MOOSE CONSERVATION IN ECOSYSTEMS OF EASTERN EUROPE

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ABSTRACT: Factors contributing to the great declines of moose from 1800 to the 1850's and in the 1920's and 30's as well as what happened to restore moose populations throughout historic ranges in Eastern Europe are evaluated. Parameters are suggested for evaluating moose populations in the 21st century as well as ideas for moose management and sustainable use.

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The decline of moose populations detected in Eastern Europe from 1980- 1990, are thought to be a result of the political instability which led to inappropriate moose management decisions (Danilkin 1996, Baskin 1998) or the result of climate cycles (Lomanov 1995). It is suggested that these situations will continue into the early 21st century. Historically, two significant population declines occurred, one from 1800-1850 and the other from 1920-1930. Utilizing past experiences, it is hoped that future declines can be prevented. Historical evidence should be used to evaluate all factors which may have contributed to the decline and used to reverse downward trends. Moose conservation in the 21st century must occur if sustainable use of this economically valuable resource is to continue (Baskin 1998).

Moose inhabit different vegetative zones (Fig. 1) and populations vary between these different zones. To analyze moose dynamics in different vegetative zones of Eastern Europe an understanding of the relationship of these populations to one another is essential. It is known that some areas have served as refuges for moose during the great depressions. Migrations resulted in populations being re-established in areas from which they had become extinct (Kulagin 1932, Kirikov 1960). The current situation in the former Soviet Union is that there is a real possibility of moose extinction. This forces management authorities to address the role refuges might play in securing moose habitat and subsequently moose in Eastern Europe.

RESTORATION METHODS

Prior to the 1930's, most of the data are from hunter records of moose abundance and hunting success. Since the 1960's, the status of moose populations can be estimated on a scale from 0 to high densities.

The simplest technique to evaluate verbal descriptions is to use a point scale: 0 - no moose; 1 - very few ; 2 - scattered but permanent populations with limited hunting; 3 - moderate densities, moose are usualy hunted with each hunter killing 1 or 2 moose; 4 - high density, moose hunting grounds are evaluated from an economical perspective, hunting success reaches 5-6 moose per hunter per winter; 5 - very high density with some hunters killing more than a dozen moose per winter.

A more contemporary approach to densities in Eastern Russia is as follows: 0 - no moose; 1-0.5 moose/10 sq. km of forested area; 2 - 1.0/10 sq. km; 3 - 3.0/10sq. km; 4 - 5.0/10 sq. km; 5 - 7.0/10 sq. km (Fig. 2). The second scale is more appropraite to evaluate current moose densities.

