Scenic views and bioenergy production

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Abstract

The aim of the study is to point out solutions that may keep or create an open, living landscape and at the same time produce biofuel. In a time when oil prices are rising and the question about future energy supply is widely debated it is important to investigate the possibilities in the close surroundings. Within the EU-market profitability in agriculture in some areas is weak and large farmland areas might be taken out of food production. The issues discussed in this study are relevant in many areas and countries. The studied area is localized close to Lake Siljan in Dalarna County in Sweden (Lat.60º51'N; Long.15º4'E; WGS84). The studied area is well-known for its beautiful cultural landscape and views of the lake and it attracts many tourists. Today these views are threatened by overgrowing of abandoned farmland. GIS is used for modeling how different landuses influence the view. Management systems are developed proposing different interests to share the land.

Introduction

Three central conditions have been considered in this study. Firstly the interest for bioenergy increases as oil prices are raising and the question about future energy supply is widely debated. Secondary, agriculture is less and less profitable. In Sweden many farms are shut down, and when land is taken out of production it is soon overgrown and the landscape become denser. The third fact is that there is a wish to keep or create an open, well kept landscape not least to maintain the tourism. This is pointed out in national and local environmental objectives [1, 2].

Why not produce energy on the unused farmland? In this article the possibility to produce bioenergy on abandoned farmland together with creating an open cultural landscape is investigated. There are many interests in the area; nature- and culture conservation, tourism, agriculture, forestry etc. These are represented by actors like tourism industry, landowners, local users and authorities.

The aim of the study is to point out solutions that may keep or create an open, living landscape and at the same time produce biofuel. The hypothesis tested is that the different actors can share the land along Lake Siljan, if suitable management systems are developed and certain conditions are fulfilled.

Energy crisis

The western culture is highly dependent on cheep energy sources, which has been provided by the oil but is now facing a big change. Production of bioenergy is supported by both National objectives [3] and Directives from the European Union [4]. In the European Commission's White Paper for renewable sources the goal was set to double the share of renewable energy in gross domestic energy consumption within the EU from 6% in 1997 to 12 % in 2010 [5]. A good deal of the Swedish energy demand could possibly be fulfilled by biofuels [6]. The energy generation from biofuel in Sweden was in 2004 about 110 TWh/year [7].

As the prices of fossil fuel have risen considerably researchers seek possibilities for a more extensive use of wood etc. in the energetics and heat management. Energy forests have been established and many studies dealing with the use of willows, birches and grey alders as energy forests have been performed [8]. In spite of the desire to use renewable energy sources as biomass, appointed in international [4] and national [1] objectives, a current doctoral thesis [6] reveals that energy crops need large subsidies to be profitable today. Regional circumstances, like the ones discussed in this paper, may therefore determine if bioenergy will be produced or not.

Farms being shut down

The farmland in use has declined in Sweden during the last decades and as a result abandoned farmland has come to existence. According to "Yearbook of Agricultural Statistics 2005" the number of agricultural farms in Sweden have declined from 96 560 in 1990 to 66 780 in 2003 [9]. It is mostly the number of small farms (2-20 hectare) that have decreased, whereas farms >100 hectares have increased. The total area of farmland has declined from 2 844 600 hectares in 1990 to 2 668 600 hectares in 2003 [9]. In Dalarna the amount of farmland has decreased with 41 % between 1900 and 2002 [10, 11].

Also the amount of grazing animals has decreased generally in Sweden during the last decades [9]. In Dalarna the amount of grazing animals has declined very much during the last century; between 1900 and 2003 cattle decreased with 54%, sheep with 73% and horses with 83% [10, 11]. However in the last years, 1985-2003, a small increase has been shown for sheep and horses [10, 12]. In 2003 there were about 37 000 cattle, 13 000 sheep and 3000 horses in Dalarna, which is not much compared to the amounts a hundred years ago [10, 11].

Landscape management

National objectives of Sweden [1] points out the importance of an open landscape and the European Union supports activities that help keeping an open landscape [13]. Issues about the cultural landscape and its values are connected to the agricultural policies of Sweden and EU. There are also connections to the nature and culture conservation. At the Swedish entry of the European Union in 1995 the Swedish agricultural policy was conformed into the Common Agricultural Policy, CAP, and this resulted in extensive consequences for the Swedish cultural landscape politics [14]. It involved a considerable improvement of economic possibilities, but also an adjustment of the landscape management means to the EU goals and administrative framework. The farmers themselves have to apply for compensation for

preserving valuable elements on their land, and this demand that they first take in and understand centrally formulated definitions of landscape values.

