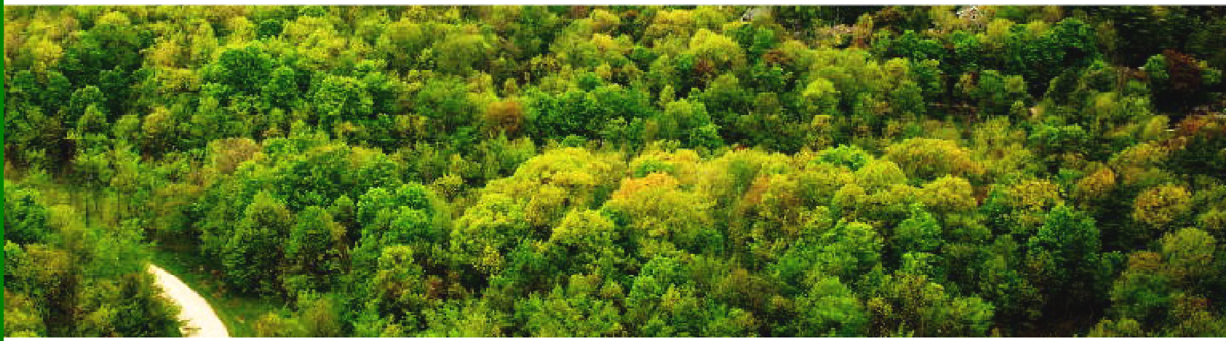

Report on national and local forest sites surveys

POLFOREX

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Spis treści

I. ON-SITE SURVEY

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General information:

The total number of interviews: **1411**
The number of forest sites: **5** (each close to a big agglomeration, the distance < 30km, in each of the chosen forest there was at least one natural reserve)
The method of interviewing: **"face-to-face", a professional polling agency**
Dates of the survey: **October and November 2009**
Interviews were carried out only with respondents who stated they came to the forest **for recreational purposes**

I.1. Descriptive statistics

I.1.1. Sites

City	Category	Number of people [1 000]	Gross monthly income [PLN]	Gross monthly income [% of the national average]	Share of unemployed people in region [%]	Share of forest cover in region [%]
BIALYSTOK	B	294	2 716	95%	5,5%	33%
LUBLIN	B	352	2 763	96%	5,7%	14%
ZIELONA GORA	A	118	2 767	96%	9,6%	49%
RADOM	A/B	225	2 557	89%	13,2%	25%
SZCZECIN	A	408	2 976	104%	7,7%	32%

A – higher social capital in terms of trust to the public institution and interpersonal trust
B – lower

City	Number of questionnaires
BIALYSTOK	296
LUBLIN	247
ZIELONA GORA	297
RADOM	292
SZCZECIN	279

I.1.2. Statistics of forest recreation in general

Q4 – What is the previous time that respondent visited any forest, N=1411

1. less than 1 week ago	23%
2. 1-2 weeks ago	21%
3. 2-4 weeks ago	16%
4. 1-2 months ago	13%
5. 2-4 months ago	7%
6. 4-12 months ago	8%
7. more than a year ago	6%
8. it's difficult to say	6%

Q5 - Number of forest sites visited by the respondent over the last 12 months, N=1406

Question	**Q5** – forests number
Mean	3
Median	2
Std. deviation	3
Min.	1
Max.	50
N	1406

Q6 – Localization of visited forest sites over the last 12 months, N

1. all of them are located in the samve voievodship	78%
2. most of them are in the same voievodship	13%
3. about half of them are in the same voievodship	5%
4. most of them are in other vioevodships	3%
5. it's difficult to say	1%

I.1.3. Statistics of the site where the interviews took place and the respondents recreation pattern in this forest

Q8 – Is the forest where the interview took place the one that the respondent visited most often over the last 12 months? , N=1392

1. yes	53%
2. no	36%
3. *"I don't know"/"it's difficult to say"*	10%

Q9 – Frequency of visits to the forest over the last 12 months – the first approach, N=1410

1. the first time	16%
2. a few times a year or more often	64%
3. once a year	12%
4. once every few years	8%

Q9.1. – Frequency of visits to the forest over the last 12 months – detailed answers of those respondents who stated they visited the forest a few times or more often over the last 12 months, N=906

Season	1	2	3	4	5	6	7	8
summer	7%	14%	24%	14%	17%	8%	13%	2%
autumn	4%	19%	25%	15%	17%	9%	9%	2%
winter	39%	19%	14%	7%	9%	4%	5%	3%
spring	15%	19%	19%	13%	14%	7%	9%	4%

1 – I don't go to the forest during this season at all
2 – once at this season
3 – once a month
4 – once per 2 weeks
5 – once per week
6 – on average 2 per week
7 – every day or almost every day
8 – *"I do not know"/ "it's difficult to say"*

Q12 – Respondents' assessment of the difficulty scale of the trip frequency question, N=1403

1 – very easy	30%
2	12%
3	12%
4	7%
5	11%
6	9%
7	8%
8	6%
9	2%
1 – very difficult	3%

Q22 – Planned frequency of trips to the forest in next 12 months, N=1403

1. more often than last year	12%
2. about the same	55%
3. less often	2%
4. *"I do not know"/ "it's difficult to say"*	31%

Q22.1. – Estimated number of the trips' increase, N=172 (N=169)

1. by 25%	27%
2. by 50%	36%
3. by 75%	6%
4. by 100% (it will be twice as high as now)	8%
5. by more than 100%	2%
6. *"I do not know"/ "it's difficult to say"*	20%

Q22.2. – Estimated number of the trips' decrease, N=34 (N=33)

1. by 25%	9%
2. by 50%	18%
3. by 75%	6%
4. I will stop visiting this forest	24%
5. *"I do not know"/ "it's difficult to say"*	44%

Q24 – Substitutes of forest in the same or shorter distance that this forest, N=1408

1. Yes	66%
2. No	19%
3. "I don't know"/"it's difficult to say"	15%

Q24.1. – Categories of substitute sites, (respondents had a multiple choice), N=937

1. another forest	75%
2. river(s)	21%
3. lake(s)	37%
4. mountains	0%
5. the sea	1%
6. other	7%

Q20 – Is this forest kind of the unique one?, N=1411

1. yes	33%
2. no	35%
3. "I don't know"/"it's difficult to say"	32%

Q20.1. – Differences between this forest and other once located in the respondent's neighborhood, (respondents had a multiple choice), N=473

1. It's older – the threes are older	18%
2. It's more biologically diversified (it has more species of trees and other plants)	35%
3. It's cleaner	27%
4. There are less tourists in it	11%
5. It's larger	23%
6. It's taken care of – broken trees and branches are being removed	13%
7. It has more mushroom	17%
8. Tourist infrasctructure (such as marked paths, picnic places) is better	35%
9. It's more accessible	21%
10. It's safer	14%
11. Other reasons	9%

Q21 – Does the respondent know about any nature reserves in this forest? (comment: in all chosen forests were natural reserves), N=1410

1. Yes	42%
2. No	15%
3. "I don't know"/"it's difficult to say"	43%

Q21.1. – Frequency of visiting the reserve, N=592

1. always	5%
2. often	18%
3. sometimes	30%
4. rarely	31%
5. I have never been there	16%

Q30 – Does the respondent agree with the following statements about the forest?, N=1410

Statments	definitely yes	rather yes	rather no	definitely no	*I don't know*
I would prefer this forest to be larger	11%	19%	41%	14%	15%
I would prefer to see more old trees in this forest	14%	26%	35%	11%	15%
I would like this forest to be more diversified, with many tree species.	17%	31%	29%	9%	13%
I would prefer to see less people here	9%	19%	42%	18%	13%
I would prefer all the dead trees to be removed	25%	35%	19%	12%	9%
I would like to see more mushroom here	48%	27%	8%	4%	13%
I would prefer to have more tourist infrastructure here: more paths, picnic places, benches, sheds etc.	28%	32%	18%	13%	9%
I would prefer the forest to be less dense, to let more light in	10%	23%	35%	14%	18%

I.1.4. Characteristics of the current visit

Q1 – Purpose (respondents had a multiple choice), N=1409

1. stroll	59%
2. watching nature	26%
3. picnic	3%
4. picking berries or mushrooms	36%
5. Nordic Walking	1%
6. riding a bike	10%
7. jogging	4%
8. other	5%

Q2 – Company during the visit (respondents had a multiple choice), N=1346

1. alone	36%
2. with children	9%
3. with a family	26%
4. with friends	30%
5. with a dog/dogs	8%

Q19 – Why this forest was chosen for a visit and not the other, N=1410

1. is the only forest close to respondent’s home/place of stay	10%
2. it is the closest forest to respondent’s home/place of stay	30%
3. it’s a habit / tradition (of respondent’s family or herself/himself)	6%
4. respondent has been to another forest last time and she/he wanted to visit this one for a change	18%
5.other people have made this choice (family, friends)	19%
6. there are other attractions in the vicinity (e.g. horse riding facilities, a lake)	4%
7. respondents simply likes visiting this forest better than other ones	4%
8. other reasons	8%

Q10 – Trip started from the respondent’s permanent residence of or the other place, N=1406

1. weekend trip (e.g. to a summer house, to respondent family’s or friends’ place)	7%
2. part of holidays outside of the respondent’s permanent residence	3%
3. trip from the respondent’s permanent residence	90%

Q10.1. – Was this forest a crucial factor for a holidays/weekend destination choice?, N=138 (135)

1. the crucial factor	12%
2. a somewhat important, but not the crucial factor	24%
3. irrelevant	64%

Q11 – Single or multi destinations trip, N=1406

1. the only reason of the respondent leaving home/the place at which she/he currently staying	62%
2. the most important reason	12%
3. one of several equally important reasons	15%
4. was a spontaneous decision made en route	11%

Q11.1. – The other destinations of the trip (respondents had a multiple choice), N=536

1. visiting family/friends	36%
2. visiting other places of outdoor recreation, such as another forest or a lake	29%
3. visiting a summer cottage	4%
4. shopping	15%
5. other	24%

Q11.3 – Time schedule for visiting other destinations, N=536 (N=555, 46-refuses)

1. before visitng the forest	38%
2. after visiting the forest	38%
3. visited some of them before and planning to visit some other afterwards	19%

Q3, **Q13**, **Q14** and **Q17** – Time on site, travel time, distance, cost

Question	**Q3** – time on site [min.]	**Q13** – one-way travel time [min.]	**Q14** – one-way distance [km]	**Q17** – stated individual cost of the round-way trip [PLN]
Mean	101	26	15	10
Median	90	20	10	5
Std. deviation	65	21	18	18
Min.	2	1	0	0
Max.	480	180	200	300
N	1392	1411	1380	1355

Q15 – Way of travelling

Respondents used travelling by particular transport modes, N=1379

1. car	53%
2. bus	7%
3. train	0%
4. motorbike	0%
5. bike	13%
6. on foot	28%
7. other	0%

Distance by a transport mode

Mode	Car [km]	Bus [km]	Train [km]	Motorbike [km]	Bike [km]	On food [km]	Other [km]
Mean	22	16	50	27	9	2	4
Median	20	11	30	20	6	1	4
Std. deviation	18	14	47	15	9	3	2
Min.	1	3	20	10	1	0,5	2
Max.	150	100	120	45	60	30	6
N	730	91	4	5	183	390	5

Q15.1. – Kind of an individual car used, N=736 (N=730)

A gasoline-fuelled car	small; engine up to 1.4 l (e.g. fiat punto, toyota yaris, renault clio)	26%
	medium; engine 1.4 to 2.0 l (e.g. ford mondeo, toyota avensis, renault megane)	30%
	large; engine over 2.0 l. (e.g. Mercedes-Benz E-class; BMW 520)	4%
A diesel-fuelled car	< 2 l.	12%
	> 2 l.	3%
An lpg-fuelled car		24%

Q15.2. – Cost of return tickets in the public transport, N=87

Ticket	Single [PLN]	Monthly [PLN]	Other (e.g. weekly, hourly) [PLN]
Mean	10	45	6
Median	5	42	6
Std. deviation	26	17	
Min.	2	2	6
Max.	20	84	6
N	71	15	1

Q16 – Source of the trip financing, N=1255

1. respondent's means	66%
2. household budget	27%
3. other people (not family members)	7%

Q18 – Does respondent prefer the trip to be shorter?, N=1410

1. yes	12%
2. no	36%
3. respondent does not care	43%
4."I do not know"/"it is difficult to say"	9%

Q18.1. – Why shorter? (respondents had a multiple choice), N=175

1. I would rather spend this time taking rest	54%
2. I would rather spend this time on my household tasks	19%
3. I would rather spend this time doing my job	1%
4. I am traveling with children and they get tired during longer trips	6%
5. I have to change the means of transportation on the way, which in inconvenient	3%
6. This trip is tiring because of trafic congestion	9%
7. This trip is tiring due to the crowds in buses etc.	6%
8. Other reasons	17%

18.2. Why not shorter? (respondents had a multiple choice), N=508

1. It is quite short anyway	72%
2. I can not see any other, more interesting ways of spending this time	6%
3. I like traveling; the trip to the forest is part of my recreation	22%
4. Other reasons	2%

Q23 – An alternative way of spending the time, if visiting the forest was not possible, N=1405

1. going to another forest.	43%
2. going to some other place close to nature (e.g. a park, a lake etc.)	22%
3. going to the theatre, to the museum, etc.	3%
4. staying at home	18%
5. doing something else	13%

I.1.5. Characteristics of the visit to the other last visited forest, different from the one, where the interview took place

Q29 – Frequency of visits to the other forest over the last 12 months, N1=1330, N2=1333, N3=N4=1326

Season	1	2	3	4	5	6	7	8
Summer	27%	27%	22%	11%	5%	2%	3%	3%
Autumn	28%	31%	20%	10%	5%	2%	2%	3%
Winter	68%	16%	7%	2%	1%	1%	1%	4%
Spring	45%	21%	16%	7%	3%	2%	2%	5%

1 – I don't go to the forest during this season at all
2 – once at this season
3 – once a month
4 – once per 2 weeks
5 – once per week
6 – on average 2 per week
7 – every day or almost every day
8 – *"I do not know"/ "it's difficult to say"*

Q25, Q27, Q28 – Distance, travel time, time on site

Question	**Q25** – time on site [min.]	**Q27** – one-way travel time [min.]	**Q28** – one-way distance [km]
Mean	39	49	118
Median	20	30	100
Std. deviation	79	73	89
Min.	1	2	5
Max.	900	720	720
N	1220	1227	1221

Q26 – Way of travelling

Respondents used travelling by particular transport modes, N=1217

1. car	68%
2. bus	6%
3. train	1%
4. motorbike	1%
5. bike	14%
6. on foot	12%
7. other	0%

Distance by a transport mode

Mode	Car [km]	Bus [km]	Train [km]	Motorbike [km]	Bike [km]	On food [km]	Other [km]
Mean	48	46	175	45	10	3	25
Median	30	15	100	20	8	2	20
Std. deviation	81	111	179	48	11	2	10
Min.	1	3	25	3	1	0,5	15
Max.	800	650	480	130	100	10	40
N	828	67	11	7	174	141	5

I.2. Ecological description of study sites

I.2.1. Lublin: the Kozłowieckie Forest and the Kozie Góry reserve

The Kozłowieckie Forest is located on the Lubartowska Plateau, which is a mesoregion of the South Podlasie Lowland. The plateau is bounded by the Lubelska Upland to the south, the Vistula River valley to the west and the Wieprz River valley to the north and east. Lublin, ninth largest city in Poland (349 500 inhabitants), is located amid farmland , and the Kozłowieckie Forest is the largest wooded area in this region, covering ca. 5500 ha. Because of the prevailing agricultural land use, only small patches of woodlands remain (mostly on the least fertile soils), covering only 23% of the Province of Lubelskie, compared with forest cover of about 29% across the whole of Poland. Poor soils and traditional management practices limit private forests to largely monocultures of Scots pine *Pinus sylvestris* containing a very low proportion of broadleaves. These forests are younger and less productive than the state owned ones.

Most of the Lubartowska Plateau is flat, but in some parts surface features include dunes (in series up to 1.5 km long), denuded plains, moraine hills, dry valleys, wind-blow hollows, and floodplains etc.. The area is covered by layers of Quaternary sediments of various thicknesses, composed of glacial Pleistocene deposits from the Würm and Riss periods along with Holocene sands. They lie on older calcareous and sandy deposits. The overlying soil cover is dominated by leached cambisols (brown soils) and podzols with narrow strips of bog, peat and gleic soils along the streams and rivers.

Polar air masses are the dominant influence on the local climate (90%), which is characterized by long, sunny summers, cold winters and moderate precipitation. According to the Romer's classification of Polish climatic regions this is defined as the temperate climate of the Great Valleys. The extensive Kozłowieckie Forest mitigates the local climate: it reduces the severity of ground frosts, extends the snow melt period, and cuts the amount of runoff water. The river network density in the vicinity of Lublin is amongst lowest in Poland. There are only four minor streams in the area of the Kozłowiecki Landscape Park and it's buffer zone. They supply water to three lake complexes: the largest is near Samoklęski village, the second in the forest at Stary Tartak and the smallest in Nowy Staw, which is expected to be developed for touristism. The hydrology and water quality of the region has deteriorated over the past few decades. This has been linked to a general trend towards lower groundwater levels and may be driving changes in the species composition and structure of local forest communities.

