Ekológia (Bratislava) Vol. 30, No. 2, p. 257–268, 2011
doi:10.4149/ekol_2011_02_257

TRANSFORMATION OF RURAL LANDSCAPES IN HIIUMAA SINCE 1956 AND THE CONSEQUENCES TO OPEN AND HALF-OPEN SEMI-NATURAL HABITATS

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Abstract

Kaasik A., Sepp, K., Raet, J. Kuusemets, V. Transformation of rural landscape in Hiiumaa since 1956: consequences to open and half-open semi-natural habitats. Ekológia (Bratislava), Vol. 30, No. 2, p. 257–268, 2011.

Landscape is a reflection of natural and socio-economic processes. When socio-economic situations change, this alters land use and leads to changed land use patterns. An extensive spatial study of rural landscapes in Hiiumaa Island in West Estonia, based on available aerial photos from 1956 to the present has highlighted significant changes. These include the simplification and polarisation of land use patterns, an overall decrease in agricultural land, especially that of natural and wooded grasslands, and also a gradual increase in forests. The greatest change in land use pattern took place by the beginning of 1980s, then the initial traditional and diverse landscape pattern had become much more simplified and polarised as a result of collectivisation, land reclamation and the wider use of industrial methods in agriculture. The remarkable changes in land ownership and agricultural land use intensity, since the end of the 1980s, have not yet caused any significant changes in developed landscape patterns. This paper examines transformations in the traditional high value farmlands of semi-natural grasslands and wooded meadows and pastures, and the impacts and possibilities of recent political and socio-economic reforms in the preservation of traditional landscapes and biodiversity in rural areas. These factors involve land re-privatisation since 1987, reclamation of independence in 1991 and accession to the EU in 2004.

Key words: rural landscapes, land use change, semi-natural habitats, Hiiumaa

Introduction

Background

Landscape change in Estonia has been well documented during the past century and it followed general European trends (Vos, Klijn, 2000). Existing studies have elucidated the main tendencies of these changes, including the simplification and polarisation of land

use patterns, the considerable increase in forests and decrease in agricultural lands and the continual decline in grasslands. They have also discussed the main socio-economic factors behind these land use changes (Mander, Palang, 1994; Palang et al., 1998). Some of the driving forces such as the land reforms of 1919, 1940, 1947 and 1989, deportations and collectivization in the 1940's and the formation of a military border zone along the coastline are specific for Estonia. However, more general factors including the concentration of agriculture, marginalization, land amelioration and the use of larger machines have reshaped rural landscapes in many other countries and contributed to the loss of valuable semi-natural land-use types such as wooded and coastal meadows (Ihse, 1995; Luoto et al., 2003). Unlike previous similar studies (e.g. Palang et al., 1998; Koppa, 2006; Tomson, 2007, etc.), this current land use analysis focuses on the last half-century, especially on agricultural landscapes, and it is based on large-scale cartographic material (1:10 000) and also on extensive field work.

Why Hiiumaa?

Hiiumaa at approximately 1000 km^2 is the second largest island in Estonia. Due to its relative isolation and poor preconditions for intensive agriculture due to young and mostly stony and thin limestone soils, the landscape changes in Hiiumaa have been slower and the land use had retained a relatively traditional character by the middle of the 1950's. So it was presumed that the first available aerial images from 1956 would reflect the diverse land use patterns that had been developed during the first independence period of Estonia from 1918 to 1939.

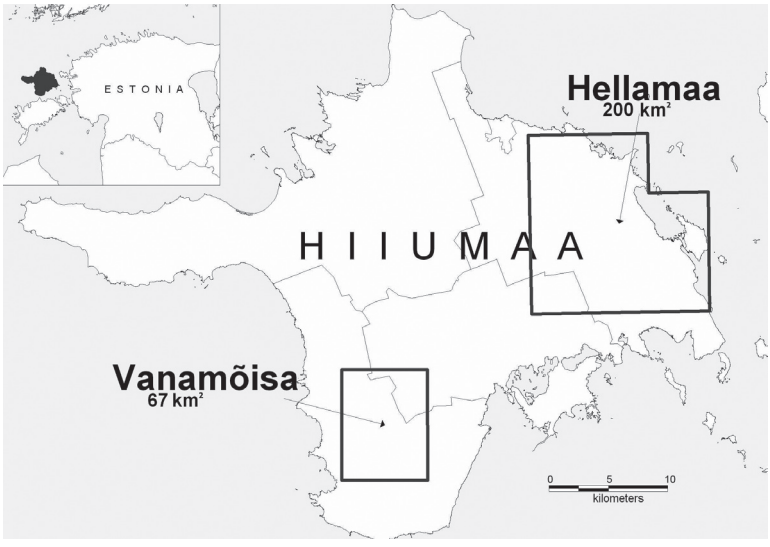

Fig. 1. Location of study areas in Hiiumaa.