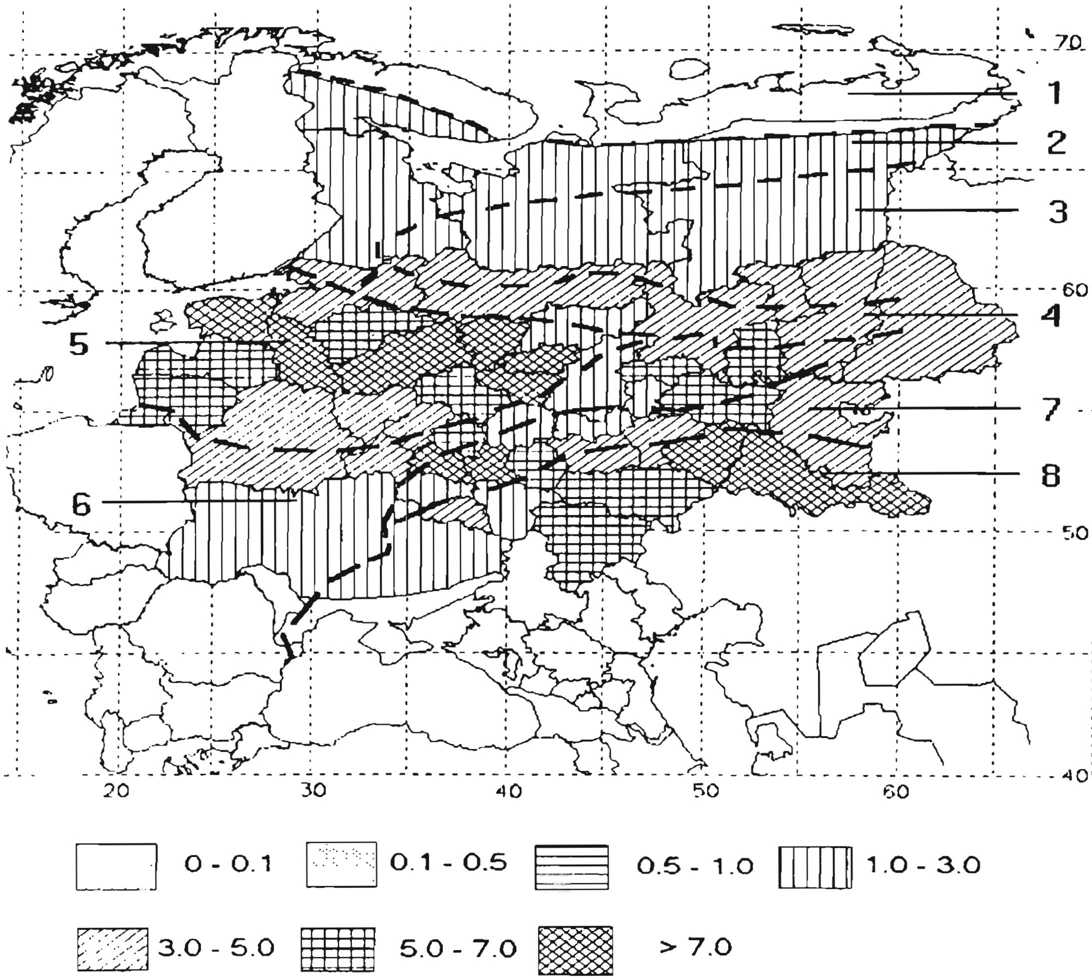

Fig. 1. Moose range and densities (moose/ 10 sq km of forested area) in 1990 (after Borisov *et al.* 1992) and vegetative zone boundaries (dashed lines). Vegetative zones: **1** - tundra, **2** - northern taiga, **3** - middle taiga, **4** - southern taiga, **5** - mixed wood forests: spruce+pine+birch+aspen, **6** - mixed wood forests: pine+spruce+oak+lime-tree+mapple, **7** - forest-steppe, **8** - steppe.

TWO GREAT DEPRESSIONS OF MOOSE IN EASTERN EUROPE

The first great decline of the Eastern European moose population commenced at the beginning of the 18th century. At this time, the Russian czar Peter the Great banned moose hunting for domestic purposes to conserve the depleted stocks. This approach to conservation was practised by other czars in the central provinces of the Russian empire. In spite of these initiatives, in the 1790's and early 1800's, moose totally disappeared from many areas of central Russia and the northern Ukraine (see geographical names in Fig. 3). Moose remained depressed in most areas until about 1850 (Fig. 3).

The important features of the first great decline were: (1) the decline was gradual; (2) total extinction occurred in many areas with some people not knowing what moose looked like; (3) extinction occurred not only

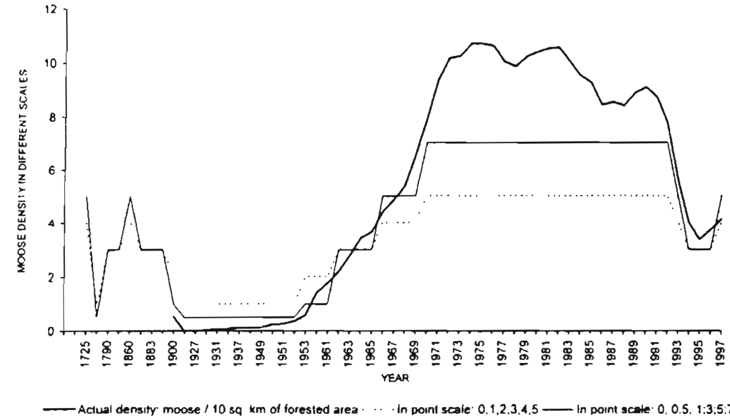

Fig. 2. Fluctuations of moose density in Estonia on different scales (after Ling 1959, Tönisson 1997).

in southern and central parts of the moose range but also in northern areas; and (4) moose populations in all of Eastern Europe suffered during the depression.

