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HISTORICAL ECOLOGY AS A BASE FOR CONSERVATION PLANNING

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CONTENT

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SECTION 1. BACKGROUND

SOCIETAL VALUES OF SEMI-NATURAL PASTURES

Many types of semi-natural pastures are low-productive compared to arable land. In spite of low production large effort is put into preserving and utilising the remaining fragments of semi-natural pasture in Europe. The reason is that such ecosystems harbour other values than production potential – societal values. In order to motivate further economic support to the use of semi-natural grassland, the habitats therefore need to be managed in a way that secures these societal values, of which the most important are:

- Biodiversity
- Cultural heritage, including biocultural heritage
- Local, regional, and national landscapes for humans
- Resource for energy-neutral production of food and biofuel, and which also contributes to reducing nutrient leakage from arable land.

This indicates a need for sufficient habitat quality in terms of status of these societal values. Here we focus on biodiversity and cultural heritage.

WHAT IS NEEDED TO PRESERVE BIODIVERSITY AND OTHER SOCIETAL VALUES IN THE AGRICULTURAL LANDSCAPE?

In order to use semi-natural grasslands, and the agricultural landscape in general, we need to know where the biodiversity values are found (tells us where to focus) and how they are formed (tells us what is needed to maintain the values). Regarding biodiversity and cultural heritage, the most important pieces of knowledge are about the historical land-use in combination with the ecology of species and landscapes.

The knowledge about relationships between biological/cultural values and land use or management regime is so far rather poorly developed. Our tools for grassland management are powerful but blunt, rargely restricted to grazing, mowing etc without sufficient knowledge about which specific components of each overall management regime. Components may relate to, for example, the timing, intensity, and dynamics of management. An increasing body of literature however indicates that biodiversity can become deteriorated surprisingly fast if, e.g., grazing is used at an improper intensity, timing, or dynamics. “Improper” often implies a management which is too different from the management that has historically formed the biodiversity at the site.

HISTORICAL ECOLOGY AS A BASE FOR CONSERVATION PLANNING

Inventories of biodiversity or cultural heritage prior to planning of conservation strategy and measures, should in the agricultural landscape be accompanied

by a brief analysis of which land-use and other factors that have been most significant for forming the landscape values. We suggest historical-ecological analysis as a useful way to perform such an analysis. The present species and habitats are linked to the historical land-use. Conversely, the historical land-use is interpreted in an ecological perspective.

Once we know which ecological conditions, including historical land-use, that best explain today's biodiversity, this knowledge can be used in order to find and develop methods for continued land-use which are economical and practical for the present farmer, given the frames set by policies for agriculture and conservation and other societal possibilities and constraints. The goal is not to reconstruct the historical land-use, but to design the modern land-use in a way that is, from an ecological perspective, similar enough to the historical land-use that have formed the biodiversity.

Modern land-use thus needs to sufficiently imitate the most important aspects of the historical conditions. New techniques, markets, products, good infrastructure, and environmental economic support are thereby factors that increase the potential for designing such imitating methods. For example, the historical labour-intense mowing may in many cases be replaced by late grazing, biofuel harvest may replace traditional coppicing, and modern transportation enables farmers to manage valuable grasslands away from the home farm. As mentioned, however, the development of new methods and productions systems must have a solid base in the knowledge of which environmental conditions that are necessary for a favourable status of biodiversity and cultural heritage.

Here, we describe a historical-ecological analysis of the farm Mellangården on Eastern Tvärnö, at the Uppland Baltic coast. We start with a brief overview of the historical-ecological background to biodiversity in the agricultural landscape.

HISTORICAL-ECOLOGICAL BACKGROUND TO BIODIVERSITY IN THE AGRICULTURAL LANDSCAPE

The historical agricultural landscape

The species-rich habitats in the agricultural landscape consists of biotopes (e.g. grassland, forest pasture, coppice woodland) and landscape elements (e.g. old trees, stone walls, ponds) of which a majority are formed by a long history of traditional land use. Traditional land use can thus be regarded as one of the major ecological processes in the agricultural landscape. These habitats provide favourable conditions for large numbers of specialised species and for species-rich organism communities. Some particularly important habitats are grazed or mown unfertilised grassland (in particular on sand, base-rich soil, and in wetland), semi-open grazed forest, coppice woodland, and shrubs and old-growth sun-exposed trees. Since such habitats are created by man but have

been colonised by wild species, they are often referred to as semi-natural. In the traditional agricultural landscape also habitats and landscape elements not entirely created by human activities were strongly affected by land-use, which has also made imprints in the current species composition.

It should be noted that this definition of agricultural ecosystems, "ecosystems that are created and maintained by traditional agricultural activities", includes also several semi-open habitats that are not considered agricultural ecosystems by the EU commission or, in particular, by the Swedish government, which has proved to apply a more restrictive definition especially regarding tree cover than the EU commission. This implies that a number of extremely species rich, management dependent semi-open habitats do not qualify for support within the Swedish RDP, and should, according to the governmed, be regarded as forest in which agricultural activities are irrelevant.

Historically, land use in the agricultural landscape was based on production without input of artificial fertilisers or fossil fuels. In order to deal with these fundamental constraints a number of traditional land use methods were developed, which include utilisation of large areas of unfertilised land. Although land use has naturally changed over time, these methods persisted for centuries and millennia, which provided long ecological continuity, being a major reason for the habitats' high biodiversity.

