A MOOSE RECOVERY PLAN FOR POLAND: MAIN OBJECTIVES AND TASKS

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ABSTRACT: Hunting statistics showed that moose (*Alces alces*) numbers in Poland declined from 5,400 animals in 1991 to 1,718 in 2000. A nation-wide ban on moose hunting was imposed in 2001 in response to this decline in moose abundance. The main purpose of this paper is to outline a moose recovery plan in Poland by using verification of hunting records related to moose population numbers, collecting data on population demographic variables, and understanding moose habitat preferences. During 1998-2002 in the forest habitat of north-eastern Poland (total area: 311,400 ha) a line intercept snow track index and plot sampling were used to estimate moose population numbers at 276 animals. It was shown that the population census in this area carried out by hunters in this period through a guess-estimate method overestimated the moose population by 46.0%. Research in Augustowska Forest (110,200 ha) shows that the autumn recruitment rate was 64.4 calves per 100 cows, and the ratio of cows to bulls was 1.34. Analysis of moose population dynamics during 4 hunting seasons (1998-2001) shows that the maximum sustainable harvest is about 30% of population numbers estimated in February. Habitat selection by moose was tested using Bailey's 95% simultaneous confidence intervals. Moose preferred habitats in bog and wet sites dominated by deciduous and mixed forests. The decline in moose populations in Poland over 20 years was caused by overestimation of population numbers and over-harvest. It is suggested that a moose recovery program in Poland should be started by locating 2 large moose management/conservation units where moose population numbers should be estimated by reliable methods, and sustained harvest would then maintain a viable moose population. At the same time, forestry in moose wintering areas should stimulate deciduous browse production as well as providing estimates of forest damage caused by moose using different standards than those applied in lowland commercial forests.

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Key words: habitat selection, moose, over-harvest, Poland, population census, recovery plan, recruitment rate

Moose (*Alces alces*) in Poland experienced several dramatic population fluctuations during the 20th century. World War I drastically reduced the moose population in the country, and only the joint efforts of wildlife biologists, foresters, and hunters allowed its restoration. By 1937 there were estimated to be 1,130 moose in Poland. World War II again threatened the existence of the moose population, leaving only 10-15 animals by 1945. The species was then declared protected, and an intensive reintroduction program was undertaken using a large enclosure in Kampinos National Park (Serafiñski 1969). Based on hunting statistics, the population was estimated at 425 animals in 1965 and 3,250 in 1975. Harvesting of moose started in 1967, with progressively increasing numbers of animals harvested in each year. Moose continued to increase however, and the population was estimated at 6,181 individuals in 1981. Winter concentrations of moose in some local forest areas caused over-browsing of tree species considered desirable by the timber industry. The harvest quota was therefore increased to 1,115 animals for the 1981/82 hunting season and 1,613 in the 1982/83 season. This harvest reduced the population to 4,900 moose in March 1983 (Bobek and Morow 1987).

Then, during the next 6 hunting seasons, the harvest quotas were reduced to 1,250 animals per year. During 1987-1991 hunting statistics showed an increase in numbers of moose from 4,100 animals to 5,400 individuals. Therefore during 1989-91 hunting seasons, the harvest quota was increased to approximately 1,660 animals per year. This hunting pressure badly affected population dynamics of moose over the next decade. Hunting statistics showed a serious decrease of moose numbers to 1,718 animals in 2000. According to official estimates, there were 2,500 moose in Poland in March 2000, 800 of which inhabited National Parks (Krajowy Zarząd Parków Narodowych 2000). A nation-wide ban on moose hunting was imposed in 2001 in response to this decline in moose abundance. It is expected that the ban will remain in effect until moose numbers recover.

The main purpose of this project is to outline a recovery plan for moose in Poland. The proposal has three main objectives: (1) verification of official hunting records related to moose population numbers in particular forest areas – these areas constitute the core habitat of the moose population in north-eastern Poland; (2) estimation of moose population demographic variables necessary to manage a sustainable harvest; and (3) understanding moose habitat preferences.