The study area embraces two agricultural regions in Hiiumaa: Hellamaa at 200 km^2 in the north-eastern and Vanamõisa with about 67 km^2 in the southern part of the island (Fig. 1). In Hiiumaa, the amount of agricultural land has drastically decreased from more than 65% in 1939 to less than 25% in 1992 (Mander, Palang, 1999) and currently most of the agricultural land use in Hiiumaa is concentrated in the above regions.

Methodology

The landscape analysis was based on decoded aerial photos (ortophoto maps) from 1956 and 1984. The large-scale ortophoto maps of 1:10,000 were scanned and the land use patterns of 1956 and 1984 were digitized in GIS software MapInfo. The state of the present land use was identified by the 1:10,000 digital Basic Map of Estonia based on 1998 aerial images. Field work subsequently identified the actual land use, namely the fields still in use and long and short-term fallows, thus distinguishing more than 30 land use types. In order to define the former spread of semi-natural wooded meadows and pastures and also to analyze successive transformations between land use categories, the land use types were digitized as precisely as possible, e.g. concerning grasslands, pastures and mires the existence of bushes and trees was defined. The current distribution of preserved valuable open and half-open semi-natural habitats listed in EU Habitats Directive was detected from data of the Estonian Nature Information System (ENIS, 2010). The land use patterns were analyzed and the first statistics and landscape metrics were calculated in MapInfo.

Findings

Simplification and polarisation of landscape patterns

This study has brought out considerable changes in rural landscapes and the first results have already been published (Kaasik et al., 2008). The greatest change in total patchiness and edge density of the land use patterns occurred between 1956 and 1984. By 1984, the traditional and extremely diverse landscape pattern of 1956 had become much more simplified and polarised as a result of farming intensification, marginalisation, collectivisation and especially land reclamation, which most likely had the greatest effect on this process (Fig. 2). In Hiiumaa the amelioration of agricultural lands commenced in 1963 and continued until the beginning of the 1980's, although the major portion of reclamation works involving more than 90% of all reclaimed areas was implemented between 1968 and 1979. By 1998, the landscape pattern and patchiness had remained almost the same as it was in 1984.

In order to analyze the impact of land reclamation on the landscape structure, the larger ameliorated fields and cultivated grasslands (in total 163 fields with a total area of 5,335 ha) were selected (Fig. 3). The spatial analysis inside the ameliorated areas showed a significant simplification in land use structure. The 163 large fields were transformed from 6,167 tiny land use patches in 1956 in the following manner: (1) grasslands and pastures formed 53% with 2920 patches, (2) former fields composed 30% with 2,127 patches, (3) forests comprised

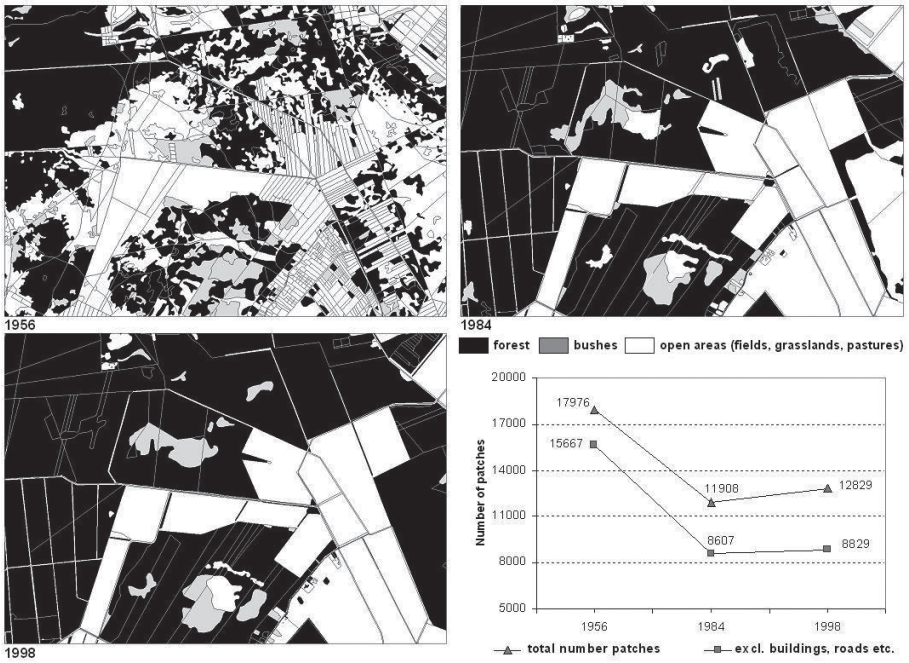

Fig. 2. Changed patchiness and examples of changed land use patterns 1956–1998 (Kaasik et al., 2008).