Biotopes and elements together built up landscape types that constituted habitats for larger and more mobile species such as birds and pollen/nectar eaters, and for species dependent on multiple habitats. Particularly important elements in such landscapes are flower-rich grassland, non-forested shores and wetlands, sun exposed sandy soils, shrubland, old-growth sun-exposed trees, and manure from grazing animals. In the traditional landscape habitat patches had a high connectivity, either by being spatially connected (structural connectivity) or because of anthropogenic or other dispersal vectors (functional connectivity). The landscapes thus supported a balance between local extinction and re-colonisation, as well as metapopulations of species with particularly high local extinction rates.

The present agricultural landscape

In the present agricultural landscape much of the species-rich traditional habitats have vanished due to production intensification in some areas and habitats and abandonment in others. For example, only c. 1 % remains of the 19th century area of semi-natural pasture (Lennartsson et al. in prep.). Intensification consists of both transformation of semi-natural habitats (for example of meadows into arable land and of pastures into production forest) and intensification in terms of increased fertilisation, use of biocides, and

homogenisation of arable land. With few exceptions the new habitats are species poor and are mainly colonised by generalist species. Abandoned semi-natural habitats, on the other hand, can for some period of time remain rich in management-dependent species due to slow succession and delayed population responses to changed environmental conditions. Later in the succession these species disappear but sometimes the forest habitats that eventually are formed are rich in threatened species, as long as such forest habitats are not transformed into production forest.

The loss of biotopes, landscape elements etc. and the general homogenisation of arable fields have in large parts of Sweden caused severe degradation of the ecological functions of landscapes.

To conclude, apart from the most generalist species, biodiversity in the present agricultural landscape is mainly connected to the remaining fragments of habitats from the traditional, pre-industrial agricultural landscape. Among those remnant habitats semi-natural pasture is the most important in terms of area and species richness.

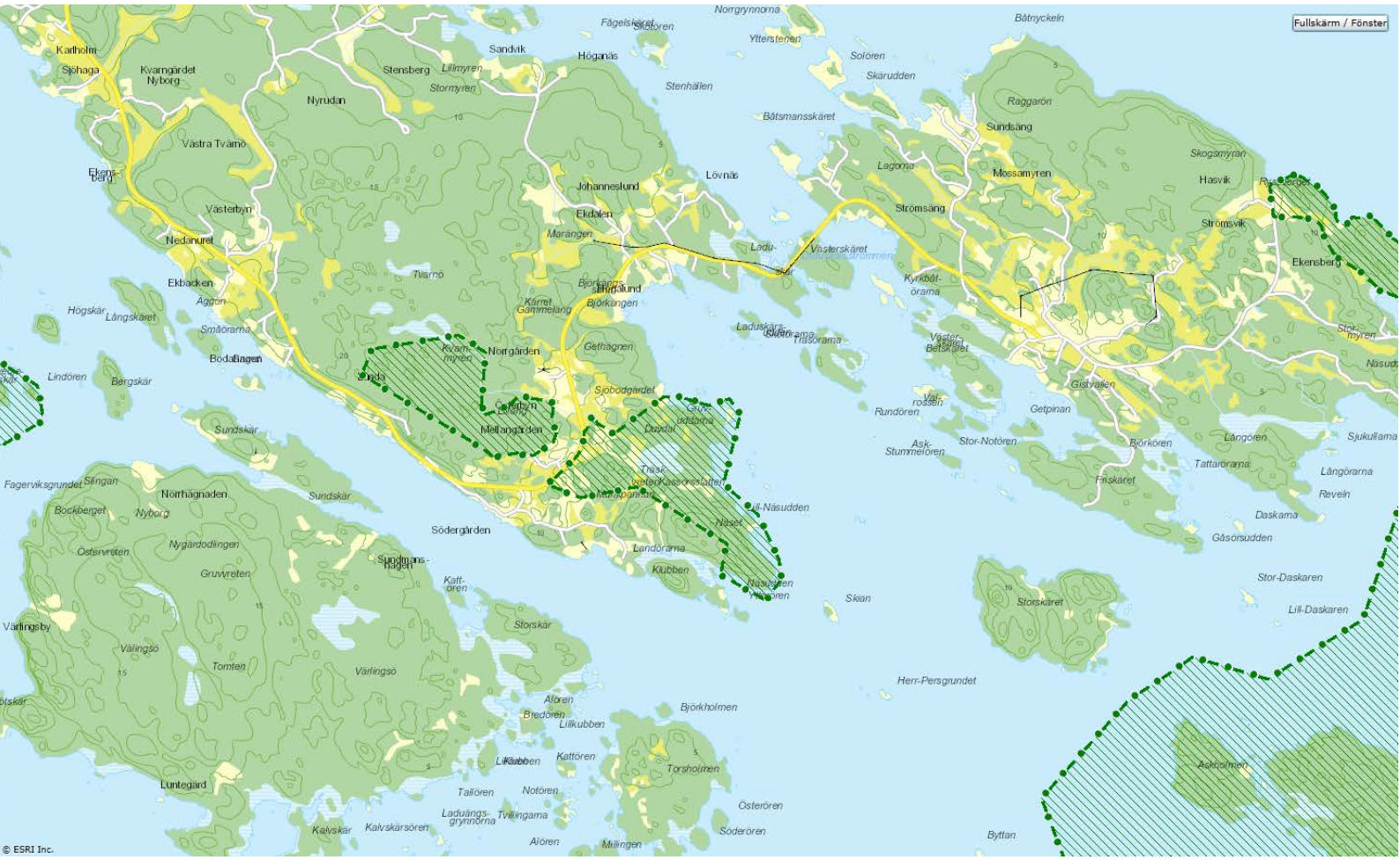

Figure 1. Localisation of Eastern Tvärnö and Mellangården (meaning The Middle farm). The nature reserve, being split into two parts by the garden and the common road, is marked with dashed green.