STUDY AREA

Research on the moose population was carried out in 4 large forests (Fig. 1) situated in north-eastern Poland: Augustowska Forest (110,200 ha), Borecka Forest (63,800 ha), Piska Forest (124,500 ha), and Romincka Forest (13,100 ha). The Augustowska and Piska forests are typical lowland forests where Scots pine (*Pinus silvestris*) is a dominant tree species. The terrain of Borecka and Romincka Forests is hilly and the main tree species are Scots pine, spruce (*Picea excelsa*), and oak (*Quercus robur*). The early glacial landscape of the study area is diversified by terminal moraines and numerous lakes, including Œniardwy Lake, the largest in Poland. Bison (*Bison bonasus),* moose (*Alces alces*), red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), and roe deer (*Capreolus capreolus*) are the largest wild ungulates in the region. Well-established populations of wolves (*Canis lupus*) and lynx (*Lynx lynx*) occur in the eastern part of the region. The climate of the study area is continental, with snow cover during 75-100 days per year (Lencewicz and Kondracki 1964, Kondracki 1998).

METHODS

Moose Abundance

Moose density and numbers were estimated using the "Carpathian Method" (Bobek et al. 2001) for comparison with estimates derived from official hunting statistics. The Carpathian method is based on the relationship between absolute population density (N/1,000 ha), as an independent variable, and a snow track density index (T/km/day) as a dependent variable.

This relationship was measured using 44 sampling plots of 400-500 ha each in the Augustowska Forest. During winter 1998 a team of 6 trackers, working in pairs, and 35-40 observers were used to sample the plots. Plot sampling began with 2 trackers marking and clearing all the moose tracks along line transects inside the plot. The following day, 2 pairs of trackers searched the perimeter of the plot and cleared all moose tracks encountered. Next, 2 trackers counted all new moose tracks left along the same transect during the previous 24 hours. After this had been done, observers entered the plot and each person searched 10-15 ha per hour, recording all moose seen. Observers recorded the sex, age, group size, and sex-age composition of the group for all moose seen. Observers also recorded the exact time of each observation and the direction of

Fig. 1. Moose study areas in northeast Poland during 1998-2002. 1 – Augustowska Forest, 2 – Borecka Forest, 3 – Piska Forest, 4 – Rominicka Forest.

the animals' escape. After the observers had completed their search, 2 pairs of trackers retraced their path around the perimeter of the plot, recording all new tracks left by moose entering or leaving the plot, along with the location and the number of tracks.

The observations of the trackers and observers were compiled on one map. Time-space analysis was used to avoid double counting of moose, estimate the number of animals entering and leaving the plot, and finally estimate the number of moose inside the plot during the count period. The number of animals in the sampling plots was converted into population density (N1/1,000 ha) and the results were regressed against track density (T1/km/day) recorded along the track transects located in the plots. Inverse prediction, using the derived regression equation, then allowed us to calculate moose population density (y) from the track density index (x).

The Carpathian Method was subsequently used to estimate moose density in the Augustowska, Borecka, and Rominicka forests in February 1998 and in the Piska Forest in February 2002. Fresh tracks (left during the previous 24 hours) were recorded along the line transects laid out along forest roads passable by trackers in off-road vehicles (at least 50 km per 10,000 ha of forest) during 5 consecutive days. The average daily track density (T2/km/day) was used to estimate moose density (N2/1,000 ha) and the number of moose per forest inventory unit (1,000-2,000 ha). The number of moose calculated from the inventory units were summed separately for each of the 4 forest research areas.

Moose abundance estimated for each forest area using the Carpathian Method was compared with the traditional guess-estimates developed for the same areas by hunters and the Forest Service. During the following 4 years, estimation of moose population numbers through the new method was continued in Augustowska Forest. Results of the population census were accepted by the local Forest and Wildlife Service and used to calculate harvest quotas.

Population Composition and Harvest

Population sex ratio and the number of calves per female in autumn were obtained by direct observation of animals in Augustowska Forest during the years 1999 and 2000. The observations were carried out by the authors and by well-experienced game managers from the local Forest Service. The Forest and Wildlife Service provided data on number, sex, and age of harvested moose in Augustowska Forest.

