren Wälder mit bis zu 240% zu überschätzen.

Die Quantifizierung der Veränderungen der Wohlfahrt über die Zeit zeigt die Effekte der Veränderung der Standort- und Reisepräferenzen auf die Bewertung der Erholung. Im Allgemeinen haben stadtnahe Wälder im Mittel 280% an Wert gewonnen, während weiter von den Ballungsgebieten entfernte Wälder bis zu 100% an Wert verloren haben. Außerdem zeigt die Fallstudie von Vestskoven, einem relativ neuen Wald, der erst in den 1970er Jahren auf vormals landwirtschaftlichen Flächen am Rande von Kopenhagen etabliert worden ist, wie dessen Werte sich um das 70fache erhöht haben. Damit ist einer der im Jahre 1977 unbeliebtesten Wälder zu einem der attraktivsten Erholungsgebiete im Jahre 1997 geworden. Sowohl die graduelle Aufforstung, das zunehmende Alter und die Diversifizierung der Vegetation in Vestskoven, als auch der generelle Wandel der Präferenzen für stadtnahe Wälder haben zu diesem steilen Anstieg der rekreativen Werte über die Zeit geführt.

VORHERSAGE DER ERHOLUNGSWERTE ÜBER RAUM

Benefit Transfers über Raum zu berechnen, bleibt die einzige Möglichkeit, die Erholungswerte von neuen Wäldern zu quantifizieren, wenn *revealed preference* Bewertungsmethoden eingesetzt werden. Drei unterschiedliche Szenarien räumlicher *benefit transfers* werden anhand der Fallstudie von Vestskoven und des 1997er *discrete choice* Modells durchgeführt und getestet. Die Gruppe von in den Szenarien zur Auswahl stehenden *policy sites* bestehen aus i) einem *benefit transfer* Modell basiert auf 51 Wäldern; ii) ein *benefit transfer* Modell basiert auf Attraktivität und iii) ein *benefit transfer* Modell basiert auf stadtnahen Wäldern.

Das erste Szenario zeigt deutlich die Wichtigkeit einer gute Varianz in den Auswahlmöglichkeiten der *policy sites*, um einen erfolgreichen Transfer der Werte zu den *study sites* zu gewährleisten. Da Vestskoven im Vergleich zu den anderen Wäldern in der Region anders geplant und geführt wurde, ist die Varianz in der *policy site*-Auswahl nicht ausreichend, um einen Wert so zu transferieren, dass er dem 'wahren' Wert nahe kommt. Der Transfer nach Vestskoven übertreibt daher den 'wahren' Wert mit 346%, dem höchsten Fehler unter den 52 durchgeführten Transfers. Für die große Mehrheit der Wälder (36) sind die Transfers nur mit Fehlerraten im Bereich von ± 20% behaftet.

Die Wichtigkeit einer guten Varianz wird auch durch das zweite Szenario unterstrichen. Es werden die attraktivsten und die unbeliebtesten Wälder aus der Berechnung ausgeschlossen.

Der Transfer von Vestskoven führt, wenn die am wenigsten attraktiven Wälder ausgeschlossen werden, zu moderaten Ergebnissen mit 31%-36% Fehlern. Werden dagegen die attraktivsten Wälder ausgeschlossen, kommen Fehlerraten von 330% zustande. Wiederum ist also die fehlende Varianz durch den Ausschluss von mit Vestskoven vergleichbaren Wäldern der Grund für die große Fehlerrate dieses Transfers.

In dem dritten Szenario wird anhand der Beschränkung auf stadtnahe Wälder gezeigt, wie wichtig eine gute Varianz der Reisedistanzen für die Berechnung des Grenznutzens des Einkommens ist. Durch die so definierte räumliche Begrenzung der Auswahlmöglichkeiten werden Personen ausgeschlossen, die bereit wären, längere Distanzen zurückzulegen und verhindert so, dass das Modell zwischen den zwei Präferenzen abwägen kann, i) eine weite Strecke zu einem attraktiven Wald zu fahren oder ii) einen naheliegenden und unattraktiven Wald zu besuchen. Das Modell unterschätzt deswegen die Erholungswerte aller Wälder in der Region und der Transfer nach Vestskoven befindet sich mit 57% unter dem 'wahren' Wert nur noch nahe dem Mittelwert.

ABSCHLIEßENDE BEMERKUNGEN

Diese Doktorarbeit versucht die Einflüsse zu untersuchen, die die Walderholung auf die Wohlfahrt über Raum und Zeit ausübt. *Revealed preference* Bewertungsmethoden sind bekannt für ihre Sensitivität gegenüber der Spezifikation von Nachfrageparametern und der beträchtlichen Zufälligkeit nicht-linearer Funktionen (Haab and McConnell, 2002). Der Grund hierfür ist die vom Forscher mit strategischen Entscheidungen erstellte Verbindung zwischen dem beobachtbarem Marktverhalten und den Werten. Die Meta-Analyse zeigt dies deutlich durch den signifikanten Einfluss, den einige Variablen, z.B. Autoren oder Länder, auf die Konsumentenrente haben bzw. dass die Benutzung der individuellen anstatt der zonalen Version der TCM zu erhöhten Werten führt.

Die *discrete choice* Modelle unterliegen derselben Sensitivität der Spezifikationen. Beispielsweise haben wir die Opportunitätskosten der Zeit in die gesamten Reisekosten nicht mit einbezogen, um ein nur von den Wissenschaftlern definiertes Niveau der Zeitkosten zu vermeiden. Frühere Reisekostenstudien haben durchschnittliche Raten von 0% bis 100% des Stundenlohns benutzt. Dieses Vorgehen würde die berechneten Werte erhöhen. Einen weiteren Einfluss auf die Wohlfahrt hat die strategische Wahl der Modellierung der Erholungsnachfrage. Diese Doktorarbeit folgt der Methode von Bockstael, Hanemann and Strand (1986), die die Auswahl der Wälder und die Häufigkeit der Besuche in zwei Stadien verbindet. Eine andere Möglichkeit wäre beispielsweise das Kuhn-Tucker-Modell (Wales and Woodland, 1983; Hanemann, 1978) oder das *repeated nested logit* Modell (Morey et al., 1993), in denen jeweils die Wahl der Wälder und die Teilnahmeentscheidung gleichzeitig modelliert werden. Es wäre zukünftig sinnvoll, die

Unterschiede zwischen diesen Modellen in Bezug auf den vorliegenden dänischen Datensatz zu untersuchen.

Diese Doktorarbeit zeigt auch, dass die Erholungswohlfahrt zu einem großen Teil von den Charakteristika der Wälder, der Einfachheit des Zugangs und den Substitutionsmöglichkeiten abhängig ist. Daher ist es mehr als notwendig, dass Originalstudien damit beginnen, detaillierte Informationen über die Charakteristika anzugeben, damit diese in weiteren Meta-Analysen und *benfit transfers* verwendet werden können.

Die durchgeführten *benefit transfers* über Raum und Zeit zeigen beispielhaft, dass wir auf originale Bewertungsstudien nicht völlig verzichten können, insbesondere wenn wir atypischen Standorten bewerten möchten und/oder wenn die Determinanten der Wohlfahrt, z.B. die Erholungsmuster, sich mit der Zeit substantiell verändern.

OVERORDNET KONKLUSION

Skove udfører en lang række vigtige samfundsmæssige funktioner udover produktion af træ, som for eksempel optag af CO_2 , beskyttelse af biodiversitet og grundvands ressourcer og udbud af populære friluftsområder. Siden FN Konferencen for Miljø og Udvikling in Rio i 1992 opfulgt af diverse internationale og europæiske aftaler drives skove i Europa i høj grad efter principperne om naturnær skovdrift, hvor friluftsfunktioner udgør et af de vigtigste sociale formål.

Skovarealet i Europa dækker tæt ved halvdelen af landområdet og øges med ca. 802.000 ha per år. Det er imidlertid i stigende grad svært at finde yderligere land til skovrejsning p.g.a. øget konkurrence mellem forskellige typer af arealanvendelse (Miljøministeriet, 2000; MCPFE & UNECE/FAO, 2003). Opprioriteringen af naturnær skovdrift betyder at økonomiske værdiansættelser af skovdriftstyper og skovrejsningsprojekter bør inkludere forsyningen af sociale og økologiske funktioner, herunder især fritidsbeskæftigelse. Det er derfor vigtigt at skovforvaltere, planlæggere og politikkere har adgang til de fornødne økonomiske redskaber som kan kvantificere betydningen af sociale og økologiske funktioner i skovdriften, både m.h.t. den eksisterende ressource og m.h.t. hvor og hvordan nye skovområder kan etableres.

NYTTEVIRKING AF FRILUFTSLIV I SKOVE I EUROPA

Værdien af friluftsliv i europæiske skove varierer betydeligt. Meta-analysen fokuserer på studier baseret på rejseomkostningsmetoden, der udleder prissætningen på udendørs friluftsliv fra rejseudgifter associeret ved brugen af bilen som transportmiddel og den negative sammenhæng mellem antal besøg og rejseafstand. Meta-analysen er baseret på 25 studier fra 9 lande som er blevet udført siden 1979 og viser en variation på konsumentoverskudet fra €0.66 til €112 per tur med en median på €4.52 per tur (2000 priser, PPP). Den undersøger hvilke parametre har indflydelse på friluftsværdien af skove. Analysen er udført i tre omgange med et stigende antal variabler. Niveau I inkluderer kun variabler som var anført i de originale studier, niveau II medtager aggregerede socio-økonomiske variabler og niveau III inkluderer karakteristika fra de enkelte skove, såsom diversitet i vegetationen, bevoksningsgrad og den geografiske placering af skoven.

De største indvirkninger på værdien af friluftsliv er relateret til både antagelser omkring modeldesign og til observeret adfærd. I forbindelse med antagelserne bag værdisætnings-modellerne, har følgende parametre en positiv indflydelse på konsumentoverskuddet: studier foretaget af K.G. Willis, studier udført i Italien, brugen af den individuelle rejseomkostningsmetode, medregningen af alternativomkostningen af tid og det valgte niveau af rejseudgifter per kilometer. I forbindelse med observeret adfærd, bliver konsumentoverskuddet positivt påvirket af den gennemsnitlige rejse-afstand og karakteristika såsom store skove, antal besøgende, monoton artssammensætning og forskelligartede aldersklasser. Blandt de exogene socio-økonomiske parametre forekommer BNP per capita overraskende at have en negativ påvirking af velfærd. En grund hertil er sandsynligvis de relativt lave antal studier og dermed utilstrækkelig grad af forskelle i research designs som muligvis underminerer de statistiske udledninger fra de tværgående analyser. Befolkningstæthed viste sig ikke at udgøre en signifikant indflydelse på velfærd, hvilket kan hænge sammen med det aggregerede niveau af variablen på befolkningstæthed.

Kapitlet viser at meta-analyser i fremtiden vil drage stor fordel af at forfattere til originale værdisætningsstudier også rapporterer beskrivende data på ressourcen der bliver værdisat.

FORUDSIGELSE AF ÆNDRINGER I REKREATIVE VÆRDIER OVER TID

Når skovrejsningsprojekter planlægges er det yderst relevant at forsøge at estimere fremtidige rekreative brugsværdier, som ofte først vil være maksimeret efter flere årtier. For at kunne teste resultatet på forudsigelser af brugsværdier over tid overføres i denne afhandling to forskellige benefit funktioner på rekreativ brug af skove fra 1977 til 1997 og sammenlignes derpå med den 'reelle' værdi af friluftsliv i de samme skove i 1997. Benefit transfers er udført på 52 statsejede skove i hovedstadsregionen i Danmark. Udover testen på effektiviteten af beneft transfer over tid kvantificeres forandringen i rekreative velfærd over den samme tidsperiode. Både benefit transfer og kvantificeringen af ændringer i velfærd over tid viser betydelige forandringer over de 20 år.

Data er baseret på to identiske nationale besøgsundersøgelser i skove fra 1976/1977 og 1996/97 (Koch, 1980; Jensen, 2003) og på repræsentative nationale husholdnings-undersøgelser fra 1977 og 1994 (Koch, 1978; Jensen and Koch, 1997). Benefit transfer funktionerne og den reelle værdisætning af friluftsliv i skove i 1997 er specificeret v.h.a.

'multi-site discrete choice' modeller som kombinerer mixed logit specifikationer på 'Random Utility Modellen' (RUM) og en Poissin model for at kunne estimere den samlede rekreative brugsværdi af adgang per skov. Estimeringen inkluderer brugen af Geografisk Informations System (GIS), som sammen med mixed logit gør det muligt at udregne heterogene præferencer i befolkningen samt er i stand til at opfange en større andel af forskelligheder på tværs af skovene. Fremgangsmåden er baseret på ideen fra rejseomkostningsmetoden beskrevet tidligere.

Præferencer på skovkarakteristika i hovedstadsregionen i Danmark ændrede sig i perioden fra 1977 til 1997 m.h.t. artsdiversitet og bevoksningsgrad af skove. 62% af besøgende i 1997-undersøgelsen foretrak en artsrig skov og 76% en tætbevokset skov hvorimod analysen af besøgende i 1977 ikke viste nogen signifikant varians i præferencer (d.v.s. at alle besøgende i undersøgelsen i 1977 foretrak en artsrig og tætbevokset skov). Det samlede udvalg af besøgende fra 1997 synes at foretrække bevokningsaldersklasser ældre end 60 år sammenlignet med 82% af udvalget af besøgende i 1977. Identiske præferencer mellem 1977 og 1997 udvalget omfatter en positiv holdning m.h.t. nåletræsbevoksning (60%-64% af udvalget), store skove (omend med en marginal faldende rate), skrånende terrain og kystnærhed. Præferencen for nåletræsbevoksning i denne region står i modsætning til resultaterne fra en national undersøgelse, hvor kun 40% af udvalget viste sig at foretrække nåletræer (Termansen, 2004b). En mulig forklaring er den dominante udbredelse af løvtræer i hovedstadsregionen som gør at skove med en høj andel af nåletræer virker mere attraktive.

De gennemførte transfers over tid sammenligner effektiviteten af at overføre velfærd over 20 år med en overførselsmodel baseret på en funktion som opdaterer efterspørgslen på friluftsliv til nyere tid (transfer model A) og en funktionsoverførsel som ikke opdaterer efterspørgslen på friluftsliv, men som bruger efterspørgslen fra 1977 (transfer model B)

Den ikke-opdaterede transfer model B producerer en gennemsnitlig fejlmargin på tværs af de 52 skove på 434%. Opdateringen af transfer modellen med nutidig efterspørgsel (transfer model A) forbedrer fejlmarginen gennemsnitligt med en faktor fire. Medianen på transfermodel A ligger på 4% og fejlmargins varierer fra –74% til 234% i forhold til den 'reelle' værdi. Størstedelen af model A transfers (32 ud af 52) har en fejlmargin på mellem plus/minus 50% og 15 transfers befinder sig indenfor en ± 20% fejl margin i forhold til den 'reelle' værdi. Udregnede konfidensintervaller af de to transfer modeller viser at værdierne af 13 skove overført med model A overlapper konfidensintervallet på den 'reelle' model, hvorimod kun værdien af 1 skov overført med model B overlapper konfidens-intervallet på den 'reelle' model. Disse 14 transfer er ligeledes de mest vellykkede transfers med fejl margin på ± 24%.

En hovedårsag til de dårlige resultater i transfer model B og de relativt gode resultater af transfer model A er et udtalt skift i transportform over perioden væk fra brugen af biler når skove besøges. Transfer model B forudsiger derfor langt flere bilbesøg i 1997 end observeret (Koch, 1978; Jensen and Koch, 1997) og estimeret i denne afhandling. I forbindelse hermed indikerer den højere rejseudgifts-parameter i 1977 RUM at længere rejser var mere fortrukket i 1977 end i 1997 på trods af relativt højere benzinpriser i 1977. Transfer model A, som godt nok korrigerer for ændringen i brug af transportmidler, bibeholder præferencen for længere rejser og undervurderer derfor værdien af bynære skove tæt på København på mellem –9% og –80% per skov sammenlignet med de 'reelle' værdier og overvurderer værdien af fjerntliggende skove med op til 240%. Afhandlingen illustrerer således grænserne for benefit transfer over tid, når både præferencer på skovkarakteristika og brugeradfærd forandrer sig væsentligt over 20 år.

Denne afhandling illustrerer også med hvor meget værdien af friluftsliv kan forandre sig over tid når præferencer i befolkningen ændrer sig m.h.t. rejseadfærd og skovkarakteristika. Resultaterne viser at bynære skove i hovedstadsregionen i gennemsnit er blevet 280% mere værd mellem 1977 og 1997 og at friluftsværdien af mere fjerntliggende skove er faldet med op til 100%. Case studiet fra Vesterskoven, der blev skabt i 1970erne, viser derudover en dramatisk stigning i friluftsværdi med en faktor 70 over den samme periode. Vesterskoven udviklede sig derved fra en af de mindst attraktive skove i 1970erne til en af de mest populære skove i regionen i 1997. Både den graduelle skovrejsning, stigende alder og diversitet i bevoksningen i Vesterskoven samt den generelle ændring i befolkningens præferencer for bynære skove har været medvirkende til den stærke stigning i rekreativ velfærd genereret af Vesterskoven over tid.

FORUDSIGELSE AF FRILUFTSVÆRDIER OVER RUM

Når man benytter værdisætningsmetoder baseret på observerede præferencer som i denne afhandling, er benefit transfer over rum den eneste måde hvorpå man kan kvantificere friluftsværdien af nye skove i planlægningsfasen. Vesterskoven er her brugt som transfer eksempel i kombination med 'discrete choice' modellen fra 1997 beskrevet ovenfor. Tre forskellige rummelige benefit transfers testes for hvor godt de kan forudsige den 'reelle' værdi af Vesterskoven. Antallet og karakteristika på skove, det såkaldte 'policy site choice set', varieres og bruges til at overføre værdier til Vesterskoven, det såkaldte 'study site'. Policy site choice sættene på de tre rummelige benefit transfers adskiller sig ved i) et choice sæt baseret på 51 skove ii) et choice sæt baseret på attraktivitet af skove, og iii) et choice sæt baseret på bynære skove.

Det første rummelige benefit transfer, baseret på et policy site choice sæt med 51 skove, viser tydeligt vigtigheden af at have den rigtige variation i choice sættet. Eftersom Vesterskoven var planlagt og drevet anderledes end de øvrige skove i regionen viser det sig at variationen i choice sættet ikke er tilstrækkeligt til at kunne udføre en god benefit transfer til Vesterskoven. Resultatet er en stærk overdrivelse af den 'reelle' værdi på Vesterskoven på 346%. Til sammenligning blev benefit transferren udført på de øvrige 51 skove. Her viste det sig at overførslen på flertallet af skovene i regionen (36) er rimelig god med en fejl margin på ± 20%.

Resultaterne af det andet rummelige benefit transfer, som enten udelukker de mest populære eller de mindst populære skove fra policy site choice sættet, tyder på at overførslen bliver værre når de mest ekstreme skove fjernes fra choice sættet, hvilket reducerer variationen i choicesættet og bekræfter vigtigheden af at sikre den rette varians i policy site choice sættene. Overførslen til Vesterskoven er rimelig (31%-36% fejl margin) når de mindst populære skove fjernes fra choice sættet sammenlignet med en fejl margin på 330% når de mest populære skove fjernes fra choice sættet. Den store fejl margin skyldes at Vesterskoven i dag er en af de mest populære skove i regionen og ved at fjerne andre meget attraktive skove fra policy site choice sættet fjerner man dermed også den rette variation i transfer modellen.

Det tredie rummelige benefit transfer, hvor policy site choice sættet kun inkluderer bynære skove, illusterer vigtigheden af at designe choice sættet med tilstrækkelig variation i afstand mellem bopæl og skov. Dette er nødvendigt for at kunne estimere den marginale nytte af indkomst. Det rummeligt smalle choice sæt udelukker folk som er villige til at rejse langt. Derved bliver modellen forhindret i at måle et trade off i præferencer mellem en længere rejse til en attraktiv skov og en kort rejse til en lokal ikke-attraktiv skov. Resultatet af det smalle choice sæt er at benefit transfer af alle skove i regionen undervurderes. Resultatet af overførslen til Vesterskoven er tæt på den gennemsnitlige undervurdering (56% under den 'reelle' værdi).

AFSLUTTENDE KOMMENTARER

Denne afhandling forsøger at illustrere de mest væsentlige indflydelser på velfærd genereret af friluftsliv i skove over tid og rum. Det er velkendt at værdisætningsmetoder som observerede præferencer er meget sensitive overfor hvordan efterspørgselsparametrene bliver specificeret og den væsentlige tilfældighed i ikke-lineære funktioner (Haab og McConnell, 2002). Forskeren spiller her en væsentlig rolle når han tager strategiske beslutninger i sin forskning for at skabe forbindelsen mellem observeret markedsadfærd og værdier. Meta-analysen understreger dette tydeligt, hvor nogle forskere og lande har en signifikant indflydelse på konsumentoverskuddet, eller hvor brugen af den individuelle rejseomkostningsmetode fører til højere værdier end når den zoneinddelte rejseomkostningsmetode benyttes.

De diskrete choice modeller er også udsat for den samme sensitivitet m.h.t. hvordan efterspørgslen specificeres. For eksempel har vi valgt ikke at tage hensyn til alternativomkostningen af tid da vi fastsatte rejseomkostningerne. Herved undgik vi at fastsætte en værdi på tid, som ville være en ren subjektiv størrelse. Tidligere rejseomkostningsstudier har benyttet tidsværdier op til 100% af timelønnen. Hvis vi havde inkluderet denne komponent ville de estimerede friluftsværdier have været højere.

En anden indflydelse på velfærd er det strategiske valg m.h.t. hvordan efterspørgslen på friluftsliv modelleres. I denne afhandling har vi fulgt fremgangsmåden først udviklet af Bockstael, Hanemann and Strand (1986) som modellerer valget af udflugtsmål og besøgshyppighed i to omgange. Beslutningstagningen kan modelleres på forskellige måder, som for eksempel ved at bruge fremgangsmåden i Kuhn-Tucker modellen (Wales and Woodland, 1983; Hanemann, 1978) eller den gentagede nested logit model (Morey et al., 1993), hvor udvælgelse af skov og besøgshyppigheden modelleres simultant. Det ville være nyttigt i fremtidig forskning at estimere og analysere forskelle i resultater mellem disse forskellige modeller på det danske datasæt.

Denne afhandling viser også at rekreativ velfærd i høj grad afhænger af karateristika af ressourcen, tilgængelighed for befolkningen og substitutions muligheder mellem forskellige udflugtsmål. Det er derfor mere end nødvendigt at originale værdisætningsstudier i fremtiden også inkluderer detaljerede informationer om karakteristika på ressourcen der værdisættes til brug i senere benefit transfers og meta-analyser.

Effektiviteten af benefit transfers over rum og tid i denne afhandling viser også tydeligt at vi ikke kan undvære originale værdisætningsstudier, især når vi forsøger at værdisætte ressourcer som er atypiske og/eller når velfærds determinanter såsom adfærd og præferencer forandrer sig væsentligt over tid.

CHAPTER 1 INTRODUCTION

1.1. Forests & Recreation in Europe

Forests produce numerous goods and services useful for human society. They play a central role in the functioning of the biosphere, they are a key repository of biological diversity, they protect against storms and flooding, sequester carbon, regulate microclimate, prevent soil erosion, provide timber and non-timber products and are, especially in the developed world, also attractive habitats for outdoor recreation.

In countries where national surveys have been carried out on the value of forest recreation, results suggest that forests are one of the most popular leisure destinations compared to other leisure activities such as cinema, beaches or museums. In the UK in 1991, an estimated 28 million visits per year were made to the Forestry Commission Estate (Willis, 1991). In Denmark, surveys estimate that up to 155 million trips per year were made to forests in 1994 with an average of 38 forest trips per person per year (Jensen and Koch, 1997). In terms of the value of forest recreation, several studies in the UK have estimated total consumer surplus to ca. €90-94 million (2000 values, PPP adjusted) based on the travel cost approach (Willis, 1991; Willis and Benson, 1989). One study in Denmark, using an open ended contingent valuation study, proposes a total recreation value of Danish forests between €57 million and €68 million per year (2000 values, PPP adjusted) (Dubgaard, 1998). Other studies on recreational values of forests in Europe have not attempted to quantify welfare at a national level.

Forests in Europe cover 47% of land area (MCPFE & UNECE/FAO, 2003) with approx. one third of predominantly evergreen needleleaf, one third of deciduous broadleaf forests and 15% mixed forests (UNEP-WCMC, 2004)[1]. Not all countries have access to as vast forest resources as in Finland, Sweden, Spain, Slovenia or the Russian Federation, where more than half the land area is covered by forests and woodlands. The lowest forest cover is found in Malta and Iceland (less than 2% forest cover) and in Denmark, the Netherlands and the UK (approximately 10% forest area). The availability of forests differs also

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[1] The remaining categories of forest types in Europe are: 4.6% sclerophyllous dry forest, 8.6% sparse trees and parkland with less than 30% canopy cover, 8.6% unspecified forest plantation and 14% unspecified forest data (UNEP-WCMC, 2004)

significantly between Western European countries ranging from 3.46 - 4.42 ha per capita in Sweden and Finland to 0.02 - 0.05 ha in the Netherlands and the UK.

Once upon a time, Europe was almost entirely covered by forests, but this was cleared for agriculture, livestock grazing, construction and heating since the middle ages and earlier. Urbanisation and industrial exploitation of forests in the late 19th century for timber and pulp further caused the forest resources to drop to below sustainable levels. The forest cover in Denmark, for instance, was reduced to 2-3% of land area by 1800 and only a major effort over 200 years managed to increase the forest cover to the current 11% (Miljøministeriet 2002). During the 20th century, similar conditions led to National Forest Laws in many European countries such as in the UK (the Crown Lands Act of 1832) and in Bavaria (Forstgesetz of 1852). Today, the forest area in Europe continues to grow by an approximately 802.000 ha per year (excluding the Russian Federation), representing 0.08% of total forest area (MCPFE & UNECE/FAO, 2003). However, it is becoming increasingly difficult to find land suitable for afforestation, due to a competition for use of land, which drives up the cost of new afforestation activities (Miljøministeriet, 2000; MCPFE & UNECE/FAO, 2003).