To protect landscape values the European Landscape Convention was signed in year 2000 and in 2004 it came into force [15]. The aims of this convention are to promote European landscape protection, management and planning and also to organize European co-operation on landscape issues.

Evaluation of landscapes

The experience of a landscape is subjective. The personal relation to the landscape decides how it is experienced [14, 16]. Some items seem to be more general though. Distant views over water are favorite themes in landscape art and poems and are frequently used in advertisements for cottages etc. Swedish people show a preference to “the open landscape” [17], which is illustrated by the popular Swedish songwriter and poet Ulf Lundell who wrote “I feel the best in open landscapes”. The reasons for this may be that Sweden historically held more open cultivated land than today and also that it is a pleasant change from the great forests within the country. It is a fact that farmland not cultivated is soon overgrown in Sweden.

A study preformed in Bohuslän in south west of Sweden showed that landowners and other local inhabitants have a big interest in qualitative landscape values [14]. The study showed that there is a desire to achieve a populated and vigorous landscape; “a living countryside” and “an open landscape”. A strong wish, shared by farmers and non-farmers, to maintain the character of an agricultural district with cultivated fields, grazed land and active farmers emerged.

Are some landscape types worth preserving? Many people feel anxiety when facing transformations of the landscape [18]. Values are lost and new created, through experience and knowledge we learn to appreciate the landscape of our own. Landscape changes have always occurred; about 100 years ago many lakes and streams in Sweden were drained, outlying land where afforested and the land of the villages “laga skiftades” which meant that the settlements were moved out on the fields and more than 100 000 farms were affected [18]. Today the agriculture is less and less profitable and therefore farmland is left to overgrow, which leads to a denser and less well kept landscape.

The need for energy has characterized human surroundings since the Stone Age. Ever since humans started to use fire to cook food there has been a need for fuel. In the 18th and 19th centuries this had led to a horrible landscape where everything within reach was cut in some parts of Sweden. Then the use of waterpower and coal developed and the vegetation could to some extent grow back. Even today there is a need for wood fuel, though to less extent. In resent years the use of other biofuels than wood from forest trees has come to interest in Sweden, i.e. growing of willow etc. Short-rotation forests are sometimes argued to be unattractive, but they are not necessary bad for the perception of a landscape. Skärbäck and Becht [19] note that Salix crops introduce new colors into the arable landscape and the green colors of the Salix lasts long in the autumn. They further note that a spatial variation from year to year appears and an increased wildlife shelter seems to make the fauna richer compared to the use of traditional agricultural crops.

Skärbäck and Becht [19] appointed that newly planted energy forest fields are most similar to fields of growing agricultural crops, i.e. agriculture. As the fields gradually develop they take the appearance of overgrown land/waste land. At time for harvest the energy forest resemble young forest, i.e. forestry. Skärbäck and Becht [19] concluded that if taking the beneficial impacts of energy forests and the subsidies into account, energy forests on arable land may well be profitable from a socio-economic point of view.

The cultural landscape of Dalarna

Many writers and poets use Dalarna in their work. August Strindberg wrote that “Lake Siljan and the Säter valley are exclusive possessions of province Dalarna as they are unequalled in Sweden”, freely translated from [18]. Already in the beginning of the 19th century Otto Sebastian von Unge wrote about the beauty of Dalarna. The following is one example: “It is told that two foreigners, probably English, on their way to Elfdalen, turned around at Bergsäng, as they did not think they would get to see anything more beautiful”, freely translated from [20]. Bergsäng is a village south of Rättvik.

Upper Dalarna is well known for its culture and the landscape has become a symbol for the truly Swedish [21]. The music, painting, buildings and not least the distinctive landscape are important components of this picture. The cultural landscape is well known for the strong fragmentation of both farmland and forest land which has caused many disputes. An important cause to the fragmentation is “realarvet” or “same right principle” which is rules for inheritance implying that all siblings inherit the parents, also concerning central located farmland, which has not been common in the rest of the country.