The Kozłowieckie Forest is located in the VI Region (Masovia and Podlasie), 5th Province of Siedlecko-Łukowska Plateau, on the official map of Polish forested regions. Accordingly, the geobotanical regionalization system, puts this area on the Lubartowska Plain.

In 1990, the Kozłowieckie Forest was included in the Ecological System of Protected Areas in the Lubelskie Province, covering over 90% of the Kozłowiecki Landcaspe Park. Much of the forest has a near-natural species composition. The prevailing forest types are mesic and moist pinewoods, accompanied by mixed oak-pine stands, but there are also patches of marshy coniferous forest, thermophilous oakwoods, dry pinewoods, riverine alder carrs and riparian forests in the Minina and the Krzywa Rzeka valleys.

Scots pine is the dominant species with admixture of pedunculate oak (*Quercus robur*), silver birch (*Betula pendula*), aspen (*Populus tremula*) and occasionally small-leaved lime (*Tilia cordata*), hornbeam (*Carpinus betulus*) and Norway spruce (*Picea abies*). Sessile oak (*Quercus sessilis*), also grows here close to the border of its natural range, forming characteristic mixed stands with other broadleaf's.

Species richness of the ground flora in the forest, in clearings, peatbogs and wet meadows is quite high and many rare or protected plants are present. Examples of the most interesting species are: southern adderstongue *Ophioglossum vulgatum,* rough horsetail *Equisetum hyemale,* stiff clubmoss *Lycopodium annotinum,* bog-rosemary *Andromeda polifolia,* mezereon *Daphne mezereum,* common ivy *Hedera helix,* Turk's caplily *Lilium martagon,* Jacob's ladder *Polemonium caeruleum,* monkshood *Aconitum variegatum,* common twayblade *Neottia ovata,* southern holy grass *Hierochloë australis,* and bastard balm *Melittis melissophyllum.*

Over fifty nesting and migrant bird species are present among the local forest fauna. These include, for example, the white-backed woodpecker *Dendrocopos leucotos* and the black stork *Ciconia nigra* which are extrememly rare in Poland. There are numerous mammals; ungulates, include both native species e.g. moose *Alces alces,* and introduced species, e.g. fallow deer *Dama dama;* small carnivores and rodents, insectivores and a few bat species), amphibians and reptiles, including the European pond turtle *Emys orbicularis* in the

Minina valley. The invertebrates from this area have only been partially investigated, but already numerous representatives of protected species are present, such as beetles from *Calosoma* and *Carabus* genus, bumblebees (*Bombus*) and many butterflies.

In 1958, the Kozie Góry natural reserve was created in the eastern part of the forest complex on the area covering 41,04 ha. The reserve was designed to conserve the forests with significant share of sessile oak in a near-natural state for environmental reasons and scientific purposes. Individual sessile oaks in the reserve are 120-150 years old. Pinewoods and mixed pine-oak stands in the reserve have been shown to support 14 species of trees, 6 – shrubs, 91 – herbs and 12 –bryophytes. Four species are under strict protection, the southern holy grass *Hierochloë australis;* bird's-nest orchid *Neottia nidus-avis;* Turk's caplily *Lilium martagon;* and bastard balm *Melittis melisophyllum,* and three more are partially protected. The fauna in the reserve is typical of large forests with high horizontal and vertical heterogeneity.

Since the Kozie Góry reserve was created, some of its component forest communities have disappeared, namely: thermophilous oakwoods, lime-oak-hornbeam forest and mesic pinewoods. Vigorous growth of understorey plants also hampers natural regeneration of sessile oak. In particular, chee reedgrass (*Calamagrostis epigeios*), lily of the valley (*Convallaria mailis),* and some synanthropic species e.g. nettle *(Urtica dioica)* and common hemp-nettle (*Galeopsis tetrahit*) have flourished and spread in the reserve.

The location of the Kozłowieckie Forest, several kilometers north of Lublin (ca. 350.000 inhabitants) and close to Lubartów (23.000 inh.), makes this area popular among the local population as a base for recreational activities and short tourist visits. Besides regular tourist trails, a network of bicycle routes of total length ca. 30 km has been created. Trails are marked with appropriate pictograms and lead tourists into the most interesting places in the forest like the Kozie Góry reserve, a settlement called Stary Tartak (The Old Sawmill); Kozłówka village and lakes. Environmental education is run from the local forestry headquarters and on the educational path “Kopanina”. This path is 2 km long and has been equipped with 14 boards describing the forest ecosystem and points of interest.

As mentioned above, the forest is a popular destination since it is easily accessible amid an attractive landscape. This causes the area to be intensively utilized by people, particularly at weekends and during the wild berries and mushroom picking seasons.

I.2.2. Radom: the Kozienicka Forest and the Jedlnia reserve

The Kozienicka Forest is situated in Central Poland, north-east to the city of Radom (about 223.500 inhabitants). It covers the area of 30500 ha. According to the geographical regionalization of Poland, its northern part belongs to the Kozienicka Plain (a mesoregion within the Central Masovia Lowland), and southern and central parts are assigned to the Radomska Plain (a mesoregion of the South-Masovia Hills). Both mesoregions have similar geology: they are a denudation area with a degraded cover of the Quarternary sediments on the Jurassic and Cretaceous units dipping towards the north-east. The Kozienicka Plain is covered by eolic sands with dunes and boggy depressions between them, while on the Radomska Plain moraine hills with loamy sands cover and with distinct valleys of the streams filled with alluvial sediments and peat are met. Describing a soil cover of the forest, one might distinguish a more fertile central part with a significant share of cambisols and the peripheries dominated by podzols. In general, thirteen types of phytogenic, autogenic, semihydrogenic and hydrogenic types of soil are present. The forest is an enclave of longer vegetation period compared to its surroundings. Mean annual temperature and precipitation are also higher.

The Kozienicka Forest is located in the catchment of two main rivers: Vistula and Radomka, the drainage pattern is quite well-developed and diverse. The central and western part belong to the basin of the Zagożdzonka river (the left-side tributary of Vistula) which valley is considered one of the most picturesque places of the region. In the northern part, surface water is less abundant than in the southern one which has a dense network of watercourses and (despite the intensive drainage) is partially moory. There are no large natural water reservoirs in the area, but some oxbow lakes are present. They are former meanders cut off the VistulaRiver.Some of the ponds in the forest are flooded peatbogs or anthropogenic reservoirs, e.g. the complex of fish-ponds in the villages of Grądy, Bąkowiec or Jedlnia-Letnisko. Some of the minor reservoir have been built by the foresters during several last years on the basis of so-called the small retention programme. Its goal is to re-establish a proper water balance in the locations where it was previously disturbed.

Historically, this region is a part of the former vast Radomska Forest which covered the area between the rivers: Pilica in the north, Vistula in the east and two small rivers: Iłżanka and Szabasówka in the south and west. Situated by the main route connecting Vilnius and Cracow, the Kozienicka Forest became a traditional royal hunting ground of the Jagiellonian Dynasty. In 1387, on the request of Polish King Władysław Jagiełło, a hunting manor house was built in the village of Jedlnia. Since the XVI century, hunting was of minor importance – bee-keeping and timber production became the main economic use of the forest. In the end of the XVIII century, a first forest management plan by Karl Mehling was created. It was very much alike present-day meaning of such document: contained the description of the forest resources and the cutting plan. Its goal was to improve the condition of the stand after a wasteful exploitation in the Saxon period. The present forest resembles very much this from the XVIII century in terms of the area covered, but is far more fragmented.

The Kozienicka Forest is an area of an extraordinary diversity of species and habitats. Scots pine *Pinus sylvestris* dominated stands cover about 84% of the area and this species is present in two forms with a different bark pattern. The most important admixtures are: pedunculate and sessile oak *Quercus robur* and *Q. petraea* (5.5%), black alder *Alnus glutinosa* (4.5%), silver fir *Abies alba* (3.2%), silver and downy birch (2%). Other species like aspen *Populus tremula,* hornbeam *Carpinus betulus,* common ash *Fraxinus excelsior*, wild cherry *Prunus avium,* Norway spruce *Picea abies*, European larch *Larix decidua,* sycamore maple *Acer pseudoplatanus*, European beech *Fagus sylvatica* and European yew *Taxus baccata* are of minor share. Three species: silver fir, European beech and sycamore maple reach the northern border of their continuous range here. The mean age of the stand is 57 years, old-growth forest constitute 10% of the total forest area.

A characteristic and unique community is so called the highland fir-dominated mixed forest (*Abietetum polonicum*). About 10% of the area is covered by subcontinental type of oak-lime-hornbeam forests *Tilio-Carpinetum* growing here on full moisture-scale of its sites. On the moist and most fertile sites, a variety with hedge woundwort *Stachys sylvatica* or fumeworts *Corydalis* sp. creates a mosaic with riverside alder and ash forest. On drier sites, a typical form of oak-lime-hornbeam forest is displaced by the variety with rough small-reed *Calamagrostis arundinacea.* There are also patches of interesting form with a share of white fir in the stand *Tilio-Carpinetum abietetosum.* Along the permanent and seasonal watercourses alder and ash forests develop, with ostrich fern*Matteuccia struthiopteris* in the understorey. Amongst the sites of coniferous stands, there are small patches of EU-protected dry pinewoods *Cladonio-Pinetum* with over-ground cup-lichens (*Cladonia* sp.) and pinewoods on swamps *Vaccinio uliginosi-Pinetum.* There are also fragments of floristically rich thermophilous oakwoods *Potentillo albae-Quercetum*, but the succession processes lead to their conversion into oak-lime-hornbeam forests. Another valuable communities are black alder stands accompanying the water-heads, with large bittercress *Cardamine amara* and dog's mercury *Mercurialis perennis*in the understorey and ash dominated forest with elms *Ficario-Ulmentum minoris.* Unfortunately, despite the well-preserved understorey, species composition of the stand is often strongly altered.

Non-forest habitats cover a relatively small area but this group is very much diversified. In the southern part of the Kozienicka Forest, there are mainly peat-bogs with bryophytes and sedges, and the presence of the alkaline moors should be emphasized. Amongst grass communities, extensively used meadows (fresh ones and of seasonally changing water regime) are also of a significant value. In the northern part, patches of grey hair grass *Corynephorus canescens* swards grow on dunes.

Due to the diversity of habitats, local flora is very species-rich. Until present, over 600 vascular plant species has been noted, including 65 legally protected taxa. They are represented by inter alia: mezereon *Daphne mezereum*, common ivy *Hedera helix*, wolf's-foot and stiff clubmoss *Lycopodium clavatum* and *L. annotinum*, ramsons *Allium ursinum*, eastern pasqueflower *Pulsatilla patens*, globe-flower *Trollius europaeus,* inundated clubmoss *Lycopodiella inundata.* Amongst about 230 lichen species, 144 taxa are rare in Poland. Four of them (lungwort lichen *Lobaria pulmonaria*, and three usnea species: *Usnea filipendula*, *U. hirta* and *U. subfloridana*) have the protection zones established. We can also talk about an extraordinary diversity of bryophytes (94 species, 24 legally protected) and algae (about 110 species). Amongst about 300 species of fungi, 44 taxa are listed on the "*The Red List of Fungi Species Threatened in Poland*". Six taxa are under strict protection, namely: beefsteak fungus *Fistulina hepatica*, *Hericium flagellum* and *H. corralloides*, giant puffball *Langermannia gigantea*, shingled hedgehog *Sarcodon imbricatus* and cauliflower mushroom *Sparassis crispa*.

Fauna of the Kozienicka forest is also exceptionally diverse. There are at least 45 mammal species present. The largest animals here are ungulates: moose *Alces alces*, red deer *Cervus elaphus,* wild boar *Sus scropha* and roe deer *Capreolus capreolus.* Small carnivores are also abundant, and migrating wolf *Canis lupus* has been noted several times. 32 species are under strict, and 6 under partial legal protection. The local population of fat dormouse *Glis glis*shows one of the highest densities in Poland. In 1991, European beaver *Castor fiber* was successfully reintroduced. Now its population is stable, sharing habitats with European otter *Lutra lutra.* The Kozienicka Forest is known for the bats living here and is placed amongst the most bat-abundant areas in Poland. Amongst 14 species occurring, several rare ones were noted, inter alia lesser noctule *Nyctalus leisleri*, parti-coloured bat *Vespertilio murinus*, Northern bat *Eptesicus nilssonii*, Brandt's bat *Myotis brandtii*, and Bechstein's bat *Myotis bechsteinii.* The Western barbastelle *Barbastella barbastellus* has its winter roosts here, and Turing summer also young individuals were found. Avifauna is also very species-rich, amongst about 160 bird species noted 148 are strictly and 6 – partially protected. The examples are: lesser spotted eagle *Aquila pomarina*, Eurasian hobby *Falco subbuteo*, black stork *Ciconia nigra*, crane *Grus grus*, stock dove *Columba oenas*, nightjar *Caprimulgus europaeus,* dunnock *Prunella modularis*, or European penduline tit *Remiz pendulinus*. There are 13 species of amphibians and 6 reptiles, including European pond terrapin *Emys orbicularis,* extremely rare in Poland. Due to various habitats available, richness of insect species is also remarkable. A critically endangered hymenopteron *Parnopes grandiori* or a butterfly (a clearwing moth) *Synanthedon loranthi*are only two examples of thisgroup. Also numerous extremely rare coleopterons from *Buprestidae, Cerambycidae* and *Cleridae* families have been noted.

The Kozienicka Forest is managed by three Forest Inspectorates (Radom, Zwoleń and Kozienice), grouped together in 1994 to establish so called the Forest Promotional Complex "Kozienicka Forest". In 1983, based on the parts of the forest the Kozienicki Landscape Park was created, later in 2001 it was enlarged to protect the whole area. The forest itself with its broad buffer zone has been also included into the EU Natura 2000 Network as the Special Protection Area "Kozienicka Refuge" PLB140013 under the Birds Directive 79/409/EEC covering 68 301 ha. Smaller area (28 230 ha) is covered by, overlapping part of the SPA, Special Area of Conservation "Kozienicka Forest" PLH140035 established under the Habitats Directive 92/43/EEC. In total, 3 830 ha of habitats listed on The Appendix I of the Habitats Directive have been noted here. Both these areas are connected in the east with the Special Protection Area "Middle Vistula Valley" PLB140004.

The most valuable ecosystems are protected as fifteen nature reserves, one of them is the Jedlnia reserve covering 86,42 ha, located near Radom. In 100-200 years old stands, Scots pine is the main species with an admixture of silver birch, silver fir, pedunculate oak and hornbeam. Large parts are covered with natural regeneration of these species, there are also some patches with young beech trees planted. The major value of the reserve are old pine trees reaching the age hardly met outside the reserve. Numerous protected plants are present in the understorey, e.g. sanicle *Sanicula europaea*, common lungwort *Pulmonaria angustifolia* or a sedge *Carex montana*. The largest sycamore maple tree in the forest grows in the reserve, on the shore of the reservoir in the village of Jedlnia-Letnisko. The reserve is also a war memorial – there are seven common graves located in the places where 450 civilians were killed by the Nazi during the World War II. There's a educational path enabling the visitors to discover the reserve.

Due to its unique values and good accessibility, the Kozienicka Forest is of a great importance not only for the Kozienice and Radom Districts, but also for the whole southern Masovia. It is also only about 1 hour trip from Warsaw. Local Forest Inspectorates and the Centre for the Environmental Education and European Integration in Jedlnia-Letnisko prepared a well-developed infrastructure for education and tourism. Numerous research conducted here and papers published in academic centers in Poland indicate a key role of the Kozienicka Forest as an important scientific field.

I.2.3. Białystok: the Knyszyńska Forest and the Krasne reserve

The Knyszyńska Forest is a large (ca. 114.000 ha) forested area to the north and east of Białystok (approx. 294.700 inhabitants). It can be divided into several historical areas, e.g. The Błudowska, Sokólska or Supraska Forest. These from a forest complex with scattered human settlements, located mainly on its edges and along the rivers. Small villages are surrounded by meadows, pastures and farmland. Supraśl and Czarna Białostocka are the biggest towns in the area.

According to the map of Polish forest regions, the Knyszyńska Forest is located in the North-Podlasie Lowland and it is comprised of two mesoregions: the Białostocka Plateau and part of the Sokólskie Hills. Part of the belt of postglacial plains, the Białostocka Plateau was formed during the Warta glaciation (Riss). It's characterized by a diverse relief with many fluvioglacial features (including kames, kame terraces and numerous glacial meltwater forms), considerable height differences (several dozen of meters) and steep slopes (inclinations up to 30°). Thickness of the most recent Quaternary cover varies from 130 to 220 m. Local depressions and river valleys are filled with the Holocene sediments (sands, loams, fluvial gravels, and peat).

The first continuous water level appears on the depth 0 to over 20 m and usually reflects the shape of the surface. In the valleys of minor streams and meltwater forms this is typical groundwater of low efficiency, with a water table from about 1 - 2 meters (close to the edges of the valleys) deep. Within the plateaus, the first water table depth is 2-5 m, increasing to over 15 m on the hills. Abundance of natural water outflows is one of the most distinctive features: 450 water-heads, effusions and bog-springs are noticed. Besides numerous streams and minor rivers, the most important watercourse is Supraśl with its tributaries. About 20% of the area has a hydrogenic character (of which half is peat-covered).