1.2. Valuing Forest Recreation

Although forests are partly commercial, large parts are also open to access for recreation. When the value of forest recreation is not captured in monetary terms, the resource is under-priced on the market, creating a preference for purely commercial land uses such as agriculture, industry and housing. Efficiency can be improved, however, if non-market goods and services, such as the value of recreation, were attributed to existing and new forest sites. Taking the value of recreation into account can therefore significantly influence the economic trade off between competing land uses. Certain types of recreational use of forest areas, e.g. fishing, shooting, campsites and holiday cabins, are well recognised and appear to be very profitable when managed commercially (NAO, 1986, para 4.30). However, the value of 'public good' and 'open access' aspects of forest recreation is less readily available in monetary terms.

Since the late 1970s, a growing literature on non-commercial, recreational use of forests has emerged in Europe, which assesses the amenity benefits of forests to the general public (for example forest walks, picnic sites, etc.). These give a ‘snap shot’ of current values of existing sites and, when summarised collectively, can provide an insight into the main influences on recreation values. However, these studies have not covered a number of central aspects in relation to valuing new recreation sites. Firstly, the valuation of new forest sites, where recreational benefits are only likely to be substantial when sites reach maturity after 50-80 years, should take into account changes in preferences and demand over time. Secondly, the spatial mix between new and existing sites as well as population centres plays a central role for the monetary valuation of recreation sites. For instance, forests that are easily accessible to large numbers of visitors will create more welfare than remote forests, and the creation of additional sites in a forest rich region will have less welfare effects than a site in a forest poor region, all else equal. A spatially disaggregated representation of forest sites should therefore be included in the valuation of new sites. Thirdly, the substitution effects between new and existing sites influence recreational values significantly. The establishment of new sites may not only create more demand for forest recreation, but may also displace visits to older sites, reducing their recreational value. Substitution is a well known issue in the valuation literature but is often poorly if at all represented. Due to the characteristics of afforestation on new locations (i.e. maximisation of welfare after long time periods, ease of access and substitution effects), time and spatial considerations are essential aspects when valuing new sites.

In many instances, time and cost constraints force policy makers and researchers to choose benefit transfers over original surveys in the valuation of existing sites. In the case of new forest sites, benefit transfers also offer the near only possibility of quantifying future use values (with the exception of contingent valuation studies that are based on hypothetical markets). Benefit transfers are based on quantified welfare estimates from sites where monetary valuation has already been carried out (policy sites) and transferred to unstudied sites (study sites).

1.3. Approaches in Valuing Forest Recreation

This dissertation combines a meta-analysis of existing valuation studies on forest recreation in Europe with original valuation and benefit transfers of forest recreation values over time and space. The meta-analysis looks at the influences on the value of forest recreation by identifying determinants of welfare across original valuation studies.

This is useful when carrying out original valuation studies and transferring values from a policy site to a study site. The original valuation studies are used to test the efficiency of transferring welfare estimates over space and over time (20 years). The insights into which benefit transfer designs produce the least errors and the analysis of welfare changes over time are essential contributions to the field of valuing non-existing or newly established forest sites.

The original valuation studies and transfers are conducted in 52 forests in the capital region of Denmark. The reason for the choice of location was partly the access to a unique dataset on national outdoor recreation from 1977 and 1997, described in more detail in Chapter 3, and partly the relevance of valuing new forest sites in Denmark, where a national forest policy from 1989 plans for the doubling of the forest area during one forest generation (80-100 years). Spurred by the UN Conference on Environment and Development in Rio 1992 and subsequent international agreements (e.g. the Convention on Biological Diversity, the Statement of Forest Principles, the forest component in Agenda 21 and the Environment for Europe process (Dobris Ministerial Conference, 1991; UNCED, 1992) the original forest policy changed in scope towards greater emphasis on multipurpose afforestation projects in urban fringe areas. This in turn has led to a significant increase in costs associated with afforestation. Unless the hitherto unmeasured benefits of forests are included in the trade off between public goods and commercial uses, e.g. in cost-benefit analyses, the current plans for forest expansion in Denmark and elsewhere in Europe will be increasingly difficult to fulfil. This dissertation does not attempt to carry out a cost benefit analysis but delivers insights into the intricacies of valuing recreation in new forest sites in monetary terms.

In order to ascertain the type of components that influence the value of forest recreation, a meta-analysis was carried out on forest recreation studies that applied the travel cost method (TCM) in Europe. In the field of outdoor recreation valuation of forests, two meta-analyses, have been conducted in the USA (Walsh, 1992; Loomis, 1996) and two in the UK (Bateman, 1999 and 2003), but none at a European level.

Meta-analysis has a long history in the health sector with the first application in 1904 by Karl Pearson, evaluating data from many studies to conclude that vaccination against intestinal fever was ineffective. Smith and Glass (1977) in their study on the effectiveness of psychotherapy were the first to name the statistical analysis of statistical analyses 'meta-analysis'. Meta-analysis is the statistical analysis of the summary findings of empirical studies and explores factors that influence variations in point estimates among individual studies (van den Bergh et al., 1997).

Meta-analysis has been used increasingly in environmental economics since the early 1990s. Rather than using experimental data as in the health sciences, meta-analyses in environmental economics apply data from different model set-ups and data-sets; besides, research results are interdependent and should not be treated as independent values within one study (Smith and Karou, 1990b). Table 1 lists past meta-analyses in the field of environmental valuation in terms of topics and valuation techniques used in the original valuation studies.

Table 1. Meta-analyses of Environmental Valuation Studies

Study	Topic	Valuation Technique[1]
Smith and Kaoru (1990a)	Outdoor recreation	TC
Walsh et al. (1992)	Outdoor recreation	CV/TC
Smith and Huang (1993, 1995)	Air pollution	HP
Boyle et al. (1994)	Ground water	CV
Sturtevant et al. (1995)	Fresh water fishing	TC
Smith and Osborne (1996)	Visibility at national parks	CV
Carson et al. (1996)	Recreation, environmental amenities, health risks	HP/TC/CVDE/market prices
Loomis and White (1996)	Rare and endangered species	CV
Brouwer et al. (1999a)	Wetland ecosystem functioning	CV
Bateman et al. (1999, 2000)	Woodland recreation	CV
Rosenberger and Loomis (2000)	Outdoor recreation	CV/TC/RUM/HP
Woodward and Wui (2001)	Wetland services	TC/HP/CV/RC/NFI
Mrozek (2002)	Value of life	VSL
Shrestha and Loomis (2003)	Outdoor recreation	CV/TC/RUM/HP

Source: Adapted and expanded from Brouwer, 2000

[1] TC: travel costs; CV: contingent valuation; HP: hedonic pricing; DE: defensive expenditures; NFI: Net Factor Income; VSL: Value of Statistical Life; RC: replacement cost; RUM: Random Utility Method

Research topics across meta-analyses as well as the types of measurements included in the individual analyses cover a wide field. The range of topics is surely a sign of the growing number of environmental valuation studies, making statistical analysis possible and interesting. The inclusion of very different measurements of welfare in individual meta-analyses is a consequence of the seemingly large differences in valuation outcomes as a result of the use of different research designs, e.g. stated and revealed preference techniques and different elicitation formats.

An important point of criticism of the use of meta-analysis in environmental valuation is the different research designs found across studies, as this undermines the inferences made from a cross-analysis (Brouwer et al., 1999a). This is especially the case for meta-analyses combining different valuation techniques, e.g. stated and revealed preference techniques, but also for meta-analyses using the contingent valuation technique, where the change in provision being valued and the estimated economic value can differ substantially across studies (See for instance Rosenberger and Loomis, 2000; Brouwer at al., 1999a; and Woodward and Wui, 2001). However, one valuation technique that measures the same type of good across studies is the Travel Cost Method (TCM).

1.3.1. Essential Elements of the Travel Cost Method

The TCM measures the value of access to recreation sites. Because of the directly comparable measurements of welfare across studies and its relevance to the valuation of new forest sites, the meta-analysis in this thesis focuses only on studies that have used the travel cost method. In addition, the travel cost approach is applied to Denmark in a random utility framework (See Section 1.3.2). TCM is the oldest indirect valuation technique for measuring the demand for a non-marketed commodity. It was first proposed by Harold Hotelling in a letter to the National Park Service in 1947 and first implemented by Trice and Wood (1958) and Clawson (1959). The aim of the National Park Service in the 1950s was to demonstrate that economic recreation benefits produced by national parks exceeded costs of management to taxpayers. Hotelling's approach linked the empirical relationships between increased travel distances and associated declining visitation rates to estimate a true demand relationship, which can be used to compute the total benefits produced to park visitors. Demand for recreation in TCM is measured by the number of trips to a specific site given the implicit costs of visiting, income and demographic characteristics of the visitor. Welfare in terms of consumer surplus is estimated as the integral behind the demand curve, which lies between the observed price of access and a derived choke price. The choke price represents the level of costs that no visitors are willing to pay and hence visitation equals zero.

The original suggestion for valuation recreation sites based on distance and costs has been the basis for theoretical and empirical research in the last 50 years. Ward and Beal (2000) give a comprehensive overview of the development and caveats of the TCM, including the issues of value and decomposition of time, multi-site and multi-purpose trips, the effect of substitute sites and loss of information by aggregation into zones in the zonal travel cost method (ZTCM).

TCM is one of the ‘success stories’ in natural resource valuation methodology (Smith, 1993), primarily because it ensures that estimates generally respect consumer demand theory with quantity being negatively related to the own price and, when applied to comparable sites, the estimates reveal a broad consistency in the relative size of price and income elasticities. Also, estimates across different types of recreation sites reveal plausible differences, e.g. demand functions for recreation sites in areas with numerous substitute facilities are more elastic than those for sites with few comparable alternatives.

In relation to the valuation of new forest sites and benefit transfer to existing sites in Europe, TCM offers a pertinent, utility consistent and robust methodology to identify factors that significantly explain variance in valuation outcomes. By focusing on TCM studies in the meta-analysis, I ensure that inferences made from the cross-analysis is not undermined by different types of measurements and valuation designs but reveal significant factors that explain variances in valuation outcomes. This thesis adds to the current meta-literature by including exogenous data on site characteristics, considered important for the choice of recreation sites. These, however, are not included as descriptions in original studies nor included in the original specification of the travel cost models.

1.3.2. Essential Elements of the Random Utility Method

The original use of travel cost models was to value the access to single recreation sites without taking into account quality and characteristics of the sites. This allowed researchers to compare the recreational value of land with the value of competing uses. However, single site models have limited appeal to major national policies, such as the afforestation programme in Denmark. Firstly, because observed recreational behaviour is typically defined over a large number of choice alternatives; secondly, because single site models ignore multiple site interaction and hence neglect important substitution possibilities for visitors; and thirdly, because not only costs between sites but also characteristics and quality of these characteristics differ across sites.

Two different approaches have sought to accommodate the need for developing multiple sites models and for including site quality: one approach models a system of demand functions for each recreational site, such as the gravity model (Cesario 1973; Cesario and Knetsch, 1976), the Burt and Brewer model (Burt and Brewer, 1971), the varying parameter model (Vaughan and Russell, 1982; Smith and Desvouges, 1985), the count demand models (Shonkwiler,1999). See Bockstael et al. (1987) for more detailed descriptions. These approaches cannot handle the fact that while many visitors use more than one site, they typically choose not to visit some sites while making multiple visits to others (so-called corner solutions).

The other approach, which is able to handle corner solutions, models the decision process where the total number of recreational trips is allocated among alternative sites, the so-called discrete choice approach based on the Random Utility Model (RUM). Developed by McFadden (1974a) and others, the random utility model grew out of efforts to model transportation choices, in which an individual chooses among a set of mutually exclusive alternatives, such as car, bus, train or other (e.g. McFadden, 1974b). Three state of the art, competing frameworks of modelling the decision process exist. One approach is the Kuhn-Tucker model (Wales and Woodland, 1983; Hanemann, 1978), which relies upon a single structural framework to simultaneously model the site selection and participation decision. It has only been applied in few cases to date due to large computational requirements making large choice sets difficult to handle. A second framework is the repeated nested logit model (Morey et al., 1993), which assumes a fixed number of choice occasions and independency in choice occasions allowing them to jointly model the participation and site selection decision. A third approach is the linked model, developed by Bockstael, Hanemann and Strand (1986) that models the selection of site and the frequency of visits in two stages. Herriges et al. (1999) describe in detail the workings of the three different frameworks of modelling recreation demand.

The major advantage with RUM is not only the capacity of dealing with a large number of alternatives and substitution effects as well as focusing on site characteristics as the basis for determining demand, it also offers the possibility of measuring the effects of introducing new recreation sites, which is central to this thesis.

This thesis applies the linked model of Bockstael et al. (1986) with a mixed logit specification combined with Geographic Information System (GIS) with a disaggregated representation of forest sites. The mixed specification allows for heterogeneity in preferences over the population and correlation in substitution patterns across sites. The use of GIS further improves the adjustment for site heterogeneity, useful in benefit transfers, and can account for the spatial pattern of population density and other demographic characteristics. To date, there has not been any validations of benefit transfers over a time for a period as long as 20 years. Also, there has only been a few benefit transfers using the RUM, and none have made use of the mixed specification of the logit model, despite the advantages of assessing changes in preferences.

1.3.3. Organisation of the Thesis

Chapter 2 presents the data, approach and estimation of the meta-analysis of forest recreation valuation studies that applied the travel cost method in Europe. The findings are partly applied in the following two chapters. Chapter 3 estimates the total recreation value for 52 forests in Denmark in 1997 using a mixed specification of the RUM and tests the efficiency of transferring demand functions over 20 years. Chapter 4 adds to Chapter 3 by estimating the total recreation value of the same 52 forests in 1977 and compares how total welfare per site has developed between 1977 and 1997. The chapter focuses in particular on one site, Vestskoven, that was created in the 1970s. The two chapters provide evidence of how values have developed over time and how well transfer models can predict future values. In addition, Chapter 4 performs and tests three different designs of spatial benefit transfers, dependent on how the choice set of policy sites is constructed. The findings reveal the sensitivity of spatial transfers, keeping time constant. Finally, Chapter 5 discusses and concludes.

CHAPTER 2 FOREST RECREATION VALUES IN EUROPE[2]

2.1. Introduction

Recreation is one of numerous services provided by ecosystems. The value that users attach to nature recreation can be substantial although it is not reflected by market prices and is provided as a quasi-public good. On a practical level, taking these values into account can make a significant difference in the management, conservation and planning options for nature recreation. On a research level, gaining knowledge on the range of values attributed to ecosystems, dependent on population characteristics, quality and quantity of the natural resource as well as specification of demand models is essential when assessing general trends and impacts on the use of forests for recreation.

This paper focuses on forests as one particular type of ecosystem, producing a range of recreation opportunities. We use statistical meta-analysis to investigate a wide range of data on the value of recreation in forests. By restraining the analysis to the travel cost method (TCM), we ensure a comparable measure of value, as TCM only values the price of access to a site as opposed to changes in on-site quality attributes.

Meta-regression analysis is a statistical technique that originates from the health sciences. The first application was by Karl Pearson in 1904, evaluating data from many studies to conclude that vaccination against intestinal fever was ineffective (Mann, 1994). Although the majority of meta-analyses have been applied to psychology, education and medicine, the technique has become widely accepted in labour and transport economics and since the early 1990s also in environmental economics (van den Bergh et al., 1997). Meta-analyses in economics differ from the experimental data used in the health sciences by reporting on data from different model set-ups and interdependent panel nature of any sample for research results (Smith and Karou, 1990a).

Meta-analyses carried out in the field of environmental valuation have been applied to a variety of fields, including the provision of wetland functions across North America and Europe (Brouwer et al., 1999a), fresh water fishing (Sturtevant et al., 1995), air pollution

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[2] This chapter was conducted in collaboration with Dr. Richard Tol, Hamburg University, Research Unit Sustainability and Global Change, Germany, and is based on the FNU86 working paper, available at http://www.uni-hamburg.de/Wiss/FB/15/Sustainability/Working_Papers.htm

(Smith and Huang, 1995) , benefits of endangered species (Loomis and White, 1996), visibility in national parks (Smith and Osborne, 1996), and general outdoor recreation (Smith and Karou, 1990a, 1990b; Walsh et al., 1992). Only two meta-analyses in Europe have focused specifically on recreation in forests as opposed to general outdoor recreation. These have been limited to studies carried out in the UK (Bateman, 1999 and 2003).

By systematically analysing the variation in data from different sources, we aim to identify the extent to which methods, design, and data affect reported forest recreation values. We limit our scope to studies conducted in Europe that have applied the travel cost method. The travel cost method is generally regarded as a robust methodology and theoretically well suited for transferring values from one site to another, despite indications that model assumptions do appear to explain some of the variability in valuation outcomes (Loomis, 1992; V.K. Smith & Y. Kaoru,1990b). By limiting our analysis to the travel cost method, which measures the price of access, we expect to obtain a higher explanatory power of the meta-model than what is generally found in meta-analyses.

The paper is organised as follows: Section 2.2 describes the regression methods applied, Section 2.3 the data collected in the literature review, Section 2.4 presents results and discusses and Section 2.5 concludes.

2.2. Meta-model

Original valuation studies often test several model specifications and report more than one result of interest for the meta-analysis. Rather than averaging the source estimates to avoid one study dominating the results in the meta-model (Stanley, 2001), the meta-analysis regression should be able to handle the variation in estimates within one study. Also, averaging values of dependent and independent variables within one study may lead to aggregation bias in the meta-regression if a non-linear specification is applied (Stoker, 1993). This, in turn, produces a data set with a grouped structure with possible intra-group error correlation (Moulton, 1986)

A random group effects model is able to recognize the common origin for a given set of estimates and the resulting implications for the correlation structure of error terms in the meta-model. We assume that the set of welfare measures generated by a given study can by described with the following model (Greene, 2003):

$y_i = \beta x_i + \varepsilon_i$ with

$$\varepsilon_i = \mu_i + e_{it} \qquad \textbf{(1)}$$

where y_i is a vector of observations on forest recreation values from study *i*, adjusted to € 2000, PPP adjusted, and x_i is a matrix of explanatory variables including study methodology, site and user population characteristics. ε_i is a vector of error terms associated with welfare measure y_i, which is decomposed into a study specific constant μ_i and a vector e_{it} with f_i iid observation-specific errors with mean zero and common variance σ_e^2. We assume that the distribution of μ_i is as follows:

$$\begin{aligned} &E[\mu_i \mid \mathbf{X}] = 0, \\ &E[\mu_i^2 \mid \mathbf{X}] = \sigma^2 \text{ if } i = j \qquad \textbf{(2)} \\ &E[\mu_i^2 \mid \mathbf{X}] = 0 \quad \text{if } i \neq j \end{aligned}$$

where E denotes the expectation operator. Each contributing study 'draws' a study-specific constant term from a normal distribution with mean zero and variance σ_μ^2. These deviations are assumed uncorrelated across studies. We also assume that μ_i, e_i, and x_i are uncorrelated within and across studies. By allowing for study-specific error terms, the meta-model can capture correlation across observations within a given study (Moulton, 1986).

If the hypothesis of random effects in the Breusch and Pagan Lagrangrian multiplier test is rejected, the fixed-effects model should be estimated more efficiently, which assumes homogenous effect sizes across studies within models. We also use a Hausman specification test. If our model is correctly specified and if μ_i is uncorrelated with x_i, the coefficients estimated by the fixed effects and the random effects estimators should not statistically differ.

2.3. Travel Cost Demand Model & Data

Our meta-analysis focuses on studies that apply the travel cost method where recreation in forests is the main attraction (as opposed to eg. studies valuing fishing resources). It includes studies, where recreation is directly linked to services provided by forests but excludes those, where other non-forest ecosystems such as water, grassland etc. are the main reasons for visiting a site.

The travel cost recreation demand model can be seen as "a derived demand for a recreation site that contributes to each individual's production of a recreational activity providing utility" (Smith, 1990a). A simple utility function U, specified in terms of the activities A_i that a person wants to consume and other goods, Z_i, could look like this:

$$U = U(A_1, A_2 ..., A_k, Z_i)\,, \tag{3}$$

where the production of each A is a combination of market goods, x_{jt}, necessary to consume in order to undertake activity A (e.g. vehicle and petrol to travel to reach a recreation site, fishing equipment for fishing trips etc.), the amount of time, t_i, to consume activity A, and non-market commodities, y_{ki} such as the characteristics and availability of a recreation site and substitute sites:

$$A_i = f_i(x_{1i},..., x_{ni}, t_i, y_{1i},..., y_{ni}), \tag{4}$$

The specification of budget and time constraints, necessary to formally derive the travel cost demand model, depends on the assumptions that the researcher applies, for instance whether or not to include an opportunity cost of time of travel and/or of time spent on site, and evaluated at which fraction of the wage rate. Demand for recreation is in travel cost studies measured by the number of trips to the site (v):

$$v = g(P, P_S, Y, d)\,, \tag{5}$$

where P is the implicit price of a trip, P_S the travel costs to substitute sites, Y is income and d are demographic characteristics, which describe the differences in taste, determining heterogeneous responses to the components in the recreation production function.

In our meta-analysis we use the normalised consumer surplus, (CS) per trip (v), to reflect differences in the condition of access across studies, as the dependent variable:

$$\begin{aligned} CS/v &= L(P_0, P_c, P_s, Y, d) \\ &= \int_{P_0}^{P_c} [g(p, P_S, Y, d)/g(P_0, P_S, Y, d)]dp, \end{aligned} \tag{6}$$

where P_0 is the current price and P_c is the choke price. In order to estimate (CS/v) we make assumptions on which variables in L(.) influence the welfare measure, based on available information in the studies and relevant exogenous data. The consumer surplus is the integral behind the demand function in (5).

In addition to the components of the travel cost demand model in (6), also features of each recreation site, specifications of the estimated demand function, and underlying assumptions in the behavioural model (e.g. treatment of substitute sites) influence estimates of (CS/v) across studies. Our basic form of the estimating meta-regression model is therefore a combination of travel cost demand parameters and modelling specifications, such that βx_i of (1) is decomposed into:

$$CS/v_i = \beta_A X_{Ai} + \gamma Z_i + \varepsilon_i, \tag{7}$$

where X_{Ai} is a vector of parameters estimated in (6) and Z_i is a vector of variables describing modelling decisions.

We have identified a total of 25 studies from 9 European countries, totalling 251 observations. 11 of the studies reported only on one welfare estimate whereas the remaining studies include up to 77 estimates of consumer surplus. This is partly because of disaggregated multi-site studies, partly due to different model specifications and changes in independent variables, e.g. looking at the effects of including and excluding opportunity cost of time. Particularly researchers in the UK and Italy have conducted many travel cost studies (8 and 6 respectively) with 145 observations in the UK alone.

Estimates of consumer surplus per trip were converted to euros, adjusted for purchasing power, per person and referenced to a common date (2000) using the consumer price index. The consumer surplus per trip varies significantly across studies, ranging from €0.66 per trip to €112 with a standard deviation of €28.14. The average welfare per trip across the studies is therefore far greater (€17.30) than the median (€4.52), whereas the within study difference between mean and median is less pronounced. An exception is the study by Elsasser (1993) where two very different groups of sites (one is predominantly holiday and one clearly for daytrip recreation) produce large differences in per trip values and hence a large variation in value estimates. Table 2 overleaf lists the studies and welfare estimates included[3].

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[3] The full database can be downloaded from the following website: http://www.uni-hamburg.de/Wiss/FB/15/Sustainability/Working_Papers.htm under Working Paper FNU-86

Table 2. Forest Recreation Studies using the Travel Cost Method & Welfare Measures

Study	Country	Type of Publication	Obser-vations	Mean Consumer Surplus (€ 2000)	Median Consumer Surplus (€ 2000)	Standard Deviation
Bateman et al. (1996)[1]	UK	Journal	2	2.92	2.92	0.28
Boatto et al. (1984)	Italy	Journal	1	5.95	5.95	.
Bojö (1985)	Sweden	Report	1	32.37	32.37	.
Christensen (1988)[2]	Denmark	Dissertation	47	0.80	0.52	0.79
Elsasser (1996)[3&4]	Germany	Dissertation	26	9.87	7.11	19.06
Everett (1979)	UK	Journal	1	4.52	4.52	.
Gatto (1988)	Italy	Journal	1	3.12	3.12	.
Glück (1977)	Austria	Journal	1	0.66	0.66	.
Hanley (1989) [1]	UK	Journal	1	4.22	4.22	.
Hanley and Ruffel (1993) [1]	UK	Book	1	4.18	4.18	.
INRA (1979)	France	Report	3	10.16	11.71	3.29
Löwenstein (1991)[5]	Germany	Proceedings	1	51.89	51.89	.
Luttmann and Schröder (1995)	Germany	MSc thesis	2	112.64	112.64	94.26
Marangon and Gottardo (2001)	Italy	Report	2	16.76	16.76	6.18
Marinelli et al. (1990)	Italy	Journal	2	23.47	23.47	26.67
Marinelli and Romano (1986)	Italy	Book	1	1.67	1.67	.
Merlo (1986)	Italy	Journal	1	2.53	2.53	.
Merlo and Signorello (1991)[6]	Italy	Proceedings	7	15.32	13.56	6.65
Moons et al. (2001)	Belgium	Journal	6	4.86	4.50	1.44
Ovaskainenet al. (2001)	Finland	Journal	1	35.76	35.76	.
Oyarzun (1994)	Spain	Journal	2	88.04	88.04	87.41
Willis (1991) [1]	UK	Journal	77	3.63	3.66	1.91
Willis and Benson (1988) [1]	UK	Journal	3	3.64	3.52	1.95
Willis and Benson (1989) [1]	UK	Journal	24	3.94	4.26	1.72
Willis and Garrod (1991) [1]	UK	Journal	36	1.82	1.12	1.81
Total Observations			251			
Total mean by study			10.04	17.30	17.30	19.36
Total median by study			2	4.52	4.50	2.63
Total standard deviation by study			18.60	28.14	28.19	32.70

Forest characteristics were made availbale from the following agencies:

[1] Forestry Commission (2003)

[2] Danish Forest and Nature Agency (1977)

[3] Landesforstverwaltung Hamburg (1994)

[4] Rheinland Pfalz Struktur- und Genehmigungsdirektion Süd (2000)

[5] Niedersächsisches Forstplanungsamt (1998)

[6] Veneto Agricoltura (2003)

The majority of gathered valuation studies report on size for forest site and annual number of visits to recreation sites, but exclude more detailed information on the physical site characteristics such as phenology, diversity and density of vegetation, type of site management, and provision of visitor facilities, which is believed to be of importance for the choice and length of recreation visits (e.g. Hanley and Ruffell, 1993). This is understandable for an individual study where these characteristics are constant, but makes post-comparisons across sites problematic. To the extent possible, we have included site relevant information as exogenous data provided by the relevant forest management authorities. These include density of forests in terms of fraction of open land, such as roads, pathways and clearances within the forest area, fraction of coniferous trees and trees older than 60 years, Shannon indices of diversity for species and age classes as well as longitude and latitude of forest sites. The Shannon indices of diversity take into account richness and evenness of species distribution (Shannon and Weaver 1949). The higher the index, the more rich and evenly distributed the age and species classes.