There are historical and cultural reasons to keep/create an open landscape in the studied area. Today it is also important for the tourism which is vital in rural areas with decreasing population. In the environmental objectives of Dalarna [2] it is stated that an open, living and attractive cultural landscape in Dalarna is important both for the inhabitants and for the tourism. The shutting down of more farms is recognized as the strongest threat to the cultural landscape of Dalarna. The Siljan region was one of the regions selected in a study of Sporrong [22] which aimed to point out agrarian environments of particular interest to scientific environmental control due to nature and culture values.

There are several ongoing projects concerning the open landscape around Lake Siljan. One is called “Framtidsutsikt Siljan” (Future outlook by Siljan) and the aim of this project is to develop trade and industry, activities and housing within the villages by means of ideas from residents and active in the villages [23]. Another project is Sörbygge betesförening (Sörbygge grazing association) which is a non-profit association with the aim to open up the landscape around Rättvik and to restore overgrown areas, fence and keep grazing animals in a long-term perspective [24].

Figure 1 below shows the view over Lake Siljan, from lookout tower “Vidablick” not far from Rättvik, today and a hundred years ago.

Figure 1. View from the lookout tower ”Vidablick”. Notice the change of the landscape from the beginning of the 20th century (left picture) until today (right picture). Photo: left Sörlins Bokhandel; right L. Blomqvist.

Synthesis of prevailing conditions

In the following analysis the need for bioenergy, the available land after farms are shut down and the wish for an open landscape are studied together in an attempt to combine the different desires. The combination is not far-fetched and there are opportunities to discover. Occupation is important if a living rural landscape is to be achieved. Tourism is an important and growing [2] income source in Dalarna. Together with an income from bioenergy production it could make it possible for more people to live in the countryside. This could give an open landscape if touristic views are well managed and bioenergy crops are chosen that do not seriously disturb the views of the landscape.

The new Common Agriculture Policy, CAP, of the European Union could motivate further activity in sparsely-populated areas. The largest change after the CAP reform, which was adopted in 2003 and entered into force in 2004-2005, is that the earlier direct support has been transformed to a “farm support”, independent from production [4]. This means flexibility in the choice of crop and the support also include non-food products. The reform also introduced a special “aid for energy crops” and maintained the possibility to use mandatory “set-aside” land for growing energy crops and other non-food crops [4]. One focus in the new CAP is to promote environmentally friendly cultivating methods that preserve the landscape [25].

Short-rotation forests might compete with cereal crops on farmland producing up to 7 tonnes of wheat per hectare, which is below average in southern Sweden but above average in the rest of Sweden [19]. Production of woody biomass on farmland might be applied over large areas and has little negative impact on the environment [26]. The early and regular cash flow is one of the economically most important features of willow short-rotation forest. It is desirable to find a production system with shortest possible rotation period, still producing commodities for several markets. As a short rotation period is essential and farmland soil is fertile it is suitable with tree species which grow fast, especially the above ground biomass [26]. Pioneer species commonly fulfill these criteria, for example *Salix* and *Populus*. *Salix* is the only species being used in Swedish short-rotation systems. But in Swedish forestry the most common pioneer species are pendula birch (*Betula pendula* Roth), pubescent birch (*Betula pubescens* Ehrh.) and European aspen (*Populus tremula* L.). Studies by Johansson [27, 28] show that grey alder (*Alnus incana* (L.) Moench), common alder (*Alnus glutinosa* (L.) Gaertn.) and birch possess qualities that make them possible to grow for biofuel production.

Telenius [26] reported that hybrid poplars yield 7.5 tonnes ha^{-1} $year^{-1}$ in planted, non-fertilized and non-irrigated stands. Telenius [26] further reported on a production of 8 tonnes (total above-ground dry biomass) ha^{-1} $year^{-1}$ for grey alder in dense plantations on farmland. Johansson [28] reported a mean annual increment of 4.4 tonnes ha^{-1} $year^{-1}$ for grey alder and 3.1 tonnes ha^{-1} $year^{-1}$ for common alder. Also birch is a possible species for short-rotation forest. For pendula birch stands growing on abandoned farmland the mean annual increment was calculated to 4.5 tonnes ha^{-1} $year^{-1}$ and for pubescent birch to 2.7 tonnes ha^{-1} $year^{-1}$ [27]. Furthermore, agroforestry is a possible way to produce bioenergy. Kuemmel et al [29] examined a Combined Food and Energy (CFE) system in Denmark and concluded that it is a profitable choice for farmers entering the heating market for smaller scale private customers and smooth the way for large-scale biofuel production.