SECTION 2. THE MELLANGÅRDEN EXAMPLE

GENERAL AGRICULTURAL AND ECOLOGICAL PROPERTIES OF THE FARM

The Mellangården ("Middle farm") is located at the island Eastern Tvärnö, on the Swedish land uplift coast in the Roslagen archipelago and the boreo-nemoral biogeographic region (Figure 1). Since all land at the coast has been under sea level, the coastal area is characterised by a pronounced variation in soil type and cover. Typically, bare rock outcrops alternate with either washed till or fine sediment, mainly clay (Figure 2). The forest in areas with till is normally dominated by coniferous trees (pine and spruce) with varying contents of deciduous trees, mainly birch, aspen, and oak. Bare rock have sparse pine-forest (Figure 3). Till areas have historically been used as wooded pastures, but are nowadays subject to clear-felling-based forestry.

Areas with fine sediment have historically been cleared for mowing, grazing or cultivation, depending on the production capacity. Due to ceased mowing and grazing much of those areas have successional deciduous forest, also at Mellangården (Figure 2).

The farms in the region have normally been based on milk production, in production units of <10–20 milking cattle. This production form is rapidly ceasing and the cattle holding is either stopped entirely or converted to meat

Figure 2. Pasture at Mellangården showing the typical mosaic of bare rock and fine sediment.

production, however seriously hampered by the too small sizes of the former milking cow-barns.

Mellangården around 2005

The farm was based on cattle milk production in a rather small barn, not reaching EU standards. The areas closest to the farm centre were used as pastures, including some traditional forest pasture. Much of the pastures and former hay-meadows had not been cleared of bushes and young trees for some decades, and were vegetated with successional forest, comprising potential restoration areas.

Considerable areas of semi-open pasture at Mellangården were logged around 1980 due to a specific legislation (§5:3), and had medium-old deciduous successional forest.

At Mellangården, unusually large areas of forest had escaped modern clear-felling forestry, part of which were grazed, although not logged, in a traditional fashion.

A majority of the old pollarded trees of ash were in use.

Figure 3. Scatterd pine forest on rocky area with thin soil layer.

Mellangården 2012

In 2007, a new cattle barn was built for 60 animals, and the production was shifted to meet production, largely based on grazing of semi-natural pasture of high conservation value, on the own farm and on other land. The new barn was enabled through economic support from Upplandsstiftelsen, WWF, the Swedish EPA, and the Uppsala county Administrative board. The old barn was transformed into a winter building for sheep.

In connection with this, a nature reserve was created, still under ownership of the farm, but with restrictions for forestry and with an aim to increase the area of grazed semi-natural pasture by restoration. The preservation and development of biodiversity is in strong focus of the reserve.

According to the nature reserve management plan, overgrown pastures have systematically been cleared and incorporated in the pasture area by fencing. As the number of grazing animals increased also the grazing intensity raised. Today, most areas of the eastern part of the reserve (Figure 1) are grazed, normally from early summer, although some areas still have too dense forest to function as pasture, ecologically and from a production perspective.

AIMS FOR A HISTORICAL-ECOLOGICAL ANALYSIS IN ORDER TO IMPROVE FUTURE GRASSLAND MANAGEMENT

The grassland management at Mellangården can affect biodiversity in different ways depending on how the management is designed. Some particularly important management variables are:

- Management type, e.g. grazing compared to mowing
- Intensity of grazing
- Timing of grazing
- Between-year variation of grazing (grazing dynamics)
- Temporary cultivation in semi-natural grasslands
- The structure of the pasture habitat, e.g. the cover of trees and shrubs

All have been variables of the historical land-use which has formed the present biodiversity, and all of the variables can also be manipulated in the present management if it is historically and ecologically justified. So far, however, only habitat structure has been subject to more elaborate ecological (but not historical) analyses, in connection to restoration planning. A major aim for the historical-ecological analysis of Mellangården has therefore been to investigate whether also other management variables in the list should be modified to better imitate historical management, in turn in order to favour management-dependent biodiversity. More specifically, we aimed at the following aspects and questions:

1. Timing of management. At present, the grazing is rather uniform in time and space regarding intensity and timing. Species being sensitive to intense and

early grazing can be assumed to become suppressed in the present pastures. Are there any historical indications of later management, either mowing or late grazing, and any species of conservation interest which would be favoured by resumed late management?

2. Management types. At present, grazing is the major conservation tool regardless of previous management regime in different areas. Are there any historical or ecological support for re-introducing other land-use types or management components, such as coppicing or mowing?
3. Habitat structure. Large parts of the farm can be regarded as forest pasture, either in present or previous use. A forest pasture is usually thought of as having a scattered and uneven, but still rather dense, tree cover. Are there any historical or ecological indications of other, for example more open, forest structure that can be restored?