In terms of socio-economic characteristics, the extent to which data such as sex, age, income and group size is included varies considerably across studies. We have therefore added averages of national data on per capita income level and population density around the sites, measured in a 1x1 degree grid cell. Although aggregate data have no direct link to the study sites, the exogenous additions are directly comparable across studies and countries and may capture differences, especially across countries.

Table 3. Explanatory Variables, means and ranges

Variable	Observations	Mean	Std. Dev.	Min	Max
Authorship Dummy Variables					
Willis (=1, 0 otherwise)	251	0.56	0.50	0	1
Christensen (=1, 0 otherwise)	251	0.19	0.39	0	1
Elsasser (=1, 0 otherwise)	251	0.10	0.31	0	1
National Dummy variables					
UK (=1, 0 otherwise)	251	0.59	0.49	0	1
Denmark (=1, 0 otherwise)	251	0.18	0.39	0	1
Germany (=1, 0 otherwise)	251	0.12	0.32	0	1
Italy (=1, 0 otherwise)	251	0.06	0.24	0	1
Site Characteristic					
longitude	251	2.72	6.75	-5	24
latitude	251	52.92	3.30	40	63
size (ha)	250	10,164.17	32,872.05	47.2	334,000
yearly number of visits	230	990,553.70	3,116,546	1,426	2.16E+07
Fraction coniferous (%)	223	0.64	0.29	0	1
Shannon age diversity index	217	1.40	0.40	0	2.29
Shannon species index	213	1.23	0.34	0.572	1.97
density of forest (%)	216	0.96	0.20	0	1
fraction of trees older than 60 yrs (%)	214	0.41	0.24	0	1
fraction open land (%)	212	0.25	0.15	0.00714	0.86
Methodology Issues					
opportunity cost of income used (=1, 0 otherwise)	248	0.69	0.46	0	1
expenditure (=1, 0 otherwise)	247	0.20	0.40	0	1
opportunity cost of time (% of salary)	246	0.25	0.29	0	1
cost per km (€ 2000 PPP)	245	0.24	0.45	0.18	6.54
OLS regression (=1, 0 otherwise)	243	0.95	0.21	0	1
left hand side linear (=1, 0 otherwise)	243	0.39	0.49	0	1
right hand side linear (=1, 0 otherwise)	243	0.92	0.28	0	1
regional study (=1, 0 otherwise)	251	0.89	0.31	0	1
multi-site (=1, 0 otherwise)	251	0.24	0.42	0	1
individual TCM (=1, 0 otherwise)	251	0.16	0.37	0	1
trip value used (=1, 0 otherwise)	251	0.98	0.15	0	1
holiday visits (=1, 0 otherwise)	242	0.23	0.42	0	1
substitute sites (=1, 0 otherwise)	238	0.51	0.50	0	1
number of zones	204	22.92	57.64	0	767

Variable	Observations	Mean	Std. Dev.	Min	Max
Socio-economic Characteristics					
population density (1x1 Degree grid cell)	251	272,416.90	234,992.30	2601	829,285
GDP € PPP per capita (national level)	251	19,436.15	2,243.98	14,083.02	25,883.90
Study Characteristics					
publication date (yr)	251	0.02	0.13	0	1
sample size	235	1,037.33	2,369.61	21	16,512
travel time (hrs)	201	0.11	0.32	0	1
average distance (km)	191	73.72	106.20	2.5	890
average time on site (mn)	182	8.96	23.29	0	112.44
maximum distance travelled (km)	158	154.23	182.89	35	1330

2.4. Meta-analysis Results & Discussion

Table 4 and Table 5 report the results of two meta-models based on different dependent variables: the log of consumer surplus, which proved superior to a linear specification and the consumer surplus normalised for size of forest. We introduced the normalised consumer surplus to compare whether the object (i.e. a value of a site) or the quantity (i.e. a per hectare value) of recreation services provided by forests provide a better fit of the meta-model to the data at hand. Each of the two models are run with a stepwise increasing number of variables, reflecting the level of data used. The first level (I) includes only information available from the studies; the second level (II) adds two aggregate variables on socio-economics, GDP per capita and population density in a 1x1 Degree grid cell around the forest site studies; the third and final level (III) introduces site attributes such as fraction of open land, age and species diversity indices as well as latitude and longitude of the forest site locations. In total, we report on six regressions, three for each of the two meta-models.

The appropriateness of including a study-specific error term was accepted in all regressions by the Breusch-Pagan Lagrange Multiplier test for the constraint $\sigma_{\mu} = 0$ as the H_0 of no intra-panel error can be rejected in all cases. Also, the Hausman test confirms in five out of six regressions that the model specification is correct, i.e. that differences between the coefficients estimated by the fixed-effects estimator and the random-effects estimator are systematic across studies.

Table 4. Robust Random-effects GLS meta-regression results with log of consumer surplus as dependent variable

Random-effects GLS regression Random effects u_i ~ Gaussian	Group variable (i): ref corr(u_i,X) = 0 (assumed)		
Dep: Variable	**Log of consumer surplus (€ 2000PPP)**		
Model Specification	I	II	III
Species diversity index			-0.2194516***
Age diversity index			0.1974244***
Open land			0.0936125
Latitude			-0.0024652
Gdp per capita		-0.0000468****	-0.0000589***
Population density		8.14e-08	3.70e-08
Year of study	0.0057084	0.0053266	0.0131585
Willis	0.30180****		
Italy	0.0720007	0.5146235****	
Size	-4.17e-06	0.0000517****	0.0000433***
Size^2		-2.17e-09****	-1.86e-09***
Cost/km	0.1497302		
Avgerage cost/km		-0.1275582****	-0.1782925
Deviation cost/km		2.351853****	2.417793****
Expenditures	-0.1658459*	0.0598405*	0.107807
Holiday	0.0427859	0.0136449	0.0082997
Opportunity cost of time	1.246246****	1.021696****	0.9512949****
Individual tcm	2.634236****	2.913397****	
Log of number of visits	.0459467****	0.0610954****	0.0758398***
Avgerage distance	0.0043266****	0.0041532****	0.0037722****
constant	-11.30185	-9.613497	-25.00426
sigma_u			
Sigma_e	0.27062271	0.26135245	0.2513972
Rho			
R-sq: within	0.3468	0.6735	0.7248
between	0.8932	0.9729	0.9999
overall	0.7617	0.8862	0.8899
Wald chi2	9019.95	27779.83	1532.84
Prob>chi2	0.000	0.000	0.000
Number of obs	168	168	151
Number of studies	10	10	5
Average obs per study	16.8	16.8	30.2
Breusch-Pagan Lagrange Multiplier Test			
Chi2(1)	0.90	1.06	1.50
Prob > chi2	0.3439	0.3034	0.2202
Hausman Test			
Chi2()	486.63(7)	17.44(7)	8.06(11)
Prob > chi2	0.0000	0.0148	0.7076

**** Significant at 1% level or better ** Significant at 10% level or better
*** Significant at 5% level or better * Significant at 20% level or better

Table 5. Robust Random-effects GLS meta-regression results with consumer surplus per hectare as dependent variable

Random-effects GLS regression Random effects u_i ~ Gaussian	Group variable (i): ref corr(u_i,X) = 0 (assumed)		
Dep: Variable	**Consumer surplus per hectare (€ 2000,PPP)**		
Model Specification	I	II	III
Species diversity index			0.0006069
Age diversity index			0.0035231
Open land			0.0097028*
Latitude			-0.0005975**
Gdp per capita		1.13e-06**	6.95e-07
Population density		-1.80e-09	-1.46e-10
Year of study	0.0004919*	0.0003665*	0.0005372*
Willis	-0.0061117***		
Italy	0.0059948****	0.0122773****	
Size	-1.37e-07****	-8.09e-07****	-9.94e-07***
Size^2		2.57e-11****	3.36e-11***
Cost/km	-0.0014398****	-0.0012815****	0.0017609
Expenditures	-0.0003039	-0.0009843	-0.0033198
Holiday	-0.0008687**	-0.000359	-0.0002894
Opportunity cost of time	0.0083232***	0.0103493***	0.0112324***
Individual tcm	0.0086803***	0.0064922**	
Log of number of visits	-0.0002476	-0.000108	-0.001074
Avgerage distance	-5.10e-06	-1.22e-06	-0.0000121*
constant	-0.9666343*	-0.7438093*	-1.038801*
sigma_u			
Sigma_e	0.00567768	0.00559828	0.00569022
Rho			
R-sq: within	0.1622	0.1980	0.2474
between	0.8430	0.9281	0.9993
overall	0.3383	0.3840	0.4090
Wald chi2	6288.96	3287.79	76.50
Prob>chi2	0.00	0.00	0.00
Number of obs	168	168	151
Number of studies	10	10	5
Average obs per study	16.8	16.8	30.2
Breusch-Pagan Lagrange Multiplier Test			
Chi2(1)=	1.17	1.60	1.47
Prob > chi2 =	0.2789	0.2053	0.2261
Hausman Test			
Chi2() =	5.15(7)	2.45(7)	2.00(11)
Prob > chi2 =	0.6421	0.9308	0.9985

**** Significant at 1% level or better ** Significant at 10% level or better
*** Significant at 5% level or better * Significant at 20% level or better

Looking at the model using the log of the consumer surplus as dependent variable, we find that we can reject the Hausmann H_0 in level II and III when decomposing the variable cost per kilometre into within and between effects, i.e. into the average and the deviation from the average, respectively. This reflects that the average cost of travelling may have one effect while transitional costs may have a different effect on forest visitation rates and hence consumer surplus. However, we find no evidence of systematic differences in coefficients between the fixed- and random-effects estimators in level I. The regressions using the consumer surplus per hectare all show evidence of systematic differences in coefficients and hence correct specification.

The scale, significance level and sign of coefficients clearly differ between the two meta-models, regardless of the level applied. The model using the log of consumer surplus appears to have a superior explanatory power (overall R^2: 74% - 87%) than the normalised consumer surplus model (overall R^2: 33% - 41%). Especially the former produce a high explanatory power compared to other meta-analyses of non-market good valuation studies with R^2 ranging from 15% and 68% (Smith and Kaoru, 1990a, 1990b; Walsh et al., 1992; Mrozek and Taylor, 2002; Shresta and Loomis, 2003;).

Looking at the year in which the studies were carried out, we find a positive and significant relationship at the 20% level or better in the normalised regression but non-significant in the semi-log model in level I and II. The trend signifies that benefit estimates generally have been increasing at a greater rate than inflation over time. This trend is also found in Rosenberger and Loomis (2001), Smith and Huang (1995), and Woodward and Wui (2001).

Although the effect of the author dummy variable ‘Willis’ on consumer surplus is significant in both models in level I, the signs change from positive in the semi-log model to negative in the normalised model. The reason for the difference lies partly in the specification of the dependent variable. When applying the consumer surplus per hectare, data shows that the normalised welfare measures estimated in the Willis studies are on average 48% lower than the overall level of the European studies, leading to a negative coefficient. This effect is not outweighed by the smaller average size of sites investigated by Willis, which inflates the dependent variable of these studies compared to other studies. Using the semi-log specification, the difference in level of consumer surplus between the Willis studies and the other studies is negligible and the positive impact on overall welfare must be attributable to other aspects. Due to multicollinearity with the variable GDP in level II and III, we removed Willis from the regression.

The coefficient for the country dummy variable, Italy, is positive and significant in both models, apart from level I of the semi-log model. Our data indicates that forest recreation values estimated in Italy are on average 79% higher than the overall average of forest recreation values found in European studies using the travel cost approach. The high values in the Italian studies are not caused by an above average distance travelled (this is among the lowest in the studies collected) but rather by using the highest cost per kilometre (€0.92) on average for the Italian studies compared to €0.36 in average over all studies.

Cost used per kilometre, size of site and average costs per kilometre are overall positive and significant in the semi-log model and generally negative and significant in the normalised model. The reason for the opposing signs lies again with the normalisation of the welfare measure by size. Sites that are larger than the average have lower normalised values than sites with smaller than average size. This reverts the positive relationship between benefits and size of site as visitors normally tend to travel further to a larger site than to a smaller site, found also in other studies (Zandersen et al. 2005; Scarpa et al., 2000). Due to the longer distance travelled to larger sites, the average distance travelled and the average costs per kilometre positively influence the level of consumer surplus. The normalised model reverts this trend such that smaller sites have comparably higher normalised benefits, causing the coefficients of costs of travelling, distance and size of site to decrease benefits. Related to this is the coefficient of log of number of yearly visits per site, which is positive and highly significant in the semi-log model, but appear to have no influence on the normalised benefit measure.

Both models agree that the individual travel cost approach has a positive and highly significant influence on benefits. This is supported by Shrestha and Loomis (2003) who find in their meta-analysis on outdoor recreation in the USA that the individual travel cost method leads to increased welfare measure. The fraction of wage used as a proxy for the opportunity cost of time is also positive and significant in both models, a relationship also found in Smith and Kaoru (1990a & 1990b).

Introducing aggregate socio-economic data in Level II indicates that 'GDP' is significant at the 1% level or better in both level I and II in the semi-log model and at the 10% level or better in the normalised model, but only at the level II. The negative relationship in the semi-log model between aggregate GDP and site level benefits is surprising. The reason may be the relatively small and thin spread of the sample on several countries, with outliers such as the study of Oyazun (1994) which estimated the highest mean consumer surplus per person and where the aggregate GDP measure ranks as the second lowest among the studies investigated. The coefficient of the population density variable is non-significant in both cases, which may be attributable to the aggregate level of the variable.

Adding site attributes in level III shows again very different results in terms of scale, significance and sign between the two models. Shannon indices of species diversity and age are highly significant in the semi-log model, where species monotone rather than diverse forests and forests with diverse and evenly distributed age classes seem to enhance welfare. In the normalised model, diversity plays no significant role but fraction of open land appears to increase consumer surplus; forest recreation in the southern parts of Europe, according to the data collected, is more valuable than in the northern parts of Europe.

Due to multicollinearity and bivariate correlation, several variables were removed from the models presented, of which the most important included longitude, functional form of the demand function, type of regression, and other authors and country dummies. Also, variables for individual TCM and the country dummy for Italy dropped out in level III due to multicollinearity. Table 6 summarises the main influences on consumer surplus derived for forest recreation in Europe.

Table 6. Average Consumer Surplus of European Forest Recreation and Main Influences

Main Influences	Semi-log Model (log of consumer surplus)	Normalised Model (cs/ha)
Species Diversity	-	
Age diversity	+	
Fraction Open Land		+
Cost per km	+	-
Willis	+	-
Italy	+	+
Opportunity cost of time	+	+
Individual TCM	+	+
Number of Visits	+	
Size	+	-
Average distance	+	
Average Consumer Surplus (€ 2000)	**5.34**	**0.0039**

Note: Total Average Consumer Surplus across studies is €17.30

Table 7 lists observations that are clearly outliers with respect to consumer surplus. In the semi-log model, three studies from Germany and Spain produced estimated consumer surplus up to 10 times higher than the average over studies. The sites are far greater than the average size (between 3 and 14 times larger) and average distance (283km – 890km) clearly not based on day-trip recreation. One further outlier from the UK can be identified with a very low consumer surplus (€0.027). The cost per kilometre used in the study is very low and the forest site relatively small (7 times smaller than the average).

In the normalised model, two observations from Germany and one from Italy differ substantially from the remaining data set by having very small forest sites (149ha– 159ha) and very low distance travelled in the German study (no information was available for the Italian study on travel distance).

Table 7. Outliers in Normalised and Semi-Log Models

Average/Outliers	Author	Site	Cs	Log(1+cs)	Cs/ha	Avg. dist	Cost/km	size
Average, All Studies			19.93	5.79	0.00267	73.72	0.27	7,457.39
Outlier, normalised model	Elsasser,P.(1996)	Niendorf, Hamburg, Germany	9	6.20	0.06338	7.5	0.13	149
	Elsasser,P.(1996)	Bergedorf, Hamburg, Germany	8.6	6.15	0.05772	7.5	0.13	149
	Merlo,M.& Signorello,G. (1991)	Abetina Reale, Italy	8.87	6.18	0.05579	.	0.25	159
Outlier, semi-log model	Luttmann,V.& Schröder,H. (1995)	Lüneburger Heide, Germany	194.53	9.27	0.00905	890	0.17	21,500
	Elsasser,P.(1996)	Pfälzerwald (aggregate), Germany	106.66	8.67	0.00101	283	0.13	106,108.2
	Oyarzun,D.A.(1994)	La Pedriza, Manzanares, Spain	162.58	9.09	0.00348	.	0.28	46,728
	Willis, K.G.& Garrod,G.D.(1991)	Cheshire (delamere forest), UK	0.03	0.49	0.00003	.	0.07	957.13

2.5. Concluding Comments

The literature review of forest recreation studies in Europe focused on studies that have applied the travel cost method between 1979 and 2001. The data indicates that there is a substantial variance in forest recreation values across studies, ranging from €0.66 to €112 per trip with a median of €4.52. The confinement to travel cost studies ensures a consistent economic concept (Marshallian willingness to pay) with value of access representing an identical change in service provision across studies. By selecting the same type of recreation activity, typology of sites and valuation methodology, our aim has been to reduce the differences across studies and countries as much as possible whilst ensuring a minimum number of studies and observations. This has resulted in a higher explanatory power of variance in the data than seen in meta-analysis studies that include different valuation methodologies (Walsh et al., 1992; Woodward and Wui, 2001; Rosenberger and Loomis, 2000).

Despite the similarities in approach and service provisions surveyed in this meta-analysis, the summarised benefit estimates reflect being carried out in different geographical locations in different studies and across long time periods. Meta-analyses in the past (Shresta and Loomis, 2003, Walsh et al., 1992, Rosenberger and Loomis, 2000; Smith and Kaoru, 1990a, 1990b) and this study to some extent have shown that values are influenced by the measurement of value (e.g. value per trip, per day or per season), by the travel cost approach (i.e. zonal versus individual travel cost method), by the definition of costs (i.e. inclusion and level of opportunity cost of time, composition of car-borne travel costs) and other methodological issues (e.g. inclusion of substitute sites, postal or face to face interviews, or specification of functional form of the meta-analysis). This study adds to the growing evidence from the meta-analysis literature by finding that number of visits to recreational sites and costs of travel have significant influence on the level of consumer surplus. Also, the inclusion of exogenous data on site characteristics reveals that site specific characteristics such as size, species and age diversity have distinctive effects on benefits summarised in a meta-analysis. These site attributes have previously shown to have significant influences on welfare in original valuation studies (Zandersen et al., 2005, Scarpa et al., 2000, Termansen et al., 2004), but have to date not been included in meta-analyses. However, site specific characteristics are rarely available in valuation studies as they are treated as constants for the purpose of the original study. Similarly, well-known problems exist in obtaining information about socio-economic values of samples not to mention socio-psychological and cultural characteristics (Brouwer et al.,1999b; Woodward and Wui, 2001). There have been numerous calls in the past for additional explanatory data to be made readily available from original studies for use in benefit transfers and meta-analyses (e.g. David, 1992; Rosenberger and Phipps, 2001). Also, meta-analyses, including the present one, would significantly improve if more observations for each type of survey design were available, for instance made available through an outlet that focus on publications that repeat published survey designs to different settings. This would to a large degree eliminate the variation in point estimates due to different survey designs and focus the analysis on variation due to site attributes, population characteristics etc.

CHAPTER 3 PREDICTING CHANGES IN VALUES OVER TIME: THE CASE OF FOREST RECREATION IN DENMARK[4]

3.1. Introduction

Benefit transfer of non-market environmental goods and services can be a cost and time-saving means of valuing sites for which there is little or no information (Boyle 1992, Rosenberger et al. 2000). Benefit transfers are based on sites where monetary valuation has already been carried out (policy-sites), and transferred to new, unstudied sites (study-sites), either in the form of single benefit values or entire benefit transfer functions. They are useful in a wide range of different contexts including cost benefit analyses of new projects and policy initiatives (e.g. Hanley et al., 1999), in general equilibrium models (e.g. Dessus and O'Connor 1999), environmental regulation (e.g. WATECO, 2003), and for calculating the adequate compensation payments in pollution accident cases (e.g. 1980-CERCLA).

In environmental economics, benefit transfers have traditionally been carried out over space from one geographical location to another. Relatively few of these spatial transfers have tested the accuracy of transferring values and functions across sites, and those who have, found transfer errors up to 475% of the original site value (Brouwer 2000, Loomis et al. 1995, Kirchhoff et al., 1997, Scarpa et al., 2002). Even fewer studies explicitly test the reliability of transfers over time even though most spatial benefit transfers are estimated on historic data. Downing and Ozuna (1995) investigate the reliability of function and welfare transfers over a short period of time (3 years). Although they come to the conclusion that many transfer functions are statistically equivalent to the original functions, they conclude that transferring values over time is not reliable. Loomis (1989), on the other hand, finds evidence that willingness to pay is relatively stable over short periods of time (9 months) when the determinants of willingness-to-pay stay constant. To our knowledge, there have not previously been any attempts to validate benefit transfers

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[4] This piece of research was conducted in collaboration with Dr. Mette Termansen, York University, Environment Department, UK, and Dr. Frank S. Jensen, Danish Centre for Forest, Landscape and Planning, The Royal Veterinary and Agricultural University, Denmark and based on the FNU61 working paper, available at http://www.uni-hamburg.de/Wiss/FB/15/Sustainability/Working_Papers.htm

over periods longer than 3 years. In this paper, we test the accuracy of benefit transfers of recreational values over a period of 20 years for 52 forests in Denmark.

The time aspect is important in environmental benefit transfers when planning long term projects e.g. afforestation or wilderness preservation where maximum welfare may only be reached 40 to 80 years after project start. The same also applies when comparing benefits to costs of long-term impacts of climate change or planning large investments in e.g. water quality from sewage treatment plants and river restoration projects. Extrapolations of estimated benefit measures are often made over periods of 10 to 50 years without knowledge about the reliability of the transfer functions, the welfare estimates or the determinants of welfare (Loomis 1989).

Non-similarity across sites in benefit transfers often poses another practical difficulty in benefit transfers. Basic criteria of transferring values between a policy- and study-site suggest that population characteristics, non-market commodity, change in provision level and sites in which the environmental resource is found should be similar (Boyle and Bergstrom,1992). However, the provision level and quality of an environmental resource may often differ significantly between new policy and study-sites, which seriously limits the application of previous study results (Brouwer, 2000). Random utility models (RUMs) and choice experiments, which are based on the same theoretical premise, are among the few tools available that may provide a solution to this problem.

RUMs are based on the principle that the consumer makes a choice among a set of available recreation sites, given a variety of site characteristics, where the choice is between a finite number of mutually exclusive alternatives. The method can be used to value changes in specific site characteristics, value the benefits of introducing a new site or the losses from eliminating a site. Because of the inclusion of multiple site characteristics, a RUM can adjust for differences across sites in benefit transfers. Combining a RUM with Geographical Information System (GIS) further improves the adjustment for site heterogeneity in a benefit transfer. It also limits the aggregation bias in random utility models, which causes the loss of essential information on individual site characteristics and consequently a loss in estimation accuracy (Parson and Needelman, 1992; Haener et al., 2004).

This chapter tests the accuracy of value function transfers over a 20-year time period at the individual site level by using a multi-site model with a mixed logit specification, which allows for heterogeneity in preferences across the population. The model is combined with the use of GIS, following the approach of Termansen et al. (2004a), to capture a larger proportion of site heterogeneity with a disaggregated representation of forest sites. Furthermore, it allows us to account for the spatial pattern of population density and other demographic characteristics.

The logit models are based on data from two identical national visitor surveys in forests from 1976/77 and 1996/97 (Koch, 1980; Jensen, 2003). The focus is on the regions of Copenhagen and Frederiksborg in Northern Zealand in Denmark. The two surveys were carried out by the Danish Centre for Forest, Landscape and Planning and are directly comparable using identical questions and identical sampling sites and schedules. To our knowledge, this is the first set of large-scale recreation surveys that allow a direct comparison of the outdoor use of forests over a time span as large as 20 years.

The purpose of this chapter is four-fold: to (a) evaluate the random utility models from 1977 and 1997, which allows us to assess changes in preference towards forest characteristics and travel over 20 years; (b) combine the 1997 random utility model with a count data model to determine total demand of each forest site in 1997; (c) conduct a benefit transfer from 1977 to 1997 with and without correction for changes in trip demand, which allows us to assess the efficiency of repeating a data-intensive random utility exercise versus transferring values over time ; and (d) test the statistical equivalence of the models and the estimated transfers.