Zoologists suggested commercial moose hunting of moose for hides was the primary reason for the first decline (Kulagin 1932). From 1700-1850's, Russian cavalrymen dressed in breeches made of moose skin. However, Alexandrova and Krasovskii (1962) found that only 6,500 skins were necessary annually for military needs. A harvest of this magnitude was not considered high enough to cause the observed

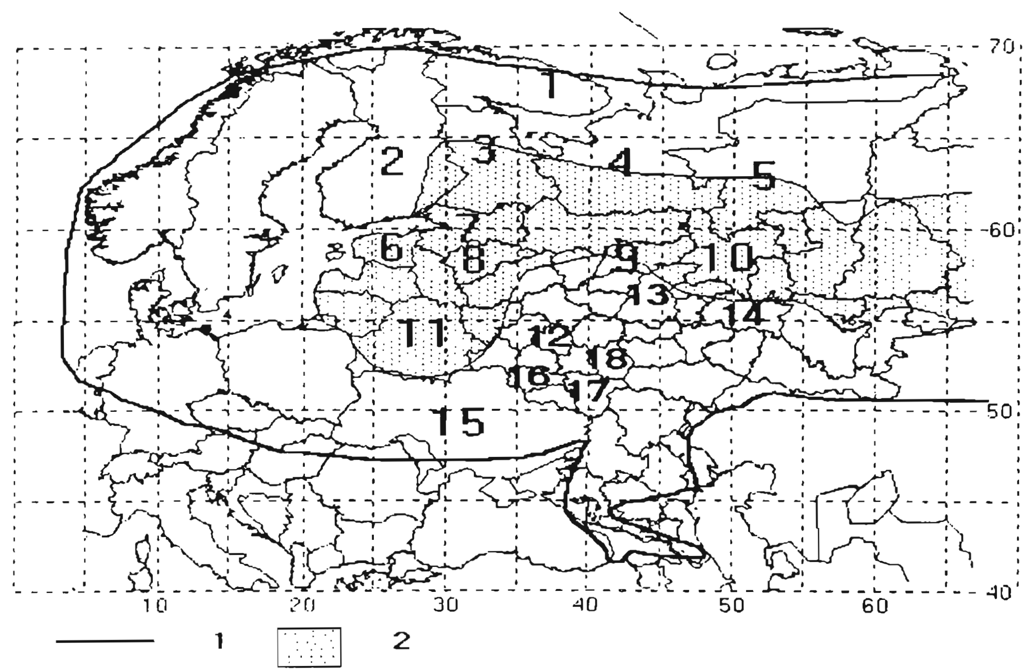

Fig. 3. Moose range in 1500 and 1850 (after Heptner 1961), (1 - a proposed boundary of the range in 1500, 2 - the range in 1850). Geographical names used in the text: **1** - the Kola peninsula, **2** - Finland, **3** - Karelia, **4** - the Arkhangel'sk oblast', **5** - Komi, **6** - Estonia, **7** - the St.-Petersburg oblast', **8** - the Novgorod oblast', **9** - the Kostroma oblast', **10** - the Kirov oblast', **11** - Belorussia, **12** - the Tula oblast', **13** - the Nizhnii Novgorod oblast', **14** - Tatar, **15** - Ukraine, **16** - the Kursk oblast', **17** - the Voronezh oblast', **18** - the Tambov oblast'.

declines.

Among other factors implicated in the first great moose decline was the climatic cooling observed in the middle of the 18th century which was the strongest in the last millenium (Flohn and Fantechi 1994). Further, habitat destruction was extensive due to forested areas being converted to agricultural land. This occurred concomitantly with the increasing human population (Tsvetkov 1957). Diseases transferred from domestic cattle were also implicated. For example, in Estonia, in 1752, most of the moose died from anthrax transmitted from cattle (Ling 1959).

The second great depression (Fig. 4) occurred from 1920-1928 (Fedjushin 1929, Jurgenson 1935, Danilov 1949). According to the data, about 48,000 moose were in Eastern Europe in 1930 in comparison with 465,000 moose in 1990.

Specific features associated with the second depression were: (1) moose were exterminated between 1918 and 1921 over vast territories; (2) excessive human use caused by economic hardship and famine was the primary reason for population declines; (3) in those areas where moose populations had declined dramatically single animals or localized small herds remained; (4) the range occupied by the remaining populations was greater than that seen during the first depression; and (5) similar to the first depression, moose den-