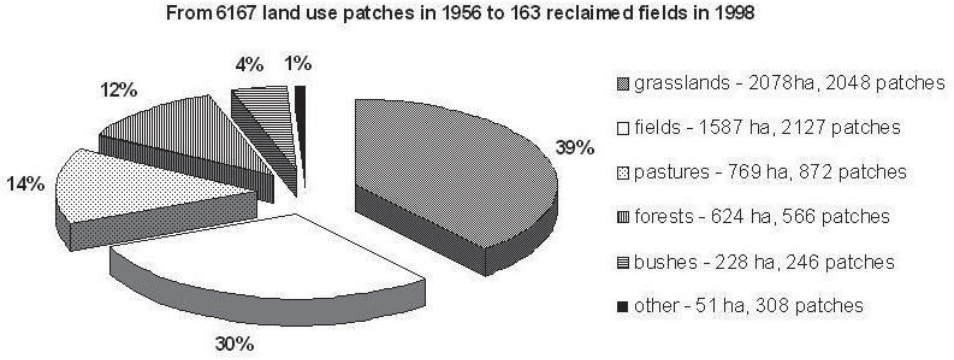

Fig. 3. Origin of 163 ameliorated fields (5,335 ha) in Hiiumaa (Kaasik et al., 2008).

12% with 566 patches and (4) bushes made up 4% (Fig. 3). Other land use types such as roads, courtyards, mires and water bodies together formed 1%. However 9 patches of mires covering 4 ha and 26 patches of water bodies with 7 ha have disappeared due to field land reclamation.

Decrease in agricultural land and increase in forests

An additional tendency was an overall decrease in agricultural land (in account of grasslands) and an increase in forests (Fig. 4a, b). The percentage of grasslands and pastures has decreased significantly, mainly in half-open land use types such as grasslands with bushes and/or trees in our classification (Fig. 5). The sharp decline in half-open farming lands also indicates the loss of species-rich semi-natural land use types and habitats, including wooded meadows and pastures which previously formed as a result of long-term traditional agricultural practices.

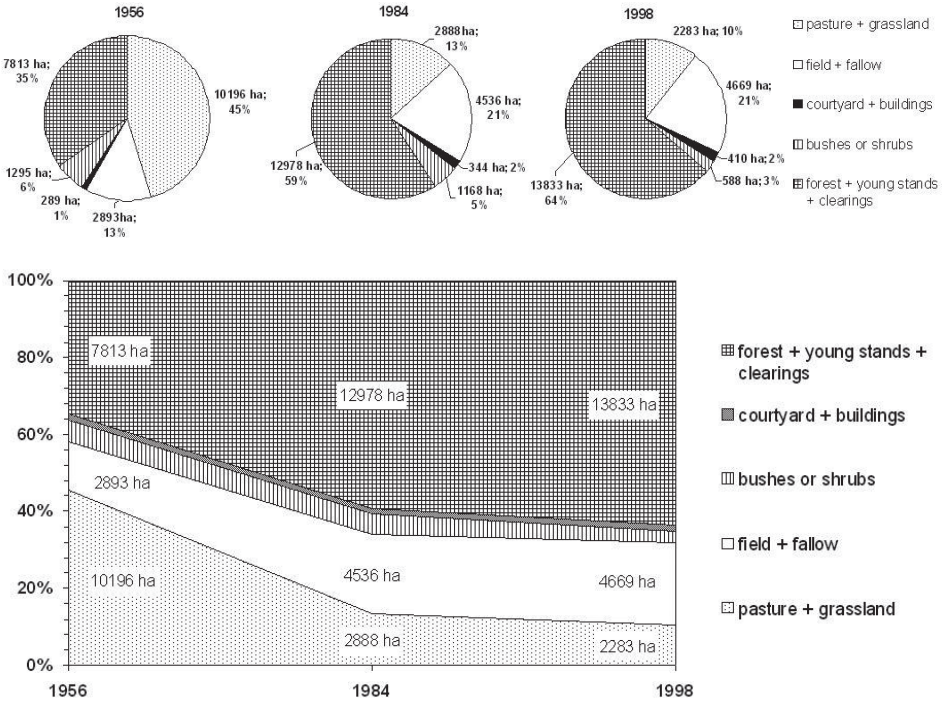

Fig. 4a, b. Changed land use 1956–1998.