The average yield of reed canary grass in Sweden in the end of the growing season was reported to 8,5 tonnes dw ha^{-1} by [30], though this may be a high estimate. Reed canary grass obtain a height of maximum 2 meters and can be harvested every year once established [31]. Spring barley yield up to 5 tonnes ha^{-1} $year^{-1}$ on irrigated soil in Denmark [32].

Landscape analysis
Landscape analysis can be used for example to evaluate how a landscape section endures certain exploitation from its existing conditions. To understand the features of a landscape, we need to regard the landscape as an environmental whole and also have good knowledge of its details. Landscapes hold vast quantities of “data”, both contemporary and left by earlier generations [33]. The landscape is an inexhaustible archive of information, which might be important when deciding how to act now and in the future.

Prediction of future landuse is difficult and scenarios analysis offers a tool to help in exploration of the future. Many studies using scenario approaches have been published in recent years [34]. Rounsevell et al [35] report on the development of quantitative, spatially explicit and alternative scenarios of future land use in Europe. There are several technical and conceptual difficulties in developing future land use change scenarios; subjectivity in qualitative interpretation, the landuse change models used in scenario development, the problem of validating future change scenarios, the quality of the observed baseline and statistical downscaling techniques.

Landuse planning is active planning of land to be used in the near future by people to provide for their needs and others [36]. There are usually a diverse set of needs in an area; industrial production sites and places to relax and to enjoy beautiful landscapes; places for human uses and places where natural plants and animals can live etc.

Material and methods

To be able to describe, analyze and plan the complex system; tourism – culture – environment – energy supply – economy, a system approach is used in this project [37]. Scenarios are used to try to compare how different landuses will influence the landscape and the possibilities to beautiful views. A quite simple GIS-model is used as a tool to visualize the view of Lake Siljan with different landuses. View analysis is performed through viewsheds from a specific viewpoint (A). Geographical Information System, GIS, is a good tool for simulation of changes in the landscape, however it does not result in perfectly realistic pictures. The software used is ESRI ArcMap and ArcScene.

The studied area in this project is called Salunäset (Lat.60º51’N; Long.15º4’E; WGS84) situated close to Lake Siljan in Dalarna County in Sweden, see figure 2. This area is quite unique in Sweden with its conflict of interests concerning landuse. Rättvik, Tällberg and many other places around Lake Siljan are well-known for its beautiful open cultural landscape and views of the lake and is often referred to in advertisements about Sweden. The area attracts many tourists which has promoted a development of hotels, spa resorts etc. In the last years the agriculture has become less profitable and more and more farms are shut down in the surroundings. Today the overgrowing has gone quite far and the impression you get of the area is quite far from that of the old days. A simplified picture is that there is a conflict of interests where the hotel owners want to open up the landscape whereas the landowners will not get any economic profit from that and then in many cases prefer to leave it to become forest. In this study an attempt is made to find a system to use the land in a way to satisfy both landowners and hotel owners.

Field studies have been preformed in the studied area to get some current data to analyze. The field data has been collected in a chosen “viewsector” of 100 hectare between the road and Lake Siljan. In this sector all stands were identified and measured. In this article only the tree height data is used. The “viewsector” was chosen so that it includes a lot of abandoned farmland [38]. Unfortunately it is almost in right angle to the road, which means that you have

to turn your head while driving to see in that direction. Though, with the desire to include old farmland and at the same time not get too big area to measure this was the angle chosen.

There is a dataset called “kNN Sweden” which contains forest variables including heights [39, 40]. The kNN data was produced through combination of satellite pictures and field data from The Swedish National Forest Inventory. This data is not accurate for small areas, like stand-level, but gives an approximate picture of the forest in the area. The kNN data for the Siljan region demonstrates what the forest looked like in September 2002. The kNN data was used for the viewsheds presented in this article. The reason for this is the wish to visualize the views over a larger area than just the “viewsector” measured in the field studies.