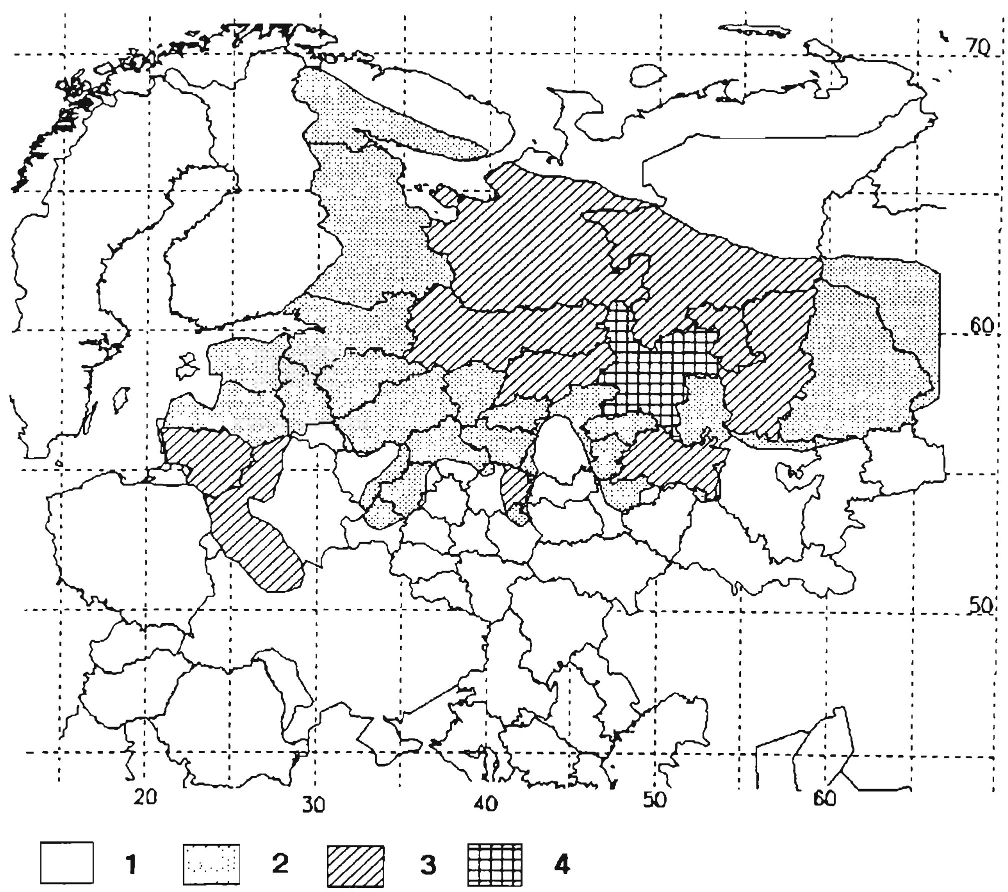

Fig. 4. Moose range and densities in 1928 (after Fedjushin 1929, Jurgenson 1935, Danilov 1949). Moose densities: 1 - 0, 2 - singles, 3 - a few, 4 - moderate.

sities became low in all provinces.

Recovery of the moose populations after both depressions was somewhat different. By 1851-1855, moose had again appeared simultaneoulsy in many districts and populations expanded quickly. The southern border of moose range moved south about 100 km per year.

In contrast to the earlier population increases, reoccupation of the range in the 20th century was delayed for about 20 years. From 1920 to the 1940's, moose reoccupied historic range in the forest zone, and later increased in numbers. Beginning in the 1950's moose started to settle the forest-steppe zone. They even appeared in the steppes and semi-deserts (Danilov 1951; Heptner 1961). This general increase continued up to 1980. During these years, moose expanded their range much more than during the reoccupation seen in the 1850's. However, in the Caucases where moose became extinct in the19th century (Vereschagin 1956) they have not reappeared.

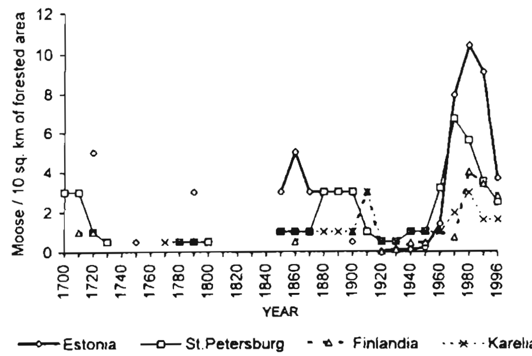

Fig. 5. Covariations of moose population density in the Transbaltic countries. Densities prior to 1920 use a simple point scale (see Restoration Methods). Thereafter, actual densities are shown (after Ling 1959, Marvin 1959, Nygren 1987, Borisov *et al.* 1992, Tönisson 1997).