The remainder of the chapter is organised as follows: Section 3.2 describes the data used to estimate the count and choice models. Section 3.3 specifies the theory and econometric estimation of the choice models. Section 3.4 outlines the benefit transfer approach and tests of reliability; Section 3.5 reports the results and Section 3.6 discusses the findings of the analysis and concludes.

3.2. Data

3.2.1. On-site Survey Data

We focus on 52 state owned forests in Northern Zealand in 1977 and 1997 in order to study in detail how the changes in forest characteristics and visitor behaviour impact forest recreation over time. Forests in this region are primarily state owned forests, and attributes such as species, age and infrastructure are available in a comparable format across sites. The 52 forests are located in the forest districts of Tisvilde, Frederiksborg, Kronborg, Jægersborg and Copenhagen and represent 93% of forest area in the region.

The surveys pertain only to day trips and were carried out during one year from April 1976 to March 1977 and December 1996 to November 1997 on 22 random days. Questionnaires were distributed simultaneously on 321 locations within the 52 forests. The same routes within the forests were used at each sampling time and were designed to ensure that all cars visiting the forest during one ½ hour received the questionnaires. Only car-borne visits are included. The identical sampling effort in each on-site survey implies a proportional random sampling where the population probabilities visiting individual sites can be assumed identical to the sample probabilities (Haab and McConnell, 2002).

The response rate was 53.7% out of a total of 16,518 questionnaires in the 52 forests in 1977 and 48% out of 18,394 questionnaires in 1997. For ease of computation and to ensure a relevant choice set of the sample population, we excluded visitors to the 52 forests who came from outside the regions of Copenhagen and Frederiksborg. Also visitors, where the address could not be identified or where the recreational trips could not be identified were excluded. The final samples retained for analysis are 6,580 questionnaires in 1977 and 6,987 questionnaires in 1997.

Origins of the trips were digitised through postal addresses using the "Befordringbidrag" software (Carl Bro, 1997) that assigns the postal addresses to the nearest node in the road network. The travel distances were calculated using a 1:200,000 scale vector road map (Kort & Matrikelstyrelsen, 1995). We calculated the actual observed distance that people had travelled from their origin of trip to one of the 52 forests. By choosing the most centrally located survey distribution point as the representative location in each forest, we also calculated a distance matrix between trip origin and each of the 51 other forests, which they could have visited. We assume all along that people used the shortest route possible. Average variable costs of travelling by car in 1977 and 1997 were applied to the return distance. Variable costs including taxes but excluding car depreciation amount to €0.22 per km in 1977 (1997 prices) and €0.187 per km in 1997 (1997 prices) (Truelsen, 1977; Vejdirektoratet, 2001).

3.2.2. Household Survey and Socio-economic Data

For the 1997 forest valuation model, we use a national household survey dataset from 1994 to estimate visit frequency (Jensen and Koch, 1997). 2,916 people between 15 and 76 years were randomly sampled from the national register during one year from November 1993 to October 1994 with a response rate of 83.7%. We retained only questionnaires of people living in the regions of Copenhagen and Frederiksborg with complete questionnaires, totalling 283 people. Potential variables, which we tested for influencing visit frequency, included income, age, distance to the nearest of the 52 forests, and ownership of car. We assume that the frequency of visits and underlying demand determinants in 1994, which we derive from the 1994 household survey, are not significantly different from 1997, where no such survey was carried out. Table 8 lists the measurements and sources.

Table 8. Count Model Variables

VARIABLE	MEASUREMENT
Income[1]	Yearly gross income at parish level
Age[2]	Year of birth
Car ownership[1]	Dummy variable. 1= owing at least one car in the household; 0 otherwise
Distance[3]	Shortest Euclidian distance through road network from home address of respondents to the nearest of the 52 forests in the choice set.
Visit frequency[4]	Total number of car-borne forest visits per year

Sources:
[1] Statistics Denmark (2004)
[2] Jensen and Koch (1997)
[3] Kort & Matrikelstyrelsen (1995)
[4] Own calculations, based on Jensen and Koch (1997)

For the 1977 forest valuation model, we calculated an average frequency of annual 18.25 car-borne trips per year per person, based on an average of 33 visits per person to forests per year and 55.3% of people travelling by car to forests in 1977 (Koch 1978). We use a fixed average, as the original data were not available.

1997 demographic data for the two regions are derived from a national digital dataset of 2,116 parishes with information on male and female population divided into 6 age classes. Population segments distributed on nodes in the road network were available from the Danish Centre for Forest, Landscape and Planning using an urban land use map (100x100m resolution). Data on average household income and car ownership were available from Danish Statistics on parish and local authority level, respectively.

3.2.3. *Forest Data*

A list of potentially important site attributes from 1977 and 1997 were added to the distance matrixes. To ensure comparability across forests and years, we use official forest data of the Danish Forest and Nature Agency from 1977 and 1997. Based on the forest inventories, we calculated Shannon indices as measures of species and age diversity. This takes into account species richness and evenness of species distribution (Shannon and Weaver 1949). Fraction of broadleaf and conifer vegetation, size of forest, fraction of trees older than 60 years and water bodies within the forests were also extracted from the forest inventories. Certain attributes that have not changed over the 20-year period, such as topography and distance to coast were available from Skov-Petersen (2002) and the land cover map "area information system, AIS" (Miljø & Energiministeriet / Danmarks Miljøundersøgelse, 2000). Table 9 lists the site attributes tested in the logit models.

Table 9. Site Attributes.

VARIABLE	MEASUREMENT	DATA SOURCE
Travel distance	Shortest distance through road network from the origin of the trip given by the respondents to the sites. The travelled distance is measured to the visited site and back to trip origin. The distance to the alternative sites are measured to the representative survey location.	Koch, N.E. (1980); Jensen, F.S. (2003) Kort & Matrikelstyrelsen (1995)
Forest area	Size of the forest	Danish Forest and Nature Agency (1977/1997)
Distance to coast	Euclidian distance from aggregate site to nearest coastline	Miljø & Energiministeriet and Danmarks Miljøundersøgelse (2000)
Slope	The average slope index of the 1 km by 1 km area around the aggregated sites.	Skov-Petersen (2002)
Distance to View point	Euclidian distance from aggregate site to nearest view point	Kort & Matrikelstyrelsen, (1995)
Planting Year	Shannon diversity index; % trees older than 60 years	Danish Forest and Nature Agency (1977/1997)
Species (family level)	Shannon diversity index; % broadleaf; % coniferous	Danish Forest and Nature Agency (1977/1997)
Water presence	Continuous variable. Fraction water within forest area	Danish Forest and Nature Agency (1977/1997)
Open Space (landscape type)	% afforested area within forest	Danish Forest and Nature Agency (1977/1997)

Table 10 below lists mean and standard deviation of forest attributes in 1977 and 1997, averaged over the 52 forests. Two-sample t-tests for equal means indicate than none of the attributes are significantly different across the two time periods.

Table 10. Differences in Site Attributes.

Attribute	*Year*	*Mean*	*Std. Dev.*	*Min*	*Max*
Shannon Species Index	1977	1.228	.230	.572	1.695
	1997	1.279	.191	.808	1.747
Fraction broadleaf	1977	.718	.180	.2	1
	1997	.744	.177	.194	1
Fraction conifer	1977	.282	.180	0	.8
	1997	.256	.177	0	.806
Fraction open land	1977	.158	.175	.027	.864
	1997	.164	.183	0	.756
Shannon Age Index	1977	1.707	.425	.163	3.639
	1997	1.731	.286	.636	2.124
Fraction older than 60 years	1977	.378	.141	.005	.72
	1997	.416	.146	.002	.803
Distance to coast	1977	5.884	4.433	.05	14.99
	1997	5.884	4.433	.051	14.99
Slope index	1977	1.151	.575	0	2.83
	1997	1.150	.575	0	2.83
Distance to viewpoint	1977	11.120	5.794	2.02	26.04
	1997	11.120	5.795	2.024	26.04
Fraction water bodies	1977	.031	.074	0	0.47
	1997	.030	.073	0	0.47
Size (ha)	1977	446.287	1023.222	34.9	7329.5
	1997	450.122	1020.911	34.9	7315.4

3.3. Theory and Econometric Estimation of the Choice Models

Random utility models estimate the probability of visiting one site out of a choice of several mutually excludable alternatives where the probability is dependent on travel costs to and attributes of the sites (Haab and McConnell, 2002; Creel and Loomis, 1992; Kaoru et al., 1995; McFadden, 1974a). The basis for examining the choice of site and hence the values of site attributes is the assumption that recreators make a choice to visit a site independently of previous visits (Yen and Adamowicz, 1993). This assumption of independence of trips necessitates a trip demand model be linked to the trip allocation model in order to estimate the total value of one site, rather than a value per visit. The first stage involves describing the model that allocates choices of visit based on the random utility approach. The second stage specifies the trip demand model, based on a zero-inflated Poisson model, which is linked to the trip allocation model via the inclusive value, described in more detail below. Finally, the calculation of value of access in the discrete choice framework is outlined.

3.3.1. First Stage - Trip Allocation Model

The allocation of trips between several sites in a given choice set is based on a Random Utility Model (RUM). These are discrete choice models based on utility maximising behaviour, where the decision maker chooses the alternative which provides the greatest utility, which in our case is one forest site with the highest level of utility out of a choice set of several forests. As researchers, we can only observe some attributes of the alternatives *j* faced by the decision maker *n*, labelled x_{nj}. These are the components of the representative utility function $V_{nj} = V(x_{nj}) \ \forall j$, which relates the observed factors to the decision marker's utility. Since we cannot observe all parts of utility, the 'true' utility U_{nj} can be decomposed as:

$$U_{nj} = V_{nj} + \mu_{nj} \quad \forall j, \tag{8}$$

where μ_{nj} captures the difference between the observed and 'true' utility. μ_{nj} is treated as random. Based on the joint density of the vector parameter μ_{nj}, it is possible to make probabilistic statements of the choices of the decision makers (Train, 2003).

The first specifications of standard conditional logit models carried out for this piece of research clearly showed a violation of the "independence from irrelevant alternatives"

(IIA) property in more than half the sites of the choice sets in 1977 and 1997. As the unobserved portion of utility is correlated over alternatives, we specified mixed logit models that allow for the correlation of errors by introducing error components and preference variation over the population by specifying a distribution for the coefficients (Train, 2003).

The representative utility function in the mixed logit specification is specified as:

$$V_{nj} = \boldsymbol{\beta}'\mathbf{x}_{nj}, \tag{9}$$

where $\mathbf{x}_{nj}$ is a vector of observed variables relating to alternative *j*, $\boldsymbol{\beta}$ is a non-observed preference parameter vector specified according to a preference distribution function with density $f(\boldsymbol{\beta}\,|\,\boldsymbol{\theta})$, where $\boldsymbol{\theta}$ are the parameters of this distribution, such as the mean and variance.

The stochastic part of the indirect utility function is denoted:

$$\mu_{nj} = \boldsymbol{\eta}' z_{nj} + \varepsilon_{nj}, \tag{10}$$

where $\boldsymbol{\eta}$ is a vector of random, non-observed terms with zero mean that varies over alternatives by σ_{ec} and has density $g(\boldsymbol{\eta}\,|\,\boldsymbol{\delta}_{ec})$. z_{nj} is the error component that allows for correlation in utility over alternatives and ε_{nj} is iid extreme value.

The probability for individual *n* of choosing site *i* out of *J* sites in a mixed logit is the integral of standard logit probabilities over a density of parameters, namely the density functions of

the random vector parameters $\boldsymbol{\eta}$ and $\boldsymbol{\beta}$, given below:

$$P_{ni} = \int_{\beta}\int_{\eta}\left(\frac{e^{\boldsymbol{\beta}'\mathbf{x}_{ni}+\boldsymbol{\eta}'\mathbf{z}_{ni}}}{\sum_{i\in J} e^{\boldsymbol{\beta}'\mathbf{x}_{ni}+\boldsymbol{\eta}'\mathbf{z}_{ni}}}\right) g(\boldsymbol{\eta}\,|\,\boldsymbol{\delta}_{ec}) f(\boldsymbol{\beta}\,|\,\boldsymbol{\theta})\, d\boldsymbol{\eta}\, d\boldsymbol{\beta} \tag{11}$$

P_{ni} is called a mixed function where the logit formula is the weighted average evaluated at different values of $\boldsymbol{\eta}$ and $\boldsymbol{\beta}$ with the weights given by the density functions $g(\boldsymbol{\eta}\,|\,\boldsymbol{\delta}_{ec})$ and $f(\boldsymbol{\beta}\,|\,\boldsymbol{\theta})$, also called the mixing distributions (Train,2003). A mixed logit model with an error-component structure is fully general (Train, 2003; McFadden and Train, 2000). In a standard logit model, the z_{nj} term is zero preventing any correlation over alternatives and the term β is considered known by the researcher and specified with a fixed coefficient;

and the mixing distribution is limited to fixed parameters $f(\beta)=1$ for $\beta = b$ and 0 for $\beta \neq b$.

The mixed logit is based on an identical choice set in 1977 and 1997 of 52 forests and using identical measures for attributes in 1977 and 1997, as described in Table 9. Coefficients of variables, which can logically take either sign and which are of particular policy relevance in this study, such as fraction of conifer trees, or fraction of open land in forests, were given an independent normal distribution with mean and standard deviation that are estimated. Other preference parameters for attributes, which remain largely constant over time such as size, slope, presence of water and distance to coast, were given fixed specifications across the population. The coefficient for travel costs have an independent log normal distribution as costs are expected to have the same negative sign for all visitors, with only the magnitude differing over the sample population. The random utility models were estimated using GAUSS, adopting the routine developed by Kenneth E. Train[5].

3.3.2. *Second Stage - Trip Demand Model*

The prediction of total demand of recreational trips to forests is based on a zero-inflated count model to account for the large number of recreational trips not undertaken by car (Yen and Adamowicz, 1993; Haab and McConnell, 1996). The frequency of car-borne trips is modelled in two parts. The first part is the inflation function which models the decision of mode of transport between a latent group A of individuals who never use the car for recreational trips, i.e. a zero trip frequency has a probability of 1, and a group B of individuals who sometimes uses a car, i.e. a positive trip frequency has a non-zero probability (Long, 1997). The second part is the decision on the number of annual recreational trips given that the individuals belong to group B. As we find evidence of over dispersion, we specify the second stage as a negative binomial, allowing the variance to exceed the mean.

Linking the trip demand model to the model specifying the choice of alternative needs to accommodate the fact that not only changes in travel costs but also changes in site attributes and access alter the frequency of visit as well as the choice of site. The present approach follows the work of Bockstael et al. (1987), where the participation function is linked to the site choice decision by including the inclusive value, calculated in the trip

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[5] The GAUSS routine for mixed logit is available from K. Train's website.

allocation model, in the regression of the trip demand model. The inclusive value represents the value of different alternatives weighted by their probabilities of being chosen (Bockstael et al., 1987). It is calculated as:

$$IV = \ln \sum_{j=1}^{J} \exp\left(\mathbf{v}_j\right)$$

The link ensures that, for instance, an increase in an attractive attribute or an inclusion of a new site increases both the probability of visiting this site and the probability of participating on any given choice occasion, hence increasing the total number of visits (Yen and Adamovicz, 1993).

Because the true welfare effect is smaller than the post-change estimate and larger than the pre-change estimate according to inequality (12), we calculate the inclusive value ex ante and ex post of changes, giving two sets of welfare estimates.

$$x^0 P \leq \text{true welfare effect } \leq x^* P \qquad \textbf{(12)}$$

where the superscript 0 indicates the initial value of days and the asterisk indicates the post-change value of days (Haab and McConnell, 2002).

The probability of individual *n* not choosing the car as mode of transport is given by:

$$\Pr(y_n = 0 \mid x_n) = \Psi_n + (1 - \Psi_n) \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_n} \right)^{\alpha^{-1}} \qquad \textbf{(13)}$$

where Ψ is the cumulative normal density function of the inflation model results, specified as a function of characteristics of an individual *n*, $F(\boldsymbol{z}_n \boldsymbol{\gamma})$, where $\boldsymbol{z}_n$ is a vector of socio-economic values of individual *n* and $\boldsymbol{\gamma}$ a vector of parameters. μ_n is specified as a linear exponential , $\exp(\boldsymbol{x}_n \boldsymbol{\beta})$, of the negative binomial model where $\boldsymbol{x}_n$ is a vector of socio-economic values, not necessarily the same as in the inflation function, and $\boldsymbol{\beta}$ a vector of parameters. α is the dispersion factor.

The conditional probability of individual *n* undertaking a given annual number of car-borne visits y, given a vector of socio-economic values, x_n, is:

$$\Pr(y_n \mid x_n) = (1-\Psi_n)\frac{\Gamma(y_n+\alpha^{-1})}{y!\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu_n}\right)^{\alpha^{-1}}\left(\frac{\mu_n}{\alpha^{-1}+\mu_n}\right)^{y} \quad \textbf{(14)}$$

where $\Gamma(\ )$ is the gamma function from which δ_i, the mean of the error term, is drawn (See Long, 1997).

Due to missing raw data from the 1977 survey, it was not possible to estimate a demand model and link it to the trip allocation model as for the 1994/1997 surveys, but in stead the national average of trip frequency was used, as described in Section 3.2.2.

3.3.3. *Value of Access in Random Utility Models*

The indirect utility function is the basis for welfare calculations in random utility models and provides a direct means of estimating welfare impacts of changes in site characteristics or access. The expected maximum utility that we seek to estimate is given by:

$$E\{max(U)\}=\ln\left(\sum_{j\in J}\exp(\mathbf{v}_{\mathrm{nj}})\right) \quad \textbf{(15)}$$

where the indirect utility function of individual *n* choosing site *j* is $v_{nj} = v(y-c_{nj},\mathbf{q}_j)$, y is income, c_{nj} is the cost for individual *n* to visit site *j* and **q** is a vector of site attributes

$$WTP_n = \frac{\ln\left(\sum_{j\in J}\exp(v_{nj}\,*) - \ln(\sum_{j\in J}\exp(v_{nj})\right)}{\beta_c} \quad \textbf{(16)}$$

The value of access to a site is calculated by increasing the cost of travel to infinity, which drives the probability of visiting a site to zero. Simulation was performed using 500 random draws for each node in the road network. The difference in welfare measures between 500 draws and 1000 draws was non-significant. Annex 6 contains the C++ code of estimating the pre- and post change value of access of the true 1997 model.

3.3.4. *Parameter Estimates of Trip Allocation Models 1977 and 1997*

Variables and parameter estimates of the two mixed logit models, listed in Table 11 at the end of this section, are similar in both sign and magnitude. Interesting results are the differences in whether the sample populations in 1977 and 1997 show preference variation in site attributes or not. Whereas preferences towards species diversity and fraction of open land in forests diverge in the 1997 model, the fixed parameter model seems to be adequate for modelling the preferences of species diversity and fraction open land for the 1977 data. The opposite is the case regarding trees older than 60 years, where the fixed parameter model does not appear to be significantly worse than a mixed model over the 1997 sample while the opposite is the case for the 1977 sample.

Preferences for species diversity and degree of openness in forests vary in 1997 with 62%[6] preferring a species diverse and 38% a non-diverse forest and 76.2% a dense forest and 23.8% open forests. The 1977 data set has no significant preference variation for these two attributes but agrees with the 1997 sample on finding species diverse and dense forests more attractive. Preferences on fraction of trees older than 60 years vary in the 1977 model with 81.6% preferring older trees and 18.4% younger forests, but stays fixed in the 1997 model with a clear preference towards forests with older trees.

Commonalities in preference between the two sample populations show that more than 60% of the sample populations in Northern Zealand appear to prefer coniferous forests to broadleaf forests with a slight increase over the period from 62% to 66% preferring forests dominated by needle leaf treas. Sloped terrain and presence of water bodies also increase the likelihood of a forest being selected in both 1977 and 1997. As expected, larger forests appear to be more popular than smaller forests, however with a declining marginal effect. Also sites close to the coast are more attractive than inland forests as the coefficient on the distance from coast is negative. The error term on distance to coast indicates a common substitutability between forests close to the coast and a difference in the substitutability with other forests.

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[2] The area under the standard normal curve for values between zero and the relative z-score, where the z-score is the mean divided by its standard deviation.

Table 11. Mixed Logit Models of Car-borne Forest Recreation in 1977 and 1997 (1997 prices, DKR)

		Mixed Logit 1977		**Mixed Logit 1997**	
VARIABLES		Estimates	asymptotic z-value	Estimates	asymptotic z-value
Travel cost	Mean of ln(coefficient)	-2,967	129.0	-2.476	106.579
	Std. Dev. of ln(coefficient)	1.092	35.226	1.020	37.449
Shannon species index	Mean of coefficient	2.461	16.085	1.116	6.409
	Std. Dev. Of coefficient			3.639	12.951
Fraction of open land	Mean of coefficient	-1.692	8.096	-4.192	12.012
	Std. Dev. Of coefficient			5.880	13.665
Fraction of trees > Age60	Mean of coefficient	3.279	15.689	3.902	16.040
	Std. Dev. Of coefficient	3.641	10.709		
Fraction coniferous	Mean of coefficient	0.538	3.611	0.831	4.737
	Std. Dev. Of coefficient	1.833	5.120	2.000	3.569
Log(size)	Mean of coefficient	0.915	48.158	1.295	38.684
Log (coast)	Mean of coefficient	-0.565	17.656	-0.539	10.789
Slope	Mean of coefficient	0.158	3.762	0.279	6.725
Fraction of water bodies	Mean of coefficient	2.316	6.598	2.752	9.998
Coast Error component	Std. Dev. Of coefficient	1.288	7.951	1.360	5.329
Mean Log-likelihood		-2.563		-2.304	
Sample size		6580		6987	
Choice set size		52		52	

3.3.5. Parameter Estimates of Trip Frequency Model 1994

The parameter estimates and z-values of the zero inflated negative binomial model are given in Table 12 below. The inflation function, which estimates the probability of a zero count, confirms that owning a car and increased distance to the forests in the choice set also increases the probability of travelling by car to forests. The negative binomial shows that an increase in inclusive value leads to increased number of car-borne trips taken in a year. Also the amount of car-borne trips per year increases for people older than 39 years. Income has a significant, albeit small influence on choice of transport mode or number of car-borne trips to forests in the region.

Table 12. Count Data Model Results

Inflation model	=	normal	Number of observations	=	283
Log likelihood (Zinb)	=	-649.85	Nonzero obs	=	122
Log likelihood (Poisson)	=	-7305.12	Zero obs	=	161

	Variable	Coefficient	Asymptotic-z
Negative binomial	Constant	-3.059	0.058
	Income	0.02	0.001
	Age 25-39	-1.078	0.01
	Inclusive value	0.0874	0.084
Dispersion parameter	Alpha	2.986	0.00
Inflation Function	Constant	2.629	0.00
	Car owner	-1.954	0.00
	Distance to nearest forest	-0.313	0.00
Vuong Test of Zinb vs. Neg. Bin: Std. Normal		5.065	

3.4. Benefit Transfer over Time – Approach

Two different benefit transfers are carried and compared to the 'true' value of access in 1997 in order to assess the reliability of transfers over time, keeping the spatial component constant. The two transfers are estimated using the 1977 model over the 1997 sample:

- Transfer "A" includes an updated demand for forest recreation, derived from a repeated national household survey in 1994 that repeats the national household survey from 1977, but allocates trips to the individual forests based on site preferences from the 1977 onsite survey. Only the preference structure is not held constant;
- Transfer "B" uses both preferences for forest attributes and demand for car-borne recreational trips from 1977 to calculate the transfer WTP. Trip demand in this model is measured as a fixed average number of trips based on the national household survey in 1977. Both the preference structure and demand for forest recreation are transferred to 1997.

We update site attributes and per unit travel cost to 1997 values in both cases.

Transfer 'A' allows us to determine the error margin when transferring only preferences over 20 years, holding the trip demand constant at 1994 values compared to the "true" model.

Transfer 'B' reveals the error margin when both preferences and a fixed average trip frequency are transferred over time compared to the "true" model results. The difference in error margin between the two transfers indicates the efficiency of repeating a household survey or not.

The 1997 'true' values of access are estimated in the linked model based on the 1994 trip demand model and 1997 trip allocation model. First, the pre- and post-inclusive values are estimated for each node in the road network and included in the trip demand model using the count data model results of the 1994 household survey (See Table 12). Secondly, the probabilistic allocation of trips is predicted using the mixed logit results of the 1997 on-site surveys (See Table 11). Finally, the total demand and allocation of trips to individual forests are combined and calculated for all nodes to obtain the total, yearly willingness to pay of access (Equation 17) to each of the 52 forests, based on preferences and demands of 1.2 million people living in the region. Results presented in this chapter are based on the post-change inclusive values only (See Section 3.3.2). For comparison, Annex 3 to 5 contains pre-change level of welfare and number of visits of the true model and of transfer model A and B respectively.

The same procedure is repeated in the two transfers, where the probabilistic allocation of trips is based on the random utility model results of the 1977 on-site survey in both transfers. The 1994 trip allocation model is used in transfer 'A' and a fixed average number of trips from 1977 in transfer 'B', which therefore does not include a linked model.

3.4.1. *Tests of Transferability*

A standard transferability test is carried out to test whether the set of coefficients of the 1977 and 1997 mixed logit models are statistically equivalent. The test is based on a null-hypothesis that the set of random utility model coefficients of the original 1997 model are the same as the set of the transfer 1977 model. The test is applied in both directions: a) we compute a standard log likelihood ratio between the log likelihood of the 1977 model coefficient estimates, computed over the 1997 sample, and the log likelihood of the 1997 model coefficient estimates, computed over the 1997 sample; b) we compute a standard log likelihood ratio between the log likelihood of the 1997 model coefficient estimates, computed over the 1977 sample, and the log likelihood of the 1977 model coefficient estimates, computed over the 1977 sample. This ensures identical sample sizes in each log likelihood ratio.