HISTORICAL-ECOLOGICAL ANALYSIS OF GRASSLAND USE AT MELLANGÅRDEN

Timing of management

A cadastral map from 1809 (Figure 4 Cadastral map from 1809 indicating land-use) showed a typical Swedish land-use mosaic of pasture, hay-meadow, and arable land. The presence of grazing animals in each of those was regulated by fencing, giving a rather straightforward map of the timing of grassland management (Figure 5 Timing of grassland management). In general, the forest pasture in the west together with some of the separate pastures (pink in Figure 4) was used in the early summer. Along with finishing of mowing in the eastern parts of the farm (green, Figure 4), the grazers could be brought from the forest for grazing of the aftermath, probably from late July in the first meadow areas. When harvest of the arable fields was finished in August–September, some new grasslands, situated in between the fields, became available for grazing (yellow, Appendix 1, Figure A).

During the 19th century this pattern became more complicated as many of the former hay-meadows (dark green in Figure 4) were cultivated and fenced separately while other meadows successively stopped being mowed. Figure 6 Land-use late 19th century shows the situation by the end of the 19th century. The change formed more small grassland areas fenced together with arable land, and also e few more small separately fenced pastures. A majority of the grasslands kept their original timing of grazing or mowing and thus have a long history of either early or late grazing.

A crucial question for the design of today's management is whether the species assemblages in different grasslands still reflect the historical timing of management. If so, biodiversity comprise a biocultural heritage and it may be

motivated to re-introduce the historical grazing regime in some areas. The flora in the historically late managed pastures indeed contained more early-flowering species than the pastures which were historically grazed earlier in the season. The species were however mainly common ones, such as Primula veris, Lathyrus vernus, L. linifolius, but also some more demanding such as Crepis praemorsa and Dactylis sambucina. A special inventory was made for Corydalis spp, as being host-plant for the red-listed butterfly Parnassius mnemosyne. The host plant was rather scarce but occurred only in historically late managed areas (Figure 4).

In the early grazed grasslands, of which a majority comprise forest pasture, no plant species were found which are obviously connected to early grazing.

The detection of plant species in general was somewhat hampered by the rather intense early grazing.

Interestingly, coppiced hazel showed to be strongly connected to grasslands fenced with former hay-meadows (Figure 5–7). Coppiced trees and shrubs are discussed below.

Figure 4. *Corydalis solida*, host plant for *Parnassius mnemosyne.*

Implications for management planning

Historical information together with the present flora motivate the use of late grazing in some of the pastures, initially where Corydalis and large coppice hazel stools are fairly common (Appendix 1, Figure E). If the flora and insect fauna in general respond positively to late management, more areas can be subject to late onset of grazing.

In order to provide enough pasture in the early summer, the historical separate pastures (pink in Appendix 1, Figure B) needs to be restored, in particular the large forest pasture in the western part of the reserve.

Management types

The major use today of semi-natural open or semi-open grassland is grazing, by sheep and cattle. Also most of the wooded land (successional forest after ceased land-use and coniferous forest with long continuity as forest pasture) is grazed. Arable fields (dark yellow in Appendix 1, Figure F) are used for fodder production.

Historical sources and the biocultural heritage in the landscape show that the historical land-use contained more types of land-use than are present in today's land-use. The most important of these are:

- Coppice meadow, in which production of hay and pasture were combined with products from coppiced hazel, ash and oak (Figure 5–7). Those products were most likely leaf fodder, but also firewood, barrel material etc may have been produced. The biodiversity effects of coppicing are in general poorly known, but relate to biodiversity connected to the stools, to the ground vegetation, and to the biotope as a whole. The latter can be described as a mosaic of shrub-like stools and open grassland, under a dynamic disturbance regime which includes frequent mowing (i.e. late management) or grazing, and coppicing in certain intervals. Probably, the habitat was excluded from grazing one or a few years after coppicing to allow regrowth of the stools.
- Mowing of semi-natural grassland, at Mellangården both of moist-wet types and mesic types. The former has to some extent been transformed into arable land during the 19th century (Appendix 1, Figure C), but it is unclear how frequent the cultivation was, and whether the arable fields remained as grass-producing areas. The mesic meadows occurred as narrow stripes surrounded by pasture (Appendix 1, Figure A), and are not in use today.

Figure 5. Coppice stool of ash, heavily grazed by sheep.

Figure 6. Giant coppice stool of ash.

Figure 7. Coppice stool of hazel, sheep grazed.

Implications for management planning

Coppice meadow and coppice pasture have historically been conspicuous landscape elements at the Uppland coast. The biodiversity of the habitats are poorly known, but might be restored if the management regime is resumed. This would also contribute to an interesting type of biocultural heritage. Judging from historical fencing, both coppice meadow and coppice pasture have been subject to late season management, se Timing of management, above, and Figure 8). Sheep eagerly graze the young regrowth shoots of hazel and ash, and late grazing thus needs to be resumed, and probably also one or two years without grazing after the stools have been cut. Cutting interval was historically probably c. 10 years for hazel and somewhat more for ash.

The biodiversity of former meadows do not at the moment justify re-introduction of mowing, but can most likely become improved also by using late grazing. Mowing may be considered if the flora and fauna develop particular values after some years of late grazing.

Habitat structure

The historical sources give no information about historical habitat structure of the coniferous forest pastures in the western part of the nature reserve. Instead, the agre structure of the tree stands together with biocultural heritage as branchy or wide-canopy "light trees", juniper shrubs, and herbs and grasses depending on light and grazing, must be used to trace the earlier openness and tree compostion in overgrown forest pastures (Figure 8–10).

The narrow stripes of former hay-meadow in the grazed forest in the eastern end of the reserve, are, in contrast, rather detected on historical maps (Appendix 1, Figure A) than in the field.