Local climate is characterized by short vegetation period, long-lasting snow cover, ground-frosts occurring in late spring and early fall, rainfalls mostly during summertime and prevailing western winds. Annual amplitude is very high (22 °C), while mean annual temperature is relatively low (7°C).

Today the Knyszyńska Forest is remains of the forest that, in the past, covered a vast area on the both sides of the Kingdom of Poland and the Grand Duchy of Lithuania border. The colonization process of this area intensified in between the XVI and XVII century, and resulted in turning a large part of the forest into farmlands. In that time, timber harvesting intensity was low enough to allow natural regeneration of the stand, but in the XIX century large scale wood exploitation started together with artificial planting of trees. To picture the scale of resources grabbing: in the period 1815-1918, area of 10.000 ha was clearcut. Production oriented forestry dominated until 1970s, and lead into a major shift in structure, functions and species composition of forest communities. Nowadays, secondary communities occupy as much as 88.3%, while the oldest tree-stands representing natural communities (of 100 - 120 years of age) cover only 11.7% of the area.

Despite the history outlined above, some fragments of the forest has kept their primeval character. This ranks the Knyszyńska Forest amongst the most valuable natural areas in Poland. The coherent forest complex is cut by agricultural used river valleys and glades. A mosaic landscape of its surroundings is dominated by extensive agriculture, also numerous peat bogs are present. The forest itself with its subboreal character resembles south-western taiga.

On the mineral soils, coniferous stands prevail. The most abundant forest community is spruce-dominated *Carici digitatae-Piceetum*, but also other types of coniferous and mixed stands occupy a significant area. On the most fertile sites, lime-oak-hornbeam forest developed, covering about 30% of the total forest area (subcontinental *Tilio-Carpinetum* – 20% and thermophilous *Melitti-Carpinetum* – 10%, mainly in central part). Forest communities on hydrogenic types of soil develop mainly in the northeastern and northwestern part of the Knyszyńska Forest, being a part of a well-preserved marshy landscape. Main tree species in the forest are: Norway spruce *Picea abies* (over 30%), Scots pine *Pinus sylvestris* (21%), pedunculate oak *Quercus robur* and birches *Betula pendula* and *B. pubescens* (app. 9% each), black alder *Alnus glutinosa* with admixture of hornbeam *Carpinus betulus,* common ash *Fraxinus excelsior*, aspen *Populus tremula*, small-leaved lime *Tilia cordata* and Norway maple *Acer platanoides*. A local ecotype of Scots pine is well known for its characteristics: remarkable height (up to 40 m), a high based crown, a straight and knot-free trunk and wood of high technical properties.

So far, 837 vascular plant species have been noticed here (with a significant share of boreal and mountain taxa). They belong to 391 genera and 91 families. 89 species are protected by law (of which 73 are under strict protection), 7 species are mentioned in the Appendix II of the UE Habitat Directive 92/43/EEC. One of them is hairy agrimony *Agrimonia pilosa* (one of the biggest Polish populations of this rare species). This area is also a mainstay of a glacial relict – leatherleaf *Chamaedaphne calyculata*, growing here on two out of several known locations in the entire country. Henriette's plant *Dracocephalum ruyschiana* and star gentian *Swertia perennis* are another examples of strictly protected, rare and endangered plants.

A knowledge of local fauna seems to be still insufficient. It is typical for the Northern European Lowlands. An assemblage of ungulates consists of all native species: red deer *Cervus elaphus*, roe deer *Capreolus capreolus*, moose *Alces alces*, wild boar *Sus scropha* and European bison *Bison bonasus* - one out of five free-ranging herds in Poland. The presence of large predators (wolf *Canis lupus* and lynx *Lynx lynx*) and number of birds typical for old, vast forests (like eagle owl *Bubo bubo*) indicates the natural character of the fauna. Among small mammals, seven species are legally protected and five are very rare in Poland, e.g. common and forest dormice (*Muscardinus avellanarius* and *Dryomys nitedula*). The Knyszyńska Forest is one out of two present, located in Poland, habitats of an extremely rare butterfly - false eros blue *Polyommatus eroides.* Avifauna is also remarkably reach – 154 species: at least 101 breeding in the area, 38 of them mentioned in the Appendix I of Birds

Directive (79/409/EEC). Thus, the Knyszyńska Forest has been recognized as The Special Protection Area PLB200003 in The Natura2000 Programme, moreover – it's a refuge of international importance (no. E28). This area is a significant breeding site for Tengmalm's owl *Aegolius funereus*, hazel grouse *Bonasa bonasia*, woodpeckers: three-toed *Picoides tridactylus* and white-backed *Dendrocopos leucotos*, red-breasted and collared flycatcher *Ficedula parva*, *F. albicollis*, honey buzzard *Pernis apivorus* and lesser spotted eagle *Aquila pomarina*.

In order to protect the unique values of the Knyszyńska Forest various forms of nature protection have been created: 21 nature reserves, the Knyszyńska Forest Landscape Park (covering 74.447 ha plus 52.255 ha of buffer zone it is the largest landscape park in Poland) and two protected landscape areas. It's also protected on basis of the UE Habitat Directive (92/43/EEC) as the Special Area of Conservation PLH200006.

One of the reserves is created in 1990 the Krasne Reserve (85,22 ha) in southwestern part of the complex. It protects natural, well-developed forest communities, mainly coniferous and mixed stands that aretypical for the area. There's also a water-head with a stream flowing out of it. 271 plant species have been recorded here: 9 trees, 16 shrubs, 202 herbacious vascular plants and 44 bryophytes. Among them, 10 species are protected (7 – strictly, e.g. very rare orchid lesser rattlesnake plantain *Goodyera repens*). Scots pine, Norway spruce and alder, with admixture of pedunculate oak, aspen, European larch, crack willow, downy birch and small-leaved lime are the most important tree species here. There are six forest associations in the reserve, the most important is spruce and pine dominated *Carici digitatae-Pinetum* (80% of the reserve's area) in two types, depending of soil fertility. Good natural regeneration of spruce, the presence of numerous mesotrophic species in the understorey and poorly developed shrub layer are the most important features of this forest type. There are also patches of other types: lime-oak-hornbeam (in northern part of the reserve), marshy coniferous forest (in local depressions), alder carrs (mainly in southern part) and on the poorest sites with deep water level – pinewoods with dwarf shrubs and mosses in the understorey.

The Knyszyńska Forest is an attractive area with numerous hiking tracks, and about 400 km of different kind of trails are present, both on land and rivers. The longest, green-marked bicycle trail (149,5 km long) is planned to become the main axis of the whole integrated system of bicycle roads in the forest. The main horse riding trail is 120 km long.

This area is also known amongst canoeing lovers – over 100 km of water trails are available on Supraśl and Sokołda rivers. An old narrow-gauge railway is also used for touristic purposes. Due to long lasting snow cover and good accessibility, this area is popular for cross-country skiing. There are numerous educational paths equipped with proper infrastructure, like information boards etc. marked in the forest. Other facilities for environmental education are alsoavailable, amongst them an arboretum, managed by State Forests (Supraśl Forest Inspectorate) in the village of Kopna Góra. It has a forest park character and presents about 500 species and varieties of native and exotic species of trees and shrubs. Broad information about tourist attractions and infrastructure available on the Internet and numerous publications, attracting people to the Knyszyńska Forest as well.

I.2.4. Zielona Góra: the Zielonogórskie Forests and the Zimna Woda reserve

Forests surrounding Zielona Góra, a city in the Lubuskie Province in western Poland with about 117.500 inhabitants, so called the Zielonogórskie Forests cover a vast, continuous forested area. They are connected with Dolnośląskie (Lower-Silesian) and - along Odra river – with Lubuskie Forests. In accordance with the geographical regionalization of Poland, they are located in two mesoregions: the Czerwieńska Plateau, the Zielonogórski Rampart and the Nowosolskie Depression. They represent different forms of a young glacial landscape. The Czerwieńska Plateau is a moraine hilly area (max. altitude 134 m asl) with numerous kame terraces, raised above the neighbouring valleys. The Zielonogórski Rampart (max. altitude 221 m asl) has glacitectonical origins: it's a frontal moraine finally formed during the Vistula and Odra glaciations (Würm and Riss) It is directed to the west – east and is characterized by significant height differences, up to 100 m. The Nowosolskie Depression is a typical ice marginal channel going down towards the east, with sandy bottom and numerous water-logged hollows.

The surroundings of Zielona Góra belong to the climatic region of the Great Valleys with a strong influence of oceanic air masses. Warm air flowing from the west influences the climate elongating the vegetation period (about 220 days) and shortening the snow-cover duration (62 days a year) while the mean annual temperature is 8,1°C. Winds from the west and north-west prevail. Numerous hills, sandy soils (brunic arenosols are the most abundant) and high forest cover rate create a specific microclimate with moderated thermal differences between seasons. Hilly parts of the region are well insolated and aerated, no thermal inversion occurs. At the same time, the valleys of Odra and smaller rivers and streams and places with high a groundwater level are characterized by higher air humidity and higher incidence of radiation fogs.

Local forests are managed by two forest inspectorates: Przytok and Zielona Góra, both having similar environmental characteristics. Forests cover about 48% of their area while the average forest cover rate of Poland is 29%. Most of them are coniferous and mixed ones, more fertile sites are located mostly along the watercourses and where moraine clays appear on the surface. Scots pine *Pinus sylvestris* is a dominant species in stands growing on the oligotrophic sites (share approx. 80% in the whole area), while the share of broadleaves (oak *Quercus robur* and *Q. sessilis,* birch *Betula pendula,* ash *Fraxinus excelsior* and other) is relatively low. Vast, continuous pinewoods are of great importance as a migration corridor and for soil and water protection, but at the same time they are of minor value in terms of floristic and faunistic diversity.

Fauna of the Zielonogórskie Forests is relatively poorly investigated, most of the available studies relate to the Odra Valley (mainly concerning birds) where most of over 150 species from the whole region were noted. Amongst other vertebrates, about 35 mammals (15 of them legally protected), 14 amphibians and 5 reptiles were noted, including extremely rare European pond turtle *Emys orbicularis.* The larges forest animals here are common species of ungulates: red deer *Cervus elaphus,* wild boar *Sus scropha* and roe deer *Capreolus capreolus.* No large carnivores were noted recently.

The major part of the Odra Valley, surrounding vast pinewoods on the east and north, has been taken under protection as a part of the Natura 2000 network. One of the Special Areas of Conservation is “Kargowskie Zakola Odry” (the Kargowskie Meanders of Odra) PLH080012. It’s a very diversified area located on a floodplain terrace with a mosaic of alluvial forests and diffent types of meadows, rushes, sedge bogs and old river-beds. It’s dominated by oak-elm-ash (*Ficario-Ulmetum*), willow and poplar riparian forests and ash-alder stands (*Salicetum albo-fragilis, Populetum albae, Alnenion*), fresh meadows (*Arrhenatherion elatioris*) and *Cnidion dubii* alluvial meadows. Well-developed riparian forest cover nearly 35% of the SAC. In total, 8 habitat types from the Appendix I of Habitats Directive 92/43/EEC were listed here (58% of the area). Another Special Area of Conservation, “Nowosolska Dolina Odry” PLH080014 (the Odra Valley near Nowa Sól) has a similar character. It’s one of the best preserved natural parts of the Odra Valley with regularly flooded forests, riverine bush, sedge bogs and wet meadows. 10 types of habitat types from the Appendix I of Habitats Directive cover as much as 77% of the SAC’s area. On the basis of the Birds Directive 79/409/EEC, the Special Protection Area called Middle Odra Valley (PLB080004) has been established. Both SACs mentioned above overlay a part of this large SPA. It's a breeding area of numerous rare or protected birds (at least 22 species listed in the Appendix I of the Birds Directive are present), inter alia: red and black kite (*Milvus milvus* and *M. migrans*), honey buzzard *Pernis apivorus,* grasshopper warbler *Locustella naevia*or European penduline tit *Remiz pendulinus.* There are also noticeable populations of corncrackes *Crex crex* and garganey *Anas querquedula.*

The smallest area of the Natura2000 project in the region is SAC "Zimna Woda" PLH 080062. This site, located south to Zielona Gora, is also a nature reserve. The area was already protected before World War II, and that time it was named "The Cold Water" ("Kalte Wasser") along with the name "Aleja Prezydencka"("Präsidentallee" = "The President's Alley") - the causeway dividing forest compartments originated. The reserve was re-established in 1958 on 32 hectares, and since 1989 it has covered 88,09 ha. It's located mainly on a lowmoor, only northern part is covered by eolian sands with podzolic soils. The prevailing habitat (and at the same time the main object of protection) is ash and black alder forest with some old ashes up to 35 m high. There are also patches of alder carrs and marshy mixed coniferous stands, especially in the spots the peat was exploited. Northern part of the reserve is dominated by fresh mixed coniferous and broadleaved stands, with a significant share of Scots pine.

Most of the reserve is periodically flooded, but even when water level drops several permanent brooks remain. There are a few punctual water outflows in the central part, and ponds in former peat excavation hollows in the east. During last several years, a general trend of groundwater level drop has been observed, resulting in changes in local flora.

Over 230 species of vascular plants have been noticed here, which is not a very high number taking into account the reserve's area. The most interesting plants here are: submountain species: broad leaved chervil *Chaerophyllum aromaticum* and several taxa rare in the region, e.g. lady's mantle *Alchemilla propinqua,* manna grass *Glyceria nemoralis*(near the water outflows), redvein dock *Rumex sanguineus*and spotted St. Johnswort *Hypericum maculatum.* In the northern part of the reserve, a invasion of alien small balsam *Impatiens parviflora* has been observed in the understorey. Amongst the animals, numerous of taxa considered to be indicators of good forest condition are present. These are e.g. different coleopterons and birds. Due to the fact of a significant species and structural diversity of the forest, the avifauna is relatively rich: 38 nesting birds, including 4 species protected on the basis of the Birds Directive. Examples of the rare species nesting here are: common kingfisher

Alcedo atthis, black woodpecker *Dryocopus martius,* middle spotted woodpecker *Dendrocopos medius,* black stork *Ciconia nigra* and common crane *Grus grus.*

There is a blue-marked touristic trail crossing the reserve ("The President's Alley" is it's part) which enables the visitors to observe the riparian habitats so much distinct from the pinewoods dominating around and enjoy the impressive ash trees. Thanks to the good location of its ends, one in Zielona Góra and second one easy to access by public transport means, the trail and the reserve are popular amongst the visitors.

Touristic values are considered to be a great advantage of the region. A diverse relief, a forest-dominated landscape and an abundance of wild berries and mushrooms attract not only local inhabitants, especially during summer and autumn. People interested in active recreation will find a network of special Nordic-walking trails..The Zielonogórski Rampart is the first region in Poland, where such an offer has been prepared and the first Open Nordic-walking Championship of Poland took place here in 2009. One of the popular places, where the environmental education is provided, is an arboretum in Nietkowo village located by the old river-bed, near the headquarters of the Zielona Góra Forest Inspectorate. It's not sure who established the arboretum in the late XIX century. According to German sources, it was the owner of nearby estate in Czerwieńsk town (former Rothenburg) . According to Polish post-war sources it was started by the Spaeth's Tree Nurseries as an exhibition for demonstrative and marketing purposes. The arboretum is recognized as a historical monument. Despite the serious damage during the great flood in 1997, when about 220 trees died as a result, it's still a very popular place amongst local people.

I.2.5. Szczecin: the Bukowa Forest and the Źródliskowa Buczyna reserve

The Bukowa Forest, covers an area of *ca.* 7.600 ha, and is situated next to the southern limits of Szczecin, the main city of West Pomerania. It is refered to as the south-western part of the Szczecin Lowland, in a mesoregion called The Bukowe Hills, according to the official map of Polish forest regions. The forest sits in quite a distinctive range of morraine hills bordered by the Lower Odra valley and the Goleniowska plain.

It holds a great diversity of relief resulting from its complicated underlying geological structure. Various young glacial forms cover older strata. Significant (exceeding 200 m) denivelations of pre-Quaternary sediments at the surface are an effect of intensive denudation and erosion in the past. These processes were strongly connected with vertical movements of the Earth's crust and translocation of the rock masses. During the Pleistocene, glaciers approaching from the north further complicated the geology, disturbing and displacing the Tertiary and Mesozoic (mainly upper Cretaceous) formations. Xenoliths found in deposits from the Odra glaciation (Riss period) can even reach the size of 60-70 m. The sediments brought during the Vistula glaciation (Würm) cover the Bukowe Hills with a thin and non-continuous layer. They contain xenoliths mixed with older glacial tills. This region was characterized by the exceptional accumulation of erratic boulders. This resource used to be intensively exploited in the XIX century as a material for construction of the cobbled roads which still exist until today. Ten of about seventy boulders larger than 2 m in circumference have been recognized as nature monuments.

The main ridge of the Bukowe Hills (the highest peak: Bukowiec, 149 m asl) is a local watershed. Due to limited water-holding capacity, this area is unable to sustain a continuous level of shallow groundwater. Numerous streams flowing in deep valleys are mainly supplied with water that accumulates in local hollows on the plateau during rainfall events, they seldom flow out from head-waters- located on slopes. The Polish names of some streams e.g. Ponikwa and Utrata, reflect their transient nature being derived from their habit of disappearing through the squamous arrangement of the geological layers. The main streams of the Bukowa Forest are: Chojnówka, Rudzianka and Kłobucki Potok.