The log-likelihood ratio tests on statistical equivalence between the 1977 and 1997 coefficients show significant differences in models. The results of the 1997 sample based log likelihood ratio in 1997 prices are 2x(-16097.506+16199.48)=203.948. With a χ^2 (10) distribution, the probability of exceeding this ratio is less than 1 and we strongly reject the null hypothesis that the sets of coefficients are the same. Similar, the 1977 sample based log likelihood ratio in 1997 prices is 2x(-16869.27+17590.43)=1442.34 and we also strongly reject the H_0 hypothesis.

In addition to the statistical equivalence test of the sets of coefficients, we test for the statistical equivalence of the welfare results by constructing confidence intervals for the mean per choice benefit for each of the three models. The intervals are obtained using the Krinsky-Robb draw procedure (Krinsky and Robb, 1986), where we draw 1,000 parameter vectors from a asymptotic normal multivariate distribution with means and variancecovariance matrix estimated in the random utility models. We use these to calculate and rank 1,000 WTP per site per model. Results show that the 95% confidence intervals of WTP for 13 forests, transferred by model "A", overlap those of the "true" model. Transfer model "B", however, only produces one result with confidence intervals overlapping the "true" model confidence intervals. ANNEX 1 lists mean and 95% confidence intervals of the true model and the two transfer models as well as the calculated transfer errors per forest.

3.5. Benefit Transfer Results

Values of access of the "true" 1997 model range between €12,225 and €10.4million with median €235,000 and in terms of visits between 5,153 and 2.9 million per site per year, with a median of ca. 72,000 visits. In accordance with estimated preferences, the most valuable forests are large and/or coastal forests with predominantly coniferous vegetation and dominated by old and species rich tree stands.

Figure 1 (I) shows the spatial distribution of the value of car borne access per year per site of the "true" model.

The results of transfer type A, which uses the 1977 on-site survey but repeats the household survey, appear to exaggerate minimum value of access to approx. €19,000 but underestimates average and maximum values by 26% - 46% to €560,000 and €5.6 million, respectively. Likewise, number of visits predicted to the least valued forest is overestimated by 30% whereas maximum and average numbers of visits are underestimated by more than 50%.

Using both the on-site survey and the average trip frequency from 1977 (transfer type B) leads to a general overestimation of 'true' values. Values of access range from ca. €75,400 to €22,8 million. This represents 434% and 65% higher values than results of the 'true' model. A similar effect is evident in the results of transferred number of yearly visits. Transfer errors of less valuable and remote sites are substantially higher than more valuable sites.

Total value per hectare reflects the same pattern: minimum values are particularly exaggerated in both models, transfer model 'A' underestimates maximum and average values and transfer model 'B' exaggerates values in general. Table 13 below presents the predicted number of visits and values in the three models.

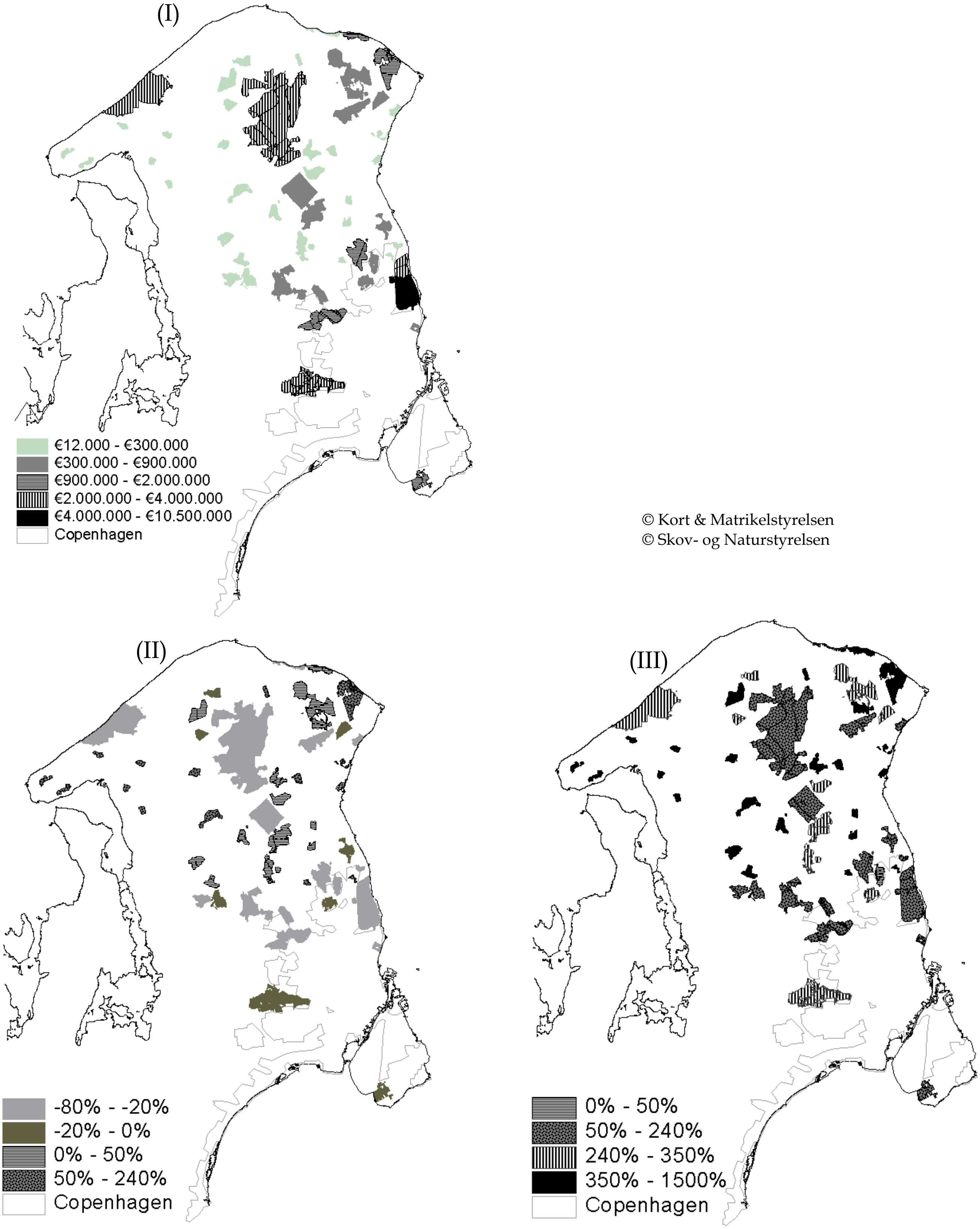
Table 13. Predicted Number of Car-borne Visits and Values of Site Access

Economic Measure	*True Model*	*Transfer Model A*	*Transfer Model B*
Numbers of car-borne visits			
Minimum	3.4×10^3	4.4×10^3	1.8×10^4
Maximum	2.9×10^6	1.2×10^6	4.8×10^6
Average	2.2×10^5	1×10^5	4.3×10^5
Median	7.1×10^4	3.9×10^4	1.6×10^5
Total Value of Car-Access per site			
Minimum (€/year/site)	1.2×10^4	1.9×10^4	7.5×10^4
Maximum (€/year/site)	10.4×10^6	5.6×10^6	22.8×10^6
Average (€/year/site)	7.5×10^5	5.6×10^5	2.4×10^6
Median (€/year/site)	2.3×10^5	1.9×10^5	8.1×10^5
Total Value of Car-Access per ha			
Minimum (€/year/ha)	147	333	1,436
Maximum (€/year/ha)	10,667	6,965	28,314
Average (€/year/ha)	1,740	1,518	6,290
Median (€/year/ha)	993	941	4,083

Figure 1 (II) & (III) present the spatial distribution of the errors resulting from applying transfer models ‘A’ and ‘B’ to predict values over 20 years compared to the true model. The urban fringe forests around Copenhagen are all underestimated by transfer model ‘A’ as well as the largest remote forests, whereas the predictions of the value of access of smaller, remote forests and coastal forests in the north eastern part of the region overestimate true values. The spatial distribution of the transfer errors in model ‘B’ show that the strongest overestimation occurs in forests where the predicted values are also overestimated in model ‘A’, i.e. smaller remote forests and north eastern coastal forests.

The distribution of errors also appears to be linked to the attractiveness of forests, measured as the ranked total value estimated in the true model. Both transfer models perform better in predicting attractive forests than less attractive forests, where attractiveness is measured as the ranked estimated values of the ‘true’ model. The ten most valuable sites are transferred with an average error of –19% and 259% in model ‘A’ and ‘B’, respectively, compared to 141% and 521% in model ‘A’ and model ‘B’ of the ten least valuable sites. Updating demand for recreation in transfer model ‘A’ leads clearly to a better transfer results than when both preferences and demand for recreation in transfer ‘B’ is transferred over 20 years. The transfer error margin of model ‘A’ of total WTP per site ranges between –74% and +234% compared to transfer type B, which produces error margins between 3% and 1443%. On average, model A overestimates total values per site by 26% compared to 434% in model B.

Figure 1. WTP of Car Access [Euro/site/year] (I), Transfer Errors using transfer type A [%] (II) and transfer type B [%] (III)



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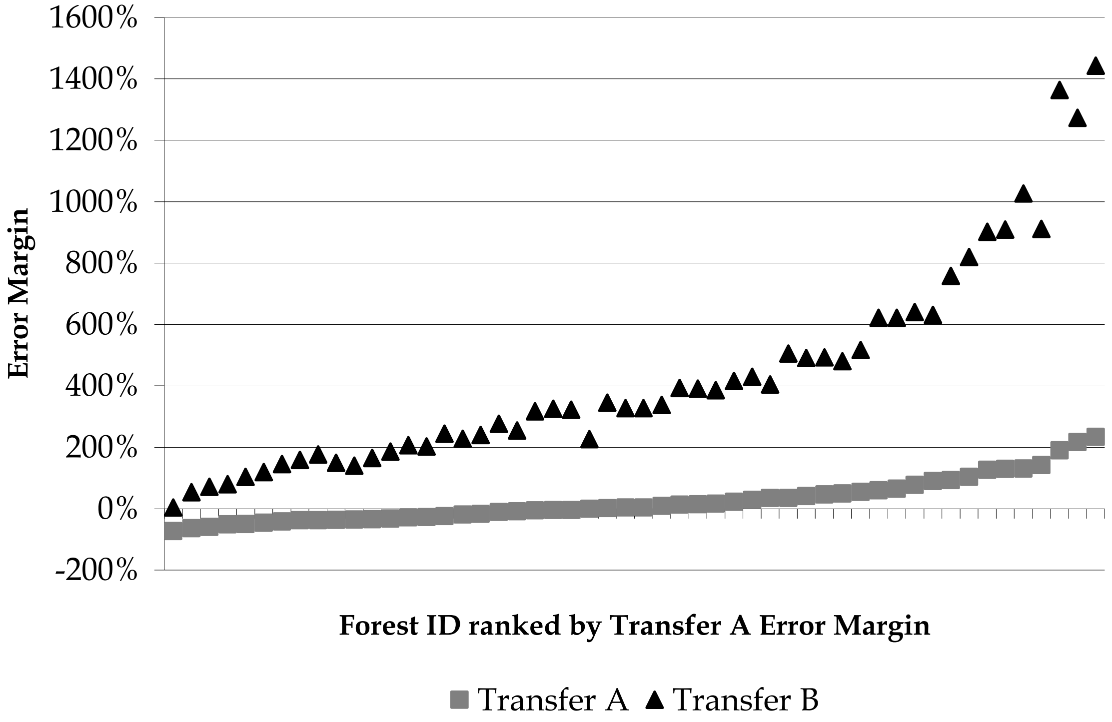
The general overestimation of total values by transfer model B is illustrated in Figure 2 below, which ranks the forest specific transfer errors by model 'A'. The majority of transfers (44) in model 'A' are predicted with less than 100% errors.

Figure 2. Error Margins of total WTP per Forest (Car-borne Visits).



3.6. Discussion and Conclusion

This chapter compared the efficiency of transferring benefits over 20 years. The comparison was made between a functional transfer model that updates car-borne forest recreation demand to recent years (Transfer type A) and a functional transfer model that does not update the demand function to recent years (Transfer type B). The latter keeps the underlying preferences and demand structures constant over 20 years. By comparing the transferred model results with the “true” model from 1997, we gained information about when a benefit transfer over time using discrete choice modelling is likely to be subject to least error. The different abilities of the two transfer models in predicting the “true” values over time show clearly that updating a functional transfer model substantially reduce prediction error. In this case, the update of trip demand in the transfer model type A reduced the error margin by a factor of 12 and on average by a factor of 4, compared to using the transfer model type B. On average, the benefit transfer model A overestimates true values by 25% and transfer model B by 434%.

The log likelihood ratio test of the set of coefficients and the development of confidence intervals of welfare estimates in the three models allowed a more rigorous comparison of the models and the WTP estimates. Despite the transfer models not being statistically equivalent to the “true” model, transfer “A” produced 13 forests and transfer “B” one forest where the 95% confidence intervals of the mean benefit measures overlap those of the “true” model. Transfer errors of these 14 forests are low, between -24% and 14%. The results suggest that transfers with less than 10% error margin also have overlapping confidence intervals with the true model, despite the fact that the set of coefficients are not statistically equivalent.

Rather than expecting a successful transfer to be one that predicts results identical to an original study, it may be helpful to agree upon an acceptable level of transfer error, depending on the purpose and use of the transfer. In this study, the best performing transfer model predicted the willingness to pay of access of 32 forests that were within an error margin of ± 50% of the “true” benefit and 15 forests that were within an error margin of ± 20%. The less well-performing transfer model only produces one value with errors lower than 50%. These results are based on a transfer over time alone, where the transferred individual site values are compared to the “true” values of the same sites.

Introducing transfer over time *and* space would most probably further reduce the reliability of the transfers.

From a policy perspective, it is interesting to weigh these transfer errors against the costs of undertaking additional original surveys. The costs of the national household survey that was repeated in 1994 amounted to approx. €13,000 for the sample in our study region and ca. €200,000 for the on-site survey in the 52 forests that was repeated in 1997. The relatively low costs of a household survey combined with the significant improvements offered by updating the transfer model with new recreation demand, as shown in model 'A', makes it an obvious choice when choosing to carry out a benefit transfer.

Looking at the reasons behind the differences in benefit measures between models, the study has shown that both demand for forest recreation and preferences for forest attributes have changed significantly between 1977 and 1997. Determinants of WTP, as described by Loomis (1989), have clearly changed between the two periods. We see two sources of this change, which cause the transfer errors: a shift in transport mode, illustrated by the differences in error margin between transfer model 'A' and model 'B', and a change in preferences towards site attributes, including distance, illustrated by the differences between the 'true' model and transfer model 'A'.

The shift in transport mode shows up clearly in the data, where the average number of trips by car to forests fell from 18.25 in 1977 to 14.6 in 1994. At the national level, however, average yearly number of visits to forests increased by 25%, and 15% when accounting for population growth. This is primarily due to more people travelling by bike and foot to forests (Koch, 1978; Jensen and Koch, 1997). As a consequence, the use of cars has dropped from approx. 55% of visits to forests in 1977 to approx. 49% by 1994. Related to the reduced use of cars, average distances travelled have dropped from 10.5km to 8.5km. The relative decrease in car-borne recreational value of forests over the period can be explained on the basis that, although people as a whole visit forests more frequently in 1994 than in 1977, the change away from the use of cars outweighs the increased visit frequency. This necessarily plays an important role when using methods that are based on the use of cars. The discrepancy between transferred and originally estimated frequency of car-borne forest visits leads to a significant overestimation of transferred benefit values due to the shift in transport mode, as illustrated in transfer model "B". Transfer model A, on the other hand, underestimates urban fringe forests due to a preference for longer distances and underestimates more remote forests due to the reduced frequency of car-borne visits from the updated demand function. Understanding the choice of mode of transport and how this changes over time is therefore central in non-market valuation methods based on the travel cost method.

A change in preferences towards forest attributes over the 20-year period explains the differences in welfare estimates between the 'true' model and transfer model 'A', as the only difference between these two models is the trip allocation models. Also, attributes of the forests as a whole have not changed significantly over the period. The parameter estimates of the trip allocation models indicate that people have developed a heterogeneous preference in relation to species diversity, measured by the Shannon diversity index, and openness of forests, measured by percentage of forest as open space. In 1997, 62% of the population appear to prefer a species rich forest and 76,2% a dense forest whereas the 1977 model does not show significant evidence of heterogeneity of these preferences. Preferences for forests with trees older than 60 years vary over the population in 1977 with 81.6% finding older trees more attractive, but showed no significant evidence of variance in preference across the population in the 1997 model. By specifying a mixed logit we have been able to assess the changes and the level of heterogeneity in preferences across the population in 1977 and 1997. Relatively few studies in the environmental economics literature have used the random utility model or the discrete choice approach in benefit transfer (Parsons and Kealy, 1994; Feather and Hellerstein, 1997; Scarpa et al., 2002; Haener et al., 2001) but none to our knowledge have included heterogeneity of preferences.

Comparing the results of attitudes towards forest attributes with other studies, species composition has been shown to have a positive impact on the recreational choice of forests by increasing the popularity in forests with a higher diversity of species compared to forests with lower diversity (Hanley et al., 2002; Scarpa, 2000; Jensen and Koch, 1997; Boxall et al., 1996). Contrary to the findings in this study, Hanley and Ruffel (1993) found the Shannon species diversity index to be insignificant and percentage of forest as open space to be positive and highly significant. This illustrates that some attributes may be subject to large variation in cross-cultural preferences.

In terms of commonalities within this study between 1977 and 1997, we have shown that 60% to 64% of people prefer coniferous forests to broadleaf forests. This is different from research on the national data set by Termansen (2004b) who shows that, on a national level, only 40% of the population prefer coniferous forests. Also, two national forest preference studies based on evaluation of black and white photographs reveal a general preference for broadleaved forest environments compared to coniferous (Koch and Jensen, 1988; Jensen and Koch, 1997). A reason for the apparent contradiction in results could be the preponderance of broadleaf in the 52 forests, which makes conifer appear more attractive in this region. The 52 forests in the study have a broadleaf cover of 72% in 1977 and 74% in 1997 respectively (Danish Forest and Nature Agency, 1977; 1997) compared to a national average of 37% broadleaved forest in 1997 (Statistics Denmark, 2001).

Other commonalities include the preference for large rather than small forests, with declining marginal effect, which also other studies confirm (Scarpa et al., 2000). The nationwide valuation study of forests in Denmark (Termansen, 2004b) also confirms the stable preference towards sloped terrain and coastal proximity. These types of preferences seem to hold over space and time.

Comparing the travel cost parameter estimates over time, the higher mean in the 1977 trip allocation model indicates that people went further than in 1997 despite the fact that petrol was relatively more expensive in 1977 (€0.22 , 1997 prices) than in 1997 (€0.187). This is also confirmed by the national surveys in 1977 and 1994 where the average distance travelled in 1977 was 14.9km compared to 12.6km in 1994 (Koch, 1978; Jensen and Koch, 1997). Transfer model A integrates both the preference for longer trips from the 1977 trip allocation model and the reduced yearly number of trips from the 1994 household survey. The preference for longer trips leads to an underestimation of urban fringe forests, where the distance travelled is relatively short for most people in the region and the reduced number of trips reduces the total value of remote sites. In the true model, however, the preference for long trips has dropped, favouring sites close to conurbations. The decrease in car-borne travel to forests despite reduced travel costs is due to a markedly shift in transport mode as found in the national household surveys (Koch, 1978; Jensen and Koch, 1997). Again, this confirms the need to understand the use of modes of transport and how this may influence the choice of recreation site, at least in the Danish population.

The present chapter has given an indication of the order of magnitudes one can experience when the determinants of willingness to pay change significantly over almost two decades, even when using state-of-the art transfer models combined with GIS. Loomis (1989), looking at the stability of willingness to pay, finds that welfare measures are relatively stable over a short period (9 months) where the determinants of willingness to pay have not changed. However, his results did not show an unambiguous one-to-one relationship between the willingness to pay in period 1 and 2. Also, Downing and Ozuna (1995) find that while benefit functions are transferable over 3 years in at least 50% of the time, practically no transfer produced statistically similar benefit estimates.

This chapter has also shown the importance of updating a transfer model, in this case with the demand for forest recreation, which decreases errors by a factor of 4 on average. Given the relatively low costs of repeating a household survey compared to an on-site survey, policy makers could advantageously only repeat the household survey, but would still need to accept an average of 25% transfer errors when conducting a transfer for these forests over 20 years. Depending on the value of the individual forest, this translates into an exaggeration of values between €3,000 and €2.6 million. The question as to which level of error one is willing to accept in order to avoid costly on-site surveys should depend on the level of the investment. If the errors in monetary terms cause a change in the policy, the errors should be considered unacceptable.

CHAPTER 4 PREDICTING FUTURE FOREST RECREATION VALUES OF NEW SITES[7]

4.1. Introduction

Afforestation plans in Denmark are ambitious with a policy in place since 1990 to double the forest area over 80-100 years from around 11% in 1990 to 22% - 25% of the total area by 2090, corresponding to a annual increase of 4.000-5.000ha (Miljøministeriet, 2002). The policy seeks to enhance the provision of goods and services produced by forests, including recreation, ground water and habitat protection, carbon sequestration and environmentally friendly production of wood and energy. The efforts to double the forest area are taken on by the State, through the Forest and Nature Agency, local authorities and private companies or people with the help of grants from the State and the EU.

Although privately led afforestation projects up to now account for the majority of new forests[8], these are generally small areas (8ha on average), located far from urban centres and provide limited recreational opportunities. Conversely, the Forest and Nature Agency and local authorities prioritise locations of new forests close to town and cities to enhance local recreation. These projects are therefore larger, on average 100 ha.

On a national scale, the State has carried out afforestation on 5,115ha in 53 projects since 1993 compared to 12,000 ha of private afforestation (Miljøministeriet, 2003a, 2005). Despite the efforts over the last 15 years, the annual target of between 4.000 and 5.000 ha new woodland has not been met. Especially public afforestation, which is planned to account for half the efforts, representing approximately 210,000ha over the next 80 years, has lagged behind. State and local authorities are therefore likely to increase the current rate of afforestation.

As public afforestation projects focus on relatively large new forests established as urban fringe forests, policymakers and planners will increasingly need information on the value of new forests in terms of location and accessibility, substitution impacts between new

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[7] This piece of research was conducted in collaboration with Dr. Mette Termansen, York University, Environment Department, UK, and Dr. Frank S. Jensen, Danish Centre for Forest, Landscape and Planning, The Royal Veterinary and Agricultural University, Denmark and based on the FNU61 working paper, available at http://www.uni-hamburg.de/Wiss/FB/15/Sustainability/Working_Papers.htm

[8] Between 1993 and 2004, private afforestation represented 70% (12.003ha) of total afforestation area (Miljøministeriet, 2005 & 2003)

and existing forests, and preferences in the population for different site characteristics. Predicting the value of a new forest is essential if policy-makers wish to use valuation of non-market goods to guide its priorities.

Transfers of recreational values from existing forests or study sites, where monetary valuation has already been carried out, to new sites or policy sites that are not yet created is one of the few ways of providing a future welfare measure. Although these transfers can perform no better than original studies available, they are considerably less cost and time consuming than original valuation studies, and are therefore frequently used in cost benefit analyses (See e.g. Hanley et al., 1999) and environmental regulation (e.g. WATECO 2003).

Benefit transfers are in most cases based on valuation studies that were not intended for transfers (Brookshire et al., 1992; Smith, 1992), causing basic problems such as non-similarity across sites and population (Boyle, 1992; Rosenberger et al., 2000). For instance, transferring values to a new forest that is very different from the study sites used for the transfer function is expected to cause large errors in transfers. Such ‘outliers’ may be important from a recreational perspective, but challenging from a benefit transfer perspective. Knowing under which conditions a transfer performs well is essential when choosing transfers from original valuation studies, but only relatively few studies have tested the reliability of transferring functions and welfare estimates across sites and those who have, found errors up to 475% of the policy site value (Brouwer, 2000; Loomis et al., 1995; Kirchhoff et al., 1997). A related issue is the impact on benefit transfers of the sampling of study sites in the original survey. Due to cost considerations, original surveys, do often not sample all available sites. Therefore, despite the appealing properties of benefit transfer, the availability of studies and the characteristics of sites included in original studies may result in diminished ability to predict values at policy sites successfully.

Another important aspect in valuing and assessing long-term projects prior to the establishment of the new site is changes in values over time. Afforestation projects will only reach maximum welfare potential after 50 to 80 years and valuation of such projects should therefore take this time aspect into account. Time is frequently only represented implicitly in benefit transfers (e.g. using historic data to transfer present values) and estimated benefit measures from original studies or benefit transfers are extrapolated over long periods of time (e.g. 10 to 50 years, depending on the project). This is often made without knowledge about changes in the determinants of welfare (Loomis, 1989), such as marginal utility of income, family structures or transport behaviour.

Public afforestation in Denmark, primarily carried out through new urban fringe forests, could benefit from information on design of transfers and reliability of transferred values over space as well as evidence on how values of new recreation areas develop over time. Both pieces of information are essential when valuing the introduction of new forest recreation sites.

In this chapter, a case study is made of how welfare of a large public afforestation project, called Vestskoven, changed between 1977 and 1997. The forest was established in the 1960s as an urban fringe forest in the western part of Copenhagen, and surveyed as part of a national on-site recreation study in 1976/1977 (Koch, 1980) and again in 1996/1997 (Jensen, 2003). The case study evaluates the extent to which values can change over time and identifies the main determinants. Different function transfers are conducted and tested based on 52 forests in North Zealand, the same region as Vestskoven, in order to test the extent to which we are able, today, to predict the value of a 30 year old forest. The transfers are used to make a systematic comparison of spatial transferability, useful for assessing new forest sites and to assess the importance of different sampling designs in conducting transfers. The transfer scenarios comprise the following three approaches: 1) transfer to Vestskoven based on preferences revealed when the transfer model is estimated for the remaining 51 forests; 2) transfer to Vestskoven based on preferences revealed when the most attractive forests or the least valued forests are excluded from the transfer model; 3) transfer to Vestskoven using only revealed preferences for other urban fringe forests in and around Copenhagen.