In both cases, however, historical and/or ecological sources may indicate open patches in the forest, which are important to restore for light and productivity reasons when grazing is resumed (Figure 11 Cleared former meadow patch).

Figure 10. Older pine with wide canopy surrounded by younger trees indicates formerly more open conditions.

Figure 8. Dead junipers indicating a fomer open patch in the forest pasture

Figure 9. Old circular coppice hazel stool, deteriorated by shade but indicating formerly more open conditions.

Figure 11. Former meadow patch that has been cleared

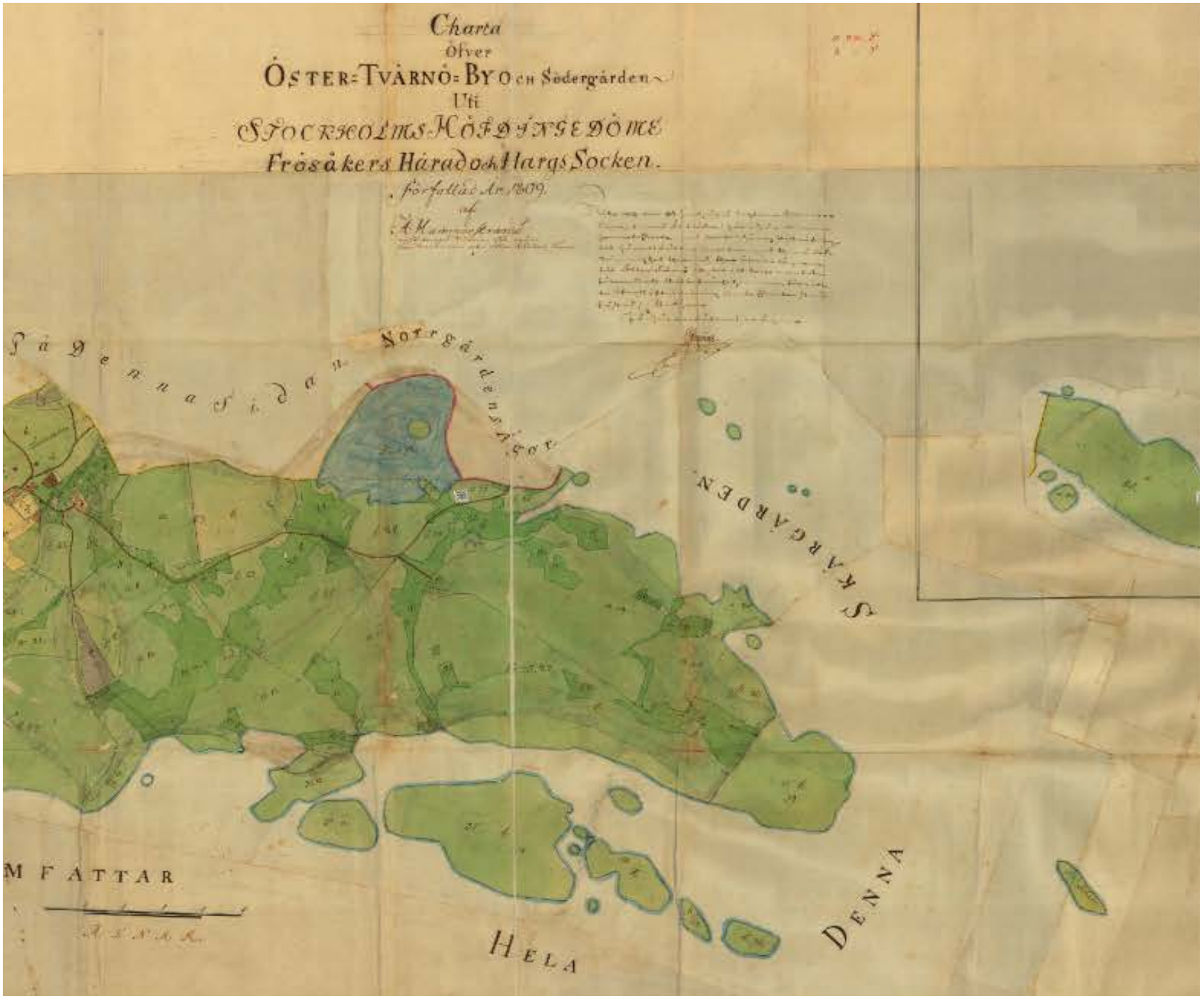

Figure A. Cadastral map from 1809 indicating land-use: Light green=pasture; with tree symbolx=forest pasture; dark green=hay-meadow.