METAPOPULATION OF EUROPEAN MOOSE

There are similarities in the population dynamics of moose populations of Eastern Europe and Fennoscandia (Fig. 5). There are good correlations between moose fluctuations in Fennoscandia and Eastern Europe (Table 1).

The northern and north-eastern taiga regions are sparsely populated with moose which almost totally disappeared in the previoulsy noted depressions. During the first great depression moose were absent in the northern and middle taiga zone, in the Komi republic (Latkin 1853), in the Arkhangel'sk oblast (Poromov 1865, Teplov 1960), in the Kola (Makarova 1981) and in northern Karelia (Marvin 1959, Rusakov 1979).

The southern taiga and northern part of the mixed wood forests (pine + spruce + birch + aspen) as well as the boggy areas of the Polesje in Belorussia are inhabited by populations which have undergone smoother population fluctuations (Fig. 6). The variation of moose density in these areas is 74-

Table 1. Correlation of moose fluctuations (Spearman rank correlation coefficient, [N] - number of years when calculation of correlation was possible).

Population	Karelia	Estonia	St.Petersburg
Finland	0.64 [25]**	0.78 [25] **	0.80 [25] ***
Karelia		0.61 [19] **	0.56 [19] *
Estonia			0.88 [25] ***

*** $p<0.001$, ** $p<0.01$, * $p<0.05$.

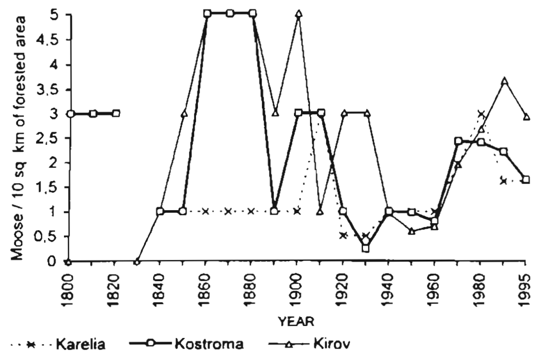

Fig. 6. Moose density variations in taiga areas. Densities prior to 1930 use a simple point scale (see Restoration Methods). Thereafter, actual densities are shown (after Djubuk 1920, Kulagin 1932, Formozov 1935, Kuklin 1946, Danilov 1949, Kirikov 1960, Bannikov and Teplov 1964, Sapozhenkov 1971, Timofeeva 1974, Rusakov 1979, Glushkov 1985, Borisov *et al.* 1992, Baskin 1994, Markovskii 1995).

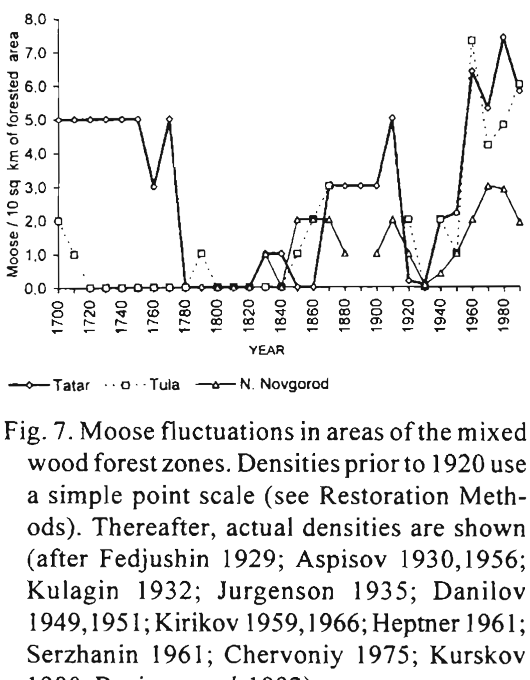

Fig. 7. Moose fluctuations in areas of the mixed wood forest zones. Densities prior to 1920 use a simple point scale (see Restoration Methods). Thereafter, actual densities are shown (after Fedjushin 1929; Aspisov 1930,1956; Kulagin 1932; Jurgenson 1935; Danilov 1949,1951; Kirikov 1959,1966; Heptner 1961; Serzhanin 1961; Chervoniy 1975; Kurskov 1980; Borisov *et al.* 1992).