In the past, water flowing out of melting glaciers created a network of deep ravines and valleys cut into the slopes of moraine hills. Those places where the subsoil is impenetrable to water, mainly undrained water-logged hollows, often fill with peat. There are 13 lakes in the vicinity of the Bukowa Forest, the largest being the Binowskie (52.4 ha) and Glinna (75.6 ha). The lakes are inter-connected by a system of watercourses with numerous small ponds. There is also Szmaragdowe Jezioro (The Emerald Lake) (2.6 ha) a man-made lake, created in 1925, when one of the local limestone quarry was flooded. Its water has characteristic blue and green tint due to high calcium carbonate content from the Cretaceous limestone.

The area around Szczecin has a mild and humid climate; with relatively cool summers, mild winters and low annual monthly-temperature variation. The amount of rainfall and its annual distribution is typical for a weak oceanic area. The air humidity is increased by the presence of large reservoirs, rivers and forests, thus precipitation is higher here than in surrounding areas.

The oldest signs of sporadic human colonization date back 8-10.000 years B.C. But not until the XII century, when the Cistercian Order was established in this area, was the environment significantly modified from natural conditions (connected with development of the agriculture). The land was partially deforestated and the remaining woodlands were used as wood-pasture. In the XVI century, after the order had been dissolved and its estate secularized, the intensity of human influence decreased allowing partial regeneration of the forest. From the second half of the XIX century the Bukowa Forest was again intensively exploited, and it was only 1958 when a new management regime was put in place to protect forest resources from further exploitation.

Since 1981 this area has been protected as the Szczeciński Landcape Park, Bukowa Forest, covering about 9.000 ha (plus a buffer zone of nearly 12.000 ha). Together with adjoining forests (Goleniowska F. and Wkrzańska F.), it became a part of the Forest Promotional Complex “The Szczecińskie Forests” in 1996. Nine years later, it was designated a Special Area of Conservation “The Bukowe Hills” PLH 320020 under the EU Habitats Directive. The most precious and well-preserved fragments of the forest are protected as seven nature reserves of total area over 560 ha. The forest is administrated by the State Forests – Gryfino Inspectorate, only north-western part belongs to Szczecin .

The great diversity of biotopes in the forest has enabled numerous and diverse plant associations (86, including 13 forest communities) to develop. Over half of the area is covered by beech-dominated, or even pure beech, stands. European beech (*Fagus sylvatica*) is characterized here by high viability and expansiveness. The most abundant type of beechwoods is *Galio odorati-Fagetum* occurring on fertile, moderately-moist sites with a characteristic mix of species in the understorey including wood melick grass *Melica uniflora* along with many other rare plants. On the steep slopes where the accumulation of ground cover is hampered and soil is nutrient-poor due to leaching out of humus, acidophilous lowland beechwoods develop. Their understorey is dominated by bryophytes and less demanding, mesotrophic herbs. The natural occurrence of pinewoods is limited to the northern egdes of the Bukowa Forest, other coniferous stands are an effect of human activity, including a post-war artificial afforestation. An interesting community is a submontane type of riverside ash (*Fraxinus excelsior*) forest, occurring next to typical for lowlands riparian forest with black alder (*Alnus glutinosa*) and ash. Alder carrs with characteristic clumpy structure and grey willow *Salix cinerea* thickets develop in depressions holding stagnating water. Peatlands are amongst the most prominent non-forest plant communities, because of their important role in water retention. The most common type are low-moors, which are supplied with organic matter and mineral soils by flowing water. In several locations with limited water flow transitional fens with mosses develop. Various vascular plants grow among the peatland mosses, notably an insectivorous round-leaved sundew *Drosera rotundifolia*, cotton-grasses (genus *Eriophorum*) and sedges (*Carex*).

Over 1100 species of vascular plants (including 45 strictly and 13 partially protected species), 280 bryophytes and 328 fungi have been recorded in the forest. These include some examples of rare plants: thin-spiked wood-sedge *Carex strigosa* (at only a few locations in Poland), eighteen species of orchids (including e.g. endangered in Poland red helleborine *Cephalantera rubra*), rare trees and shrubs (e.g. wild service tree *Sorbus torminalis* and honeysuckle *Lonicera periclymenum*). The lakes also harbour habitat for a unique flora, including nodding waternymph *Najas flexilis* - strictly protected by Appendix I of the Berne Convention (Glinna and Binowskie lakes are two of the four known Polish sites for this species!) , floating water-plantain *Luronium natans*, and a floating fern - water spangles *Salvinia natans*.

Despite the forest's proximity of an academic center (Szczecin), local fauna seems to have been little investigated. Amongst vertebrates, 48 species of mammals, 141 nesting birds, 5 reptiles and 11 amphibians have been recorded. The invertebrates are represented by about 400 butterflies, plus rare species of coleopterons, arachnids and mollusks. Strict protection has been given to 169 species of animals, and there are a number of specially protected zones imposed around the nesting sites of white-tailed eagle *Haliaeetus albicilla,* red kite *Milvus milvus*, lesser spotted eagle *Aquila pomarina* and black stork *Ciconia nigra*.

In 1956, the Źródliskowa Buczyna reserve was established (155,33 ha), on the southern slopes of the Bukowe Hills and an alluvial depression by Glinna Lake. The reserve protects the natural complex of beechwoods, ash and alder stands of high biocenotic and esthetic value, for scientific and environmental reasons. These communities developed under various habitat conditions, which is a result of the complicated relief with height differences reaching several dozens of meters. Especially diverse microhabitats in moist, fertile valleys with numerous gaps in the stand, fallen trees and clumps of undergrowth are characterized by extraordinary diversity of mosses, liverworts and fungi. Numerous stones along the watercourses offer favourable conditions for calciphilous bryophytes.

Highly nutrient-rich (especially in Ca ions), generally moist, black soils with strong seasonal groundwater fluctuations cover about 20% of the area. In such sites ash-dominated stands grow along with the rare eutrophic beechwood type (*Mercuriali-Fagetum*), and a rich diversity of orchids in the understorey. The soil type on the slopes is dominated by cambisols providing another type of a fertile beech forest - *Galio odorati-Fagetum* and patches of an oak-hornbeam forest and acidophilous beechwood. Along the watercourses, on mud soils, ash dominated riverside forests have developed, while on waterlogged sites (mainly on the Glinna Lake), black alder carrs and grey willow thickets grow. The reserve has a well-preserved flora, although several of 239 plant species recorded here are probably already extinct or close to extinction. Intensive penetration of the area caused series of unfavorable changes in a forest ecosystem, e.g. invasion by alien species like small balsam *Impatiens parviflora.*

Near the north-eastern border of the reserve three tourist trails and 4-km long educational path cross. Three large erratic boulders (coarse-grained pink granite) are situated nearby. A plaque has been attached to one of them commemorating dr. Jerzy Jackowski – an eminent forester and environmentalist. One of the trails, marked blue, leads through the reserve.

The proximity of Szczecin (over 400.000 inhabitants) and its special attractions make the Bukowa Forest one of the main locations for leisure and recreation and a very important site for environmental education and research. Numerous hiking (approx. 200 km) and cycle routes, equipped with appropriate facilities, cross the forest. One of the attractions is a dendrological garden located in Glinna village and managed by the State Forests. Its history dates back to 1823, when the first tree nurseries were established. Nowadays, there are over 600 species and varieties of trees and shrubs in the collection. There is also a Forest and Environmental Information operating in the arboretum, which itself is a very popular place for tourists to gather from whole West Pomerania and the surrounding provinces.

I. 3. The demand for forest recreation in Poland

I.3.1. Survey design and data

The data were collected in an on-site survey in fall 2009 by a professional polling agency. Analyzed interviews were carried out at four forest sites: Lasy Kozlowieckie, Puszcza Kozienicka, Puszcza Bukowa and Lasy Zielonogorskie, all selected because they are in close proximity to large urban areas (less than 30 km away) and these regions have similar average household incomes. Additionally, the survey sites were chosen to represent different geographical regions of Poland with various levels of forest cover ranging from 14% to 49% (see Table 1). All four sites are public forests managed by the State Forests National Forest Holding.

Table 1. Selected forest sites

Name of the site	Conservation regime	Type of forest	Dominant species	Adjacent city	Forest cover in region	Location
Lasy Kozlowieckie	LP [a]	mixed, broadleaved	pine, sessile oak	Lublin (352,000)	14%	SE
Puszcza Kozienicka	LP, PA [b]	mixed	pine, sessile oak, oak	Radom (225,000)	25%	C
Puszcza Bukowa	LP, PA	broadleaved	beech, alder, hornbeam	Szczecin (408,000)	32%	NW
Lasy Zielonogorskie	None	coniferous, broadleaved	pine, ash, alder	Zielona Gora (118,000)	49%	SW

[a] A landscape park is a protected area due to its unique environmental, historical, and cultural or landscape values in order to protect and popularize them in terms of sustainable development. They have been established by local Polish governments. In 2008, there were 121 of these parks with a total approximate area of 2.5 million hectares, representing 8% of Polish territory. Forests account for half of this area (GUS, 2009).
[b] Promotional areas (PA) are large compact forest areas characteristic for a given region, where a pro-ecological forest policy has been implemented.
Note: The number of inhabitants is given in parentheses. SE, C, NW, and SW refer to southeast, central, northwest, and southwest, respectively.

Forest visitors were randomly polled along main paths, picnic areas and parking places during the day time and all days of the week. The target group was limited to people over the age of 18 who only came to the forest for recreation purposes. In all selected sites, interviewers approached 1,345 people, among whom around 10% opted out and 1% did not finish the interview. This results in 1,128 interviews from all four sites.

The questionnaire, which was tested in a pilot version interviewing 50 respondents and evaluated by forest experts, consisted of two main components with the first one directed at revealing forest visits – the travel cost (TC) part and the second part directed at recording peoples' willingness to pay for two forest management programs – the contingent valuation (CV) part. The TC part aimed at estimating the recreational value per visit as well as revealing forest visitation patterns. The CV part, which is not a subject of the present analysis, focused on valuing biodiversity and aesthetical aspects of the forest. To avoid the problem of multi-destination trips, the data set was confined to observations where respondents had stated that visiting the forest was the only or the most important reason for leaving their home that day. Moreover, for the present analysis, only day trips are taken into account. This results in 740 observations.

Information about the frequency of visits to the study sites was obtained from a two-stage question format. Firstly, respondents were asked how often they had visited the forest in the last 12 months. They could choose answers from the following options: "I am here for the first time," "A few times a year or more often," "Once a year," or "Once every few years." Secondly, those who responded "A few times a year or more often" were then asked about the frequency of their trips in each season.

Respondents in the analyzed sample stated that on average they had visited three forest sites in the last 12 months. For 60 % of them, the forest site where they were interviewed was the most frequently visited forest.[1] Table 2 shows the frequency of visits to this particular site.

[1] For a particular forest in an analyzed group of sites, this share varied from 47% to 74%. Respondents could choose the option "I do not know."

Table 2. Stated frequency of visits to the forests where respondents were interviewed

Answers concerning frequency of the forest visits	Shares (%)			
"I am here for the first time"	11.77			
"A few times a year or more often"	67.79			
	Summer	Fall	Winter	Spring
- *"I do not normally go to the forest during this season at all"*	4.80	0.00	**41.40**	15.00
- *"Once this season"*	14.80	16.20	19.60	19.00
- *"Once a month"*	**24.80**	**30.20**	16.80	**23.20**
- *"Once per two weeks"*	17.80	18.40	8.20	14.20
- *"Once per week"*	17.60	17.60	7.60	13.00
- *"Twice per week on average",*	8.00	9.80	3.20	6.40
- *"Every day or almost every day"*	11.20	6.80	2.20	6.20
- *"I do not know/it is difficult to say"*	1.00	1.00	1.00	3.00
"Once a year"	13.53			
"Once every few years"	6.90			

Almost 68% of respondents stated they had visited the chosen forest site a few times per year or more often. In each season except winter, the highest share of recreationists claimed that on average they went to the forest once a month. 41% of respondents said they did not visit the forest during winter. Table 3 presents information about the trip and visit to the forest during which respondents were interviewed.

Table 3. Summary statistics for the trip to the selected sites on the day of an interview

Forest	Lasy Kozlowieckie	Puszcza Kozienicka	Puszcza Bukowa	Lasy Zielonogorskie	All forests
Variable	Mean (Sd)	Mean (Sd)	Mean (Sd)	Mean (Sd)	Mean (Sd)
One-way distance traveled (km)	18 (12)	7 (10)	18 (18)	13 (19)	14 (15)
One-way travel time (min)	27 (14)	17 (16)	31 (26)	29 (27)	25 (22)
Time spent on site (min)	112 (57)	105 (67)	115 (81)	94 (50)	108 (67)

At all study sites, most respondents were visiting the forest accompanied by other people. The most popular mode of transport for reaching the forest was a car. It was chosen by over half of all respondents. One third of all respondents stated that they walked to the forest. Table 4 reports the socio-demographic characteristics of the samples interviewed.

Table 4. Descriptive statistics of the respondents

Forest	Lasy Kozlowieckie	Puszcza Kozienicka	Puszcza Bukowa	Lasy Zielonogorskie	All forests
Variable	Mean (Sd)	Mean (Sd)	Mean (Sd)	Mean (Sd)	Mean (Sd)
Sex (female=0; male=1)	0.54 (0.50)	0.46 (0.50)	0.39 (0.49)	0.36 (0.48)	0.45 (0.50)
Age	37.84 (12.85)	40.69 (17.56)	39.48 (15.42)	41.71 (17.60)	39.80 (15.93)
Education (in years)	13.10 (2.37)	11.75 (2.56)	12.75 (2.54)	13.26 (3.00)	12.62 (2.62)
Number of household members	3.00 (1.22)	3.49 (1.42)	2.91 (1.29)	2.71 (1.20)	3.08 (1.33)
Net household income	2965.47 (1482.25)	3002.63 (2160.09)	3915.32 (2358.26)	2788.89 (1818.64)	3224.88 (2054.94)
Net individual income	1652.24 (698.27)	1154.82 (981.08)	1514.95 (1242.79)	1445.06 (890.38)	1433.95 (1003.48)

Note: Household and individual income was calculated based on the mean values of selected income intervals of respondents.

I.3.2. Results

The dependent variable in our models was *y*, defined as the number of trips an individual took. The explanatory variables were distance traveled (round trip) as a proxy for travel cost, gender, age, education measured in years, net individual income in 1,000 PLN, and dummies for forest sites analyzed. The advantage of using the distance traveled instead of travel cost measured in monetary terms is that it might be expected that travel patterns for longer periods of time remain unchanged compared to fuel price fluctuations. Additionally, this approach allows us to arbitrarily choose a cost per km in welfare estimates, which can also be an advantage since the issue of travel cost estimations is still controversial.

We estimated both models with a constraint of the same constant and distance for the four seasons imposed (the annual forest recreational demand) and models without this constraint (i.e., where each season has its own demand). Also, since the influence of income is often found to be weak in travel cost studies, we examined models with and without this explanatory variable. Additionally, in these models, we included three dummies for forest sites. The selected exponential and Poisson models have following notification numbers: models with identical seasonal demand - I, models with seasonal demands with all explanatory variables - II, and seasonal demands models without income and one forest site dummy (Puszcza Kozienicka) - III.

Table 5. Estimation results

Variable	Poisson Models			Exponential Models		
	I	II	III	I	II	III
Constant	1.9252*** (0.5700)			1.6430* (0.6445)		
Round-trip distance	-0.0418*** (0.0077)			-0.0275*** (0.0039)		
Summer						
Constant		2.3580*** (0.5968)	2.3070*** (0.4688)		3.4081*** (0.9084)	3.3600*** (0.7243)
Round-trip distance		-0.0483*** (0.0106)	-0.0477*** (0.0098)		-0.0415*** (0.0051)	-0.0413*** (0.0049)
Autumn						
Constant		1.9083*** (0.6088)	1.8598*** (0.4767)		1.1474 (0.7820)	1.1250* (0.6469)
Round-trip distance		-0.0340*** (0.0081)	-0.0335*** (0.0071)		-0.0230*** (0.004)	-0.0229*** (0.0038)
Winter						
Constant		1.0328 (0.6445)	0.9840* (0.5074)		0.8330 (0.8104)	0.8074 (0.6768)
Round-trip distance		-0.0424*** (0.0106)	-0.0418*** (0.0094)		-0.0301*** (0.0061)	-0.0299*** (0.0060)
Spring						
Constant		1.8787*** (0.6185)	1.8284*** (0.4836)		2.0976-- (0.8371)	2.0645*** (0.6776)
Round-way distance		-0.0497*** (0.0091)	-0.0490*** (0.0078)		-0.0365*** (0.0049)	-0.0363*** (0.0047)
Demographics						
Sex (male=1)	0.0784 (0.1453)	0.0818 (0.1591)	0.1045 (0.1623)	0.1658 (0.1739)	0.2462 (0.1740)	0.2422 (0.1705)
Age	0.0092* (0.0048)	0.0103* (0.0056)	0.0106* (0.0056)	0.0115** (0.0058)	0.0116** (0.0058)	0.0112* (0.0058)
Net individual income (in 1000 PLN)	0.0447 (0.0586)	0.0490 (0.0690)		-0.0208 (0.0635)	-0.0160 (0.0425)	
Education (years)	0.0318 (0.0254)	0.0347 (0.0294)	0.0412 (0.0284)	0.0133 (0.0406)	0.0154 (0.0409)	0.0144 (0.0366)
Number of household members	-0.0645 (0.0576)	-0.0720 (0.0652)	-0.0771 (0.0659)	-0.0604 (0.0593)	-0.0264 (0.0531)	-0.0277 (0.0586)
Forests						
Puszcza Kozienicka	-0.0308 (0.3228)	-0.0283 (0.2730)		0.2501 (0.2285)	-0.0669 (0.2570)	
Puszcza Bukowa	0.2391 (0.2714)	0.2656 (0.2516)	0.2989 (0.1834)	0.5799** (0.2342)	0.4991** (0.2462)	-0.5259*** (0.1866)
Lasy Zielonogorskie	0.0740 (0.3063)	0.0855 (0.3033)	0.0982 (0.2573)	0.5534 (0.4052)	0.6709 (0.4270)	0.7143 (0.4103)
Log likelihood	-13729.7387	-12591.6663	-12605.7456	-4989.7742	-4720.7611	-4721.3254

Note: ***, **, * indicates significance at 1%, 5%, and 10% levels, respectively. Heteroskedasticity-consistent (robust) standard errors are reported in parentheses.