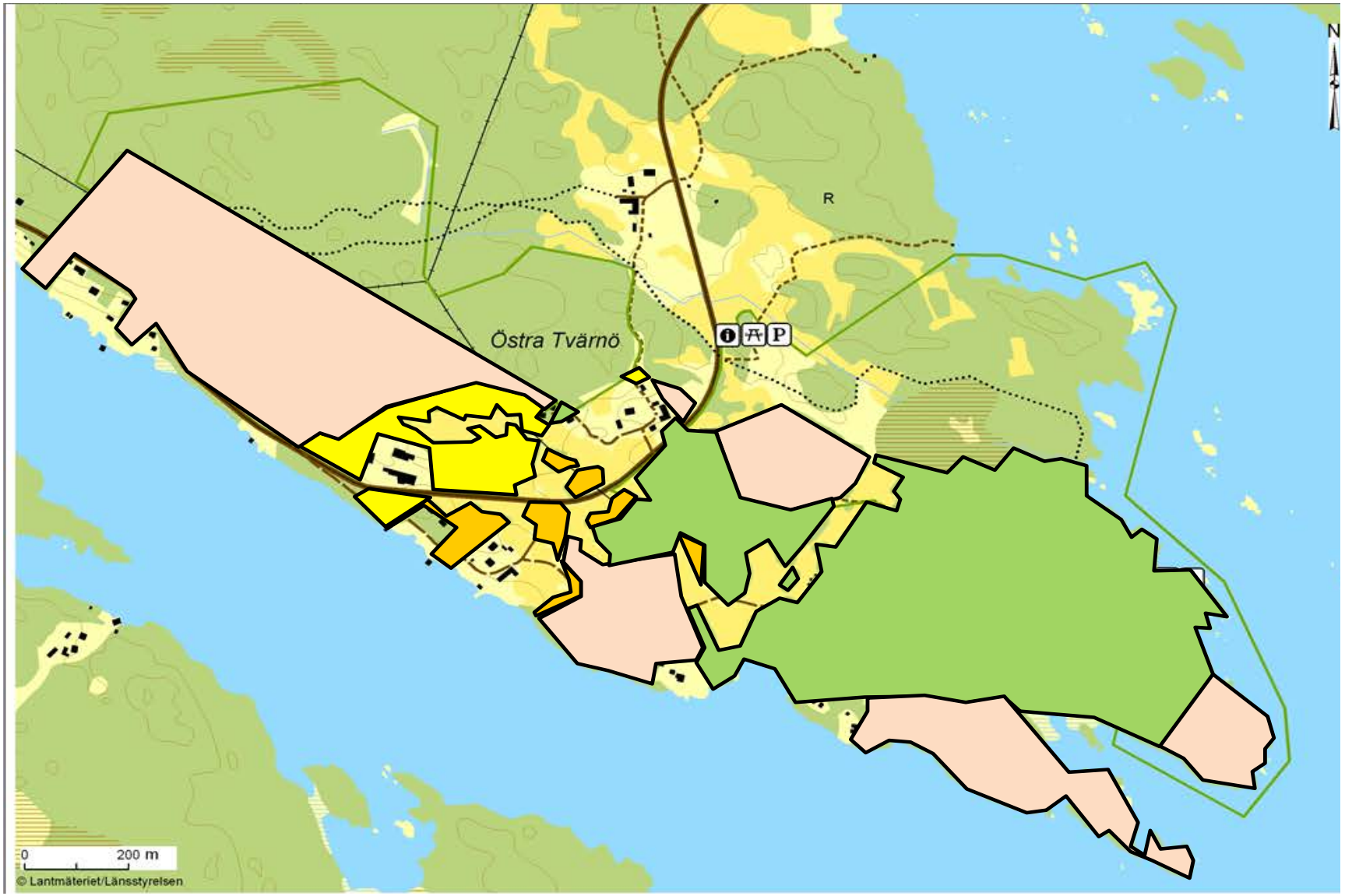

Figure B. The 1809 timing of management in today's semi-natural grassland. Pink=no particular timing, probably grazing from early summer;
Green=Hay-meadow or pasture fenced together with hay-meadow.
Moving July–August or grazing from July–August, after finishing of mowing.
Yellow=Pasture fenced together with arable land. Every second year grazing from August–September after finishing harvest on arable land.
Every second year grazing from early summer. Alternating with orange.
Orange=As yellow, alternating with yellow.

Figure C. Land-use late 19th century.
White=pasture
Green=hay-meadow
Orange=arable land