Disappearance of wooded meadows and pastures

In 1956, the half-open land use types, such as grasslands and pastures with bushes and/or trees, were widely spread in both study areas, on a total of 7492 ha (Fig. 6). It is now difficult to identify how much of these half-open lands was actually long-term wooded meadows or only recently abandoned farmlands resulting from World War II, deportations and collectivisation. By 1984, only about one tenth of these land use types, comprising 695 ha, were

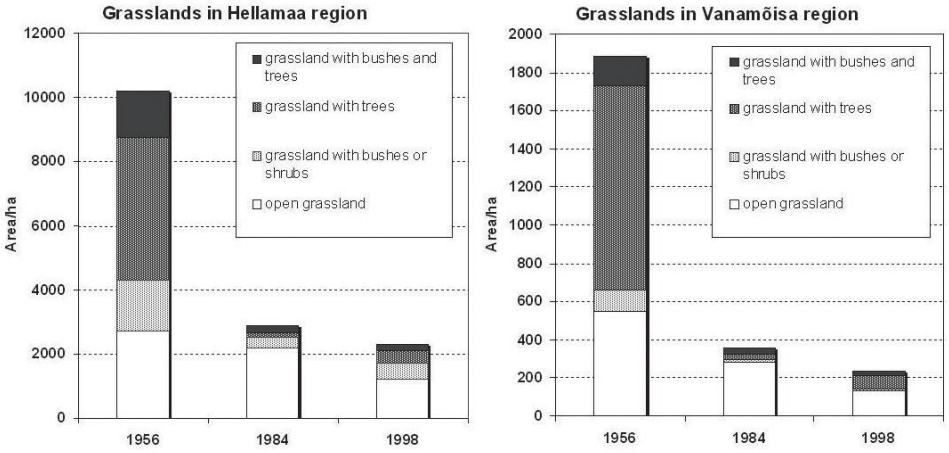

Fig. 5. Decline in grasslands 1956–1998 (Kaasik et al., 2008).

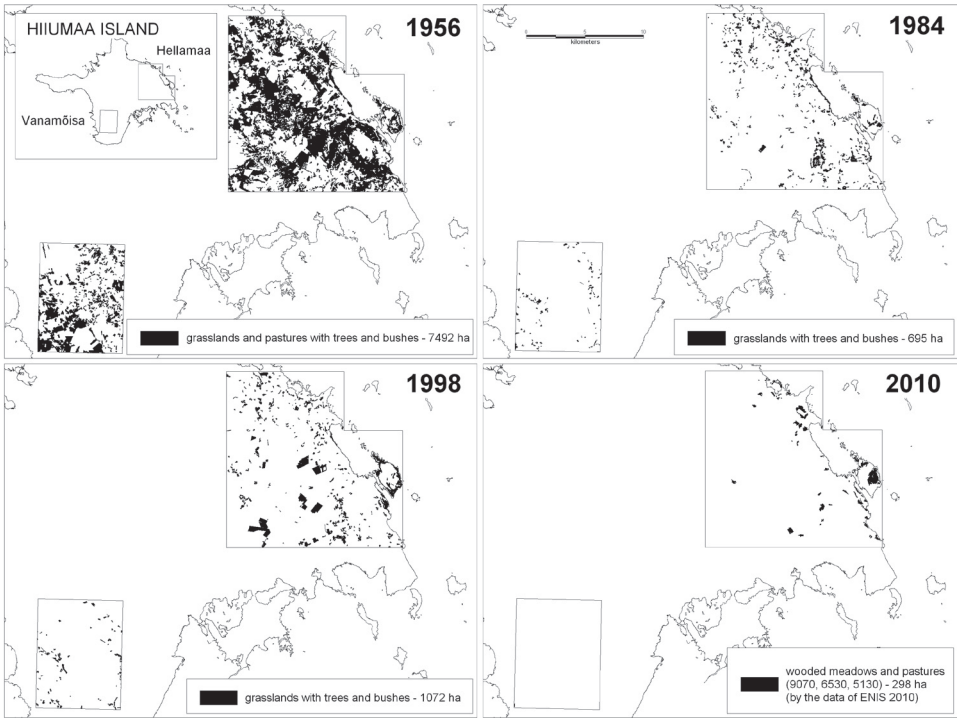

Fig. 6. Disappearance of wooded grasslands in Hiiumaa 1956–2010 (Habitat types according to EU Habitats Directive).