Table 5 displays estimation results for the models analyzed. For all six models, the constant terms were positive. They were significantly different from zero (at the 1% level) for all Poisson models except for winter. In the case of the exponential models, an intercept is significant for summer and spring. In all models, the round-trip distance coefficients were negative and significant at the 1% level, showing the downward sloping forest recreational demand curves as was expected. While we tried several socioeconomic variables in our analysis, only respondents' age appeared to be significant in all models (at the 10% level), with a positive sign suggesting that older people visit forests more often. There were no sign changes observed across models with different distributions, apart from the income parameter and the parameter for the Puszcza Koziencka. However, in all models analyzed, these parameters were highly insignificant.

In two of three exponential models analyzed, the Puszcza Bukowa dummy variable was also significant as well, suggesting that this forest is visited more than other investigated sites. This site is a part of a landscape park and a promotional forest complex. Compared to the other sites, Puszcza Bukowa has a very dense network of walking and biking paths and it is located on a hilly area with a few panoramic viewpoints of the city. Additionally, in this case, interviews were carried out near an arboretum. These factors could be behind the significantly higher number of trips to Puszcza Bukowa than to the other forests analyzed.

Likelihood ratio tests showed that the econometric specification that best fits the data among the Poisson distributed models is Model II. Among exponential models, the likelihood ratio test did not resolve the difference in fit between Model II and Model III. The complete results of the likelihood ratio test are displayed in Table 6.

Table 6. Likelihood ratio test results

Comparison	Test statistic	Significance
Poisson Model I vs Poisson Model II	2276.1442	Prob> $\chi^2_{0.1}(6)=10.645$
Poisson Model III vs Poisson Model II	28.1586	Prob> $\chi^2_{0.1}(2)=4.605$
Exponential Model I vs Exponential Model II	538.0262	Prob> $\chi^2_{0.1}(6)=10.645$
Exponential Model III vs Exponential Model II	1.1286	Prob> $\chi^2_{0.1}(2)=4.605$

The Vuong non-nested selection test was used to compare the econometric specification between models with different distributions (see Vuong (1989), Englin and Lambert (1995)). The Voung test is a two-step procedure. In the first step, the sample variance of log-likelihood ratio is compared to the critical value from a multivariate chi-squared distribution. If the calculated value of sample variance exceeds the multivariate chi-squared value, the null hypothesis that two conditional models are distinguishable is rejected. For this case, Vuong developed a second step, a directional test, to indicate either that one model dominates the other, or that neither model is preferred. For our data, as reported in Table 7, the results of two pair-wise comparisons of model selections indicated a strong preference for Exponential Model II and Exponential Model III over Poisson models ($p<0.01$).

Table 7. Vuong test results at 5% significance level

Models	First stage		Second stage	
	Multivariate χ^2 Critical Value	Vuong test statistic	Vuong test statistic	p-value
Poisson Model II vs Exponential Model II	134,274.66	479,950.91	-7.319586	0.00000
Poisson Model III vs Exponential Model III	98,866.93	365,158.78	-9.14876	0.00000

Consumer surplus estimates per season are reported in Table 8. The results from each seasonal demand models indicate that respondents valued a single trip taken in the fall the most. In both exponential models (II and III), consumer surplus measured in km was 44.

Table 8. Consumer surplus (in km) for forest recreation

CS per person per visit per season	Poisson			Exponential		
	I	II	III	I	II	III
- *Summer*	23.93 (0.37)	20.70 (0.38)	20.97 (0.36)	36.33 (0.42)	**24.09 (0.24)**	**24.24 (0.23)**
- *Fall*	23.93 (0.37)	29.40 (0.59)	29.88 (0.54)	36.33 (0.42)	**43.49 (0.63)**	**43.75 (0.60)**
- *Winter*	23.93 (0.37)	23.58 (0.51)	23.93 (0.46)	36.33 (0.42)	**33.21 (0.56)**	**33.47 (0.56)**
- *Spring*	23.93 (0.37)	20.11 (0.31)	20.41 (0.27)	36.33 (0.42)	**27.42 (0.30)**	**27.57 (0.29)**

Note: Standard errors are reported in parenthesis.

Additionally, since the confidence intervals for consumer surplus per trip per season do not overlap, we can assume that these values are significantly different (the 5% level). Assuming that the cost per kilometer traveled was 0.36 PLN,[2] the consumer surplus per trip in

[2] The assumed average consumption of fuel was 8 l/100km. The price of 95 octane unleaded petrol in the fall of 2009 equaled around 4.3 PLN per liter.

monetary terms equaled 8.7 PLN, 15.8 PLN, 12.1 PLN, and 9.9 PLN, respectively for summer, fall, winter and spring. The results of the consumer surplus in monetary terms are presented in Table 9.

Table 9. Consumer surplus for forest recreation in monetary terms

CS per person per visit per season	PLN	Euro	USD
- *Summer*	8.73	2.03	3.12
- *Fall*	15.75	3.66	5.63
- *Winter*	12.05	2.80	4.30
- *Spring*	9.93	2.31	3.54

Note: Nominal exchange rate for November 2009: 1 EUR=4.3 PLN, 1 USD=2.8 PLN

Although the likelihood ratio test did not resolve which exponential model was a better fit, for the sake of simplicity, subsequent discussion will concentrate only on parameters obtained from the exponential model without the income effect and a dummy for the Puszcza Kozienicka site. Since the estimated parameters in both models are almost identical, the discussion would not be substantively different using the other model.

Table 10. Implied compensated demand parameters for the seasonal demand system (Exponential Model III)

Variable	Summer	Fall	Winter	Spring
Constant	3.3600	1.1250	0.8074	2.0645
Price coefficient				
Summer	-0.0413	0	0	0
Fall	0	-0.0229	0	0
Winter	0	0	-0.0299	0
Spring	0	0	0	-0.0363
Demand shifter				
Age	0.0112	0.0112	0.0112	0.0112
Puszcza Bukowa	0.5259	0.5259	0.5259	0.5259

In Table 10, the results from Exponential Model III are expanded to show an entire compensated demand system. The results reported include intercepts for all seasons, the own-price parameters, age, and the Puszcza Bukowa shift parameters. Since the income effect for the chosen Exponential Model III model is zero, the cross-priced effects between seasons also equaled zero.[3] This result suggests that the number of trips to forests in different seasons is independent from each other.

I.3.3. References

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[3] In the case of the exponential model II, the income parameter was close to zero and insignificant.

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II. NATIONAL SURVEY

Authors: *Mikołaj Czajkowski, Anna Bartczak, Marek Giergiczny, Ståle Navrud, Tomasz Żylicz*

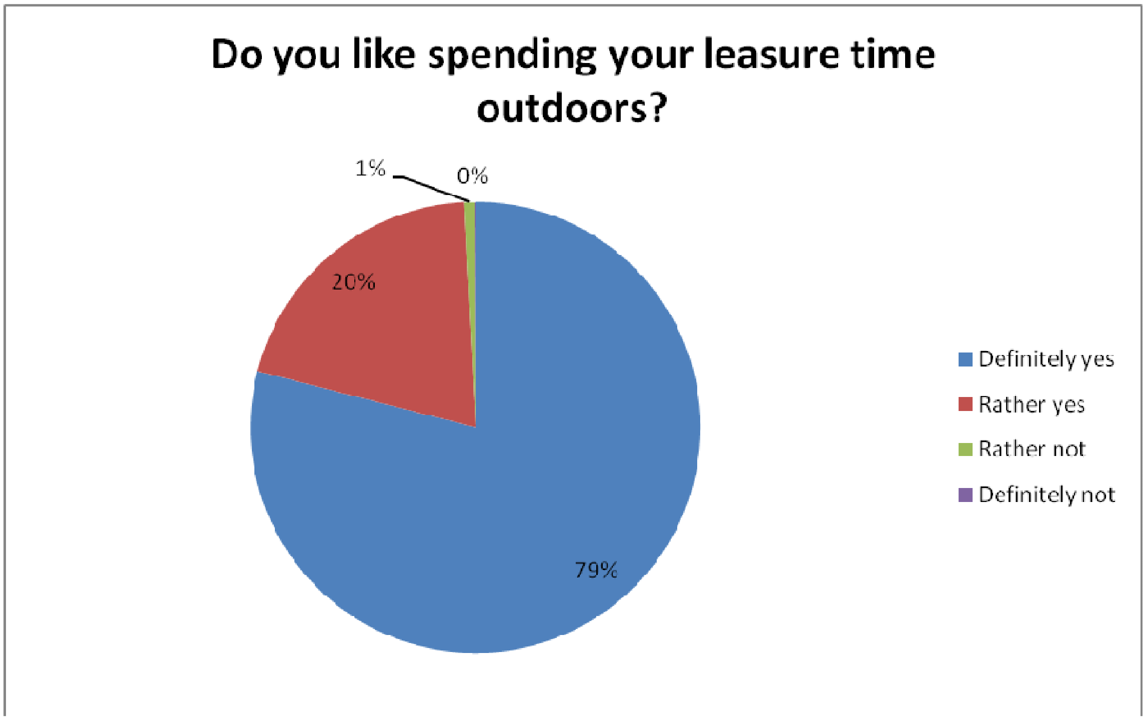
General information:

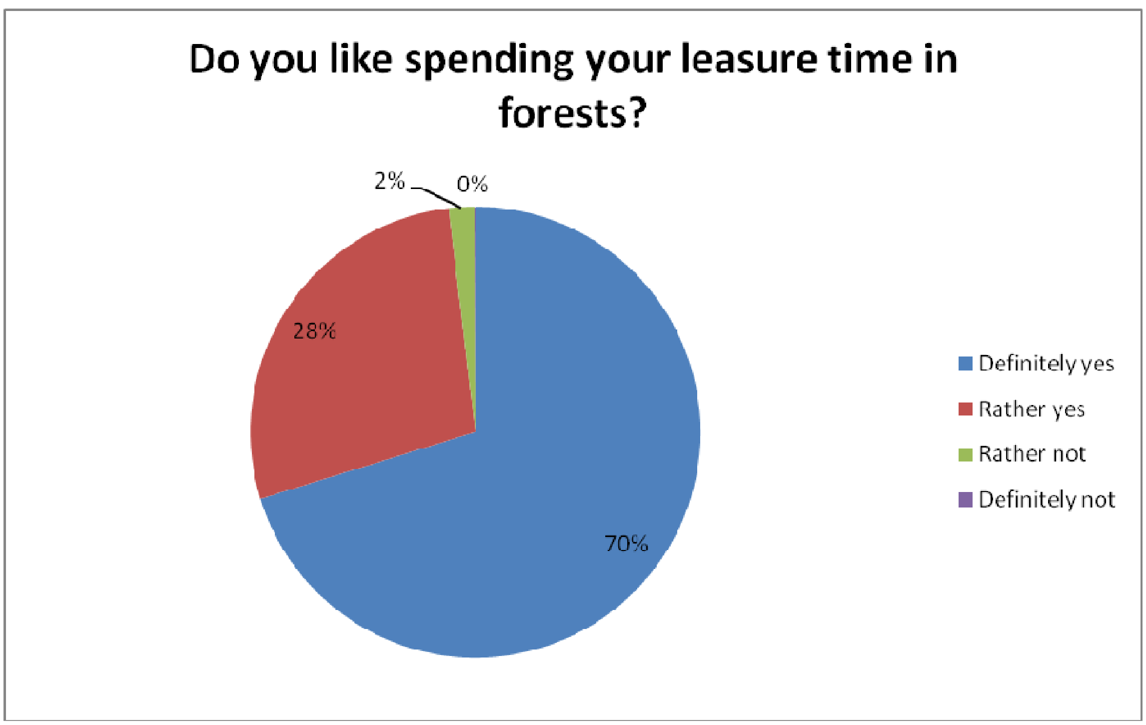
The total number of interviews: **1000**
The method of interviewing: **"face-to-face", a professional polling agency**
The sample: **representative for the entire Polish population (18+)**

II.1. Descriptive statistics

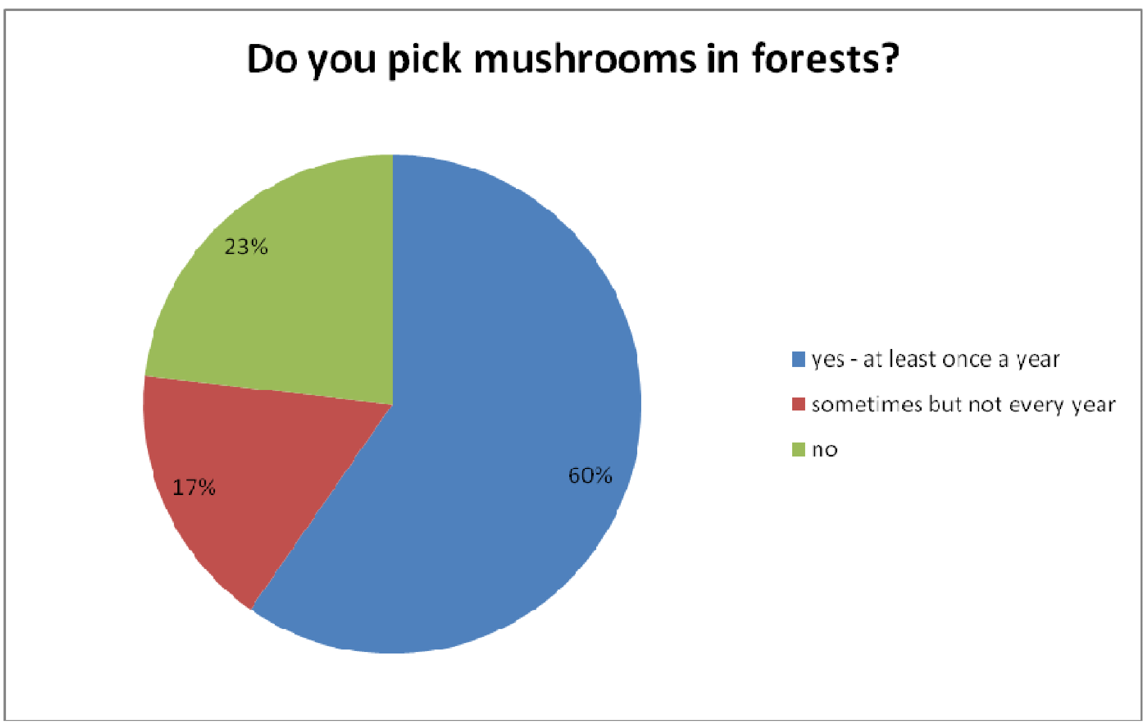
In this report we present general descriptive statistics of our respondents. Since the sample used in our study was representative, these results may be considered the attitudes and characteristics of general adult Polish population.

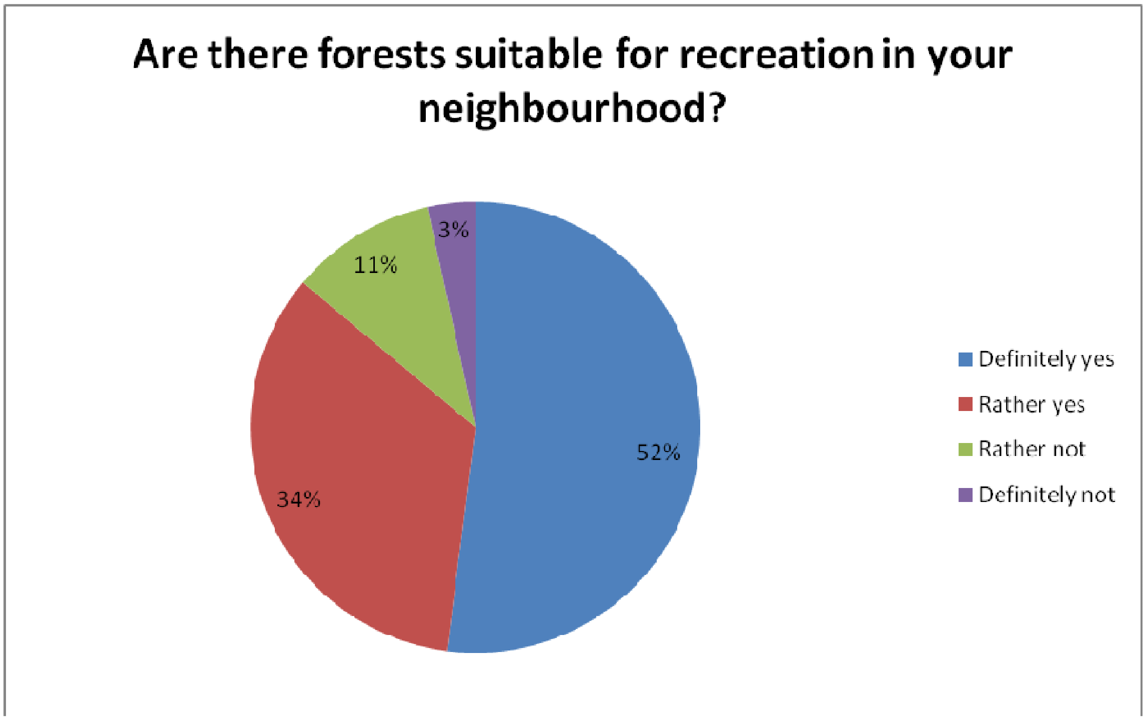
We present the results in the form of diagrams which represent the answers of our respondents. These results accompany the more quantitative results derived from our choice models, but in addition they illustrate the profile and attitudes of general population with respect to Polish forests.