The land is very fragmented with countless landowners in the studied area, which is not taken into account. It is assumed that the landowners are able to cooperate. Exact costs/incomes are not analyzed. It is assumed that a small income is better than no income; the oil prices will rise and make bioenergy production more profitable and the EU subsidies will support bioenergy production. It is also assumed that there is a local market for bioenergy. It could be used by the landowner direct as cheep heating or it can be sold to the local heating company.

Analysis

Different landuse suggestions are studied in this project. Production of bioenergy is defined as a separate landuse, even though it could be counted as agriculture or sometimes as forestry. Bioenergy could be produced from slash (felling residues like tops and branches) or through cultivation of grey alder, birch, salix, hemp, reed canary grass, barley, oat, rape etc. on farmland. Table 1 shows how the landscape will be affected by different bioenergy production. The field studies showed that alder and birch is abundant in the studied area. As mention above alder and birch could be grown as short-rotation forest. According to [41] and [42] a height of about 10 meters is likely for fifteen-year-old grey alder and birch. Note that grey alder and birch grown as short-rotation forest give a dense closed landscape only if it covers the whole view and only the last 10 out of 15 years before harvesting. The height presented for conifers/broadleaves is based on the measured tree heights from the field studies. The height for reed canary grass is based on [31], for hemp it is based on [43] and for salix on [44].

Table 1. Classification of landscape density with different crops for bioenergy production.

Landscape	**Crop system**	**Dominant height (m)**	**Rotation period (years)**	**Crop**
Open landscape	Small energy crops	≤ 1	1	Barley, oat, rape
Quite open	Quite low energy crops	≤ 2	1	Reed canary grass
		≈ 3	1	Hemp
		5-8	3-5	Salix
Quite dense	Quite high energy crops	≈ 10	15	Grey alder
			15	Birch
Dense landscape	Tall energy crops	≈ 25	50-100	Conifers/broadleaves for timber production

Except for production of bioenergy the land could be used for traditional agriculture, forestry, grazing or for buildings or small businesses. It is also possible to use agroforestry, with trees/bushes combined with agricultural crops or grazing. In the area tourism is very important as it gives large income to the county. For tourism the landscape should be open and well kept [45].

As mentioned in the introduction the hypothesis for this study is that different actors with different interests can share the land along Lake Siljan, if a suitable management system is developed. At different sites the interests have altered priority. Some areas should be kept open as they are important for the general picture facing tourists on their way to Rättvik, but also for the inhabitants that should have a attractive vicinity. In these areas grazing, agriculture or production of “small” energy crops are suitable. In other parts of the area the vegetation could be allowed to be denser with forest.

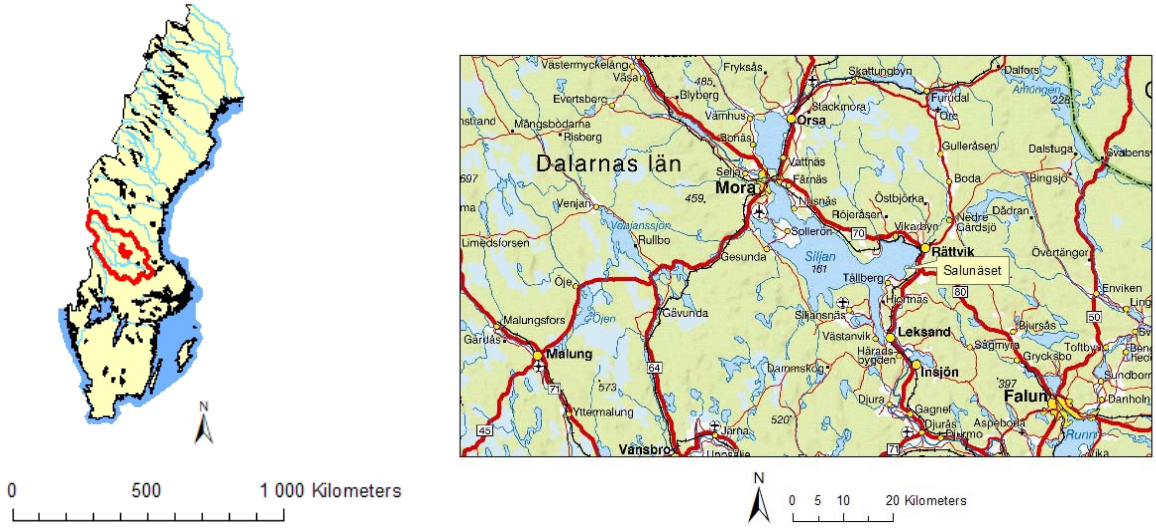

Figure 2. To the left is a map of Sweden with Dalarna County and Lake Siljan marked in red (© Lantmäteriverket, Sverige1000plus). To the right is Lake Siljan with surroundings, with Salunäset marked (© Lantmäteriverket 1998. from GSD-Översiktskartan, dnr 507-98-4720).