Habitat Selection

To determine moose habitat selection, track transect lines along roads in Augustowska Forest were precisely drawn on forest maps. Using a car odometer and forest maps, the location of all moose tracks were recorded together with forest types and age classes (10- or 20-year intervals) in which they occurred. Then, using forest maps, the length of forest types and forest age classes along the line transects were measured and these proportions were defined as the availability of forest habitats. Habitat selection by moose was tested according to Cherry (1996) using Bailey's 95% simultaneous confidence intervals (Bailey 1980).

Population Simulations

Computer simulations were used to gain a better understanding of moose population dynamics in Poland (Bobek 2002). Simulations were based on official harvest and moose abundance estimates. The annual recruitment rate was assumed to be 30% of the population size in February; i.e., after the hunting season. This assumption is based on reliable moose abundance and harvest data for Augustowska Forest. This forest area is part of the most important moose habitat in north-eastern Poland. The recruitment rate of the moose population in Augustowska Forest can also be considered as representative of the second core area of moose population in Polesie Lubelskie (east-central Poland), because of a similar habitat, climate, and predation.

The simulation represents 2 different separated periods: 1981-92 and 1995-2001. These periods cannot be compared because some of the hunting districts existing from 1992 to 1995, where a large portion of the moose population lived, were discontinued when Biebrza National Park, Polesie National Park, and Narew National Park were created.

RESULTS

Relationship between Track Indices and Moose Abundance (Carpathian Method)

Moose and track counts were conducted in a total of 44 sampling plots (the total area of which was 21,410 ha) in the Augustowska Forest (Table 1). Moose were observed in 12 plots and tracks were recorded in 3 plots where no moose were seen. No moose or tracks were recorded in the remaining 29 plots and these were not included in our regression analysis.

The moose density ranged from 0 to 8.25 animals per 1,000 ha (Fig. 2). The track index varied between 0.00 and 0.90 tracks/km/day. The relationship between moose population density (N/1,000 ha) and track density index (T/km/day) is defined by the following formula:

$$T/km/day = 0.20 * \tan (0.14*N/1000 \text{ ha})$$

$R^2 = 0.56$, $n = 15$.

Table 1. Estimation of moose population size by the line intercept track index in Augustowska Forest (110, 200 ha), north-eastern Poland. Data were collected by using 225 line transects of a total length of 735 km in February 1998.

Days of tracking	1	2	3	4	5	Mean
Number of tracks	37	32	36	35	34	34.8
Tracks/km/day	0.050	0.043	0.049	0.048	0.046	0.047
Population density (N/1000 ha)	1.74	1.51	1.68	1.67	1.56	1.63
Population size (N)	192	167	185	184	172	180[1]

[1]Accuracy of mean at 95% confidence level is 6.3%; i.e., 167-191 animals.

Inverse prediction, using the derived regression equation, allowed calculation of population density from the track density index according to the following formula:

$$y = (7.17) * \arctan (5.07 * x)$$

$R^2 = 0.56$, $n = 15$,

where, y is population density (N/1000 ha) and x is the track index (tracks/km/day).

Estimation of Moose Population Numbers

The relationship between tracks and moose density developed for the Augustowska Forest was used to estimate moose numbers in the 4 forest areas studied (Table 2). In addition to the estimated 180 in the Augustowska Forest, there were 28 moose in the Borecka Forest, 56 in the Piska Forest, and 12 in the Romincka Forest, for a total estimate of 276 animals in the 4 forests studied. Average population density was 0.88 moose/1,000 ha and ranged from 0.44/1,000 ha in the Borecka and Romincka forests to 1.63/1,000 ha in Augustowska Forest.