The reliability of transfers to Vestskoven is tested by comparing the transfer value to the value estimated in the full model for all 52 forests and by making standard log likelihood tests for model transferability. To compare the relative performance of the Vestskoven transfers, we report results of the same 3 transfer approaches for the remaining 51 forests in the region.

The valuation over time and spatial transfers are carried out using Random Utility Models (RUMs), described in Chapter 3, which is one of the few tools capable of solving the problem of substitution and non-similarity across sites in benefit transfers (Brouwer, 2000) and link a count data model to the RUM in order to capture total demand for forest recreation in Northern Zealand.

We combine the RUM with the use of Geographic Information System (GIS), following the approach of Termansen et al. (2004). This captures a larger proportion of site heterogeneity with a spatially disaggregated representation of forest sites. Furthermore, it allows us to account for the spatial pattern of population density and other demographic characteristics.

The logit model is based on the same data as described in Chapter 3, from a national visitor survey in forests from 1976/1977 (Koch, 1980) and 1996/97 (Jensen, 2003), where the focus is on the regions of Copenhagen and Frederiksborg in Northern Zealand in Denmark. The surveys were carried out by the Danish Centre for Forest, Landscape and Planning and are directly comparable using identical questions and identical sampling sites and schedule.

The remainder of the chapter is organised as follows: Section 4.2 describes the establishment of the new forest, Vestskoven, and Section 4.3 refers to the data used to estimate the count and choice models for valuing recreational benefits over time. Section 4.4 reports the resulting econometric estimation of the choice and count models and uses these to predict welfare measures for Vestskoven and the other 51 forests in 1977 and 1997. Section 4.5 outlines the benefit transfer approach and reports on tests of reliability and benefit transfer results. Finally, Section 4.6 discusses the findings of the analysis and concludes.

4.2. Establishment of a New Forest - Vestskoven

Vestskoven is a large recreational area in the western part of Copenhagen that was introduced in the 1960s and expanded and developed up through the 1990s. The first plans to create Vestskoven as a forest park for recreation started back in 1936 but it was only in 1964 that the first 35ha of former agricultural land were donated to the state (Skovreguleringen 1974 & 1980). Later in 1967, the state, local and regional authorities agreed to an overall budget to buy up agricultural land for recreational use. Planners had for 40 years attempted to create a forest area on the flat, windy and forest-poor area west of Copenhagen. In addition, by the 1960s concerns were raised that the increasing movement of people north of Copenhagen, wanting to live in green areas, close to forests, would ultimately lead to serious urban sprawl. By 1972, a total of 821ha of primarily agricultural land was bought up followed by a further 418ha by 1980 and totalling 1361ha in 1997. Plans emphasised the combination of large open plains (400 ha), lakes, streams and meadows with forested areas, with a majority of broadleaved species. Vestskoven is necessarily very different from other forests in the region with young tree stands and more open land as afforestation has been ongoing since the establishment. Also the design of the site differs from the average forest in the region with deliberately wide open spaces, high diversity in species, and a size three times larger the average size of forests in Northern Zealand. Table 14 summarises the development of Vestskoven in terms of size and other physical attributes and compares Vestskoven with the average characteristics of 51 other forests in the region.

Table 14. Site Characteristics of Vestskoven 1972-1997 & Average Attributes of Other 51 Forests

Site Characteristics	*1972*	*1977/80*	*1997*	*Average 51 Forests 1997*
Total Area (ha)	821	1239	1361.24	445.453
Afforested (ha)	269	535	665.74	375.4
Open land (ha)	552	704	695.5	70
Fraction broadleaf (%)	74%	74%	70%	0.745
Open land (%)	53%	86%	51%	16%
Shannon species index	0.997	0.879	1.747	1.270
Shannon age index	n/a	0.163	0.636	1.752
Fraction of trees older than 60 years	n/a	0.005	0.002	0.424

Sources: Skovreguleringen, 1974 & 1980; Danish Forest and Nature Agency, 1997.

4.3. Data and Model

Data and model applied in this chapter are identical to the 1997 estimation of the choice models used in Chapter 3, Section 3.3.

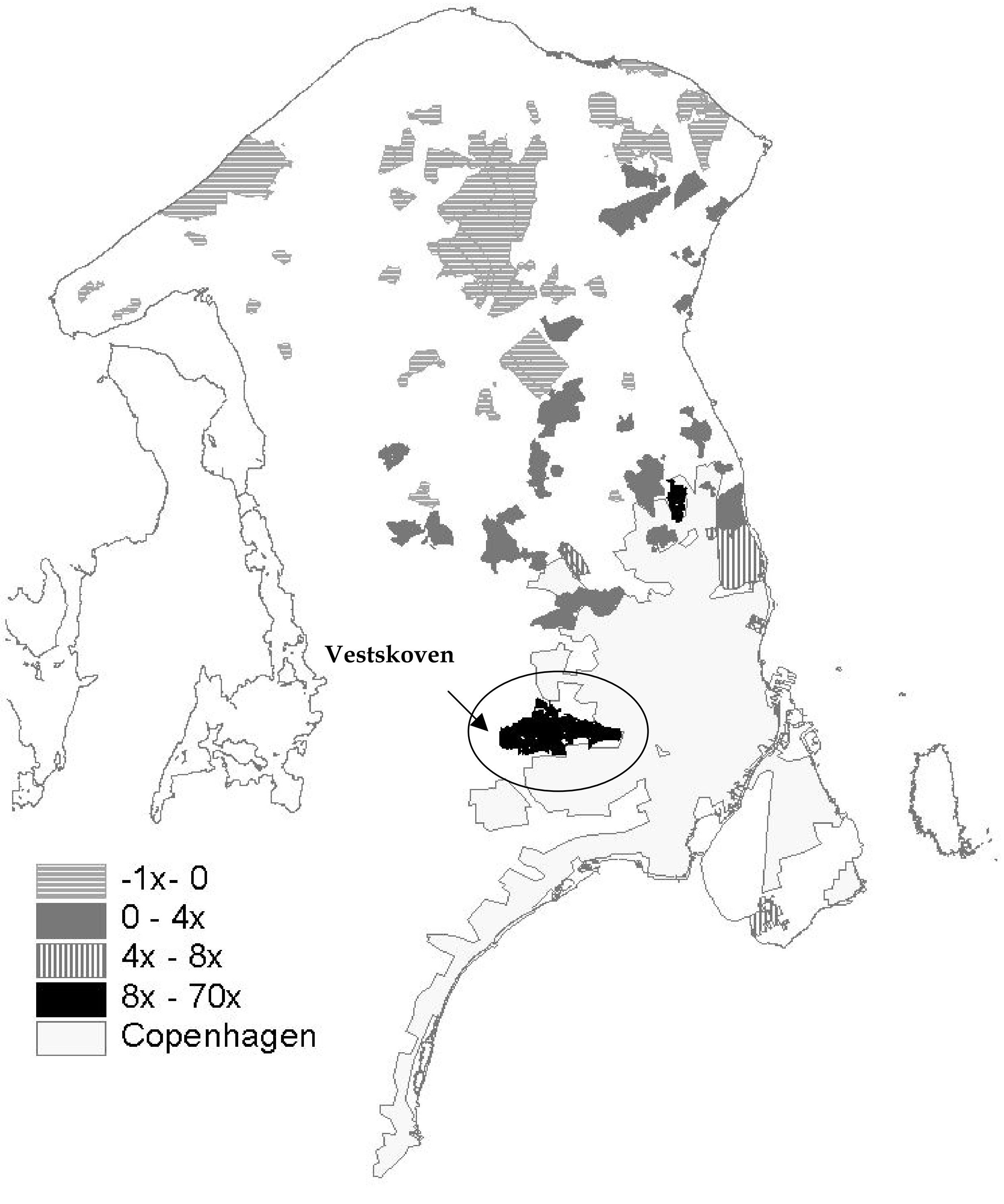
4.4. Estimation Results

Results, shown in Table 15 below, suggest that the value of Vestskoven has increased dramatically from an annual value of approx. €44.600 to €3.6 million between 1977 and 1997 (both values in 1997 prices). Predicted yearly number of car-borne visits increased from approx. 9.700 to 1.3 million. The popularity of the new forest has thus advanced from a ranking as the second least popular site to the 3rd most attractive site of forests in the choice set. Despite the general increase in value, 22 forests actually lost in value over the period. The reduced values generally occurred in relatively remote coastal sites towards the north in the region whereas benefits of forest recreation have increased at a higher rate the closer sites are located to Copenhagen. Vestskoven is by far the site that has gained the most in relative terms in attractiveness over the 20 year time period. Figure 3 shows the spatial distribution of changes in value over 20 years across the 52 forests.

Table 15. Predicted Number of Car-borne Visits and Values of Site Access

Economic Measure	*1977**	*1997*
Vestskoven		
Total Value of Car-Access per site (*€/year)*	$44.6*10^3$	$3*10^6$
Total Value of Car-Access per ha (*€/year)*	36	2.201
Number of car-borne visits *(site)*	$9.7*10^3$	$1.2*10^6$
All 52 Forests		
Total Value of Car Access (*€/year/site)*		
Minimum	$13.9*10^3$	$12.2*10^3$
Maximum	$6.3*10^6$	$10.4*10^6$
Average	$7.1*10^5$	$7.5*10^5$
Total Value of Car-Access (*€/year/ha)*		
Minimum	14	26
Maximum	9.233	22.437
Average	500	1.630
Number of car-borne visits *(site)*		
Minimum	$3.7*10^3$	$3.4*10^3$
Maximum	$1.87*10^6$	$2.9*10^6$
Average	$1.2*10^5$	$2.2*10^5$

Figure 3. Changes in Forest Recreation Values over Time



4.5. Benefit Transfer Approaches and Results

The previous section showed how a relatively young forest increased its value nearly 77 times in 20 years from one of the least popular to one of the most attractive forests in the region. This section investigates to what extent transfers are capable of predicting the value of a relatively new forest with significantly different attributes from other forests in the region. It also assesses the influence on transferability of choosing different sampling designs, for instance, the effects of not sampling in attractive or unattractive sites, or the effects of reducing the sample based on geographic location of sites.

The first scenario transfers a value function based on 51 forests to Vestskoven. This gives us the best possible variety of sites, including size, and other attributes, deemed ideal in benefit transfers. In order to compare the performance of the Vestskoven transfer, we also report on transfers of each of the remaining 51 forests.

The second scenario tests for sampling implications. We assume that the study planner excludes certain sites in order to reduce the sampling effort and then transfers the value function to Vestskoven. We have chosen to exclude the five and ten least attractive sites and test the performance of the value functions in predicting the value of Vestskoven[9] and repeat the exercise for the five and ten most attractive sites. We expect the extreme sampling to reveal information about error structures in benefit transfers.

The third and final benefit transfer approach is based on a geographically limited sample. We restrain our choice set the urban forests in and around Copenhagen and transfer the value function to Vestskoven. This constitutes a sample of 14 sites[10]. The reason for the geographic sampling is related to the development of forest recreation values since the 1970s, where forests closer to Copenhagen have clearly gained and forests further away have lost recreational values based on car-borne recreation. By using other urban fringe forests, with a similar recreation trend over time, we test whether this transfer may be superior to the two previous scenarios.

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[9] Vestskoven is removed from the choice set along with the five and ten least attractive forests.
[10] Vestskoven is removed from the choice set of urban forests.

4.5.1. Benefit Transfer Function based on 51 Forests

The first scenario conducts a benefit transfer to Vestskoven based on preferences for the remaining 51 forests. The trip allocation component of the benefit transfer function is estimated after removing respondents who were sampled in Vestskoven in 1997 and excluding Vestskoven as an alternative in the choice set. We then adjust the inclusive value in the trip demand model and calculate the total yearly welfare measure for Vestskoven. The transfer value of Vestskoven is compared to the true value, mentioned in Section 3.5 and the difference makes out the 'transfer error'. We test for equivalence between true and transfer models with a standard log likelihood ratio. To ensure identical sample sizes, we compute a ratio between the log likelihood of the transfer model coefficient estimates and the log likelihood of the full model coefficient estimates, both computed over the full sample. In order to assess the performance of the Vestskoven we repeat the tests and transfer for each forest in the choice set.

The log likelihood test was not performed on the Vestskoven transfer model as the specification of the transfer trip allocation model differed substantially from the full model. Fraction of water and open land appeared no longer significant, indicating the outlier properties of Vestskoven. As a result, Vestskoven was overestimated by 346% from the true value, exaggerating the transfer by €10.5 million. In comparison with the other forests in the region, the Vestskoven transfer performed the worst. The 51 other transfers were on average underestimated by 4%, ranging from –86% to +251%. The largest transfer errors are generally those, where the specification of the transfer trip allocation models differ from the full model. Nevertheless, transfers of only two forests proved to have statistically equivalent models with the full model. These produced transfer errors of 3% and 9%. For the remaining models that failed the equality test, 34 had a log likelihood ratio between 47 and 100[11] and transfer errors ranging between -47% and +20% and 36 of the 52 transfer models performed within an error range between –20% and +20%. Table 16 shows average error margins of the full choice set and errors of the Vestskoven transfer and Figure 4 ranks the error margin in ascending order. Vestskoven appears as the extreme point. Annex 2 lists the log likelihood tests and transfer errors.

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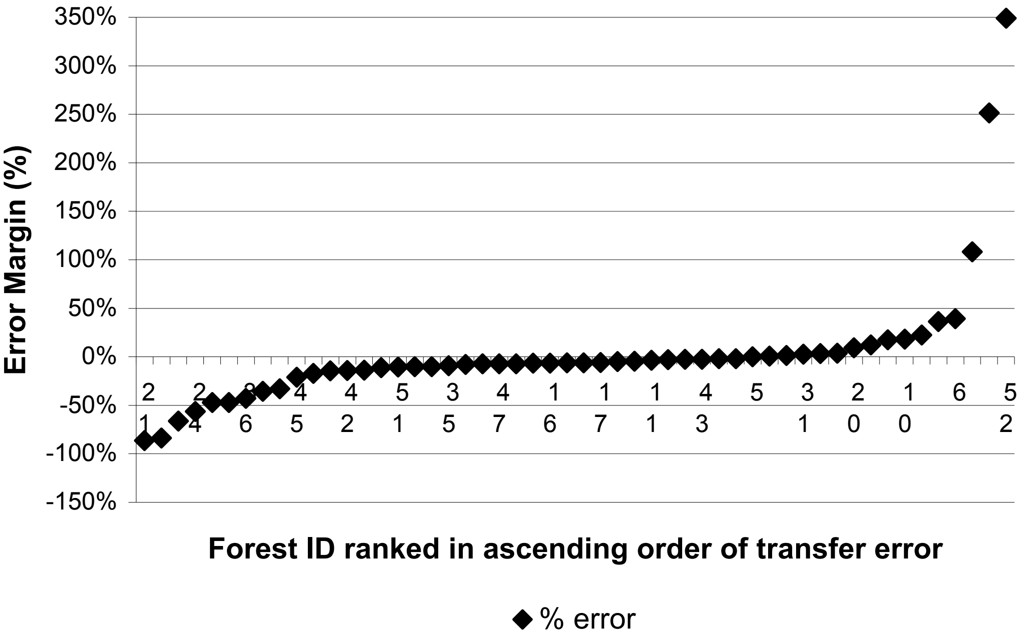
[11] χ^2 distribution and 11 degrees of freedom. The critical value of P=0.001 is 31.26

Table 16. Error Margins of Three Transfer Scenarios

Transfer Scenario			Error Margin
Transfer based on 51 forests		average	-4%
		min	-86%
		max	349%
		Vestskoven	349%
Transfers based on Least Attractiveness	**5 Forests excluded**	average	26%
		min	-28%
		max	169%
		Vestskoven	36%
	10 Forests excluded	average	21%
		min	-32%
		max	154%
		Vestskoven	31%
Transfers based on Most Attractiveness	**5 Forests excluded**	average	55%
		min	-49%
		max	330%
		Vestskoven	330%
	10 Forests Excluded	average	-8%
		min	-191%
		max	55%
		Vestskoven	-28%
Transfers based on Urban Forests		average	-66%
		min	-99%
		max	-19%
		Vestskoven	-57%

Figure 4. Benefit Transfer Results of one forest at a time, all forests



4.5.2. Benefit Transfer Function based on Attractiveness

The second scenario transfers values to Vestskoven, based on four different samplings of the study sites, and excludes five and ten of the most attractive sites and five and ten of the least popular sites. Attractiveness is measured as the predicted values of the full model. We aim at finding out to what extent excluding the most attractive sites impacts the predictive power of the transfer model compared to excluding the least attractive forests. We expect that excluding the most attractive forests will lead to large transfer errors and highly significant differences between transfer and full models. Likewise, we do not expect the true model to be significantly different from the transfer models of the least popular forests; neither do we expect the transfer values to be very different from the true model results.

We first exclude five forests and respondents from of the most valuable sites from the sample and the choice set and estimate a new set of coefficients of the trip allocation model. We conduct the transfer by applying the new trip allocation model on the full sample to calculate the willingness to pay. We repeat this with a transfer of the 10 most popular sites. The same set up is followed in the benefit transfers based on the five and ten least valuable forests. As previously, we calculated the transfer error margin and the standard log likelihood ratio test, to test for model transferability. We tested for transferability using the log likelihood ratio with a χ^2 (11) distribution. The four transfer models strongly reject the H_0 that the sets of coefficients are the same. As expected, excluding the five and ten most valuable forests from the trip allocation model result in larger and more non-significant likelihood ratios (812.40 and 250.7, respectively) than when excluding the five and ten least attractive sites (128.5 and 48.6, respectively). Excluding five rather than ten attractive or unattractive sites produce larger log likelihood ratios.

Results of transferring value functions where sampling is limited based on attractiveness of study sites suggest that removing the least popular sites from the sampling induces lower transfer errors than when we limit the sampling of the study sites for the most popular sites. Errors in the Vestskoven transfer when excluding the least attractive sites are found to be between 36% and 31%, depending on how many sites are excluded from the sample compared to between 55% and 330% when excluding the most popular sites. In general, it is surprising to find than excluding fewer sites produce higher transfer errors than transfers excluding more sites in both popular and non-popular samplings. Table 16 lists the error margin of Vestskoven and summary statistics of the full choice set.

4.5.3. Benefit Transfer Function Based on Urban Fringe Forests

The third and final transfer uses only urban fringe forests as study sites. We identified 14 forests that are located in Copenhagen or spatially linked to the city and estimated the trip allocation model based on the revealed preferences observed in these forests.
The transferability test was not performed as the full model and the geographically limited transfer model have different significant variables explaining preferences. The variables Shannon species index, fraction of water bodies and distance to coast did not contribute significantly to the model and were removed. Also a fixed parameter model seemed more adequate for modeling the preferences of fraction of coniferous forests in transfer model.

Results suggest that such a design would underestimate the true value of Vestskoven by 57% or by €1.7 million. The sampling also underestimates the true values of the other forests in the region. Table 16 shows the average results of this transfer.

4.6. Discussion and Conclusion

In this paper, we have sought to shed more light on the development of values over time and on the properties of spatial transfers in relation to the establishment of new forest sites for recreational use. The Danish Government and local authorities pursue an ambitious afforestation plan over the next 80 years to create additional 210.000 ha. Much of the public forest expansion is likely to be carried out as new urban fringe forests, creating green belts around towns and cities, much like Vestskoven in the 1970s. A recent example of the efforts made by the State and local authorities to enhance access to forests for city-dwellers are eight strategically located new forests around Aarhus, the second largest urban area in Denmark. Between 1988 and 2005, close to 1,000 ha was afforested, creating a 'green belt' around the city (Aarhus Kommune, 2005).

The current forest cover in Denmark is relatively sparse with 11% of the land area afforested corresponding to 486.000 ha and with only 0.1ha available per capita. This is low compared to other Nordic countries (2.2 ha) or Europe (0.3 ha) (Miljøministeriet, 2002). Because competition for land is high in Denmark between agriculture, industry and urban areas, attaching a value to where and how new forests should be established is important for making informed decisions about developments in land use.

The valuation of carborne recreation in Vestskoven in 1977 and 1997 suggests that benefits have increased nearly 77 times over 20 years from one of the least attractive to one of the most attractive sites in the region. This sharp increase in benefit is unmatched in the region. Although Vestskoven was expanded by some 10% over the period, the continued afforestation efforts, decreasing open land and increasing species diversity, are far more accountable for the trend.

In general, also other urban fringe forests around Copenhagen appear more popular since the 1970s while sites further away from the population centre now provide significantly reduced welfare. The main determinants for this development can be found in a pronounced shift in mode of transport and a general change in recreation patterns in forests. Although the average yearly number of visits to forests increased by 15% at the national level, the number of car-borne trips to forests decreased over the period. This is primarily due to more people travelling by other means of transport than by car (Koch, 1978; Jensen and Koch, 1997). As a consequence, the time spent on-site and the average travel distance have dropped. Because recreationists now prefer to travel shorter distances and more often, forests far away from Copenhagen have received less visits and urban fringe forests have become more popular to visit by car. Both the changes in attributes as Vestskoven matures and the preference for urban forests have contributed to the increased welfare derived from Vestskoven.

Tracking changes in behaviour illustrates the core challenge in discrete choice modelling when predicting future benefits of new sites. Chapter 3 transferred recreation value functions from 1977 to 1997 in the same region and found that updating the transfer model with present demand for forest recreation improves the transfer errors by a factor of 4 on average compared to transferring both demand and preferences from 1977 to 1997.

Not only demand for forest recreation and wider societal influences on recreation behaviour play a role in valuing sites over time. Also changes in preferences of site attributes may have a significant effect. Commonalities of preferences over time suggest that people’s positive attitude towards coniferous forests in this region of Denmark has remained stable, although national studies indicate the opposite (Koch and Jensen, 1988;

Jensen and Koch, 1997). This is primarily due to the above average preponderance of broadleaf forest in Northern Zealand. Other commonalities that appear to stay constant include preference for large rather than small forests, sloped terrain and coastal proximity. Differences over time are found in preferences towards species diversity and openness of forests. In 1997, 62% of the population appear to prefer a species rich forest and 76,2% a dense forest whereas the 1977 model does not show significant evidence of heterogeneity of these preferences. Preferences for forests with trees older than 60 years appear to vary over the population in 1977 with 81.6% finding older trees more attractive, but showed no significant evidence of variance in preference across the population in the 1997 model. Although a few benefit transfer studies have applied random utility models to transfer value functions (e.g. Feather and Hellerstein, 1997; Parsons and Kealy, 1994), we are not aware of any examples that transfer heterogeneous preferences.

We illustrated the importance of how study sites are selected in a transfer using multiple sites by choosing three scenarios based on i) a large number of sites, ii) a restricted sampling excluding extreme attractive or not attractive sites, and iii) a sampling that only includes sites from a geographically very limited area.

The benefit transfer based on 51 forests shows the complexity of selecting study sites. Transfer errors, using this sampling, range from –84% to 346% although with a large majority (36 forests) producing a transfer error of ± 20%. Vestskoven, as an outlier in the region, performed the worst (346%), suggesting that transfers without a range of study sites, which cover similar characteristics as the policy site, fare poorly.

Results of the benefit transfers that exclude extreme sites, be they attractive or of little interest, indicate a complex relationship between which sites are included as study sites and the resulting transfer performance. The most extreme transfers where the five most valuable and least valuable sites are excluded perform generally worse than transfers of the ten most and least interesting sites. Transfers to Vestskoven appear fairly decent when excluding least valuable sites (31%-36%) whereas excluding the five most popular sites leads to nearly as large an error as the transfer based on 51 study sites (330%). The non-linearity of the sampling effect on willingness to pay is confirmed with a relatively good transfer to Vestskoven (28%) when as many as ten popular sites are excluded.

The transfer using only urban fringe forests illustrates the importance of designing sampling with a sufficient variety in distances in order to estimate the marginal utility of income. If the specification of the choice set does not allow the researcher to reveal the trade off between travelling further to an attractive site or visiting a local non-attractive forest, the recreation model may not be able to predict the true variance in preferences and will eventually not properly account for the fact that some forests are too far away and therefore have a low probability of visit. Estimating total willingness to pay is bound to underestimate the true value as the people who are willing to travel far are excluded. Our transfer therefore produces an underestimate of values of all forests in the choice set.

The transfer to Vestskoven produces near average results. Termansen et al. (2004) finds positive cost coefficients when specifying the choice set too narrowly and recommends that the impact of the choice of the size of spatially defined choice sets on parameter estimates is tested before choosing a particular choice set size. The effect on the narrow choice set size can be detected in the travel cost coefficient of the transfer model, which appears slightly reduced to mean -2.44 standard deviation 0.8055 from mean –2,48 and standard deviation 1.020 of the full model specification.

The log likelihood ratio test of statistical equality of models is one of frequently used tests in the benefit literature stating that if transfer and true model are not statistically identical, the transfer is not valid (Loomis, 1992; Bergland et al., 2002, Downing and Ozuna, 1996). Applying the stringency of this test to this study would mean that only two transfers in the scenario based on 51 forests should be carried out. Despite the poor performance of the transferability test, we find a relatively clear link between the level of significance of the log likelihood ratios and the level of transfer errors. For instance, we find that forests in the transfer scenario based on 51 sites with log likelihood ratio scores between 48 and 65 (which is significant at the 0.1% level) all have transfer errors between ± 20% while forest transfers performing worse have either a far higher significance level or a differently specified trip allocation model altogether. A similar link between transfer errors and log likelihood ratios can be detected in the transfer based on attractiveness. Here, the log likelihood ratios of the transfer models with most extreme exclusions have far higher significance levels and higher transfer error than models excluding either 10 of the most popular or least popular forests. Downing and Ozuna (1996) conclude in their benefit transfer study that although the transfer model may be statistically equivalent with the true model, the same is not necessarily so for the willingness to pay measures.