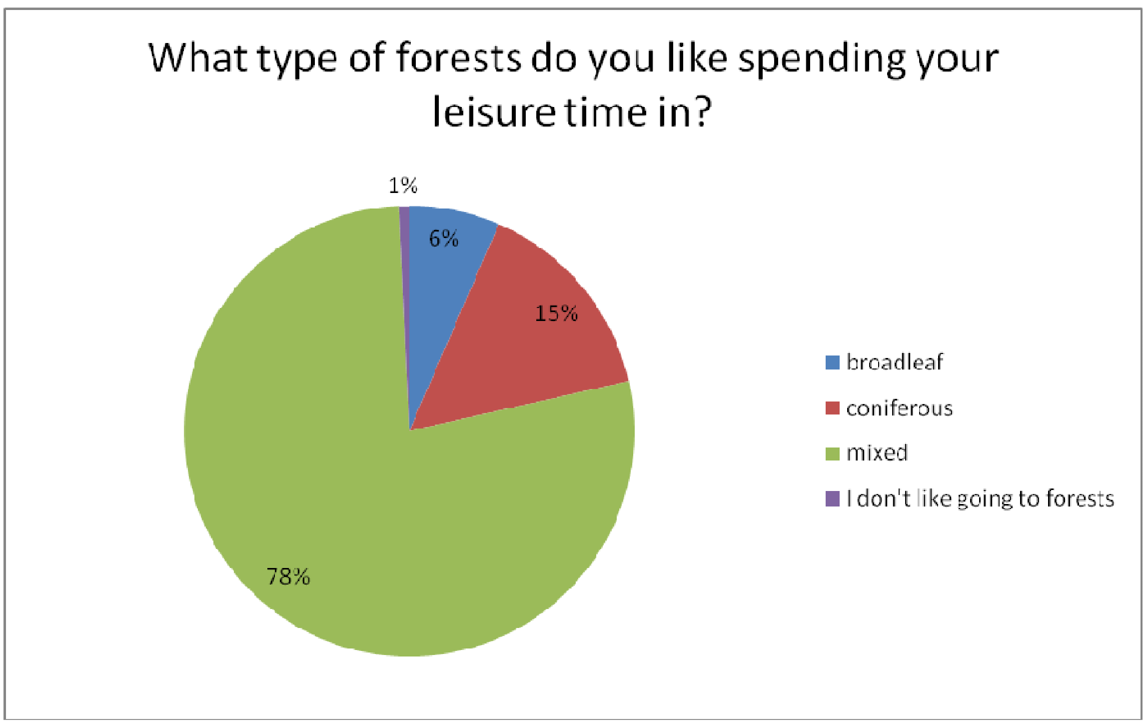

Do you like spending your leasure time outdoors?
1%
0%
20%
79%
Definitely yes
Rather yes
Rather not
Definitely not

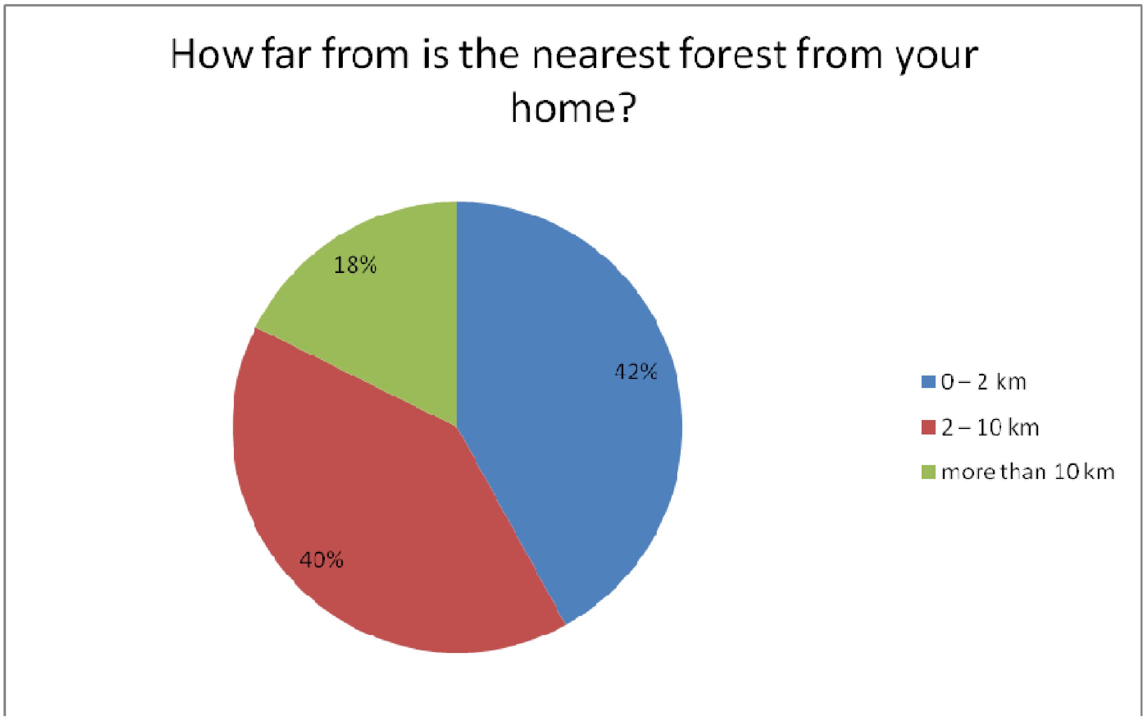

Do you like spending your leasure time in forests?
2%
0%
28%
70%
Definitely yes
Rather yes
Rather not
Definitely not

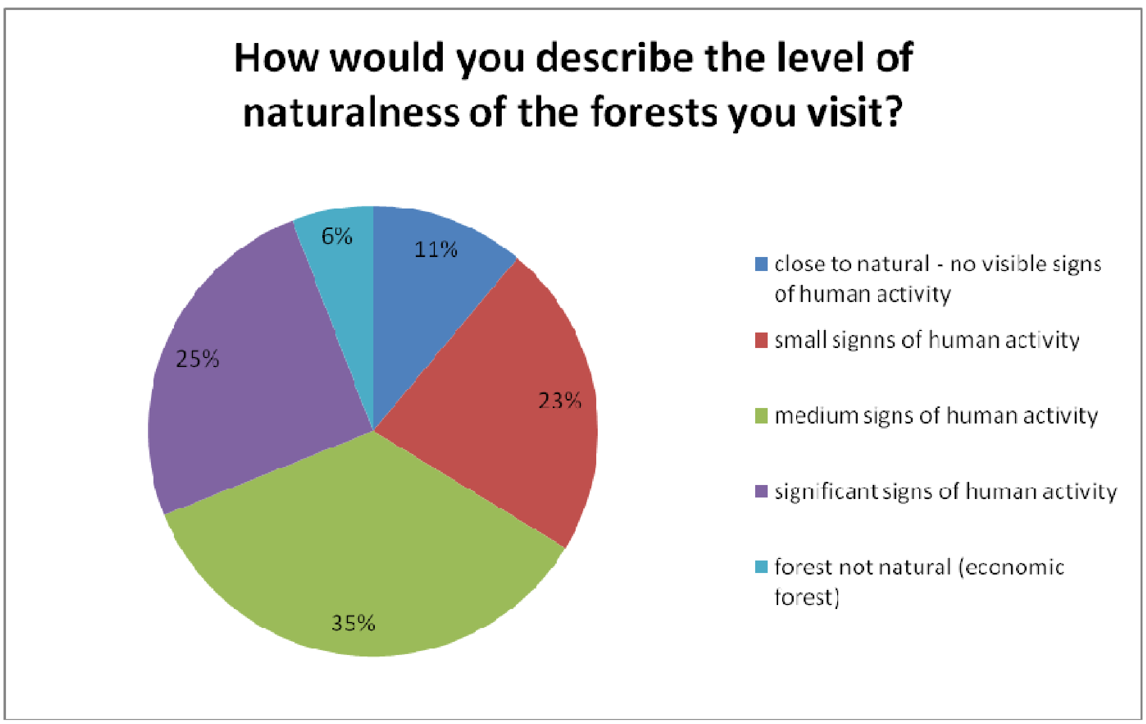

How often do you go for a 20-minute (or longer) walk?
1%
23%
47%
29%
once a week or more
once, twice a month
a few times a year
almost never or never

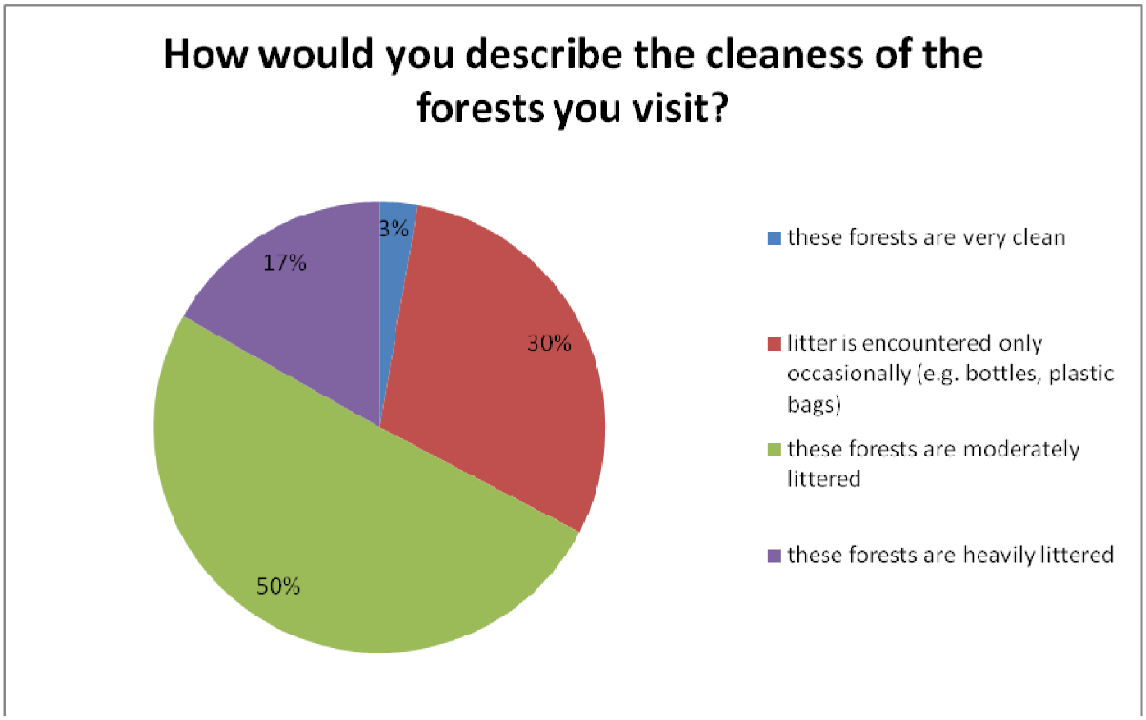

Do you pick mushrooms in forests?
23%
17%
60%
yes - at least once a year
sometimes but not every year
no

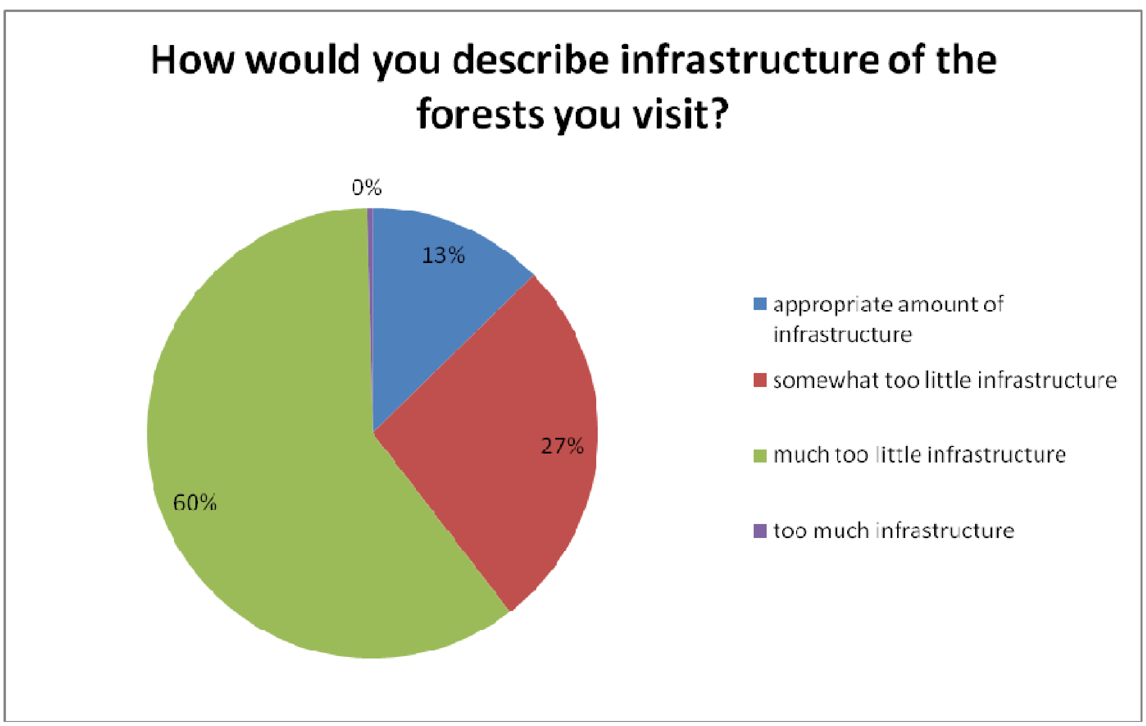

Are there forests suitable for recreation in your neighbourhood?
3%
11%
52%
34%
Definitely yes
Rather yes
Rather not
Definitely not

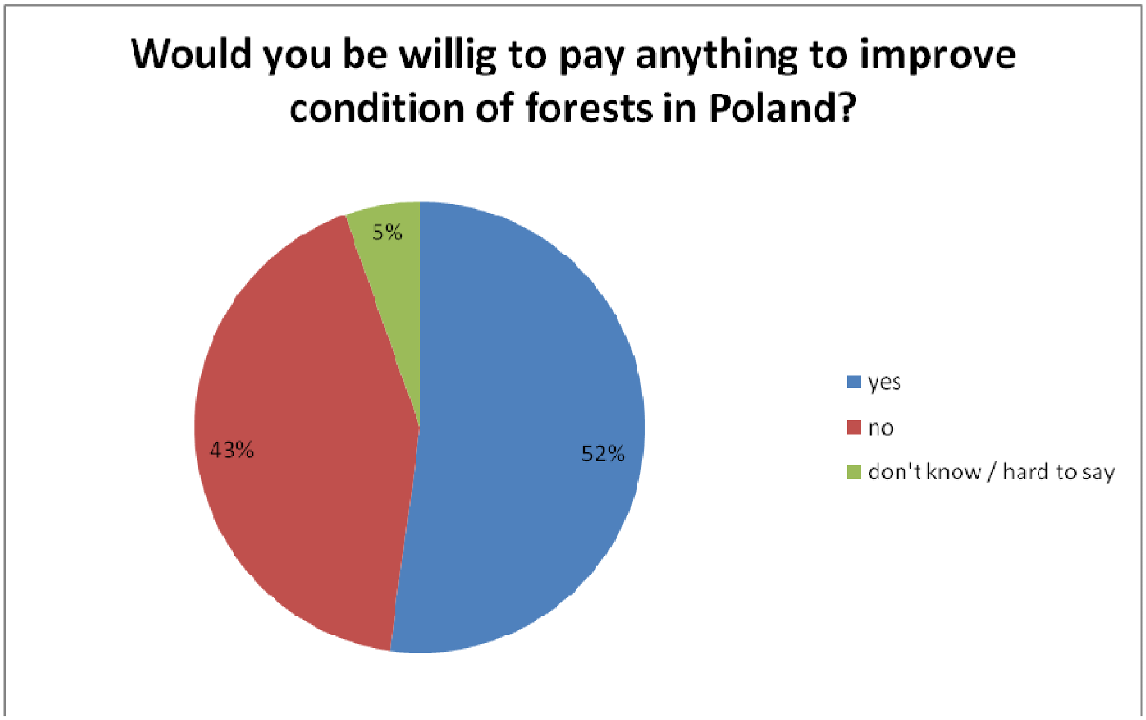

What type of forests do you like spending your leisure time in?
1%
6%
15%
78%
broadleaf
coniferous
mixed
I don't like going to forests