Moose population estimates based on the Carpathian Method were much lower than

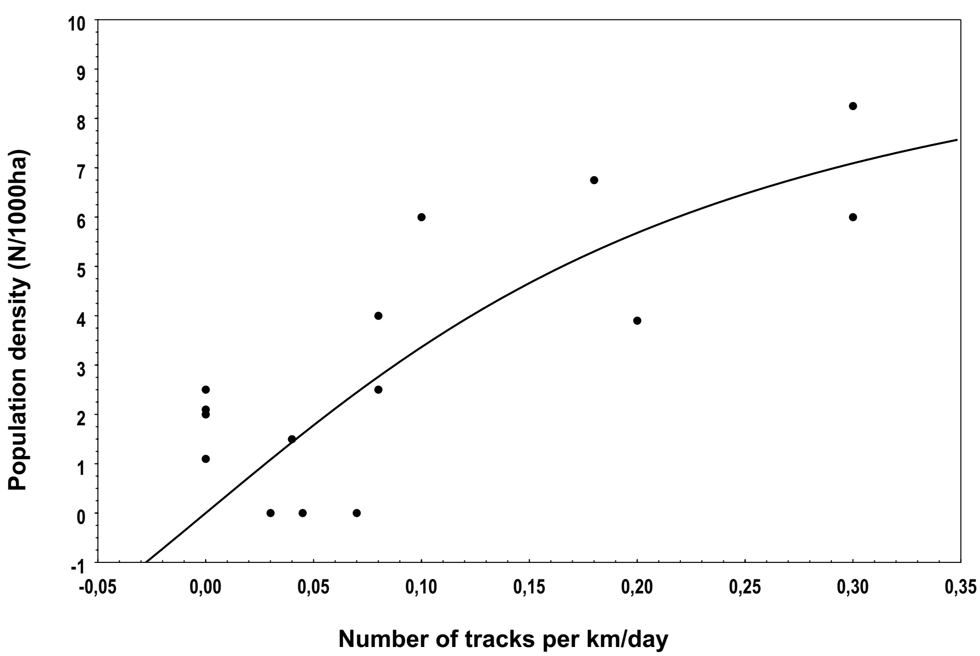

Fig. 2. Relationship between snow track index (x) and population density (y) of moose in Augustowska Forest. $y = (7.17)*\arctan(5.07*x)$, $R^2 = 0.56$, $n = 15$.

guess-estimates prepared by the Forest Wildlife Service and the Polish Hunting Association (Table 2). This implies that the official hunting statistics consistently overestimated moose abundance in the studied forests by an average of 46.0%**.** Overestimates in individual forests ranged from 8.2% in the Piska Forest to 128.6% for the Borecka Forest.

Moose Population Dynamics in the Augustowska Forest

Of 227 moose observed in Augustowska Forest in the autumns of 1999 and 2000, 41.7% were cows, 31.7% bulls, and 26.8% calves. The autumn recruitment rate was 64.4 calves per 100 cows and the ratio of cows per one bull was 1.34. According to harvest data, 39.2% of the 166 moose harvested in Augustowska Forest between 1998 and 2001 were cows, 32.5% were bulls, and 28.3% calves. Hunting pressure on bulls and calves was therefore slightly higher than their occurrence in the population.

A harvest rate of 31-33% of the winter population caused a small decline in population numbers (Table 3). A 25.0% harvest rate led to an increase in population numbers. It is evident that the ban on moose hunting in the 2001/2002 season caused a 31.0% increase in moose numbers in this area.

Habitat Selection

The spatial distribution of 348 sets of moose tracks showed significant moose preferences for forest habitats occupying wet and bog sites, which were dominated by deciduous, mixed deciduous, and mixed coniferous forest types (Table 4). Moose avoided fresh (i.e., mesic soil conditions) coniferous forest types. The other 5 forest types; fresh deciduous, fresh mixed deciduous, fresh mixed coniferous, wet, and bog coniferous were used in proportion to their availability. Young forest age classes (11-20 years old) and stands older than 100 years were preferred by moose, while age class 81-100 years was avoided (Table 4).

DISCUSSION

Our research suggests that official estimates of moose abundance, developed by the Forest Wildlife Service and the Polish Hunting Association, for our 311,600 ha study area were too high. One likely reason is the non-objective (guess-estimate) nature of the official estimates that were based on year-round observations and the personal intuition of game managers. Another related reason may be the seasonal migratory patterns of moose in the region. In Poland, moose winter mainly in forests (Morow 1975, Dzięciołowski and Pielowski 1979), but during spring and summer a substantial part of the moose population

Table 2. Moose population estimates and densities estimated by (A) the line intercept track index and (B) official population estimates developed by the Forest Wildlife Service and the Polish Hunting Association for selected forest habitats of north-eastern Poland. Ninety-five percent confidence intervals are given in parentheses.