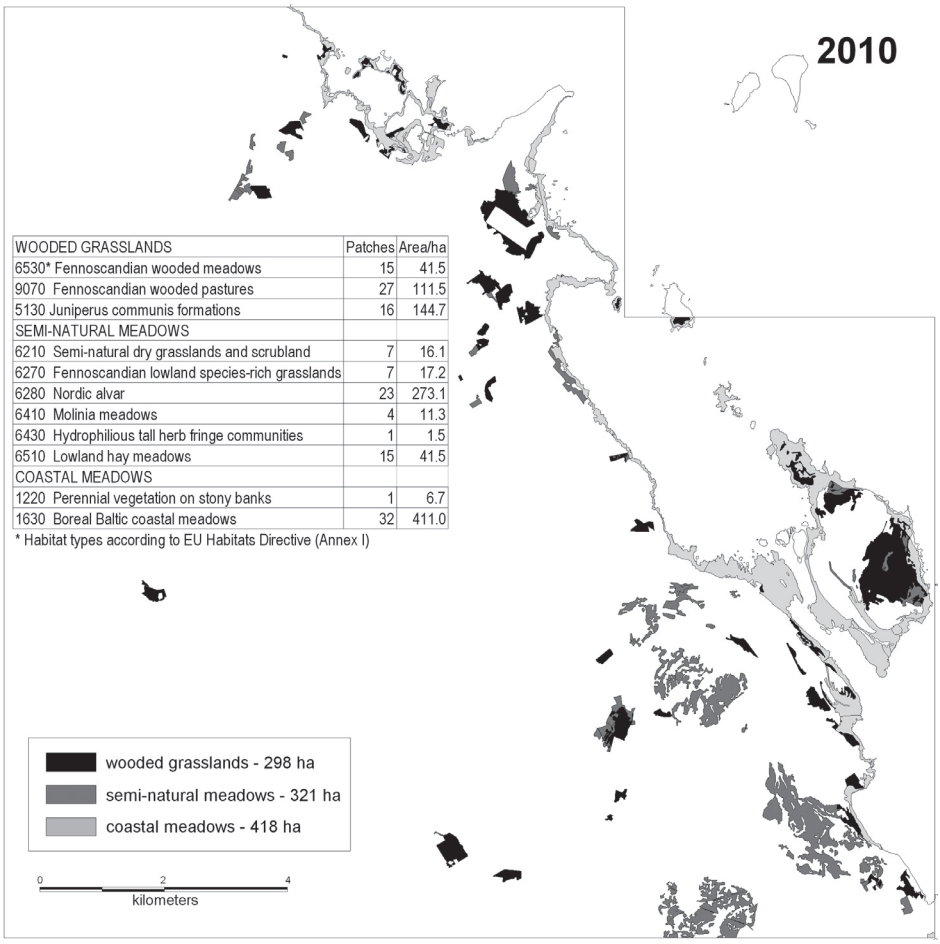

Fig. 7. Current distribution of open and half-open semi-natural habitats in the Hellamaa region (From data of ENIS, 2010; habitat types according to EU Habitats Directive).

preserved mainly due to marginalisation, forestation and amelioration. By 1998, the area of half-open farmlands of 1072 ha slightly increased most likely due to secondary afforestation of abandoned fields and grasslands. By that time, agricultural land use had probably attained its lowest level as a result of reorganization of agriculture involving the collapse of collective farming, land re-privatisation and the formation of small-scale private farms from the end of the 1980's (Peterson, Aunap, 1998). In fact, a great portion of the agricultural areas was fallowed by the end of the 1990's. According to the Estonian Rural Development Plan of 2004–2006, the use of agricultural land in Hiiumaa decreased by up to 50% from 1993 to 2001 (ERDP, 2005).

This general trend leading to the disappearance of extensive half-open land use types has still continued. The present situation only indicates the distribution of valuable half-open habitat types as listed in the Annex I of EU Habitats Directive. These are the Fennoscandian wooded meadows and pastures (6530, 9070) and the *Juniperus communis* formations on heaths or calcareous grasslands (5130) as in Fig. 6. According to data of the Estonian Nature Information System (ENIS, 2010), the valuable open and half-open habitat types have now been preserved only in the coastal region of the Hellamaa study area. These comprise wooded meadows and pastures on 298 ha, semi-natural meadows (6210, 6270, 6280, 6410, 6430, 6510) on 321 ha and coastal meadows (1220, 1630) on 411 ha (Fig. 7).

What has happened to former pastures and grasslands?