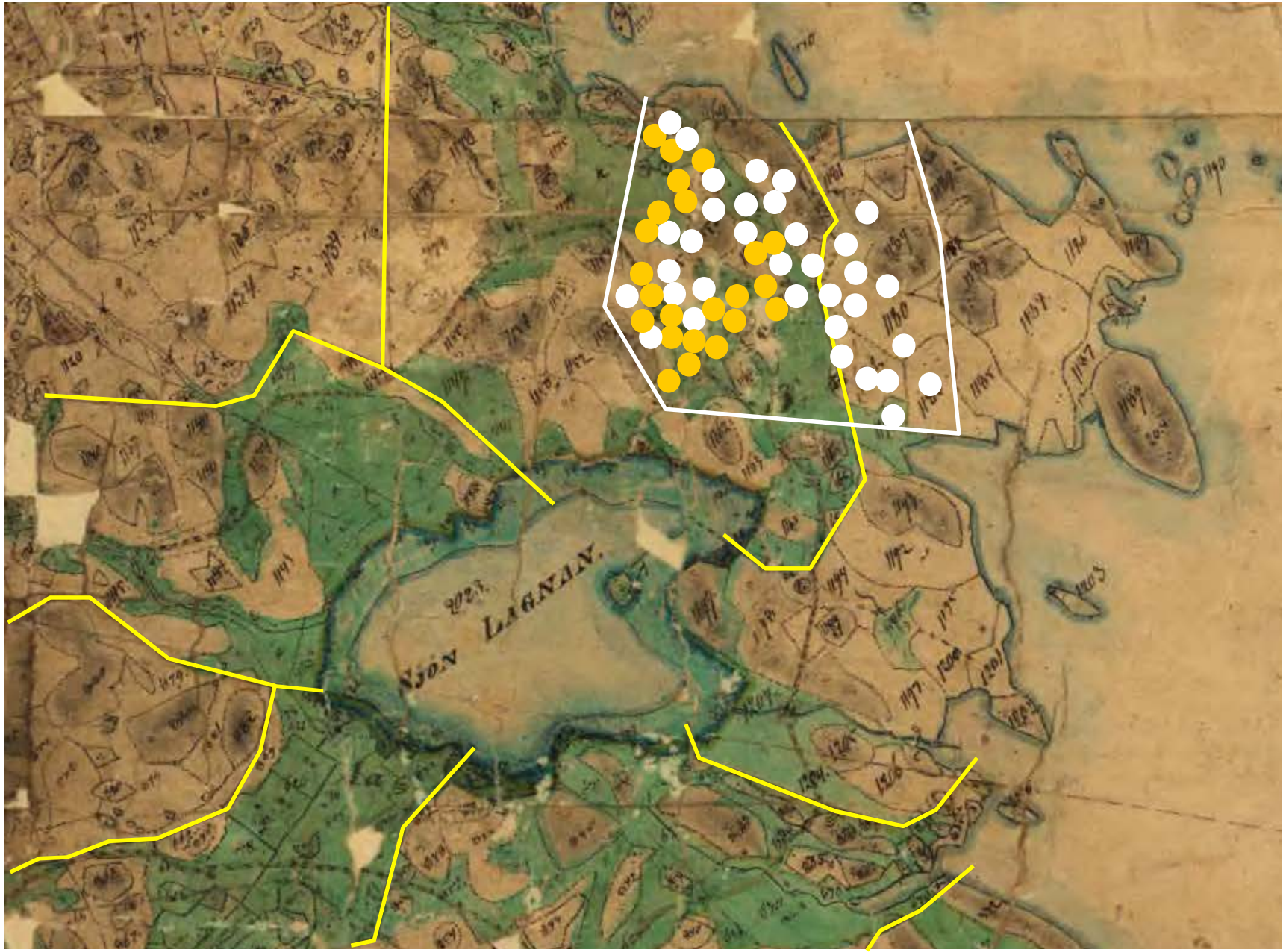

Figure D. Occurrence of coppice hazel (orange dots) compared to uncut hazel (with dots) in an area (delimited by white line) subjet to either early grazing (to the right of the yellow fence which goes through the studied area) or late grazing and mowing (left of the yellow fence line)

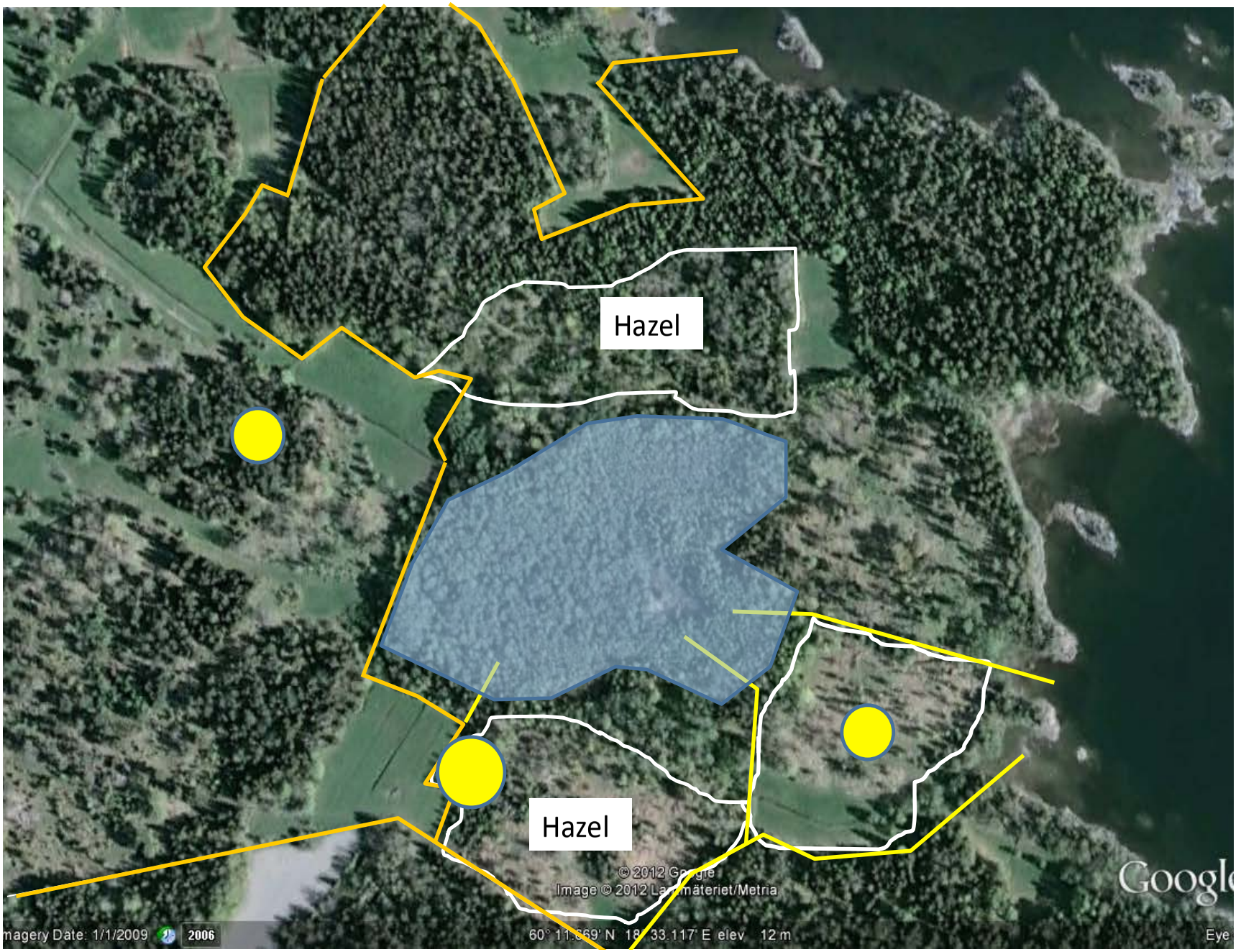

Figure E. Suggested modifications of the timing of grazing. Orange lines show existing fences, yellow suggested new fences. The areas delimited by white line show priority areas with large hazel stools and *Corydalis* (yellow dots).