Name of forest	Year	Forest area sampled (ha x 10^3)	Population density (Moose/1000 ha)	Population size (N)	
				A	B
Augustowska	1998	110.2	1.63	180 (67-191)	263
Borecka	1998	63.8	0.44	28 (23-33)	64
Piska	2002	124.5	0.45	56 (46-66)	61
Romincka	1998	13.1	0.92	12 (11-13)	15
Total/mean		311.6	0.88[1]	276	403

[1] weighted mean.

Table 3. Annual variation in the moose population and harvest in the Augustowska Forest in north-eastern Poland. N_1 is the population size estimated using the line intercept track index in February. N_2 is the calculated population size before hunting season in September. $N_{1(Ł+1)}/N_{1(Ł)}$ is the population growth rate.

Year	Population size		Annual harvest (N_3)	Harvest rate		Population growth rate
	N_1	N_2		N_3 / N_1	N_3 / N_2	$N1_{(Ł+1)}/N_{1(Ł)}$
1998	180	246	59	0.33	0.24	0.98
1999	176	240	44	0.25	0.18	1.11
2000	195	266	63	0.32	0.24	0.93
2001	182	249	0	0.00	0.00	1.31
2002	238	325	-	-	-	-

migrates to wetland areas (Gêbczyñska and Raczyñski 1992). As a result, in some hunting districts, migrating moose may be mistaken for resident individuals.

It is highly probable that similar mistakes were made throughout Poland. These errors led to overestimates of moose abundance, over-harvesting, and ultimately, declines in moose populations throughout Poland (Gêbczyñska and Raczyñski 1998).

Population simulation results (Bobek 2002) indicate that if there had been 6,200 moose in Poland in 1981, the harvest of 1,115 and 1,613 animals in the 1981/82 and 1982/83 hunting seasons would not have caused a decline in population numbers as official hunting statistics claimed (Fig. 3). There were probably no more than 4,400 moose in Poland in 1982. According to population simulation results, the harvest during the 1980s caused only a small decline of moose numbers in Poland. During the late 1980s and 1990s, harvesting 1,650-1,670 animals per year resulted in a large decline in the moose population, which was not recorded by official estimates. At that time, according to official hunting statistics, there was an increase in the moose population in Poland (Fig. 3). It is likely that at the end of moose hunting season in March 2000 there were only about 800 moose in all hunting districts; substantially lower than the official estimate of 1,917 (Fig. 3). Taking into consideration moose occurring in national parks, the total moose population in Poland probably numbers about 1,250 animals.

The goal of the Polish moose recovery program is to create both a viable moose population and a harvest strategy designed to maintain a stable population. However, the lack of research on moose in Poland is a serious problem. It is therefore highly recommended that a national research program be created. It should include the following measures:

1. Establish 2 core areas that could be used for both management and conservation of the moose population. They should include wetland, which is preferred by moose during the growing season, as well as forest habitats, which are moose wintering areas. In north-eastern Poland, such conditions occur in 240,000 ha of the wetlands of Biebrza National Park and neighbouring large forest areas. The other core area, Polesie Lubelskie (about 110,000 ha), should be located at the Polish-Ukrainian border and include the wetlands of Polesie National Park and adjacent forest areas.
2. In 2 areas, viable moose population size must be calculated. A sustainable harvest may take place only outside of National Parks and it should be lower than recruitment rate. These 2 populations will act as source populations for rebuilding the moose population elsewhere in Poland. Moose population objectives for these areas should be developed with input from the Polish Hunting Association, the State

Table 4. Winter habitat selection by moose in Augustowska Forest estimated by spatial distribution of 348 snow tracks in various forest types and forest age classes. Preference, "+", is indicated when the available proportion of habitat type (AHT) falls below the lower 95% confidence limit. Avoidance "-" is indicated when ATH exceeds the upper 95% confidence limit. "Fresh" refers to mesic soil conditions.