Although there are no firm relationships between landscape metrics and ecological values, the shape and size indices/parameters of pastures and grasslands of 1956 indicate their semi-natural character. The mainly used shape metrics are based on perimeter/area ratio (Wu et al., 2000), such as:

$$SI = \frac{0.25P_i}{\sqrt{A_i}}, \quad (1)$$

where *Pi* is the perimeter, *Ai* the area and *SI* the shape index of an individual patch *i*. *SI* estimates the individual shape complexity or compactness. The minimum value is about 0.89 related to the circle and 1.0 for the square. The mean shape index (*MSI*) is calculated for a set of patches composing a class or for a whole area, where *N* is the number of patches within a class or a whole area:

$$MSI = \frac{\sum_{i=1}^{N} \frac{0.25P_i}{\sqrt{A_i}}}{N} \quad (2)$$

The total area of pastures in 1956 was 4,505 ha, with the number of patches (*N*) = 3102, a mean size (*MS*) of 1.45 ha, *SI* – 0.92–4.02 and *MSI* – 1.34. By 1984, 50.4% representing more than half of the pastures were transformed into forests and 13.4% into fields. The transformation of open grasslands, with a total area of 5,706 ha, *N* – 4192, *MS* – 1.36 ha, *SI* – 0.92–5.66 and *MSI* – 1.38 in 1956, was quite similar. By 1984, 43.7% of the grasslands were transformed into forests and 24.4% into fields. From 1984 to 1998, the transformation of previous pastures and grasslands mainly continued by successive transformations, with the gradual overgrowth of bushes and trees. By 1998, more than 56% of the pastures and about 51% of grasslands present in 1956 had been transformed into forests, and only about 3% of previous pastures and 12% of grasslands were maintained and classified as open grasslands.

Discussion

Change is considered an essential property of landscape (Antrop, Van Eetvelde, 2008), and since changing natural or socio-economic conditions alter land use, these are sooner or later reflected in changed land use patterns. Additionally, quantitative changes described by landscape metrics should influence qualitative parameters, such as the historical, aesthetical and biodiversity values of landscapes. However, landscape metrics are difficult to relate to both the processes which cause the change and the qualitative impacts/consequences of the changed land use patterns (Li, Wu, 2004). Due to the complexity of landscapes, the impacts of broader processes can be divided into direct or indirect impacts. These may be positive or negative and some are intended while others are not. This raises the question of how to to direct landscape change. By understanding the general mechanisms which reshape our landscapes and knowing the values and/or features we want to preserve, is it possible to direct these processes?

In Hiiumaa, Soviet period changes brought about the loss of traditional diverse land use patterns that had formed as a result of long-term traditional farming practices. Fortunately, due to unfavourable conditions for intensive agriculture, semi-natural farmlands, including wooded meadows and pastures, are still apparent in many places. When comparison is made with intensive farmlands and economic aspects are, disregarded, the scenic, biodiversity, cultural and potential tourist and recreational values of these landscapes are still considerably higher. There were great expectations that the latest reforms of land re-privatisation and the formation of small-scale private farms from 1987 would help to restore the diverse land use pattern that was characteristic for the first independence period. In fact, a great portion of the privatised agricultural areas remained fallowed for short or longer periods (Raet et al., 2010). As a general trend, until 2004 land use changed towards marginalisation and re-naturalisation of agricultural areas.

Accession to the EU in 2004 opened several subsidiary schemes for Estonian farmers. Some of these were financed by the EU and others by the Estonian Government as part of the National Rural Development Plan. Subsidiary schemes in Estonia are implemented by the Agricultural Registers and Information Board (ARIB). The main objective of a general Area-related Aid and Crop Farming Aid is to preserve open landscapes and to compensate the costs of maintaining land so that its fertility is retained. Several other subsidiaries are designed to improve the environmental awareness of agricultural producers. These are aimed at preserving semi-natural biotic communities and valuable landscape features and maintaining land use. They will also compensate costs incurred in regions with unfavourable or restricted environmental conditions. As preservation of semi-natural habitats and landscape features needs continuous management, and this can not be achieved by traditional nature conservation methods, certain aid schemes are intended to support the reconstruction of stone fences and the management of semi-natural communities. This will supply 238 EUR/ha for wooded meadows and 185 EUR/ha for other ones in 2010. Additionally, there will be encouragement for such undertakings as organic farming and environmentally friendly management (ARIB, 2010). The variety of subsidiaries for Estonian farmers, together

with structural changes in the rural economy as more organic and recreational farms join profit-oriented agricultural ones, certainly provides hope that current landscape changes will ensure a more diverse and well-managed rural scene.

Several studies have proven the close relationship between landscape change and biodiversity, wherein a decrease in species-rich wooded meadows and pastures is directly linked to biodiversity loss (e.g. Burel et al., 2004; Grashof-Bokdam, Van Langevelde, 2004; Hietala-Koivu et al., 2004; Bergman et al., 2004). There is no doubt that significantly changed land use and landscape patterns in Hiiumaa have influenced species composition, population numbers and the distribution of several species living, feeding or nesting in these landscapes. The assembled spatial information on landscape change affords further challenges to study the effects of altered agricultural landscapes on biota, and also to calculate potential population numbers of certain species by comparing their habitat preferences with distinct land use types.