Complementary to this, we find that, although the set of coefficients of the transfer models are not equivalent to the full model, transfer results may still perform within reasonable limits, e.g. ± 20%. It should be noted though, that these errors appear in the case of benefit transfers within one region where the maximum distance to one of the forests by the sample population is 156km. The total value of access of the transfer models is estimated over the same population and the recreation opportunities are constant across the transfers (with the exception of the study-site(s)). These are very favourable conditions for a benefit transfer, not normally the case in benefit transfers.

This study has exemplified a number of issues necessary to take into account when valuing new forest sites, including capturing changes in preferences over time, tracking changes in recreational behaviour and dealing with the complexity of selecting the right choice set in terms of size, location and attributes. The study and results have only been made possible through the availability of a unique data set, repeated twice over a long time period. Combining this data set and valuation of new afforestation sites spurred by the expansive Danish forest policy should be a must.

CHAPTER 5 CONCLUSION

This thesis has estimated and analysed the values of forest recreation in Europe and considered the spatial and time aspects of valuing existing and new forest sites. Forests cover nearly half of Europe and offer one of the most multi-purpose natural environments of which recreation is acknowledged as one of the main contributors to welfare derived from forestry today. In addition, the European forest area increases by ca. 802.000 ha per year (MCPFE & UNECE/FAO, 2003). It is therefore important for forest managers, planners and politicians to have appropriate economic tools that quantify the non-market benefit implications of how to manage the current forest resource and how and where to establish new forest sites.

5.1. Forest Recreation Benefits in Europe

Forest recreation values in Europe vary considerably, as shown in Chapter 2 where a summary of forest recreation studies showed that consumer surplus range as much as from €0.66 to €112 per trip with a median of €4.52 per trip (PPP 2000 values). The analysis was based on 25 studies from nine countries using the travel cost method (TCM) and used in a meta-analysis to ascertain the type of components that influence the value of forest recreation.

The meta-analysis of the collected studies was conducted with a step-wise increasing number of variables where level I included only data available from the studies, level II aggregate socio-economic variables and level III site specific characteristics such as diversity, fraction of open land, and location. It is a commonly acknowledged problem of meta-analyses in environmental economics to find sufficient information in original studies. The data in level II and III were therefore added to the regression based on exogenous sources. Information on site characteristics were collected from relevant forest authorities and tested for significant influence on forest recreation benefits, which is new to meta-analysis. In addition, the study included several variables from the studies, which have not previously been tested in meta-analyses, such as number of visits, cost per kilometre and distance travelled.

Results of the best performing specification suggested that forest recreation benefits are positively influenced by an increasing level of costs per kilometre, opportunity cost of time and average distance travelled, which is in line with theoretic expectations. In terms of site characteristics, large forests and sites with many visits, monotone vegetation and diverse age classes influence benefits significantly and positively. In terms of socio-economic exogenous data, GDP per capita appeared to have a negative impact on benefits, which was surprising. The relatively small number of studies and differences in research designs may have undermined the inference made from the cross-analyses. Population density at a 1x1 degree grid level appeared not to contribute significantly to predicting recreation welfare, which may be due to the aggregate level of the variable. Also study specific factors, such as studies carried out by Willis, survey conducted in Italy or the use of the individual TCM instead of the zonal TCM appeared to increase consumer surplus, proving that specifications and research designs play a significant role in valuing sites, as has been found previously in the literature (Smith and Kaoru, 1990a & 1990b).

Although the traditional TCM does not take site attributes into account, results of the meta-analysis suggested that site characteristics have a substantial influence on recreational values. Researchers working with meta-analyses have previously called for more information to be included in original studies on socio-demographic characteristics of the samples and statistical information on estimation results such as sensitivity analyses and confidence intervals (Brouwer et al., 1999b; Woodward and Wui, 2001). This chapter showed that meta-analyses would also gain considerably from site attributes being included as additional data in original studies. The types of site characteristics were subsequently included in the random utility models (RUM) in Chapters 3 and 4.

5.2. Predicting Changes in Recreation Values over Time

Assessing future values of forest recreation is highly relevant when planning long-term afforestation projects. Chapter 3 tested the performance of transferring benefit functions over time from 1977 to 1997 of 52 forests in the capital region of Denmark and Chapter 4 quantified the changes in welfare over the same period and forests. Results showed that demand for forest recreation and preferences towards site attributes underwent substantial changes over 20 years leading to subsequent large transfer errors when transfer updates are not undertaken.

Results of the RUM simulations in Chapter 3 indicated that preferences for forest characteristics in the Copenhagen region of Denmark changed with respect to species diversity and openness of forests, i.e. people have developed a heterogeneous preference with 62% of the population preferring a species rich forest and 76% a dense forest whereas the 1977 sample did not show significant evidence of variance in preferences. Also, the full sample in 1997 appeared to prefer tree stands older than 60 years compared to 82% in 1977. Commonalities of taste between the 1977 and 1997 sample included a favourable attitude towards coniferous vegetation (60%-64% of the sample), large forests (albeit at a marginal declining rate), sloped terrain and coastal proximity. The preference for coniferous forests in this region contrasts with findings at the national level, where only 40% prefer coniferous sites (Termansen, 2004b). A probable explanation is the prevalence of broadleaf forests in the capital region, making coniferous seem more attractive. These differences and commonalities across time and space were only possible to detect by applying a mixed logit.

The transfers over time compared the efficiency of transferring benefits over 20 years. The comparison was made between a functional transfer model that updated car-borne forest recreation demand to recent years (transfer type A) and a functional transfer that did not update the demand function to recent years (transfer type B). The non-updated transfer type B produced an error margin across the 52 sites that was on average 434% higher than the 'true' value. Updating the transfer model with present demand for recreation improved the error margins considerably by a factor of 4 on average. The median transfer error of this model was 4%, ranging from –74% to 234% of the 'true' value. 32 of the 52 transfers of transfer type A were found to be within a ± 50% and 15 transfers within a ± 20% error margin of the 'true' value. The confidence intervals of the two transfer models indicate that the values of 13 forests of transfer type A overlap the confidence interval of the 'true' model whereas only one transfer value of type B overlaps the confidence intervals of the 'true' model. The 14 transfers with overlapping confidence intervals were also the most successful transfers, producing error margins below ± 24%.

A main contributor to the poor results of the transfer type B and the relatively good results of transfer type A was a pronounced shift in transport mode over the period towards other means of transport than cars when visiting forests. The transfer type B therefore predicted far more car-borne visits in 1997 than was observed (Koch, 1978; Jensen and Koch, 1997) and estimated in this thesis. A related aspect to the shift in transport mode was the higher travel cost parameter in the 1977 RUM, which indicated a preference for longer trips in 1977 than in recent times, despite a relatively higher petrol price in 1977. Transfer model A therefore underestimated urban fringe forests close to Copenhagen and overestimated the value of remote forests.

The effects of changes in site and travel preferences on recreation valuation over time became evident in Chapter 4. Generally, urban fringe forests have gained in value on average by 280% and values of forests further away from the densely populated areas have decreased by up to 100%. In addition, the case study of Vestskoven, which is a relatively new forest that was established in the 1970s on former agricultural and horticultural land at the outskirts of Copenhagen, showed a dramatic increase in value by nearly 70 times. This changed the ranking of the new forest from one of the least attractive in 1977 to one of the most attractive sites in the region in 1997. The gradual afforestation, increasing maturity and diversification of the vegetation in Vestskoven as well as the general change in preference towards urban forests led to the steep increase in welfare over time.

5.3. Predicting Changes in Recreation Values over Space

The predictions of how values develop over time and how well transfer models can estimate future values in Chapters 3 and 4 revealed which determinants are necessary to take into account when valuing recreation over time using discrete choice modelling. Predicting changes in recreation values over space is equally important when including recreation in economic appraisals of afforestation projects. This is due to the fact that it is not possible to conduct revealed preference valuation of non-existing sites. Thus benefit transfer over space remains the only solution. Using the case study of Vestskoven and the 1997 discrete choice framework of Chapter 3, Chapter 4 performed and tested three different scenarios of spatial benefit transfers where the choice set of policy sites differed between i) a benefit transfer function based on 51 forests; ii) a benefit transfer based on attractiveness and iii) a benefit transfer based on urban fringe forests.

The first scenario clearly showed the importance of having the right variation in the policy site choice set in order to successfully transfer values to study sites. As Vestskoven was planned and managed differently from the remaining forest sites in the region, the variance in the policy site choice set was not sufficient to transfer a value close to the 'true' value. The transfer to Vestskoven exaggerated the 'true' value by 346%, which was the highest error produced in the 52 transfers. For the large majority of forests (36), transfers performed within a ± 20% error margin.

The second scenario, which excluded the most attractive or the least attractive sites from the policy site choice set, indicated that excluding the most extreme sites worsen transfer efficiency. The importance of appropriate variance in the policy site choice set was reconfirmed. The Vestskoven transfer, when excluding the least attractive forests, led to fairly decent results (31%-36% error) compared to a 330%transfer error when excluding the most attractive sites. The large transfer error of excluding the most attractive sites is attributable to the fact that Vestskoven is today one of the most popular forests, and hence excluding comparable sites from the choice set removes the appropriate variance in the transfer model.

The third scenario, where the choice set of policy sites only included urban fringe forests, illustrated the importance of designing sampling with a sufficient variety in distances in order to estimate the marginal utility of income. The spatially narrow choice set excluded people who are willing to travel far and thereby prevented the model to detect a trade off in preferences between travelling further to an attractive site and visiting a local non-attractive forest. As a result, all forests in the region were underestimated and the transfer to Vestskoven was close to the average under-prediction (56% below the 'true' value).

5.4. Limitations and Future Research Needs

The valuation applied in this thesis has focused on revealed preference methods using the travel cost and distance as proxies for deriving the demand for recreation. This means that only the provision of recreation that is based on car-borne visits is valued and not recreative trips where people travel by foot or by bike, for instance. Therefore, sites that are reached frequently by other modes of transport than cars are undervalued. In the case of the Danish forest recreation, slightly more than half of all visits are not made by car, on average (Jensen and Koch, 1997). Urban fringe forests most probably receive even higher shares of recreators not using the car.

The opportunity cost of time was voluntarily omitted from the utility function in Chapter 3. The meta-analysis showed that the inclusion and level of the cost of time is a significant contributor to welfare estimates. Travel cost studies to forests in Europe have used the percentage of wage ranging from 0% to 100% with a mean of 25%. However, the level of opportunity cost of time is in most cases decided by the researcher based on individual beliefs, which we wanted to avoid here.

The TCM generally reveals a great sensitivity of welfare estimates in the actual specification, as shown in the meta-analysis. The method has been perceived more or less overtly to be closer to the truth because it is based on observed market behaviour as opposed to hypothetical questions asked in contingent valuation studies. However, the link between market behaviour and values is created by strategic research decisions and substantial randomness in non-linear functions, whereas welfare estimates from contingent valuation do not tend to be very sensitive to specification (Haab and McConnell, 2002). Testing the use of other approaches of specifying the RUM framework could therefore expand understanding the sensitivity of revealed values to specification of forest recreation, such as the Kuhn-Tucker model and the repeated nested logit model. Herriges et al. (1998) compare the Kuhn-Tucker model and the linked model on angling behaviour in the U.S. and find that welfare measures vary by magnitude and sign across the specifications. Whether a similar pattern is the case for forest recreation in Denmark could be interesting to find out.

Combining stated and revealed preference methods could also be used to validate the results of the RUM. Another advantage of such an approach would be to capture the value of recreation for people not travelling by car. This, however, would necessitate careful design in the inception phase of the survey such that the two types of valuations can be pooled together under a single preference structure.

The study has clearly shown that patterns of recreation and transport mode play a highly central role when using revealed preference methods to value forest recreation. It has only been possible to model the temporal substitution and assess the main influences on values over time by repeating the on-site and household surveys. This is, however, very rarely done. Most valuation studies are single site, performed only once in time and rarely repeated elsewhere. This poses probably one of the largest hindrances to a mainstream solid use of non-market good valuation, and it prevents researchers from understanding the spatial and time aspects of non-market values without the 'noise' of different specifications. Both meta-analyses and original surveys would greatly benefit from using panel data compared to only cross-sectional analysis.

Due to the multi-purpose forestry in Europe, a social efficient afforestation policy depends to a large extent on the provision of non-market benefits, especially recreation opportunities. Economic appraisals of afforestation projects should therefore include the value of recreation. This thesis has shown that recreational welfare depends to a large extent on the characteristics of forests, the ease of access and substitution possibilities. It has also shown that changes in recreation patterns over time can lead to substantial changes in welfare provided by the individual forests. The ability of the RUM to deal with substitution effects and inclusion of new sites while quantifying the value of access and quality changes in site attributes makes it an attractive tool in selecting the optimal location of new forests. In the case of Denmark, the national household survey in 1994 and the on-site survey in 592 nature areas offer a rare opportunity to create a recreation demand model framework at the national level. This could, along with the valuation of other non-market goods provided by forests, be included in cost benefit analyses on selecting the optimal use of land.

Use and hence the type of value produced by forests can change dramatically over time. An example from Denmark illustrates that although one use becomes obsolete over time it can create entirely different benefits. Since the 17th century through to the 19th century, one of the prime purposes of forestry had been to deliver sufficient timber to the navy. After Denmark lost its fleet to the British in 1807, the country decided to plant large areas of oak to ensure that a new fleet could be built (Miljøministeriet, 2003b). The planning at that time surely did take into account that it takes 2-300 years for an oak tree to grow to a size that is useful for ship construction. However, they didn't consider the possibility that oak naval ships may not be needed when the trees are ready for shipbuilding at the end of the 20th century. Today, these oak plantations are protected[12] and well known in the public as the 'naval oaks'. The history of the oak trees and the amenity benefits of protecting them were impossible to predict at the time of establishment, but none the less they represent today a considerable ecological and recreational asset. Depending on the scale of time relevant for the use being valued, a forest may simply outlive the services that we value today. This places some humility on the attempts to value future benefits of long-term effects of afforestation.

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[12] Only under special circumstances, such as for restoration of ships and windmills, can some of the oaks be harvested.

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ANNEX 1. MEAN AND 95 PERCENT CONFIDENCE INTERVALS.

Forest	True Model	Transfer Model A	Transfer Model B	Model A Error Margin	Model B Error Margin
1[a]	$1.04x10^5$ ($9.79x10^4$ - $1.11x10^5$)	$9.87x10^4$ ($9.73x10^4$ - $9.95x10^4$)	$4.41x10^5$ ($4.14x10^5$ - $4.61x10^5$)	-5%	326%
2	$2.19x10^4$ ($2.12x10^4$ - $2.34x10^4$)	$4.97x10^4$ ($4.94x10^4$ - $5.02x10^4$)	$2.19x10^5$ ($2.06x10^5$ - $2.31x10^5$)	127%	901%
3	$1.22x10^4$ ($1.15x10^4$ - $1.33x10^4$)	$1.9x10^4$ ($1.77x10^4$ - $2.04x10^4$)	$7.54x10^4$ ($7.42x10^4$ - $7.6x10^4$)	55%	517%
4	$1.85x10^4$ ($1.85x10^4$ - $1.97x10^4$)	$6.16x10^4$ ($6.1x10^4$ - $6.25x10^4$)	$2.85x10^5$ ($2.64x10^5$ - $3.03x10^5$)	234%	1443%
5	$6.78x10^4$ ($6.53x10^4$ - $7.17x10^4$)	$7.91x10^4$ ($7.87x10^4$ - $7.96x10^4$)	$3.29x10^5$ ($3.09x10^5$ - $3.48x10^5$)	17%	386%
6	$8.16x10^5$ ($7.79x10^5$ - $8.76x10^5$)	$5.33x10^5$ ($5.31x10^5$ - $5.46x10^5$)	$2.17x10^6$ ($2.07x10^6$ - $2.27x10^6$)	-35%	165%
7	$5.49x10^5$ ($5.16x10^5$ - $5.89x10^5$)	$3.72x10^5$ ($3.65x10^5$ - $3.77x10^5$)	$1.57x10^6$ ($1.48x10^6$ - $1.63x10^6$)	-32%	186%
8	$2.12x10^5$ ($2.04x10^5$ - $2.27x10^5$)	$1.22x10^5$ ($1.19x10^5$ - $1.25x10^5$)	$5.19x10^5$ ($4.73x10^5$ - $5.59x10^5$)	-42%	145%
9[a]	$5.06x10^5$ ($4.83x10^5$ - $5.35x10^5$)	$5.03x10^5$ ($4.97x10^5$ - $5.1x10^5$)	$1.65x10^6$ ($1.56x10^6$ - $1.74x10^6$)	0%	226%
10	$7.79x10^4$ ($7.47x10^4$ - $8.51x10^4$)	$1.29x10^5$ ($1.25x10^5$ - $1.32x10^5$)	$5.62x10^5$ ($5.4x10^5$ - $5.79x10^5$)	65%	622%
11	$2.04x10^5$ ($1.92x10^5$ - $2.16x10^5$)	$1.7x10^5$ ($1.68x10^5$ - $1.71x10^5$)	$6.95x10^5$ ($6.58x10^5$ - $7.27x10^5$)	-17%	240%
12	$6.01x10^5$ ($5.61x10^5$ - $6.55x10^5$)	$4.39x10^5$ ($4.22x10^5$ - $4.55x10^5$)	$1.82x10^6$ ($1.76x10^6$ - $1.84x10^6$)	-27%	203%
13[a]	$4.95x10^5$ ($4.64x10^5$ - $5.38x10^5$)	$4.52x10^5$ ($4.39x10^5$ - $4.66x10^5$)	$1.76x10^6$ ($1.69x10^6$ - $1.81x10^6$)	-9%	254%
14	$3.43x10^6$ ($2.94x10^6$ - $4.12x10^6$)	$2.44x10^6$ ($2.13x10^6$ - $2.79x10^6$)	$1.05x10^7$ ($9.7x10^6$ - $1.11x10^7$)	-29%	207%
15[a]	$2.61x10^5$ ($2.47x10^5$ - $2.79x10^5$)	$2.71x10^5$ ($2.66x10^5$ - $2.74x10^5$)	$1.11x10^6$ ($1.05x10^6$ - $1.16x10^6$)	4%	328%
16	$1.35x10^5$ ($1.3x10^5$ - $1.43x10^5$)	$1.92x10^5$ ($1.89x10^5$ - $1.93x10^5$)	$7.99x10^5$ ($7.53x10^5$ - $8.35x10^5$)	42%	491%
17	$4.18x10^4$ ($4.1x10^4$ - $4.39x10^4$)	$9.63x10^4$ ($9.59x10^4$ - $9.78x10^4$)	$4.71x10^5$ ($4.43x10^5$ - $4.97x10^5$)	131%	1027%
18[a]	$4.54x10^5$ ($3.78x10^5$ - $5.75x10^5$)	$5.19x10^5$ ($4.3x10^5$ - $6.18x10^5$)	$2.23x10^6$ ($1.95x10^6$ - $2.48x10^6$)	14%	391%
19	$1.93x10^6$ ($1.75x10^6$ - $2.09x10^6$)	$7.82x10^5$ ($7.57x10^5$ - $8.09x10^5$)	$3.3x10^6$ ($3.2x10^6$ - $3.38x10^6$)	-59%	71%
20[a]	$1.15x10^5$ ($1.05x10^5$ - $1.29x10^5$)	$1.1x10^5$ ($1.06x10^5$ - $1.14x10^5$)	$4.87x10^5$ ($4.68x10^5$ - $4.97x10^5$)	-4%	322%
21[a]	$9.42x10^5$ ($8.2x10^5$ - $1.1x10^6$)	$1.06x10^6$ ($9.92x10^5$ - $1.16x10^6$)	$4.65x10^6$ ($4.55x10^6$ - $4.68x10^6$)	13%	393%
22	$2.99x10^5$ ($2.36x10^5$ - $3.74x10^5$)	$1.87x10^5$ ($1.56x10^5$ - $2.35x10^5$)	$8.27x10^5$ ($7.16x10^5$ - $9.48x10^5$)	-38%	176%
23	$2.01x10^6$ ($1.9x10^6$ - $2.18x10^6$)	$1.29x10^6$ ($1.26x10^6$ - $1.32x10^6$)	$4.85x10^6$ ($4.65x10^6$ - $5.01x10^6$)	-36%	141%
24	$1.04x10^7$ ($9.61x10^6$ - $1.15x10^7$)	$5.6x10^6$ ($5.23x10^6$ - $6.03x10^6$)	$2.28x10^7$ ($2.24x10^7$ - $2.29x10^7$)	-46%	119%
25[a]	$4.27x10^5$ ($4.19x10^5$ - $4.47x10^5$)	$4.35x10^5$ ($4.31x10^5$ - $4.37x10^5$)	$1.9x10^6$ ($1.76x10^6$ - $2x10^6$)	2%	345%
26	$1.96x10^4$ ($1.95x10^4$ - $2x10^4$)	$4.74x10^4$ ($4.69x10^4$ - $4.77x10^4$)	$1.98x10^5$ ($1.83x10^5$ - $2.1x10^5$)	142%	912%

Forest	True Model	Transfer Model A	Transfer Model B	Model A Error Margin	Model B Error Margin
27	3.77x10^{4} (3.6x10^{4} - 4.09x10^{4})	7.16x10^{4} (6.86x10^{4} - 7.47x10^{4})	2.75x10^{5} (2.68x10^{5} - 2.78x10^{5})	90%	631%
28	1.11x10^{6} (1.08x10^{6} - 1.22x10^{6})	9.01x10^{5} (9.04x10^{5} - 9.17x10^{5})	3.63x10^{6} (3.42x10^{6} - 3.85x10^{6})	-19%	228%
29	1.99x10^{5} (1.91x10^{5} - 2.13x10^{5})	3.54x10^{5} (3.5x10^{5} - 3.58x10^{5})	1.48x10^{6} (1.39x10^{6} - 1.53x10^{6})	78%	641%
30	2.19x10^{5} (2.05x10^{5} - 2.34x10^{5})	3.22x10^{5} (3.14x10^{5} - 3.3x10^{5})	1.3x10^{6} (1.24x10^{6} - 1.33x10^{6})	47%	493%
31	2.78x10^{4} (2.77x10^{4} - 2.91x10^{4})	5.38x10^{4} (5.3x10^{4} - 5.5x10^{4})	2.38x10^{5} (2.2x10^{5} - 2.56x10^{5})	94%	758%
32	1.46x10^{5} (1.37x10^{5} - 1.57x10^{5})	1.8x10^{5} (1.75x10^{5} - 1.84x10^{5})	7.53x10^{5} (7.23x10^{5} - 7.77x10^{5})	23%	416%
33	1.62x10^{4} (1.59x10^{4} - 1.73x10^{4})	3.74x10^{4} (3.67x10^{4} - 3.85x10^{4})	1.64x10^{5} (1.57x10^{5} - 1.7x10^{5})	130%	909%
34	4.45x10^{5} (4.11x10^{5} - 4.81x10^{5})	1.64x10^{5} (1.63x10^{5} - 1.65x10^{5})	6.84x10^{5} (6.46x10^{5} - 7.2x10^{5})	-63%	54%
35[a]	3.82x10^{5} (3.56x10^{5} - 4.16x10^{5})	3.63x10^{5} (3.5x10^{5} - 3.76x10^{5})	1.59x10^{6} (1.53x10^{6} - 1.62x10^{6})	-5%	317%
36 [a]	2.44x10^{5} (2.32x10^{5} - 2.59x10^{5})	2.53x10^{5} (2.46x10^{5} - 2.59x10^{5})	1.04x10^{6} (9.94x10^{5} - 1.07x10^{6})	4%	328%
37	1.33x10^{6} (1.2x10^{6} - 1.47x10^{6})	8.39x10^{5} (7.94x10^{5} - 8.82x10^{5})	3.31x10^{6} (3.25x10^{6} - 3.32x10^{6})	-37%	149%
38	8.55x10^{4} (8.32x10^{4} - 8.99x10^{4})	1.15x10^{5} (1.15x10^{5} - 1.16x10^{5})	4.31x10^{5} (4.02x10^{5} - 4.57x10^{5})	35%	405%
39	2.46x10^{5} (2.3x10^{5} - 2.62x10^{5})	1.23x10^{5} (1.23x10^{5} - 1.24x10^{5})	5x10^{5} (4.69x10^{5} - 5.29x10^{5})	-50%	103%
40	1.55x10^{4} (1.52x10^{4} - 1.65x10^{4})	4.92x10^{4} (4.86x10^{4} - 4.98x10^{4})	2.13x10^{5} (2.01x10^{5} - 2.23x10^{5})	217%	1273%
41[b]	8.89x10^{5} (7.48x10^{5} - 1.1x10^{6})	2.35x10^{5} (2x10^{5} - 2.74x10^{5})	9.2x10^{5} (8.28x10^{5} - 1x10^{6})	-74%	3%
42	4.47x10^{4} (4.18x10^{4} - 4.98x10^{4})	9.12x10^{4} (8.79x10^{4} - 9.54x10^{4})	4.11x10^{5} (4x10^{5} - 4.16x10^{5})	104%	819%
43	7.91x10^{5} (7.41x10^{5} - 8.52x10^{5})	4.89x10^{5} (4.76x10^{5} - 5x10^{5})	2.05x10^{6} (1.95x10^{6} - 2.1x10^{6})	-38%	159%
44	7.65x10^{4} (7.62x10^{4} - 7.96x10^{4})	1.14x10^{5} (1.12x10^{5} - 1.17x10^{5})	4.44x10^{5} (4.06x10^{5} - 4.8x10^{5})	50%	481%
45	1.19x10^{6} (1.07x10^{6} - 1.37x10^{6})	1.92x10^{6} (1.76x10^{6} - 2.11x10^{6})	8.62x10^{6} (8.3x10^{6} - 8.8x10^{6})	61%	622%
46 [a]	3.65x10^{6} (3.03x10^{6} - 4.4x10^{6})	2.77x10^{6} (2.42x10^{6} - 3.22x10^{6})	1.26x10^{7} (1.15x10^{7} - 1.34x10^{7})	-24%	244%
47 [a]	4.95x10^{5} (4.62x10^{5} - 5.41x10^{5})	5.39x10^{5} (5.17x10^{5} - 5.6x10^{5})	2.17x10^{6} (2.11x10^{6} - 2.2x10^{6})	9%	338%
48	2.25x10^{5} (2.2x10^{5} - 2.34x10^{5})	1.09x10^{5} (1.06x10^{5} - 1.14x10^{5})	4.06x10^{5} (3.68x10^{5} - 4.48x10^{5})	-51%	80%
49	1.14x10^{5} (1.07x10^{5} - 1.24x10^{5})	1.48x10^{5} (1.44x10^{5} - 1.52x10^{5})	6.06x10^{5} (5.82x10^{5} - 6.26x10^{5})	29%	430%
50	1.96x10^{4} (1.96x10^{4} - 2.05x10^{4})	5.69x10^{4} (5.61x10^{4} - 5.83x10^{4})	2.87x10^{5} (2.65x10^{5} - 3.06x10^{5})	191%	1364%
51	1.17x10^{5} (1.12x10^{5} - 1.26x10^{5})	1.59x10^{5} (1.57x10^{5} - 1.61x10^{5})	7.1x10^{5} (6.72x10^{5} - 7.41x10^{5})	35%	506%
52 [a]	3x10^{6} (2.63x10^{6} - 3.39x10^{6})	2.68x10^{6} (2.36x10^{6} - 3.05x10^{6})	1.13x10^{7} (1.05x10^{7} - 1.2x10^{7})	-11%	277%