Category of habitat	Proportion of tracks in habitat	Available proportion of habitat	Bailey's 95% simultaneous confidence intervals
Forest types			
Fresh coniferous	0.433	0.546	0.358-0.509 (-)
Fresh mixed coniferous	0.279	0.251	0.212-0.349
Wet mixed coniferous	0.069	0.047	0.035-0.114
Fresh deciduous	0.014	0.016	0.002-0.041
Fresh mixed deciduous	0.054	0.045	0.025-0.096
Wet and bog coniferous	0.032	0.021	0.010-0.066
Wet deciduous + bog and wet mixed deciduous + wetland bog and mixed coniferous	0.052	0.015	0.023-0.090 (+)
Alder	0.037	0.028	0.014-0.074
Forest meadows	0.029	0.031	0.009-0.062
Forest age class (years)			
0-10	0.035	0.026	0.011-0.068
11-20	0.100	0.052	0.059-0.154 (+)
21-40	0.232	0.228	0.161-0.290
41-6	0.232	0.248	0.161-0.290
61-80	0.227	0.254	0.156-0.284
81-100	0.109	0.167	0.066-0.164 (-)
Over 100	0.063	0.022	0.032-0.110 (+)

Forest Service, and National Parks. It will be a very difficult task because moose are an attractive target for hunters and ecotourists. At the same time, they cause serious damage to young forest plantations. Therefore, it would be necessary to establish moose wintering areas that would be mainly deciduous and mixed deciduous forests growing on wet and bog sites. In the moose wintering areas, acceptable levels of forest damage caused by moose should be much higher than in lowland commercial forest. Forest management in winter moose concentration areas should result in an increase in the biomass of winter browse and should be based on natural forest succession.

3. After the moose population targets for these areas have been reached, harvest quotas should be based on reliable population estimates and annual population recruitment rates. Estimation of popula-

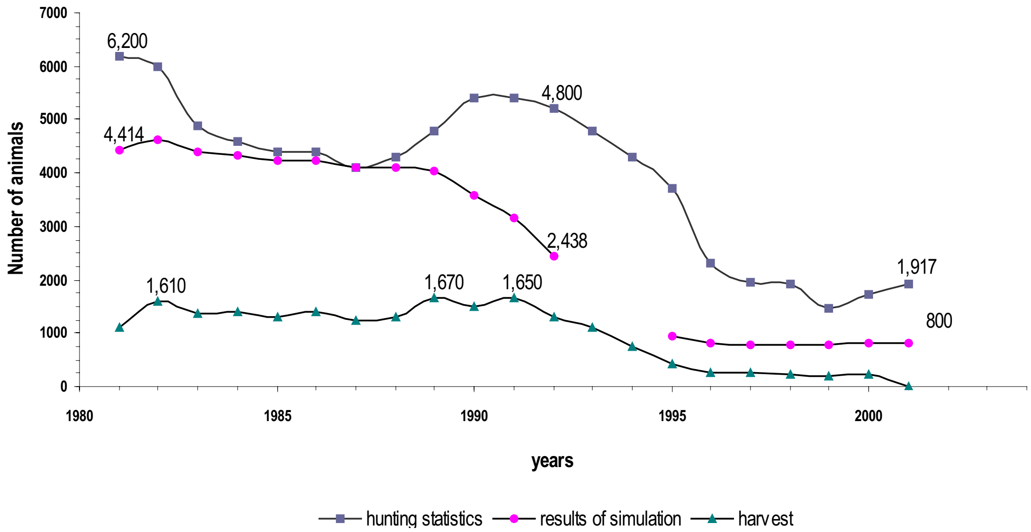

Fig. 3. Dynamics of moose populations in Poland. Data represent official statistic records on moose numbers inhabiting hunting districts, population harvest and result of simulation moose population dynamics (Bobek et al. 2002). For more explanation see text.

tion numbers should be based on snow tracking along line transects. These line transects have been successfully used for a few years for estimating the numbers of big game animals in north-eastern Poland. It appears that the maximum sustainable harvest under Polish conditions is around 30% of population numbers estimated after each hunting season. This is higher than that applicable to the moose population inhabiting Scandinavia (Solberg et al. 1999) and similar to that for moose living in the Baltic countries (Baleishis et al. 1998). Polish guidelines currently recommend a high harvest rate for calves and young bulls. This policy has caused the disappearance of males older than 10 years, which are an attractive target for hunters and ecotourists. Appropriate proportions of calves and young males in the harvest should be decided on through computer simulation models. These models should include the age structure of males.

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