VISUALIZING MOOSE HABITAT CHANGES DUE TO INFRASTRUCTURE CONSTRUCTION IN SOUTHERN FINLAND

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ABSTRACT:

New road constructions in southern Finland are causing significant changes in the natural behavior of moose populations. All major roads within this area are protected by fences to minimize the danger of traffic-accidents. The decrease of natural areas is problematic in the urban land use planning, as the continuity between different protected areas is crucial to maintain the endurance of wildlife. Moose tend to migrate between their summer and winter habitats to different locations within southern Finland. Without proper investigation and integration of animal crossing structures into the infrastructure the natural migration patterns and habitats of moose and other wildlife are distorted. We are investigating the Finnish moose population changes for the years 1999 to 2003. Data is available as points representing individual moose observations. How do we transform these data into information and subsequently into knowledge? Using geostatistical methods, available in GIS (Geographic Information System) analysis tools, the data can be interpolated to density surfaces for the different years. By applying overlay and data fusion procedures with road data for the same instances, we can highlight changes in moose habitats caused by infrastructure. The results are displayed as a four-dimensional animation. Thus, we intend to provide appealing visualizations attracting the public to participate in the planning procedures for future infrastructure. Furthermore we will evaluate the effects of infrastructure construction for deriving guidelines on adaptation of existing means of transport to ecological requirements. The Finnish Road Administration in cooperation with the Helsinki University of Technology – Department of Cartography & Geoinformatics finances this research as part of the MOSSE research project. More information is available on the following Website:
http://www.hut.fi/Units/Cartography/research/mosse/index.html

1. INTRODUCTION

Habitat fragmentation is a severe problem in Central Europe and the same development is seen also in southern Finland although our country has still much sparse inhabited nature and forest areas. The major roads cut their way through forest joining built up areas to each other and cause isolation to animal populations. The species of deer family are common animals in Finland. There is about 100.000 moose, 30.000 white tale deer, 10.000 roe deer and 200.000 reindeer wandering in the Finnish forests, and the amount of animals will almost double every spring due reproduction. Figure 1 shows a moose as they exist in Finland.

Figure 1. Finnish moose (Törmänen, 2002)

Moose have their annual behavior means to survive in the northern hard climate. The animal accidents have forced the road authorities to built wildlife fences along high-speed roads to protect drivers from sudden and often unexpected animal accident.

The development of models and methods to integrate and visualize experts' knowledge into planning procedures will also be in the future one of the most important tasks for scientists (Woess & Grillmayer, 2002). To examine space and spatial relationships is of growing importance. To model the influence of spatial objects towards its environment is a challenge for cartographic representations. In addition to that, an extraordinary challenge is to transform data in to information and subsequently into knowledge (MacEachren & Kraak, 2001). Furthermore this knowledge has to be integrated into legislation or planning procedures. We suggest that the presentation and visualization of information in cartographic form can play a crucial role to incorporate the knowledge into planning procedures.

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1.1 Research motivation

New road constructions in southern Finland are causing significant changes in the natural behavior of moose populations. All major roads within this area are protected by fences to minimize the danger of traffic-accidents. The decrease of natural areas is problematic in the urban land use planning, as the continuity between different protected areas is crucial to maintain the endurance of wildlife. Moose tend to migrate between their summer and winter habitats to different locations within southern Finland. Without proper investigation and integration of animal crossing structures into the infrastructure the natural migration patterns and habitats of moose and other wildlife are distorted.

The long distances in Finland cause, that almost every second person has a car. The transportation of goods and merchandise causes also lots of traffic. The animal accidents are then very common. Overall 2000-3000 moose accidents, 2000-2500 white tailed deer and roe deer accidents and 2500 reindeer accidents are reported in Finland each year. In average 5-10 humans were killed and 250-400 person injured in recent years. The estimated costs for society was about 150-190 million € per year (FinRA, 2003). The Finnish Museum of Natural History has re-enacted a possible moose accident and its consequences, which are shown in Figure 2.

Figure 2. Moose accident consequences (Reconstruction in the Finnish Museum of Natural History)

Research in this field is crucial to preserve animal habitats and avoid threads to traffic safety.

1.2 Aims

Generally this study intends to look into the metapopulation changes of moose affected by road corridors and wildlife fences. How do the fenced road change the places of winter pastures of moose and brings also problems to the movement of animals increasing traffic accidents in new places or causes damage to forestry in sapling stands.

The results are displayed as a four-dimensional animation. Thus, we intend to provide appealing visualizations attracting the public to participate in the planning procedures for future infrastructure. That may support deriving guidelines on adaptation of existing means of transport to ecological requirements.