Many tourists first see Lake Siljan from the thoroughfare road 70 or the alongside railroad traveling north towards Rättvik, see figure 2 and 3. Therefore it is the view from this road/railroad that is analyzed in this study. At the moment you get the first real view of the lake, the area you have between the road/railroad and Lake Siljan is called Salunäset, and that is the studied area.

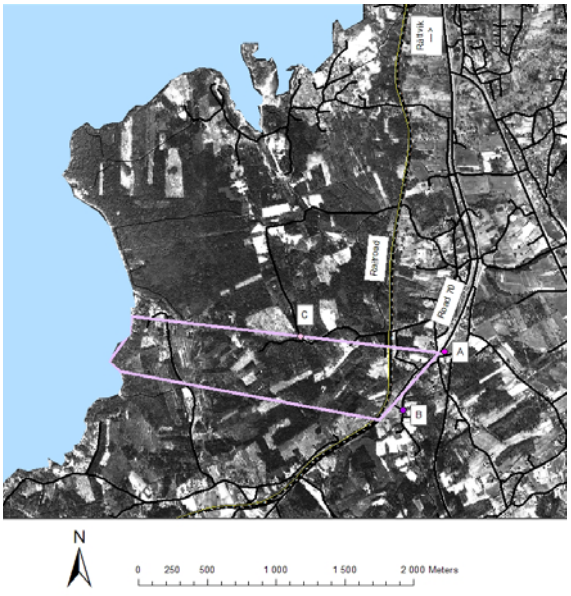

Figure 3. Map showing Salunäset, south of Rättvik. Viewpoints A, B and C are marked and the purple figure is the viewsector where the field data was collected. Also note the railroad and to the right of it; road 70.

Analyzed landuse alternatives

For the analysis some relevant landuse options were chosen, presented in the landuse column in table 2. These were then grouped into four different height alternatives; where grazing, traditional agriculture and growing of agricultural crops for bioenergy utilization are all considered alternative 1. Reed canary grass is considered alternative 2. Grey alder or birch grown as short-rotation forest is alternative 3. Full grown forest of different kinds is alternative 4. Bioenergy is produced in all landuse options except grazing and traditional agriculture. In alternative 4 the main product is timber or pulpwood, but the leftovers are used as bioenergy. The field studies showed that mixed forests with conifers and broadleaves are common in the area. The heights presented in table 2 are the ones used in the analysis. It is a simplified version of the dominant heights presented in table 1.

Table 2. Analyzed landuse alternatives with the heights used in this study.

Alternative number	Landuse	Height (m)	Totally open every… years	Production of bioenergy
1	Barley, oat, rape	0	1	X
	Traditional agriculture	0	1	-
	Grazing	0	-	-
2	Reed canary grass	2	1	X
3	Grey alder	10	15	X
	Birch	10	15	X
4	Broadleaved forest	25	50	x
	Coniferous forest	25	100	x
	Mixed forest	25	50-100	x

A viewpoint has been selected (see figure 4 and 5) from where the view has been analyzed. The viewpoint, further referred to as viewpoint A, is placed in one of the corners of the measured viewsector. As a suggestion a small rest stop could be prepared in this spot, which is very close to road 70.

Figure 4. View from viewpoint A today (2005). Photo L. Blomqvist.

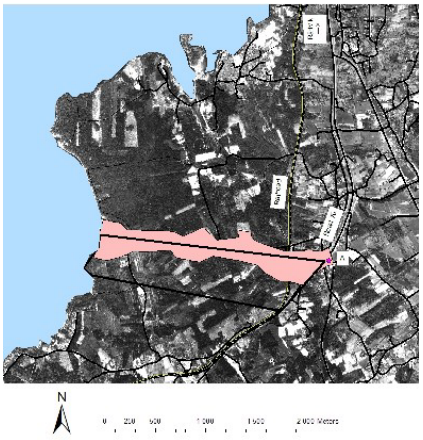

Figure 5. The zone used fore the viewsheds is shown in pink. Also note viewpoint A.