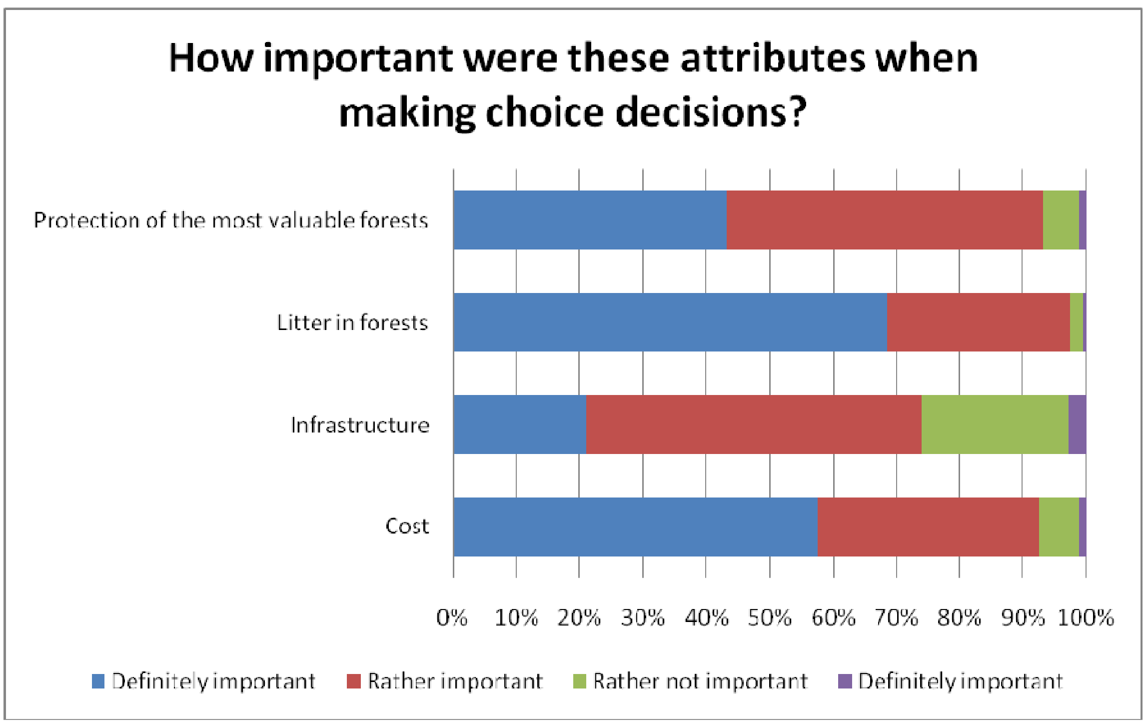

How far from is the nearest forest from your home?
18%
42%
40%
0 – 2 km
2 – 10 km
more than 10 km

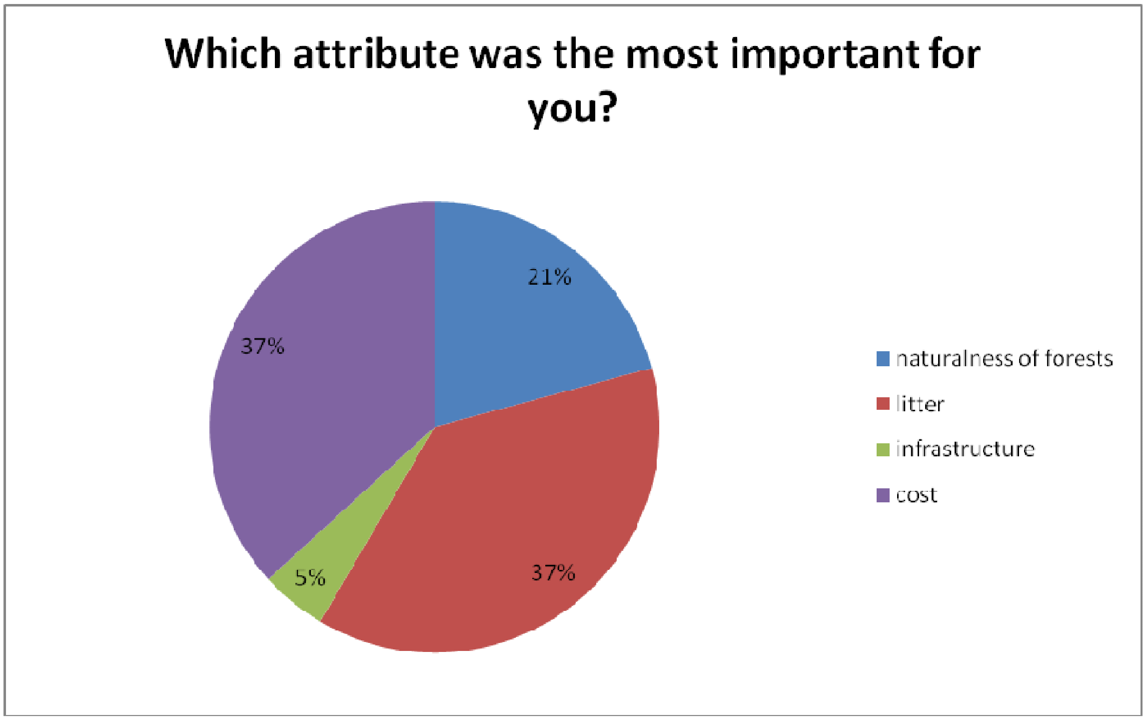

How would you describe the level of naturalness of the forests you visit?
6%
11%
25%
23%
35%
close to natural - no visible signs of human activity
small signns of human activity
medium signs of human activity
significant signs of human activity
forest not natural (economic forest)

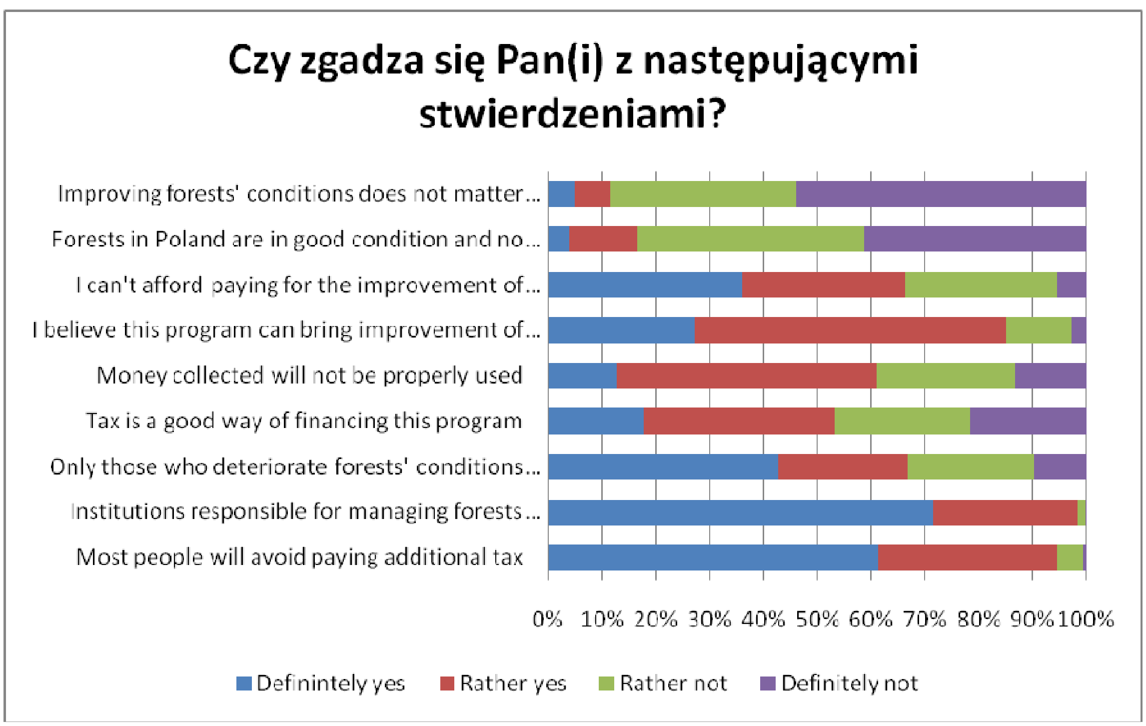

How would you describe the cleaness of the forests you visit?
3%
17%
30%
50%
these forests are very clean
litter is encountered only occasionally (e.g. bottles, plastic bags)
these forests are moderately littered
these forests are heavily littered


How would you describe infrastructure of the forests you visit?
0%
13%
27%
60%
appropriate amount of infrastructure
somewhat too little infrastructure
much too little infrastructure
too much infrastructure


Would you be willig to pay anything to improve condition of forests in Poland?
5%
43%
52%
yes
no
don't know / hard to say


How important were these attributes when making choice decisions?
Protection of the most valuable forests
Litter in forests
Infrastructure
Cost
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Definitely important
Rather important
Rather not important
Definitely important


Which attribute was the most important for you?
21%
37%
5%
37%
naturalness of forests
litter
infrastructure
cost


Czy zgadza się Pan(i) z następującymi stwierdzeniami?
Improving forests' conditions does not matter...
Forests in Poland are in good condition and no...
I can't afford paying for the improvement of...
I believe this program can bring improvement of...
Money collected will not be properly used
Tax is a good way of financing this program
Only those who deteriorate forests' conditions...
Institutions responsible for managing forests...
Most people will avoid paying additional tax
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Definintely yes
Rather yes
Rather not
Definitely not

II.2. Providing social-preference based support for large scale forest management strategy in Poland

II.2.1. Introduction

This study aimed at investigating social preferences for changes in forest management strategies in Poland. We have utilized qualitative analysis to identify the forest attributes that people would like to see changed the most. Through the application of a choice-experiment study we elicited public preferences for alternative management options of forests in Poland, including implicit prices of the attributes considered and welfare changes associated with possible policy scenarios.

II.2.2. Methods

The choice experiment (CE) is a popular method to elicit preferences and monetary values associated with non-market goods and the attributes that comprise such goods. Respondents are usually asked to state which of the several alternatives they prefer the most. A standard practice is to pool choice data from individuals and estimate a population model. Since respondents are likely to have heterogeneous preferences and differ in error variances (scales) it becomes crucial to account for this preference and scale heterogeneity in modelling approach.

There have been many attempts to allow for heterogeneous tastes in discrete choice modelling. The most straightforward is based on including interactions between attributes and socio-demographic variables into utility function (Brock et al., 2007). This approach allows to account for systematic taste variation only, and not for unobserved taste heterogeneity. Another frequently used approach is the random parameters logit model (RPL, McFadden et al., 2000; Revelt et al., 1998). It extends the multinomial logit model to allow for unobserved preference heterogeneity by making the utility function parameters random variables that follow an a priori specified type of distribution; parameters of these distributions are estimated using maximum likelihood methods. This approach allows for a lot of flexibility in specifying distributions for random parameters.

In the above model specifications the error term has a scale (variance) that has been implicitly normalized to allow for identification. An alternative cluster of models – scale heterogeneity models – allow for heterogeneous scale coefficient in the population (e.g. the Heteroscedastic Extreme Value Model, Allenby et al., 1995; Bhat, 1995; or Covariance Heterogeneity Nested Logit Model, Bhat, 1997). These models allow for otherwise homogeneous utility weights to be proportionally scaled up or down for different respondents, making the deterministic part of their utility function larger or smaller in relation to the non-observable random part.

Only recently it has been proposed to combine these 'preference-heterogeneity' and 'scale-heterogeneity' approaches into one Generalized Multinomial Logit Model framework (Fiebig et al., 2010). The model nests both approaches and allows to simultaneously account for both preference and scale heterogeneity. In this paper we employ this state-of-the-art method to simultaneously account for preference and scale heterogeneity.

II.2.2.1. The G-MNL Model

In the G-MNL model (Fiebig et al., 2010) the random utility expression of an individual i's utility function associated with alternative j at choice situation t is:

$$U_{itj} = \left[\sigma_i \mathbf{b} + \gamma \boldsymbol{\eta}_i + (1-\gamma)\sigma_i \boldsymbol{\eta}_i\right]' \mathbf{x}_{itj} + \omega_{itj}. \quad (1)$$

The utility associated with each alternative is a function of observed attributes $\mathbf{x}_{ij}$ and accompanying individual-specific (random) parameters, $\boldsymbol{\beta}_i = \mathbf{b} + \boldsymbol{\eta}_i$, where $\mathbf{b}$ is a vector of population means of these parameters, and $\boldsymbol{\eta}_i$ is a vector of random errors with zero means and a specified variance-covariance matrix over the population (usually following multivariate normal distribution). By introducing the error term ω_{itj} the modeller assumes utility levels to be random variables, as it is otherwise impossible to explain why apparently equal individuals (equal in all attributes which can be observed) may choose different options. This error term can further be disaggregated to $\omega_{itj} = \mathbf{Y}'_{itj}\boldsymbol{\Omega}_{itj} + \varepsilon_{itj}$, where $\boldsymbol{\Omega}_{itj}$ is a vector of stochastic components of utility function which follow identical and independent distribution specified by a modeller, and $\mathbf{Y}_{itj}$ is a vector of loadings that map the error component according to the desired structure (and hence allow for generic correlations). This specification of the random term of the utility function allows to include numerous error structures, and hence to account for heteroscedascity, correlation, cross-correlation, and autoregression of error components (Greene et al., 2007; Hensher et al., 2003; Train, 2003).

In addition to this usual specification of any mixed-logit model, σ_i is an (individual) scale of the error term ε_i, and γ is a new parameter between 0 and 1 that governs how the variance of preference heterogeneity varies with scale.[1] From this generalized model one can obtain the usual RPL model (if $\sigma_i = \sigma = 1$), the scale-heterogeneity model (if $\operatorname{var}(\boldsymbol{\eta}_i) = 0$) or a simple MNL model (if $\sigma_i = \sigma = 1$ and $\operatorname{var}(\boldsymbol{\eta}_i) = 0$).

Since the person-specific scale coefficient should be positive, to impose it in estimation it is convenient to assume it is log-normally distributed, i.e.:

$$\sigma_i = \exp\left(\bar{\sigma} + \tau\varepsilon_i\right), \text{ where } \varepsilon_i \sim N\left(0,1\right). \quad (2)$$

The new parameter τ captures the scope of scale heterogeneity – as it approaches 0 the model becomes the usual RPL model, and for any $\tau > 0$ there is individual scale heterogeneity in the model.

II.2.3. Empirical study

Our empirical study was based in the context of environmental protection – management changes in the protection of Polish forests. We were interested in the attributes of the Polish forests that are the most significant for the general public in terms of recreation and biodiversity conservation. Through the extensive qualitative studies we discovered that the forest attributes that Poles would like to see changed the most were: (1) protection of the most ecologically valuable forests, (2) less litter in forests, and (3) an increasing the amount of recreational infrastructure. These were the attributes that we used for the hypothetical scenario of our CE study.

[1] See Fiebig et al. (2010) for a discussion.