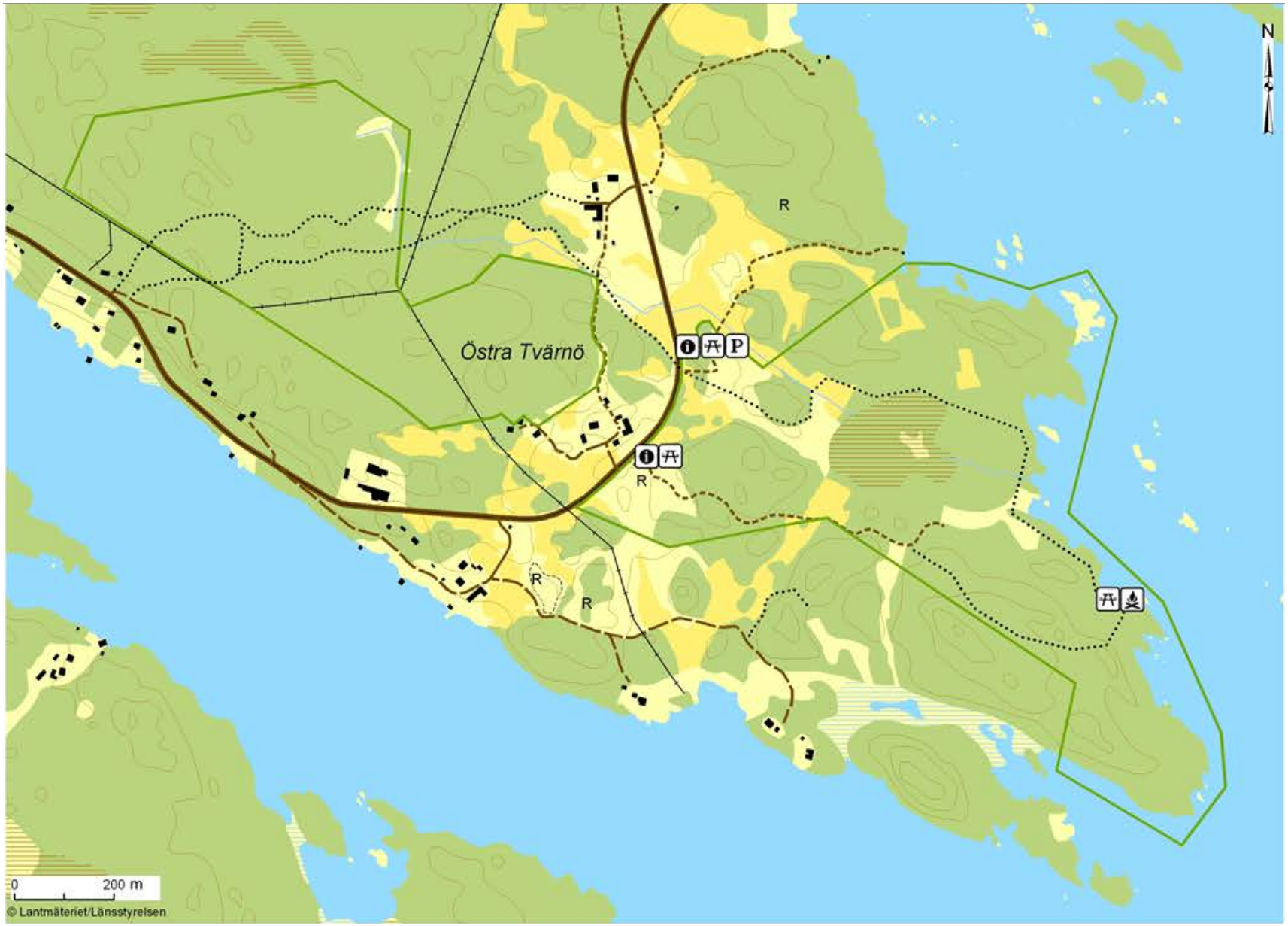

Figure F. General properties of the Östra Tvärnö area and nature reserve (the latter delimited by green line).
Dark yellow=arable field.
Light yellow=open grassland, mainly grazed former meadows, often with a period of arable land.
Green=land with tree cover.
Dashed=wetland

Inventories of biodiversity or cultural heritage prior to planning of conservation strategy and measures, should in the agricultural landscape be accompanied by a brief analysis of which land-use and other factors that have been most significant for forming the landscape values. We suggest historical-ecological analysis as a useful way to perform such an analysis. The present species and habitats are linked to the historical land-use. In this report a historical-ecological analysis has been made on the farm Mellangården. It is an exampel of how this methodology can be used when writing a management plan for semi-natural grasslands on a farm.

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