As with all changes, the Soviet period landscape change of expansive land reclamation and the formation of huge fields was not completely harmful for all species. There are always so-called winner-species which can adapt, adjust, and even profit from changed conditions. Hiiumaa's agricultural region is an important place for many waterfowl and other species with a most impressive numbers of birds there during spring and in the autumn migration. For instance, cranes and geese on their migration route feed almost exclusively on the cereal fields, cultivated grasslands and pastures of agricultural land. Their breeding success and the species' general state and multitude are considered to be dependent to a large extent on these agricultural resources. The main interest in the large-scale spatial land use data of the last 50 years was induced by the ambition to compare and combine it with available biodiversity data. This especially applied to the existing bird census data from the same period. Due to the long intervals of the spatial analysis of 1956–1984 and 2004–2010, it is difficult to find solid correlations between available annual bird count numbers from the 1960's and changes in land use patterns. Nevertheless, correlation between statistical data for cereal production and the count numbers of the Eurasian crane (*Grus grus*) has already been confirmed (Leito et al., 2008). There is still a lot of uncertainty whether, and to what extent, the changed numbers of some bird species counted in Hiiumaa from the 1960's actually indicated the state of the entire migrating populations or only temporary relocations to new or different feeding and staging areas.

Conclusion

(1) The rural landscapes in Hiiumaa have changed considerably since 1956.
(2) The land use pattern has simplified and polarised as a result of marginalisation, land reclamation, collectivisation and intensification of farming. As the major portion of reclamation works were carried out between 1968 and 1979, the greatest change in landscape patterns took place between 1956 and 1984. In 1998, the general land use pattern remained approximately the same as in 1984.

(3) The area of agricultural lands decreased in grasslands by approximately 43% and forest areas increased by about 44% from 1956 to 1998. Here, the percentage of grasslands decreased significantly especially in natural types of grasslands. By 1998, more than half of the pastures and grasslands of 1956 had been transformed into forests.
(4) The area of half-open land use types such as grasslands and pastures with trees and bushes decreased significantly by more than 10 times from 1956 to 1984. The slight increase from 1984 to 1998 is most likely related to the abandonment of agricultural areas. In 2010, the valuable types of half-open habitats of wooded meadows and pastures have been preserved mainly in the coastal region of the Hellamaa study area which has remained untouched by land reclamation.
(5) The ameliorated fields were mainly transformed to grasslands and pastures (53%), former fields (30%), forests (12%) and bushes (4%). The 163 larger fields existing in 1998 were transformed from more than 6000 land-use patches in 1956.
(6) As a result of land re-privatisation and the formation of small-scale farms since 1987, large portion of farmlands remained fallowed for short or longer periods. The general trend in land use between 1987 and 2004 was abandonment and forestation of farmlands.
(7) Enforcement of the EU agricultural subsidiary schemes since 2004 provides the opportunity to direct current and future landscape change. Aid schemes have been designed to support the reconstruction of stone fences, the management of semi-natural communities and also to assist organic farming and environmentally friendly management.
(8) The decrease in species-rich wooded meadows and pastures is directly linked to biodiversity loss. The accumulated spatial information of landscape change affords further challenges to study the effects of altered agricultural landscapes on biota. Due to the long intervals in spatial analysis between 1956–1984 and 2004–2010, it was difficult to find solid correlations between the annual bird count numbers from the 1960's and landscape metrics. Nevertheless, correlation between statistical data for cereal production and the count numbers of the Eurasian crane (*Grus grus*) has already been confirmed (Leito et al., 2008).

Translated by the authors
English corrected by R. Marshall

Acknowledgements

This study was supported by the Target Funding Project No. 1090050s07 of the Ministry of Education and Science, Estonia.

References

Antrop, M., Van Eetvelde, V., 2008: Mechanisms in recent landscape transformation. In Mander, U., Brebbia, C. A., Martin-Duque, J. F. (eds), WIT Transactions on the Built Environment, Vol. 100, Geo-Environment and Landscape Evolution III: Third International Conference on Evolution, Monitoring, Simulation, Management