1.3 Overview – Moose natural migration patterns in southern Finland

Moose change pastures and make seasonal migration from winter pastures to summer pastures and vice versa. The distances they move when changing pastures are 10-20 km (Väre, 2003) and quite often they have to cross major highways. In southern Finland the main pattern for moose is that the winter pastures are at the undisturbed, big forest areas inland and the summer pastures are in south at seashore or archipelago of sea or lake. The mean density of moose can be 2.5-3,5 animals/1000ha in summertime but 13-16 animals/1000 ha in wintertime at the best winter pastures.

A usual gravel or quiet tarmac road is no hindrance for moose or deer but it affects to the movements of middle-sized animals. The road channels the movements and dispersal of the middle sized animals and the traffic increases to animal mortality. According to a research by Väre (Väre & Grenfors, 2004) within the MOSSE research project, the animal movement was monitored at highway environment. About 50% of the animals, which were approaching the highway will cross it, 30% move along the highway and fewer than 20% turned back away from the highway.

The moose accidents have spatial differences due season and animal densities. The movements of moose follow the same pattern in every year. At wintertime accidents are few and they concentrate near winter pastures. In spring when winter populations start to scatter the accidents are in places where the moose routes cross major highways. The moose use the same familiar routes every year, when they move to summer pastures. Calves are born at the same areas as previous year. In summer the moose accidents happen at the coast area, near the places where the yearlings start their independent life. The accidents happen every year at the same 1.5-2 km section in the highways. There are accidents also in the Metropolitan area, where the inexperienced young moose try to reach seashore.

The animals have also learned to find the weak spots in the wildlife fences and the intersections, where the fence is open in the grossing road. The accident amounts are now as big as they were before building the fence in years 1993-1995. The amount of moose and the amount of traffic has been growing during the decade and the animals have actively search and found the places where to cross the highway in spite of the fence. The annual movements gather moose to same favorable locations in the forest areas, where there is enough food to survive over the limited winter. Built up areas and especially roads cut these areas and the effects of fencing are clearly seen in populations.

Previous research by Häggman (Häggman, 1999) used moose population data from 1997, which was collected as individual moose observation points to interpolate a density surface. Figure 3 shows the results for the greater Helsinki metropolitan area. The dark grey indicate winter pasture areas, where moose population is dense.
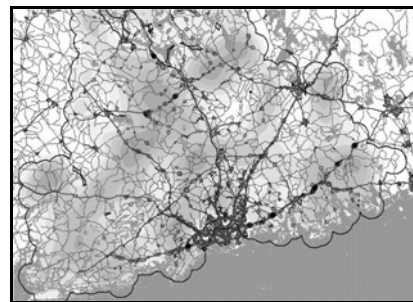

Figure 3. Potential moose habitats in the greater Helsinki region in 1997.

Additionally he used point data from wildlife traffic accidents to calculate an accident density surface. The changes in the

concentration of moose accidents in connection to the moose density has been examined (Häggman, 1999). The density surface model played a crucial role also in the definition of the ecological network (Väre & Krisp, 2003) and in the application for land use planning for the regional plan in Uusimaa (Väre, 2001).

2. METHODS – CALCULATING THE MOOSE DENSITY

Using geostatistical methods, available in GIS (Geographic Information System) analysis tools, the data can be interpolated to density surfaces for the different years. By applying overlay and data fusion procedures with road data for the same instances, we can highlight changes in moose habitats caused by infrastructure. Based on previous research experience we decided to use a Kernel estimation method to calculate the moose density. Our research area is the area of Uusimaa in southern Finland

2.1 Data

Finland is divided into 15 game management districts. They govern hunting associations, which are usually same size as local communes. At Uusimaa district there is over 30 associations, which are furthermore divided to over 300 hunting clubs or parties. The data about big game animals (moose, white tailed deer, roe deer, wild boar, wolf, bear etc.) is gathered at the beginning of March by track index. The information dates back 20 years. Earlier the data was at hunting association level nowadays in hunting area level. The Finnish Hunting Association provided data, available as points representing individual moose observations. The inventory took place every year in beginning of March, representing winter habitats of moose. Datasets for the Uusimaa region, i.e. the Uusimaa game management district, are available from 1997 – 2003. Starting from 2001, individual moose locations with x/y coordinates were inventoried as point data.

Furthermore we were provided with road network data and wildlife accident records for 2002 from the Finnish road administration (FinRA).

2.2 Determination of the moose density

To determine changes in the habitats of moose we calculate the moose density for different years using a Kernel interpolation method. Kernel estimation was originally developed to obtain a smooth estimate of a univariate or multivariate probability density from an observed sample of observations (Bailey & Gatrell, 1995). Given a random data sample, i.e. in our case moose population at defined locations, the probability distribution needs to be estimated. Applying a kernel to these statistical estimations is useful, as the method allows adjustment in cases of high variance from a „normal" distribution and the amount of smearing. This is made possible by an adjustable width of the kernel - with a wide kernel allowing for higher smoothing - and an adjustable bandwidth, influencing the amount of detail in the resulting plot (Silverman, 1986).