91% while in other areas it is 84-152%. Moose are permanent residents here but densities are low - the maximum in 1960-1980 was about 3 /10 km^2 (Filonov 1983). The correlation coefficient between moose density and percentage of the area covered

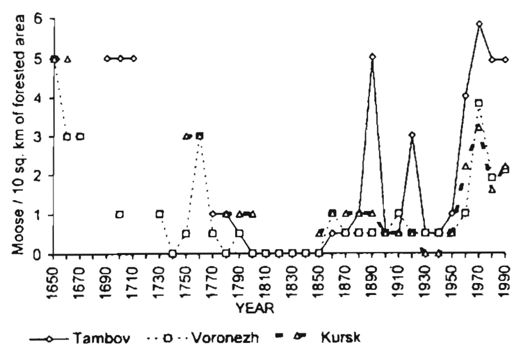

Fig. 8. Moose fluctuations in the forest-steppe zone. Densities prior to 1960 use a simple point scale (see Restoration Methods). Thereafter, actual densities are shown (after Gorbachev 1915; Kulagin 1932; Danilov 1951; Vereschagin 1956; Kirikov 1959,1966; Heptner 1961; Lebedev 1972; Fadeev 1992; Borisov *et al.* 1992).

by forest is r=0.77 (p<0.01).

The mixed wood forests of central Russia, Belorussia and the Baltic republics are inhabited by moose populations which have experienced high peaks and abrupt declines to extinction (Fig. 7). This vacant habitat has subsequently been occupied with migrants from the adjacent taiga regions where more than 50% of the territory is covered by forest.

The forest-steppe regions of Russia and the Ukraine (Fig. 8) are inhabited by moose populations which have experienced great population fluctuations and when populations have disappeared they have done so for longer periods and later have been re-colonised by northern migrants. In open areas of the steppe and tundra, moose find shelter and food primarily in flood plains or ravines, forest plantations and shrub habitats even if they are situated in semi-desert conditions. Again, some populations have disappeared and the vacant habitat has been reoccupied by migrants from adjacent populations.

Emigration from areas where moose have survived is the most important factor in restoring moose populations after the great depressions (Kirikov 1960, Heptner 1961). Moose were numerous in refuges from which surplus animals migrated. Eyewitness accounts suggest that moose did not settle in suitable neighbouring areas but moved as far as possible. They began to appear in areas located great distances from areas already occupied by moose. During 1850-1852, the southern border of moose range advanced southward 500-600 km (Kirikov 1960, Heptner 1961). This migratory behaviour is based solely on eyewitness accounts (Zhirnov 1967) and not on data generated by marking.

The European moose could be considered a metapopulation with the connection between populations being dispersing individuals. These local populations periodically become extinct and these vacant habitats were again re-colonised. This phenomenon conforms to the metapopulation definition of Hanski and Gilpin (1991). With the metapopulation model it is suggested that cessation of migratory flows which replenish declining populations is an important factor.

Two metapopulation models proposed by Hanski and Gillpin (1991) can be considered. The first is a hierarchial model of the mainland-island type. Areas of the southern taiga and mixed wood forests can be considered as mainland and local populations in areas of other zones considered as islands. Flows of emigrants from the "mainland" population to the "island" populations ("downstream" flows) are suggested. The converse of the metapopulation model would be a structure of populations of equal significance. In this model, downstream as well as upstream flows of emigrants are proposed (Hanski and Gilpin 1991). In depression periods, the flow of emigrants from the southern taiga re-establishes moose populations which exist in neighboring plant zones (i.e., to the north in middle taiga and to the west and south in mixed wood forest zones). In periods of moose abundance in mixed wood forest zone, migrations replenish populations of the southern taiga. The second model is a better explanation of how northern forest populations can be re-established.

It is speculated that destruction of the population structure is the main reason for the long periods of low density of northern populations (for example, in the Arkhangel'sk oblast', the Komi republick) encompassed in the moose metapopulation of Eastern Europe. It is comparable to the difficulty of restoring timber if seed trees are removed.

RESTORATION AND MANAGEMENT IN THE FORMER USSR

The important measures taken to restore moose populations after the extreme lows of the 1920's in the former Soviet Union were: a total ban of hunting, establishing reserves, regular censuses of moose populations, development of a hunting management system which is designed to protect populations when numbers are low, as well as harvest control when they become numerous. Conservation of moose populations in the USSR was considered more important than maximizing use. The care demonstrated moose conservation had an ideological significance, as is considered a sign of a state politics.