[a] Confidence intervals of transfer Model A WTP overlaps the confidence interval of the true model

[b] Confidence intervals of transfer Model B WTP overlaps the confidence interval of the true mode

ANNEX 2. STANDARD LOG LIKELIHOOD RATIO TEST & TRANSFER ERROR MARGIN OF ONE-BY-ONE FOREST TRANSFER

Transferred Forest ID	Maximum Log likelihood of Transfer Model	Ratio	Error margin
1	-16121.86	48.71	-14%
2	-16122.69	50.37	-14%
3	-16122.27	49.53	-11%
4	-16097.70	0.39	3%
5	-16121.69	48.37	0%
6	-16164.93	134.85	39%
7	-16123.62	52.23	18%
8	-16130.59	66.16	-47%
9	-16122.68	50.34	-6%
10*			18%
11	-16123.86	52.70	-4%
12	-16122.95	50.88	-10%
13*			12%
14*			-47%
15	-16124.06	53.11	1%
16	-16121.64	48.27	-7%
17	-16122.43	49.85	-6%
18*			108%
19*			-33%
20	-16100.13	5.25	9%
21	-16200.32	205.63	-86%
22	-16306.08	417.14	-84%
23	-16138.50	81.99	-10%
24	-16261.68	328.34	-56%
25	-16121.63	48.25	-7%
26	-16121.87	48.73	-3%
27	-16121.29	47.58	4%
28	-16155.54	116.07	1%
29	-16121.58	48.15	-6%
30	-16121.67	48.33	-5%
31	-16121.91	48.81	3%
32	-16121.77	48.53	-7%
33*			-66%
34	-16134.47	73.93	-35%
35	-16127.41	59.80	-9%
36*			-43%
37	-16128.26	61.50	-2%
38	-16130.32	65.63	-3%
39	-16123.68	52.34	-17%
40	-16122.68	50.35	-7%
41*			251%
42	-16124.51	54.00	-14%
43	-16127.96	60.91	-3%
44*			23%
45	-16134.23	73.46	-21%
46	-16130.13	65.25	-5%
47	-16122.30	49.60	-7%
48*			36%
49	-16122.31	49.62	-8%
50	-16121.55	48.10	-2%
51	-16122.74	50.47	-10%
52*			349%

*The significant specification of the transfer model was not similar to that of the full model.

Note: the P=0.001 critical value with a χ^2 (11) distribution is 31.26

Annex 3. Post- and Prechange Values of Access and Numbers of Visits of True Model (*€ 1997*)

Forest	Post change WTP	Prechange WTP	Postchange visits	Prechange visits
1	103,554.25	103,556.15	22,588.50	22,589.39
2	21,907.76	21,908.32	3,617.03	3,617.20
3	12,225.22	12,226.27	5,153.53	5,154.28
4	18,463.49	18,469.85	3,732.66	3,737.75
5	67,755.53	67,757.30	16,498.07	16,498.85
6	816,078.77	816,103.24	665,478.68	665,500.72
7	548,539.00	548,709.24	116,316.72	116,365.28
8	211,559.96	211,560.70	49,548.68	49,548.98
9	505,692.10	506,073.88	252,778.81	253,039.60
10	77,859.98	77,881.24	24,861.42	24,876.50
11	204,153.37	204,164.58	74,888.72	74,895.07
12	600,764.96	601,916.54	201,009.15	201,544.06
13	495,260.93	496,221.81	249,097.32	249,834.92
14	3,431,872.51	3,447,764.93	522,544.82	525,737.13
15	260,662.04	260,746.45	66,256.02	66,283.78
16	135,119.90	135,166.83	35,038.02	35,059.99
17	41,762.11	41,772.91	7,908.42	7,914.25
18	454,302.13	459,183.75	80,970.24	82,204.25
19	1,930,015.53	1,930,962.81	937,363.32	937,844.57
20	115,298.15	115,302.86	21,685.89	21,687.66
21	941,937.86	974,772.92	126,497.91	131,502.00
22	299,244.19	299,815.43	41,279.73	41,385.70
23	2,013,086.15	2,014,303.98	674,677.27	675,163.58
24	10,389,898.53	10,429,474.67	2,940,551.64	2,952,947.09
25	426,682.47	426,904.73	76,472.60	76,524.10
26	19,577.12	19,577.30	5,457.93	5,458.03
27	37,666.47	37,666.68	15,219.96	15,220.17
28	1,107,848.71	1,116,201.78	438,131.19	440,283.96
29	199,095.86	199,130.53	49,947.97	49,964.50
30	219,215.10	219,225.89	68,890.98	68,896.84
31	27,755.06	27,757.06	12,509.83	12,511.42
32	145,927.12	145,949.98	55,637.19	55,651.65
33	16,241.85	16,242.32	5,033.00	5,033.40
34	445,063.66	445,069.79	183,018.50	183,021.32
35	381,819.91	381,944.69	90,664.49	90,719.89
36	243,564.56	243,671.18	74,745.15	74,801.17
37	1,327,145.31	1,328,322.12	494,325.78	494,859.28
38	85,490.61	85,496.94	40,449.51	40,454.41
39	245,634.37	245,640.30	102,427.58	102,431.24
40	15,523.56	15,523.79	3,434.85	3,434.96
41	888,953.80	891,283.71	262,950.86	263,818.45
42	44,657.33	44,674.15	9,860.40	9,868.82
43	790,678.02	790,993.62	210,878.22	211,002.40
44	76,461.21	76,477.86	25,599.53	25,607.59
45	1,193,776.74	1,199,880.16	199,883.96	201,487.57
46	3,651,095.06	3,704,469.73	426,948.47	436,103.55
47	495,118.22	495,620.15	134,069.58	134,259.96
48	225,198.58	225,200.84	81,561.27	81,562.70
49	114,415.39	114,445.86	47,494.46	47,515.05
50	19,583.86	19,587.09	4,525.01	4,527.25
51	117,258.42	117,282.05	25,923.16	25,936.67
52	2,996,947.32	3,490,596.45	1,154,551.02	1,344,601.32

Annex 4. Post- and Prechange Values of Access and Numbers of Visits of Model A (€ *1997)*

Forest	Post change WTP	Prechange WTP	Postchange visits	Prechange visits
1	98,715.66	98,749.32	11,345.46	11,351.88
2	49,739.21	49,744.62	4,886.29	4,887.04
3	18,993.04	18,993.30	4,453.54	4,453.61
4	61,620.01	61,626.47	6,258.74	6,259.85
5	79,099.30	79,106.20	11,964.01	11,965.23
6	532,823.70	534,957.61	263,831.84	264,973.35
7	371,715.31	371,956.39	48,327.81	48,365.22
8	121,997.00	122,087.60	16,812.48	16,831.25
9	503,171.14	503,387.15	131,126.52	131,199.62
10	128,598.55	128,616.13	20,684.90	20,689.12
11	169,645.81	169,701.24	36,075.53	36,091.34
12	438,881.97	438,993.42	85,527.21	85,552.07
13	451,897.20	452,151.84	127,690.78	127,772.47
14	2,444,475.36	2,451,133.90	250,537.48	251,313.42
15	271,131.13	271,298.04	41,423.56	41,453.60
16	191,641.17	191,703.46	27,647.95	27,659.31
17	96,298.65	96,321.23	9,600.31	9,604.67
18	519,243.42	519,859.51	58,283.79	58,362.94
19	782,487.62	783,017.66	229,975.28	230,147.89
20	110,232.52	110,265.86	12,768.37	12,773.69
21	1,062,927.24	1,066,542.37	96,556.10	96,947.33
22	187,022.73	188,177.77	18,906.93	19,066.54
23	1,287,539.92	1,291,610.94	282,164.07	283,136.69
24	5,602,265.19	5,889,797.95	1,222,013.46	1,287,741.37
25	434,718.54	434,909.49	46,903.99	46,928.34
26	47,388.91	47,390.46	6,853.82	6,854.11
27	71,636.33	71,655.09	17,651.59	17,656.87
28	900,858.98	901,504.46	241,936.79	242,108.42
29	354,175.24	355,261.19	49,360.08	49,560.40
30	322,244.27	323,248.87	52,662.02	52,887.96
31	53,796.66	53,802.01	9,643.30	9,645.10
32	179,720.71	179,796.09	34,538.55	34,559.35
33	37,373.94	37,374.58	5,373.05	5,373.20
34	163,593.02	163,625.86	40,939.67	40,948.73
35	363,047.73	363,491.50	48,765.71	48,846.40
36	253,233.38	253,279.26	45,667.93	45,677.49
37	839,267.03	840,329.70	196,070.99	196,337.72
38	115,333.63	115,351.93	27,572.73	27,578.25
39	123,384.07	123,405.05	29,078.96	29,086.48
40	49,187.98	49,192.38	5,315.86	5,316.50
41	235,135.57	235,328.12	62,193.39	62,250.16
42	91,201.84	91,213.11	10,422.52	10,424.62
43	489,232.40	489,502.17	81,242.82	81,296.37
44	114,373.44	114,387.63	21,244.55	21,247.51
45	1,916,800.63	1,943,837.44	184,263.69	187,691.28
46	2,772,367.86	2,814,490.84	222,085.13	226,544.03
47	539,315.82	539,698.81	89,085.67	89,155.17
48	109,436.09	109,447.42	25,197.37	25,200.30
49	147,565.79	147,593.52	30,949.98	30,958.44
50	56,909.71	56,917.02	5,479.04	5,480.81
51	158,725.00	158,764.47	18,866.43	18,873.93
52	2,682,176.43	2,683,354.39	751,695.85	752,043.27

ANNEX 5. POST- AND PRECHANGE VALUES OF ACCESS AND NUMBERS OF VISITS OF MODEL B (*€ 1997)*

Forest	Post change WTP	Prechange WTP	Postchange visits	Prechange visits
1	440,952.89	440,952.89	61,096.71	61,096.71
2	219,377.76	219,377.76	24,583.42	24,583.42
3	75,409.33	75,409.33	18,356.08	18,356.08
4	284,868.95	284,868.95	39,805.40	39,805.40
5	329,004.95	329,004.95	52,635.69	52,635.69
6	2,166,069.51	2,166,069.51	1,083,814.20	1,083,814.20
7	1,570,340.72	1,570,340.72	219,488.02	219,488.02
8	518,593.75	518,593.75	79,766.30	79,766.30
9	1,651,021.74	1,651,021.74	308,890.29	308,890.29
10	562,499.72	562,499.72	104,396.21	104,396.21
11	694,845.27	694,845.27	144,174.22	144,174.22
12	1,819,517.60	1,819,517.60	362,722.97	362,722.97
13	1,755,129.52	1,755,129.52	478,095.22	478,095.22
14	10,529,774.99	10,529,774.99	1,127,270.91	1,127,270.91
15	1,114,455.50	1,114,455.50	179,006.37	179,006.37
16	799,048.49	799,048.49	123,349.91	123,349.91
17	470,589.54	470,589.54	66,483.54	66,483.54
18	2,228,535.19	2,228,535.19	271,202.13	271,202.13
19	3,301,473.48	3,301,473.48	1,004,533.92	1,004,533.92
20	486,692.97	486,692.97	65,876.16	65,876.16
21	4,645,107.65	4,645,107.65	454,549.21	454,549.21
22	827,095.75	827,095.75	91,282.56	91,282.56
23	4,845,120.80	4,845,120.80	982,997.11	982,997.11
24	22,788,212.47	22,788,212.47	4,845,952.51	4,845,952.51
25	1,897,617.77	1,897,617.77	229,168.71	229,168.71
26	198,046.55	198,046.55	31,488.97	31,488.97
27	275,433.41	275,433.41	65,558.87	65,558.87
28	3,633,553.67	3,633,553.67	1,041,604.22	1,041,604.22
29	1,475,346.64	1,475,346.64	216,350.07	216,350.07
30	1,300,426.49	1,300,426.49	208,479.21	208,479.21
31	238,069.35	238,069.35	46,355.34	46,355.34
32	753,337.79	753,337.79	145,682.64	145,682.64
33	163,949.06	163,949.06	26,568.44	26,568.44
34	683,847.72	683,847.72	177,885.51	177,885.51
35	1,591,857.06	1,591,857.06	258,175.63	258,175.63
36	1,042,527.30	1,042,527.30	198,473.74	198,473.74
37	3,306,164.63	3,306,164.63	758,891.52	758,891.52
38	431,453.38	431,453.38	89,191.33	89,191.33
39	499,598.36	499,598.36	109,432.70	109,432.70
40	213,134.34	213,134.34	25,040.76	25,040.76
41	919,894.65	919,894.65	237,874.53	237,874.53
42	410,520.30	410,520.30	58,541.74	58,541.74
43	2,045,986.52	2,045,986.52	365,773.57	365,773.57
44	443,915.26	443,915.26	77,288.06	77,288.06
45	8,617,177.50	8,617,177.50	934,228.10	934,228.10
46	12,563,268.13	12,563,268.13	1,086,837.38	1,086,837.38
47	2,167,293.33	2,167,293.33	356,645.21	356,645.21
48	406,160.91	406,160.91	82,937.05	82,937.05
49	606,037.47	606,037.47	123,771.51	123,771.51
50	286,724.74	286,724.74	46,819.26	46,819.26
51	710,341.87	710,341.87	101,290.06	101,290.06
52	11,288,485.75	11,288,485.75	3,188,969.07	3,188,969.07

ANNEX 6. CODE FOR CALCULATING POST- & PRECHANGE VALUES OF ACCESS POST- AND PRECHANGE VALUES OF ACCESS – 'TRUE' MODEL 1997[13]

```
#include <iostream.h>
#include <stdlib.h>
#include <fstream.h>
#include <math.h>
#include <stdio.h>
#include <strstream>
#include <generat.h>
#include <cnd.h>

FILE *fpdist1459,*fppeople1459,*fpattrib,*fpud;
int m,h,d,n,b,q,g,i,p,j,l,k,o,vejidper,skovid,PATCHNO, patchno, SKOVID, coastdum[53], vejskov;
char comma;
double infmod,phi,u,beta[501],betacost[501],
gammashanspec[501],gammaage[501],deltaconif[501],alphaopen[501],betasum,WTPpost[53],WTPpre[53],
omegacoast[501], pohigh[53][501],novisitshighpost[53],novisitshighpre[53];
long double vsumhigh500pre[1460], vsumhigh[501],ev[53][501],vhigh[53][501],
vsumhighpost[501][53],vsumhigh500post[1460][53],ivpost[1460][53], avgvsumhighpost[1460][53] ;
float drawno, drawnof, travdist, slope, SLOPE[53], FRACBROAD[53], fracbroad,
enatfrac,EDGENATFR[53],LNFOR[53],lninfo[53], VISITPERADULTpost[1460][53],
VISITPERADULTpre[1460][53], shanspec,SHANSPEC[53], fracconif,FRACCONIF[53], fracopen, FRACOPEN[53],
shanage, SHANAGE[53], age60, AGE60[53], sizef, SIZEF[53], coast, COAST[53], fracwater, FRACWATER[53],
VIEW[53], view, ALLPOPTOT, TRAVDIST[1460][53], TRAVCOST[53], travcost, lncoast, LNCOAST[53],
VIEWPOINT[53], viewpoint, LNVWPNT[53], lnviewpoint, lnsizef, LNSIZEF[53],iv, IV[53],ALLPOP, income,
INC[1460][53], adults,pop[1460][53], dist,DISTNEAR1[1460][53], distnear1, CAROWN[1460][53],
carown,AGE[1460][53], age2539, avgvsumhighpre[1460], ivpre[1460], BETAAGE, betaage, BETASIZE, betasize,
BETASLOPE, betaslope, BETAFRACWAT, betafracwat, BETACOAST, betacoast, GAMMASHSPECMN,
GAMMASHSPEC, gammashspecmn,GAMMASHSPECSTD,gammashspecstd,
DELTACONIFMN,DELTACONIF[15],deltaconifmn,DELTACONIFSTD,deltaconifstd,
ALPHAOPENMN, alphaopenmn,ALPHAOPENSTD,alphaopenstd,ALPHAOPEN, OMEGACOASTSTD,
omegacoaststd,OMEGACOAST, BETACOSTMN, betacostmn, BETACOSTSTD, BETACOST, betacoststd;

main()
{
comma = ',';
q = 10;
betasum = 0.0;
ALLPOP=0.0;
ALLPOPTOT=0.0;
fpud=fopen("WTP1997_postchange.txt","w");
fppeople1459=fopen("people1459.txt","r");
fpattrib = fopen("1997.txt","r");

//READ IN CHARACTERISTICS OF 52 FORESTS
for(h=1;h<=52;h++)
   {
   fscanf(fpattrib, "%d %f %f %f %f %f %f %f %f %f %f %f", &patchno, &shanspec, &fracbroad,
   &fracconif, &fracopen, &shanage, &age60, &sizef, &coast, &slope, &viewpoint, &fracwater);
   PATCHNO = patchno;
   SHANSPEC[PATCHNO] = shanspec;
   FRACBROAD [PATCHNO] = fracbroad;
   FRACCONIF[PATCHNO] = fracconif;
```

---

[13] This code is based on and adapted from Termansen et al. (2004a)

```
   FRACOPEN[PATCHNO] = fracopen;
   SHANAGE[PATCHNO] = shanage;
   AGE60[PATCHNO] = age60;
   SIZEF[PATCHNO] = sizef;
   lnsizef = logl(sizef+1);
   LNSIZEF[PATCHNO] = lnsizef;
   COAST[PATCHNO] = coast;
   lncoast = logl(coast+1);
   LNCOAST[PATCHNO]= lncoast;
   SLOPE[PATCHNO] = slope;
   VIEWPOINT[PATCHNO] = viewpoint;
   lnviewpoint = logl(viewpoint+1);
   LNVWPNT[PATCHNO] = lnviewpoint;
   FRACWATER[PATCHNO] = fracwater;
   if(COAST[PATCHNO] <= 1.0) coastdum[PATCHNO]=1;
   else coastdum[PATCHNO] = 0;
   }
fclose(fpattrib);

drawno = 500;
drawnof = 500.0;

fpdist1459=fopen("dist1459.txt","r");

srand(3);

for(g=1;g<=1459;g++)
{
   DISTNEAR1[g][h] = 0.0;

   for(h=1;h<=52;h++)
   {
   for(b=1;b<=drawno;b++)
   {
   ev[h][b] = 0.0;
   vhigh[h][b]= 0.0;
   pohigh[h][b] = 0.0;
   }
   }

for(b=1;b<=drawno;b++)
   {
   betacost[b] = 0.0; gammashanspec[b] = 0.0; deltaconif[b]=0.0;
   alphaopen[b]=0.0;omegacoast[b]=0.0; vsumhigh[b]= 0.0;
   }

for(b=1;b<=drawno;b++)
   {
//500 RANDOM DRAWS OF COEFFICIENTS. 1997 TRUE MODEL SPECIFICATION
   betacost[b] = (double)expl((double)(-2.476 + 1.02 * gauss()))*(-1.0) ;
   gammashanspec[b] = (double)(gauss()* 3.639 + 1.116);
   deltaconif[b] = (double)(gauss()* 2.0 + 0.831);
   alphaopen[b] = (double)(gauss()* 5.88 - 4.192);
   omegacoast[b] = (double)(gauss()* 1.360);
   }
for(h=1;h<=52;h++)
   {
```

```
   fscanf(fpdist1459, "%d, %f, %d, %d", &vejidper, &dist, &skovid, &vejskov);
   PATCHNO = skovid;
   TRAVDIST[g][h] = dist;
   }
for(h=1;h<=52;h++)
   {
for(b=1;b<=drawno;b++)
   {
//1997 GAUSS SIMULATION RESULTS ARE USED TO MODEL THE SITE SELECTION:
   vhigh[h][b] = (double) betacost[b]* 2.0*1.39* TRAVDIST[g][h]/1000.0+
   3.902* AGE60[h]+ deltaconif[b]* FRACCONIF[h]+ 1.295* LNSIZEF[h]- 0.539* LNCOAST[h]+
   0.279* SLOPE[h]+ 2.752* FRACWATER[h]+ gammashanspec[b]* SHANSPEC[h]
   + alphaopen[b]* FRACOPEN[h]+ omegacoast[b]* coastdum[h];

   ev[h][b] = (long double)expl(vhigh[h][b]);

   vsumhigh[b] = (long double)(vsumhigh[b] + (long double) expl(vhigh[h][b]));
   }
   }

//PRE-CHANGE INCLUSIVE VALUE:
for (b=1;b<=drawno;b++)
   {
   vsumhigh500pre[g] = (long double) vsumhigh500pre[g]+ vsumhigh[b] ;
   }
   avgvsumhighpre[g] = (long double) vsumhigh500pre[g]/drawnof;
   ivpre[g] = log(avgvsumhighpre[g]);

//POSTCHANGE INCLUSIVE VALUE:
for(b=1;b<=drawno;b++)
   {
for(h=1;h<=52;h++)
   {
   vsumhighpost[b][h] = (long double) vsumhigh[b] - (long double) ev[h][b];
   }
   }
for(h=1;h<=52;h++)
   {
for (b=1;b<=drawno;b++)
   {
   vsumhigh500post[g][h] = (long double) vsumhigh500post[g][h]+ (long double) vsumhighpost[b][h];
   }
   }
for(h=1;h<=52;h++)
   {
   avgvsumhighpost[g][h] = (long double) vsumhigh500post[g][h] / drawnof;

   ivpost[g][h] = log((long double)avgvsumhighpost[g][h]);
   }

//THE DEMAND FOR FOREST RECREATION IS ESTIMATED BASED ON THE COUNT DATA MODEL:
for(h=1;h<=52;h++)
   {
   fscanf(fppeople1459, "%d,%f,%f,%f,%f,%f,%d,%d", &vejidper, &adults, &income, &age2539, &distnear1,
   &carown, &vejskov,&skovid);
   DISTNEAR1[g][h]= (distnear1 / 1000);
   PATCHNO = skovid;
```

```
   pop[g][h] = adults;
   AGE[g][h] = age2539;
   INC[g][h] = income;
   CAROWN[g][h] = carown;

   infmod = 2.629422421 - 0.3134965600 *DISTNEAR1[g][h] - 1.954379830* CAROWN[g][h] ;
   phi = CND(infmod);

   VISITPERADULTpost[g][h]= expl((double)(-3.059097645+0.02000624623*INC[g][h]-1.078260372 *AGE[g][h]
  +0.08738025192*ivpost[g][h]))*(1 - phi);

   VISITPERADULTpre[g][h] = expl((double)(-3.059097645+0.02000624623*INC[g][h]-1.078260372 *AGE[g][h]
  +0.08738025192*ivpre[g]))*(1 - phi);
   }

//The total Post- & pre Value of Access is calculated:
for(h=1;h<=52;h++)
   {
   for(b=1;b<=drawno;b++)
   {
   if(vsumhigh[b] > 0)
   {
   if( vsumhigh[b]- ev[h][b]>0)
   {
   pohigh[h][b]=(double)expl(vhigh[h][b])/vsumhigh[b];

   novisitshighpost[h]=pohigh[h][b]* pop[g][h]* VISITPERADULTpost[g][h]/drawnof + novisitshighpost[h];

   WTPpost[h]=WTPpost[h]+(double)(log((double)((vsumhigh[b]-ev[h][b]) /vsumhigh[b])) /(betacost[b]))
  *pop[g][h]*VISITPERADULTpost[g][h]/drawnof;

   novisitshighpre[h]=pohigh[h][b]* pop[g][h]* VISITPERADULTpre[g][h]/drawnof + novisitshighpre[h];

   WTPpre[h]=WTPpre[h]+(double)(log((double)((vsumhigh[b]-ev[h][b])/vsumhigh[b])) /(betacost[b]))
  *pop[g][h]*VISITPERADULTpre[g][h]/drawnof;
   }
   }
   }
   }
}
   fprintf(fpud, "Skovid postWTP postvisits preWTP previsits \n");

for(o=1;o<=52;o++)
   {
   fprintf(fpud, "%d %f %f %f %f \n", o, WTPpost[o], novisitshighpost[o], WTPpre[o], novisitshighpre[o]);
   }
fclose(fpud);
fclose(fppeople1459);
fclose(fpdist1459);
return 0;
}
```

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