For habitat modeling, kernel methods for bivariate data must be applied, building upon a bivariate function of data points representing individual moose observations on a plane – in our case the study area Uusimaa U. x is the number of moose of a

total of n observations with each observation point s_n. The density λ at each observation point s is estimated by

$$\lambda(s) = \left\{ \sum_{i=1}^{n} K_h(s - s_i)x_i \right\}, s \in U$$

with K representing the kernel and h the bandwidth. The bandwith (h) for moose density habitats is set to a radius of 7.5 km. It is based on an estimated moose movement radius in the winter time.

Selecting an appropriate bandwidth is a critical step in kernel estimation. The bandwidth determines the amount of smoothing of the point pattern and defines the radius of the circle centered on each grid cell, containing the points that contribute to the density calculation. In general, a large bandwidth will result in a large amount of smoothing and low-density values, producing a map that is generalized in appearance. In contrast, a small bandwidth will result in less smoothing, producing a map that depicts local variations in point densities. (Bailey & Gatrell, 1995).

3. VISUALIZATION OF THE RESULTS

3.1 Changes in the moose habitat data in combination with the road network

We use the individual density maps for the years 2000 to 2003 and overlay them with the road network. The road network data is available from 2002. Figure 4 a,b,c shows the moose density maps for the years 2001 to 2003 combined with the road network.
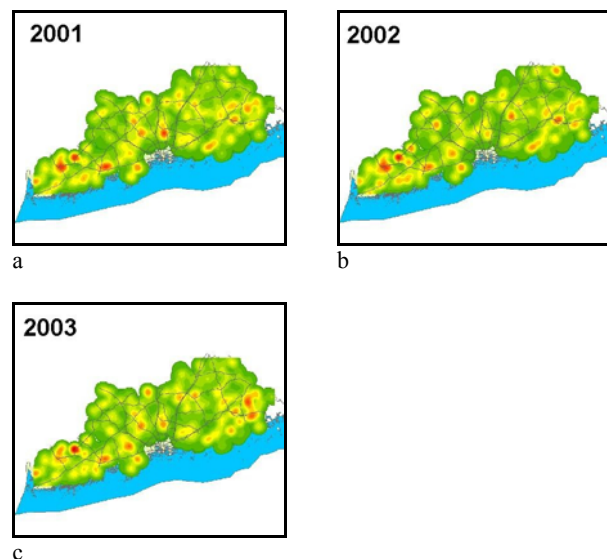

a

b

c

Figure 4. a,b,c - Moose density in winter 2001 to 2003 for Uusimaa, Finland.

We take the calculated moose density as an indicator for the moose habitats in the winter season. To combine this data with the road network aims to visually indicate changes in the habitats caused by the road network.

3.2 Visualizing the moose density in the third dimension

Much of cartography's familiarity with three-dimensional landscapes originates from digital elevation models (DEMs), panoramas, sculpted physical models and orthographic globes. The fundamentals to design "classic" three-dimensional visualisations, using greyscale DEMs, vertical exaggeration and illumination are explained by Raper (Raper, 1989) and Petterson (Patterson, 1999) among others.

The possibilities to use the third dimension to visualize thematic data have been explored by Krisp & Fronzek among others. The use of the third dimension can aid the visualisation of spatial datasets consisting of two thematic variables and allows comparing them more directly. It can also help to stress certain components of the information. Selecting and intensifying of specific parts of the information is especially important in the creation of thematic maps (Krisp & Fronzek, 2003).

Figure 5 illustrates the moose density in the third dimension. Hills indicate a high moose density while valleys a low amount of moose. The map stresses this information further by a color scale from red (high) to green (low).
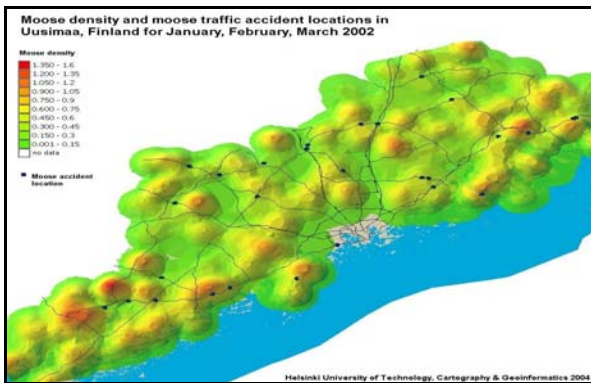

Figure 5. Moose density in winter 2002 for Uusimaa, Finland in a three-dimensional map with a color scale from red to green

3.3 Integrating moose accident data

We include accident data considering passenger vehicles and moose from the year 2002. The accident data has been collected over the whole year. We classified the seasons into different parts, taking into consideration the moose migration patterns shown in Table 1.