Censuses from air planes and helicopters in heavy forested areas often gave unuseable data. Also, the primary method used was counting tracks and the data often were not useable (Baskin and Lebedeva 1987). In the USSR few studies were done to determine the age of animals by examining *cementum annuli*. Radiotelemetry or marking of moose in other ways has never been done. Managers do not have good models to calculate annual population estimates. Also, they do consider the poaching factor and the abundance of predators and plan for low annual harvest to guard against over-harvesting.

A total ban on moose hunting was effective because of the strict control which existed in the country concomitant with the totalitarian regime. However, when licensed hunting was permitted more opportunity for poaching occured. Hunters would kill two or more moose while having only one license. Commercial hunting also had a significant impact on moose populations. Due to the decline of agriculture and a shortage of red meat, moose were hunted and the meat sold in state shops for purchase by locals. The special commercial hunting licenses were distributed among hunters, most of whom were state conservation officers. The normal ratio of commercial/sport licenses was 8:2. Hunting was a routine activity of many state conservation officers. Having a personal desire to earn money for meat taken to state shops, they hunted moose everywhere including hunting reserves.

Decline and Restoration Factors

Human persecution is undoubtedly a major factor in the decline of moose numbers. Professional hunting is especially damaging and results in extirpation. In the taiga zone, high predator populations can accelerate the decline. The population structure of metapopulations is being significantly altered by anthropogenic factors such as hunting, destruction of forests, and other development activities impacting the environment. This makes it impossible to restore local populations. Urban sprawl, modern forms of transportation, more efficient weapons, and other devices promoting hunting efficiency will inevitably lead to population declines or total disappearance without contemporary controls (Fedjushin 1929, Kulagin 1932, Danilov 1949, Heptner 1961, Filonov 1983, Baskin 1998).

Moose populations are particularly vulnerable to hunting by professionals. These hunters, who keep up to 8-10 dogs, need to cover their expences and do so by intensive moose hunting. They are proficient at finding single animals most of which are females and which constitute an important resource for recolonizing areas. A study of the great moose extinction in the 1920's and 30's revealed that single animals survived even in comparatively open habitats (Aspisov 1930). It is documented that moose consistently stayed in some specific habitats even when humans approached close to these areas. In the face of mass persecution by man, a hiding strategy in its familiar home range was found to be more profitable compared to moving to unfamiliar habitat. It can be demonstrated that during the great lows, moose totally disappeared in areas hunted by professional hunters such as the Komi, Bashkir, and Mari.

In the northern taiga the impact of excessive hunting was compounded by deep snow and an abundance of predators and human persecution resulting in extinction of moose (Formozov 1946, Nasimovich 1955, Heptner 1961).

Climatic changes play an important role in moose population fluctuations. Lomanov (1995) believes this to be the primary reason for the decline of moose. His logic is based on the fact that willow and aspen are the main food of moose and, by 1980, a decline in the diameter of willow branches was discovered. This was correlated with more frequent dry and hot springs causing a decline in overall biomass production resulting in a decline in moose numbers. Because of the 14-16, 30-35, and 90-100 dry year cycles which are dependent on cycles of the sun's activity (Chizhevskii 1976), Lomanov (1995) predicts the next low of moose numbers will occur in 1998 and 1999 with the most severe low being in 2014 and

2015. The evidence of Lomanov cannot be accepted at face value, and other factors must also be examined. Having stated this, the conclusion of meteorologists that cooling in the next century will begin around 2015-2020 (Flohn and Fantechi 1994) must be reckoned with and management decisions developed to offset the impact.

In the southern taiga and adjacent areas of other vegetation zones high moose productivity offsets mortality factors and these areas served as refuges where moose survived (Fig. 3, 4). Later, these surviving populations expanded and re-colonised other areas. An important feature of these refuges is that the forest cover generally exceeds 50% and in some cases comprises 60-70% of the total areas. In these areas hunters are at a disadvantage as there are few clearings and few roads, which in turn restrict hunter mobility. In such areas, hunting dogs are frequently killed by wolves. The carrying capacity of these areas averages about 3-4 moose/10 km^2 of forested area (Filonov 1983). There is a surplus of winter food but a shortage of summer food (Baskin 1994). Productivity of the moose populations is low (Danilov 1987). In addition, predators abound which diminishes the chances of new borns surviving.