and Remediation of the Geological Environment and Landscape, 16–18 June 2008, The New Forest, UK. WIT Press, Southampton, p. 173–192.
ARIB, 2010: Estonian Agricultural Registers and Information Board, http://www.pria.ee/en
Bergman, K., Askling, J., Ekberg, O., Ignell, H., Wahlman, H., Milberg, P., 2004: Landscape effects on butterfly assemblages in an agricultural region. Ecography, 27, 5: 619–628. doi:10.1111/j.0906-7590.2004.03906.x
Burel, F., Butet, A., Delettre, Y.R., Millàn de la Peña, N., 2004: Differential response of selected taxa to landscape context and agricultural intensification. Landsc. Urban Plann., 67: 195–204. doi:10.1016/S0169-2046(03)00039-2
ENIS, 2010: Estonian Nature Information System – Environmental Register: The Estonian Environment Information Centre, http://loodus.keskkonnainfo.ee/w5/index.php?lang=eng
ERDP, 2005: Estonian Rural Development Plan 2004–2006, Estonian Ministry of Agriculture, Tallinn, http://www.agri.ee/public/juurkataloog/TRÜKISED/s_raamat_eng_01.pdf
Grashof-Bokdam, C.J., Van Langevelde, F., 2004: Green veining: landscape determinants of biodiversity in European agricultural landscapes. Landsc. Ecol., 20: 417–439. doi:10.1007/s10980-004-5646-1
Hietala-Koivu, R., Lankoski, J., Tarmi, S., 2004: Loss of biodiversity and its social cost in an agricultural landscape. Agric., Ecosyst. Environ., 103: 75–83. doi:10.1016/j.agee.2003.10.015
Ihse, M., 1995: Swedish agricultural landscapes – patterns and changes during the last 50 years, studied by aerial photos. Landsc. Urban Plann., 31: 21–37. doi:10.1016/0169-2046(94)01033-5
Kaasik, A., Raet, J., Sepp, K., Leito A., Kuusemets, V., 2008: Land use changes on Hiiumaa Island (North-western Estonia) in the last fifty years. In Mander, U., Brebbia, C.A., Martin-Duque, J.F. (eds), WIT Transactions on the Built Environment, Vol.100, Geo-Environment and Landscape Evolution III: Third International Conference on Evolution, Monitoring, Simulation, Management and Remediation of the Geological Environment and Landscape, 16–18 June 2008, The New Forest, UK. WIT Press, Southampton, p. 173–182.
Koppa, H., 2006: Land cover changes as indicated by historical maps: the case study from Vana-Kuuste manor, Estonia (in Estonian). MSc Thesis. Institute of Geography, University of Tartu, Tartu, 86 pp.
Leito, A., Truu, J., Õunsaar, M., Sepp, K., Kaasik, A., Ojaste, I., Mägi, E., 2008: The impact of agricultural policy and practice on birds: a case study of autumn staging Eurasian cranes in Estonia. Agric. Food Sci., 17, 1: 53–62. doi:10.2137/145960608784182281
Li, H., Wu, J., 2004: Use and misuse of landscape indices. Landsc. Ecol., 19: 389–399. doi:10.1023/B:LAND.0000030441.15628.d6
Luoto, M., Rekolainen, S., Aakkula, J., Pykälä, J., 2003: Loss of plant species richness and habitat connectivity in grasslands associated with agricultural change in Finland. Ambio, 32, 7: 447–452.
Mander, Ü., Palang, H., 1994: Changes of landscape structure in Estonia during the Soviet period. GeoJournal, 33, 1: 45–54.
Mander, Ü., Palang, H., 1999: Landscape changes in Estonia: reasons, processes, consequences. In Krnert, R., Baudry, J., Bowler, I.R., Reenberg, A. (eds), Land-Use Changes and Their Environmental Impact in Rural Areas in Europe. MAB Series, Vol. 24. The Parthenon Publishing Group, Paris, p. 165–187.
Palang, H., Mander, Ü., Luud, A., 1998: Landscape diversity changes in Estonia. Landsc. Urban Plann., 41: 163–169. doi:10.1016/S0169-2046(98)00055-3
Peterson, U., Aunap, R., 1998: Changes in agricultural land use in Estonia in the 1990s detected with multitemporal Landsat MSS imagery. Landsc. Urban Plann., 41: 193–201. doi:10.1016/S0169-2046(98)00058-9
Raet, J., Sepp, K., Kuusemets, V., Kaasik, A., 2010: EU impact on land use dynamics in Estonia. In Machar, I., Kovář, P. (eds), International Conference in Landscape Ecology: Landscape structure, functions and management: response to global change, Brno/Prague 3–6th September 2010. CZ-IALE, Prague, p. 64.
Tomson, P., 2007: The Impacts of Historical Land Use on Formation of Landscapes and Biotypes and Development of the Protection Regime in Karula National Park (in Estonian). MSc Thesis. Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Tartu, 145 pp.
Vos, W., Klijn, J., 2000: Trends in European landscape development: prospects for a sustainable future. In Klijn, J., Vos, W. (eds), From Landscape Ecology to Landscape Science. Kluwer Academic Publishers, Wageningen, p. 13–30.
Wu, J., Jelinski, D.E., Luck, M., Tueller, P.T., 2000: Multiscale analysis of landscape heterogeneity: scale variance and pattern metrics. Geographia Information Sciences, 6: 6–19.