Time	Habitat	Movement
Winter (January to March)	winter pasture	Little
Spring (April – May)		Fast and straight
Summer (June to August)	summer pasture	Unspecific, abundant
Early Autumn (September-October)	autumn pasture	Mating season
Late Autumn (November-December)		Slow and delay

Table 1. Moose movement patterns in different seasons

To visualize and analyze changes in the accident patterns of the year we integrated the different maps into an animation by using the Macromedia Director authoring tool. Figure 6 illustrates the system as a screenshot for the winter season 2002.

Figure 6. Moose density and accidents in the Winter 2002, Uusimaa, Finland

The system shows changes in the accident data over one year. Connecting this information with the moose density

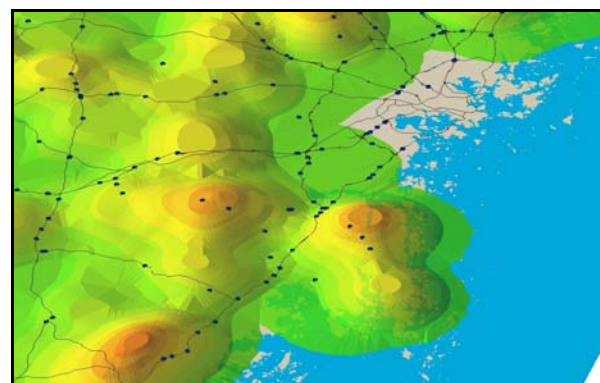Figure 7 illustrates the moose density by using the third dimension.

Figure 7. Moose density overlay with the road network and moose accidents 2002, Kirkkonummi region, Finland

In the Kirkkonummi area west of Helsinki, we can identify a road cutting through two major moose habitats. The road is not fenced (at the time of the data collection) and shows a number of moose accidents in this area.

3.4 Four dimensional animation

A four-dimensional map integrates the x, y locations as well as a z variable over time (t). To create a four-dimensional animation we generate three-dimensional maps for all available years (2001-2003) and combine them into an interactive system illustrated in Figure 8. The system has been put together by using the Macromedia authoring tool.
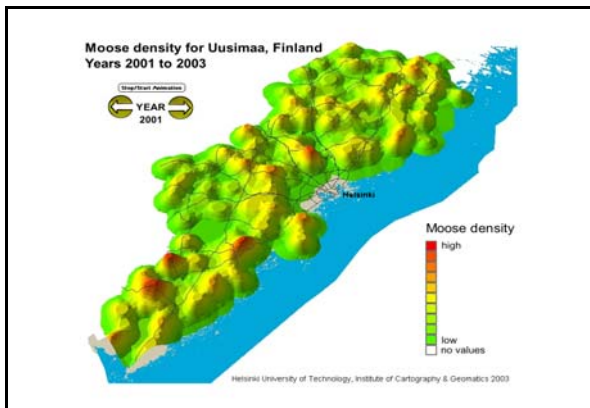
Figure 8. Interactive animation of the 3D moose density maps for Uusimaa including the years 2001-2003.

The interface for this system is the same as for the moose accident analysis tool. The maps intend to stress the information about the moose density by a color scale from red to green.

4. CONCLUSIONS

The highways with wildlife fences and other major roads with heavy traffic have sectored the southern Finland to dozen parts. The fences hinder the long distant movements of moose and cause changes in the functioning of moose metapopulations. The changes can be seen as different moose densities in the separate sides of the fenced highways. The gradual changes occur also when highway is fenced. The fenced highway without proper green bridges or underpasses cuts the winter pasture areas of the continuous moose population the moose density peaks start to move gradually away from the highway. Animals look for better pasture areas. At such areas where there is good under or overpasses in highways suitable for animal use, such change has not been discovered. The changes are gradual and they can be seen in decade long time series.

To calculate the moose density for different years provides us with the basic data to show us changes in the moose density, which might be caused by the roads. The Kernel method proves to be a good tool to calculate the density patterns of the individual moose locations. By creating a smooth of density values in which the density at each location reflects the concentration of points in the surrounding area, analysts are able to identify how densities vary across a study area. To overlay of the moose density and road network map can to identify "hotspots" concerning the location of a traffic wildlife accident.

A four dimensional animation can help to visually analyze the moose density patterns over time. Integrating the maps into an interactive system makes it easy to navigate between the different maps created for each point in time. In our example the time span from 2001 to 2003 appears to be too short to identify significant changes in the moose density. Further research should aim to integrate data from a longer time period. The Finnish hunting association will continue to record moose data points with individual coordinates, so future research will be able to consider longer time spans.

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