MOOSE CONSERVATION AND MANAGEMENT IN THE 21ST CENTURY

I suggest the history of moose in the 21st century will be similar to that of the 20th century with some variations. There will be a decline from 2000-2015, a restoration from 2015-2030, and a rapid growth from 2030 to 2050.

Since 1991, when a total reconstruction of the state system started, controls on hunting have been weak. Also, subsistence hunting has again increased as seen in the 1920's. It is speculated that subsistence hunting will continue up to about 2015. A lack of state money will hinder conservation efforts. The impact of anthropogenic effects on moose will be exacerbated by climatic influences.

An increase in the welfare of human populations will not have an immediate impact on over-exploitation of moose. As previously stated, in the Soviet Union there was total curtailment of activities of the people, inlcuding the strict control of personal firearms. Considering the traditional disregard by the Russians for the state regulations, it is suggested that a more democratic life style will prolong the role of poaching in declines of moose.

As moose populations continue to increase slowly, a sharp increase is predicted to occur from 2030-2050. As the history of moose in Eastern Europe shows, a more rapid increase will occur in areas with abundant food. The restoration of moose will also depend on how contemporary logging practices are carried out in eastern Europe. Here, nearly all mature forests were cut from 1935-1955. In 20 years the oldest clear- cuttings will be 80-90 years and a new round of logging will begin. The younger forest stages will provide copious quantities of browse compared to semi-mature and mature forests.

Nowadays there is not a tendency to enlarge agricultural areas at the expense of forests. During the era of the USSR the share of the land base covered by forests increased. In the northern parts of Russia the human influence factor would be weak for a longer period. In the northern part of Russia's moose range, human densities are low and there are few large industrial centres which suggests that an extensive road network will not occur. Only in the Tatar and Bashkir republics, in southern European Russia and in the Ukraine will the human factor continue to impact moose.

In the Russian forests snow is usually very friable, so vehicles such as snowmachines are only effective on roads. However, it is anticipated that vehicles which can travel on a cushion of air will appear and be more reliable in all types of snow conditions. These machines will be used to both search for and chase moose in the more remote, pristine forests. This will create a new and serious threat for moose as has been witnessed in many parts of North America.

Moose conservation efforts in Eastern Europe must centre around maintaining viable populations, i.e., a population which maintains its vigour and its potential for evolutionary adaptation (Gilpin and Soule 1986). If the concept of eastern European metapopulations of moose is true, viable populations can be maintained if several local populations are conserved to provide an uninterrupted abundance of the entire metapopulation, facilitating animal exchange. To determine the required number of animals necessary to maintain the population's ability to rapidly increase and expand to all parts of the historical range, the status of moose in the 1946/47 period is taken as the usual. The metapopulation for that period was capable of restoring numbers to vacant or low density ranges within a few years. Danilov (1949) determined an average moose density in areas of the forest-steppe and mixed wood forests to be 0.3-0.4 animals / 10 km^2. In areas of mixed wood forests (pine+spruce+birch+aspen) and all types of taiga, the moose density in 1946- 1947 was about 0.6-1.0 moose / 10 km^2.

As mentioned earlier, a curtailment of moose hunting in areas where the density declined lower than the 1946-47 levels is more effective than other regulations such as regulating license numbers and delineating small hunting areas (20-30,000 ha) where hunting is permitted. Nature reserves with a total hunting ban for all game species were found to give the maximum profits for wildlife conservation, including restoration of moose populations. The establishment of reserves in the southern taiga for moose conservation is essential.

Before moose numbers decline to unacceptable levels, management programs must be initiated to ensure the annual harvest can be sustained rather than curtailing hunting for periods of time. The participation of the public in management programs as well as increased funding for moose management will have significant benefits for Russia's moose population and the economy. Professional hunting as seen in the past does not have a place in Russia's contemporary moose management system.

Moose sign during the snow period can facilitate hunting. This enables hunters to easily find moose and then decide how to conduct an effective hunt. Following tracks in the snow while hunting moose is an important hunting technique in the taiga zone where, as previously mentioned, moose refuges are located. When new types of snowmachines appear, hunters in the taiga areas will have a further advantage over moose. An effective measure which must be considered is prohibition of moose hunting during the snow period. Currently, moose hunting starts in early October and continues to the end of January. It would be more appropriate for moose management to start hunting in the middle of September and continue until the end of October. This would still give hunters an advantage, as the hunt would be occurring during the rutting period when bulls are more vulnerabe and when experienced hunters can call them, which adds immeasurably to the overall quality of the hunt.

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