Of the 90 000 km^2 Polish forests about 3% are forests which are the most ecologically valuable in terms of having many of the characteristics of natural forests, such as age and structure of trees, the presence of natural environmental processes, large amounts of dead wood, rare species of fauna and flora and high biodiversity in general (see Annex 1a for illustration). About 50% of these forests are currently properly protected, usually in the form of national parks and nature reserves. The rest is under much human pressure and often is treated as regular economic forests. Annex 2 provides a map of locations and areas of the most ecologically valuable forests in Poland. Therefore, the first attribute in our CE scenario was the area change of ecologically valuable forests that could be protected. The possible levels of this attribute were:

Status quo

Passive protection of **50%** of the most ecologically valuable forests

(1,5% of all the forests)

Partial improvement

Passive protection of 75% of the most ecologically valuable forests

(2,25% of all the forests, 50% increase)

Substantial improvement

Passive protection of 100% of the most ecologically valuable forests

(3% of all the forests, 100% increase)

The second attribute used in the final study was the amount of litter that was present in the forest. This could be left in forests by tourists or as illegal trash-dump sites (see Annex 1b for illustration). Litter obviously decreases recreational value of a forest, may leak dangerous substances, and constitutes a hazard for animal life and health. In our hypothetical scenario it was proposed to reduce the amount of litter by 50% or by 90%, though tougher law enforcement and increasing forest cleaning services. The available levels of this attribute were:

Status quo

No change in the amount of litter in the forests

Partial improvement

Decrease the amount of litter in the forests by half

(50% reduction)

Substantial improvement

Litter found in the forests only occasionally

(90% reduction)

Qualitative pretesting also showed that for the recreational value of forests it was important that enough tourist infrastructure was available. This could include local roads allowing easier access to a forest, parking places, paths and trails for tourists, organized resting areas (e.g. picnic sites) or toilets. Our scenario proposed and described two levels of increased amount and quality of infrastructure. It was explained that such infrastructure would be built only where necessary and only in a way that does not influence the environment. In short, these were:

Status quo

No change in tourist infrastructure

Partial improvement

Appropriate tourist infrastructure in **a half more** forests

(50% increase)

Substantial improvement

Appropriate tourist infrastructure available in **twice more** forests

(100% increase)

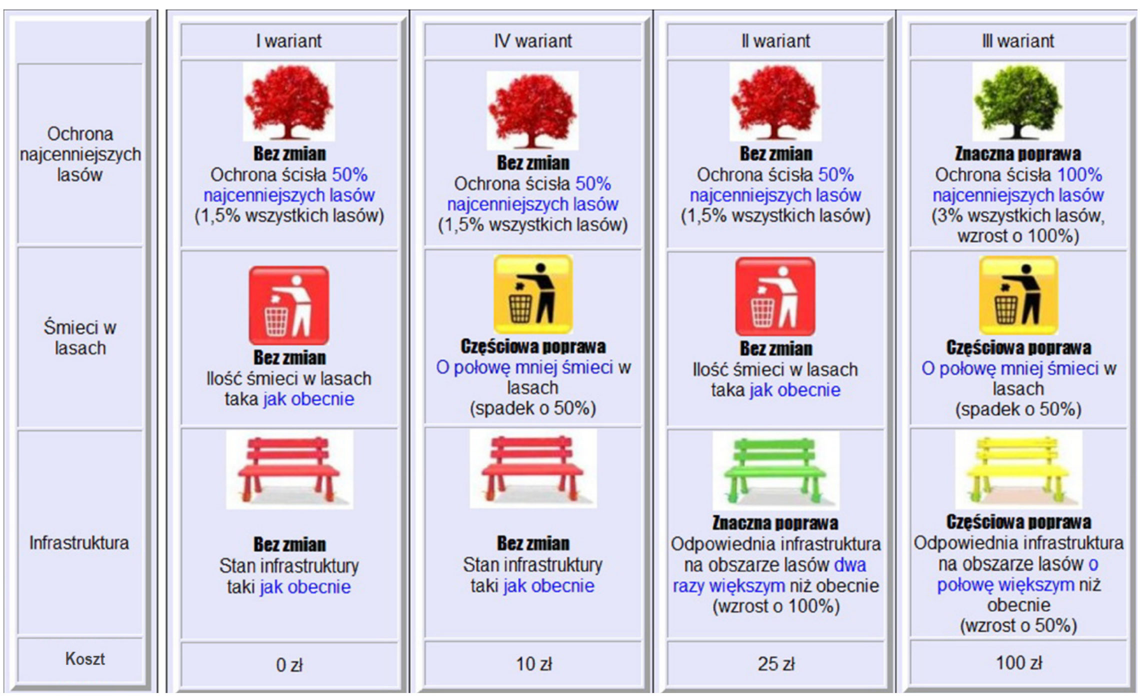
The last attribute was monetary – additional annual cost per household, in the form of increased income taxes.

The final survey was conducted on a representative sample of 1001 Poles. We hired a professional polling agency that collected the questionnaires using high-quality, face-to-face computer-assisted surveying techniques. The choice sets utilized in our study were prepared using Bayesian d-efficient design optimized for the RPL model (Bliemer et al., 2008; Ferrini et al., 2007; Sándor et al., 2001; Scarpa et al., 2008). To obtain initial estimates (priors) and to verify the qualitative properties of the questionnaire itself we conducted a pilot study on a sample of approximately 50 respondents.

Each respondent was faced with 26 choice-situations, each consisting of 4 alternatives. Each alternative was described with the 4 attributes specified above. Our design was counterbalanced – we randomized the order of 26 choice-sets presented to each respondent. In addition, we randomized the order of the 3 non-status-quo alternatives for each choice-situation and each respondent.

An example of a choice card shown to respondents is given in Figure 1.

Figure 1. Example of a choice card



II.2.4. Results

We estimated our G-MNL model using 1000 shuffled Halton draws. In addition, we accounted for the panel structure of our dataset (since each respondent faced 26 choice-sets) by introducing random effects type of treatment – additional random term for all observations from the same individual. The estimation results of the G-MNL model are presented in Table 1.

The qualitative attributes were dummy coded with status quo as a reference level, and so the variables are:

- NAT_1, NAT_2 – partial (50%) and substantial (100%) improvement in the area of passively protected ecologically valuable forests,
- TRA_1, TRA_2 – partial (50%) and substantial (90%) reduction of litter in the forests,
- INF_1, INF_2 – partial (50%) and substantial (100%) increase of forests with tourist infrastructure present,
- FEE – monthly cost per household in PLN,
- SQ – alternative specific constant for the status quo alternative (no change).

All the coefficients were modelled as normally distributed random parameters. In addition we allowed for correlations between all random parameters.[2] The estimated correlation matrix is

Before asking each respondent to proceed through the choice situations we asked them if they would be willing to pay anything at all for changes in the attributes used in our study. This question was aimed at verifying if respondents have positive WTP, since they were asked to choose the most preferred alternative anyway – in case the respondent's WTP was zero, he could have chosen the 'status-quo' alternative at no cost, although we noticed that some of them changed their minds and picked one of the other alternatives.

In order to explicitly account for different utility functions of the two classes of respondents: class 1 – those who *a priori* declared that they would not be willing to pay anything at all (48%), and class 2 – those who declared that they would be willing to pay (52%). We included interaction terms of the parameters of the attributes and a dummy variable for the class 2. These interaction parameters were denoted with the i prefix.

---

[2] The estimated variance-covariance matrix is available from the authors on request.

We begin by noting that all explanatory variables turn out to be significant determinants of choice and to be of expected sign. The statistical significance of the coefficients associated with the standard deviations of the random parameters' distributions indicates that they are significantly different from zero, and hence that the variables should indeed be modeled as random. This is a strong evidence of unobserved preference heterogeneity. On the other hand, the tau scale coefficient is significantly larger than 0 what indicates substantial heterogeneity in individual scale coefficients. Therefore, we found strong evidence of unobserved heterogeneity in both preferences and scale.

Table 1. The results of the Generalized Multinomial Logit Model (standard errors given in parentheses)

	Means of normally distributed random parameters	Standard deviations of normally distributed random parameters
Coefficients		
SQ – alternative specific constant for the status quo alternative (no change)	.23892** (.11480)	5.65570*** (.22301)
NAT_1 – partial (50%) improvement in the area of passively protected ecologically valuable forests	1.23519*** (.07149)	.98660*** (.06926)
NAT_2 – substantial (100%) improvement in the area of passively protected ecologically valuable forests	1.53316*** (.07923)	1.62002*** (.07577)
TRA_1 – partial (50%) reduction of litter in the forests	1.52455*** (.07869)	1.25869*** (.08991)
TRA_2 – substantial (90%) reduction of litter in the forests	2.20647*** (.09189)	1.98033*** (.09452)
INF_1 – partial (50%) increase of forests with tourist infrastructure present	.85169*** (.07135)	.63101*** (.06904)
INF_2 – substantial (100%) increase of forests with tourist infrastructure present	1.20026*** (.07122)	.92083*** (.05262)
FEE – monthly cost per household in PLN	-5.78226*** (.19952)	5.59557*** (.13952)
iSQ – alternative specific constant for the status quo alternative (no change) – interaction with $WTP > 0$ dummy	-4.63611*** (.32033)	4.14401*** (.19738)
$iNAT_1$ – partial (50%) improvement in the area of passively protected ecologically valuable forests – interaction with $WTP > 0$ dummy	.74990*** (.09754)	1.04866*** (.08184)
$iNAT_2$ – substantial (100%) improvement in the area of passively protected ecologically valuable forests – interaction with $WTP > 0$ dummy	1.23166*** (.11358)	1.23655*** (.08976)
$iTRA_1$ – partial (50%) reduction of litter in the forests – interaction with $WTP > 0$ dummy	.82116*** (.10737)	1.27283*** (.08082)
$iTRA_2$ – substantial (90%) reduction of litter in the forests – interaction with $WTP > 0$ dummy	1.37241*** (.13366)	1.75092*** (.09367)
$iINF_1$ – partial (50%) increase of forests with tourist infrastructure present – interaction with $WTP > 0$ dummy	.28578*** (.09887)	1.08808*** (.09762)
$iINF_2$ – substantial (100%) increase of forests with tourist infrastructure present – interaction with $WTP > 0$ dummy	.40196*** (.09431)	1.08872*** (.07807)

$iFEE$ – monthly cost per household in PLN – interaction with $WTP > 0$ dummy	1.02322*** (.24218)	3.68691*** (.19915)
G-MNL parameters		
γ – gamma parameter	.09399*** (.02164)	–
τ – tau scale parameter	.44851*** (.01699)	–
	Pseudo-R^2 (McFadden's) 0.5326352 AIC (normalized) 1.308	

***, **, * – Significance at 1%, 5%, 10%

Our results indicate that even the respondents who *a priori* declared that they would not be willing to pay anything for improvements in the study attributes had significant and positive utility function coefficients associated with them. They also had a positive coefficient associated with the 'status quo' alternative specific constant, indicating that ceteris paribus they preferred no change. In comparison, the other respondents had (1) larger utility function coefficients associated with the attributes, (2) lower absolute value of the coefficient of cost, leading to higher implicit prices, and (3) negative coefficient for the 'status quo' alternative. These differences become easier to compare when implicit prices of the two groups are compared. We do this in the next section.

II.2.4.1. Implicit prices of the attributes and welfare estimates

We now turn to estimating the implicit prices of the attribute levels. This can be done by calculating the marginal rate of substitution of monetary parameter for an attribute of interest.

Table 2 shows median implicit prices in EUR, along with associated standard deviations. These were generated using parametric bootstrapping following Krinsky and Robb (1986). Since our price parameter was also random we have followed the simulation method similar to that proposed by Hu et al. (2005); in order to avoid 'exploding' implicit prices, when a random price parameter was very close to zero we averaged over 10^4 draws of each parameter, for each of the 10^4 Krinsky and Robb draws from parameter distributions. As the main moments of WTP distributions do not exist in this case (Daly et al., 2010) we turned to estimating median WTPs.

Table 2. Implicit prices of the choice attributes [PLN]

	Class 1 (48%)		Class 2 (52%)	
	Implicit price	90% confidence interval	Implicit price	90% confidence interval
SQ – alternative specific constant for the status quo alternative (no change)	4.15	0.33 – 8.00	-92.34	-109.13 – -77.55
NAT_1 – partial (50%) improvement in the area of passively protected ecologically valuable forests	21.40	19.01 – 23.88	41.71	35.95 – 48.48
NAT_2 – substantial (100%) improvement in the area of passively protected ecologically valuable forests	26.53	23.81 – 29.51	58.19	50.69 – 67.00
TRA_1 – partial (50%) reduction of litter in the forests	26.38	23.65 – 29.26	49.21	42.66 – 56.97
TRA_2 – substantial (90%) reduction of litter in the forests	38.16	34.70 – 41.91	75.19	65.92 – 86.06
INF_1 – partial (50%) increase of forests with tourist infrastructure present	14.73	12.52 – 17.02	23.91	19.22 – 29.17
INF_2 – substantial (100%) increase of forests with tourist infrastructure present	20.79	18.42 – 23.26	33.69	28.56 – 39.67

Our results indicate that the attribute that consumers are willing to pay the most for is the reduction of litter in the forests. This finding is similar to what we found in qualitative analysis conducted during pretesting, and at the time was surprising to us. Respondents seem to be concerned about this primarily because it reduces their surplus from spending recreational time in the forests they most often visit. The next attribute consumers found significant was extending the area of passive protection over the area of ecologically valuable forests in Poland. Since these forests needed not be located nearby respondents' homes, we expect their WTP was mostly driven by non-use values. Finally, we found that the respondents were willing to pay for tourist infrastructure to be extended.

The implicit prices estimated for the two classes of the respondents were quite different. Overall, those who *a priori* declared that they would be willing to pay for changes in management strategy had substantially (over 50%) higher implicit prices. Nonetheless, we observed that even the respondents who a priori declared that they would be not be willing to pay for the changes, did not necessarily always choose the status quo alternative, after the possible management scenarios were presented to them. This resulted in positive and statistically significant implicit prices of the attribute levels also for this class of respondents.

The above findings are in line with the class 1 respondents being satisfied with the current management of the forests; going away from the status quo would be equivalent of -4.15 PLN for them. On the contrary, class 2 respondents would be willing to pay 92.34 PLN to adopt some other management programme, irrespective of the attribute levels. We find this result a yet another manifestation of the fact that respondents WTP might depend not only on the physical attributes of the good, but may also consist of a constant component associated with the value of a label (Czajkowski et al., 2009).

Finally, we calculated median equivalent variations associated with minimum and maximum improvement scenarios for both classes of respondents. Note that these are not simply the sum of implicit prices of the attribute levels, since we allowed the utility function parameters to be correlated. These results are presented in Table 3 below.

Table 3. Welfare estimates of new management scenarios [PLN]

	Class 1 (48%)		Class 2 (52%)	
	Implicit price	90% confidence interval	Implicit price	90% confidence interval
Minimum improvement scenario – NAT_1, TRA_1, INF_1	62.52	56.00 – 70.19	114.97	99.60 – 133.92
Maximum improvement scenario – NAT_2, TRA_2, INF_2	85.65	76.82 – 95.72	167.27	145.39 – 194.48

II.2.5. Summary and conclusions

In this study we investigated the issue of preferences for forest management strategies in Poland. Our study provides interesting results in terms of general public preferences for alternative management options of forests in Poland. It seems the respondents are willing to pay considerable amounts to reduce the amount of litter in the forests, passively protect the most ecologically-valuable forests, and provide tourist infrastructure in more forests than currently. The willingness-to-pay per household seems high. It might be, however, explained with a wide-spread culture of forest-based recreation in Poland (see e.g. Bartczak et al., 2008).

Interestingly, we found that even the respondents who *a priori* declare that they would not be willing to pay anything for changes in forest management strategies do change their minds and after considering possible improvement levels and costs often choose the alternatives which are associated with non-zero costs. It remains unknown if this behaviour is observed because such respondents simply ignore the cost attribute or they reveal their true preferences after more careful consideration of the alternatives. This issue could be a subject of further analysis.

Finally, our results are valuable, because for the first time unobserved individual preference and scale heterogeneity was accounted for within the G-MNL model in the context of environmental and resource economics. This has been recently made possible with the G-MNL model (Fiebig et al., 2010).

In conclusion, our study lays foundations for future forest management strategies in Poland. Our results provide the policy-makers with inputs necessary to devise a strategy aiming at maximizing social welfare in terms of non-market forest externalities, namely recreation and biodiversity protection. Comparing the benefits of possible changes with the costs of their implementation in a cost-benefit analysis framework would provide clear indications of how to manage Polish forests in the future.

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Annex 1a – the illustration of economic forest and close-to-natural forest

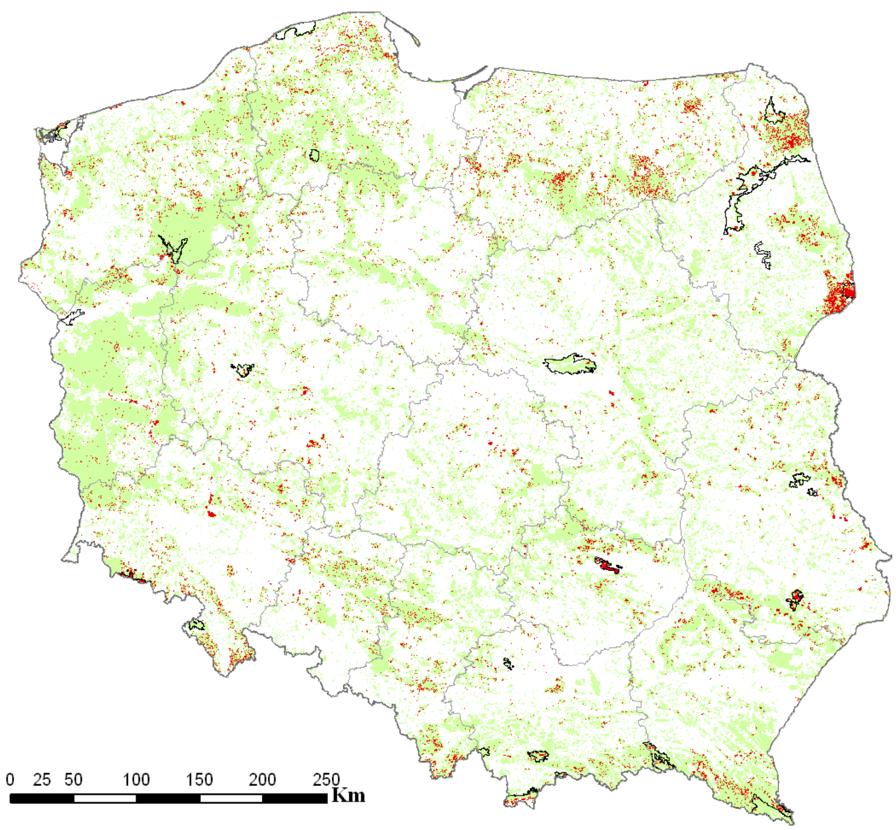
Economic forest

Close-to-natural forest

Annex 1b – the illustration of litter in the forests

Annex 1c – the illustration of tourist infrastructure

Annex 2 – The most ecologically valuable forests in Poland



Ecologically-valuable forests

Other forests

National parks

Warsaw Ecological Economics Center. Warsaw, Poland
Forest Research Institute, Warsaw, Poland
Norwegian University of Life Sciences, Ås, Norway
Department of Resource Economics, University of Nevada, Reno

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