Visualization of four scenarios

Four scenarios have been developed. Scenario “today” represents the tree heights today (based on the kNN data). Scenario “business as usual” corresponds to what the landscape would look like in 20 years (2025) if nothing is done (kNN + 3 m).

In scenario “cut” all trees are cut in one zone and replaced by small crops or grazing. The zone is placed so that it includes mostly areas already cleared today or old farmland. Though, a few forest stands are also cut in this scenario. In this zone grazing, agriculture and “small” energy crops are used. The analyses showed that the view is not apparently influenced if reed canary grass, which grows to about 2 meters height, is used. The idea is not to have one big field in this zone, but to keep the small scale experience with a mosaic of different crops and land use, as long as it is “low”. There is a need of balancing the wish for a small scale landscape and the urge for economically profitability.

Scenario “all cut” illustrates the area if all trees were cut on Salunäset. This may not be a realistic alternative but can be used as a comparison to the other scenarios and may also give an idea about how the land looked in earlier times when the agriculture was widespread.

Figure 6 shows 3D viewsheds of Salunäset from viewpoint A for the four scenarios. The view of Lake Siljan will be more distant in scenario “business as usual” compared to scenario “today”. The viewshed of scenario “cut” shows that Lake Siljan will be visible almost all the way to the shore, the view will be narrow but good. Obviously the best view of Siljan is achieved in scenario “all cut”. Though, it is also apparent that a cleared zone represented with scenario “cut” makes it easier to see Lake Siljan, than if nothing is done.

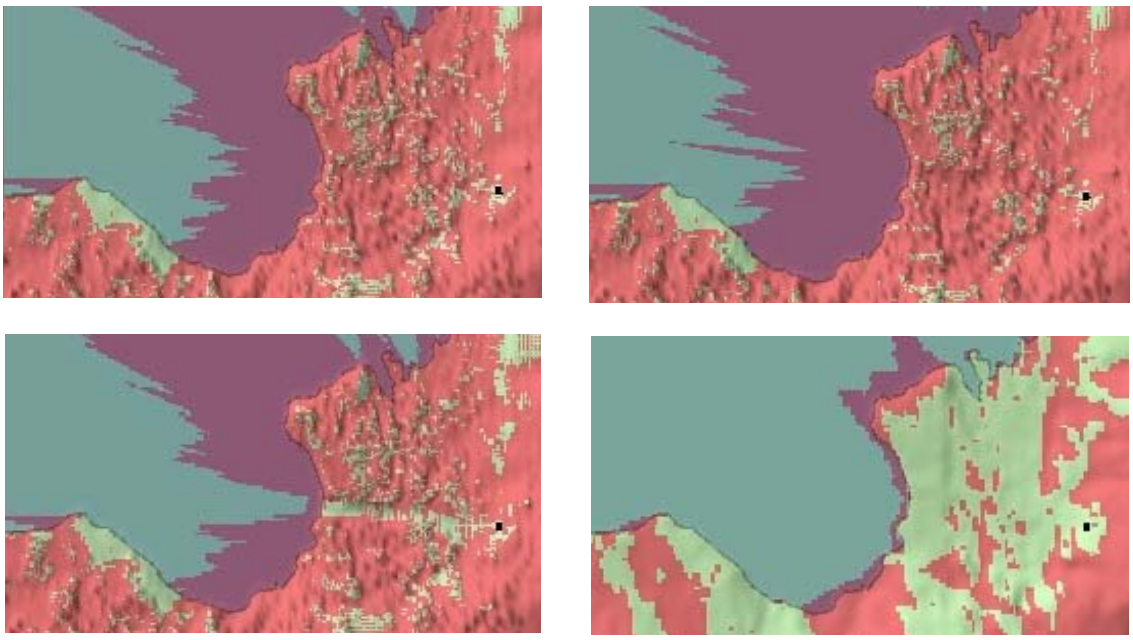

Figure 6. Viewsheds presenting the view from viewpoint A (the black dot) for the four scenarios. The green (light) areas represent visible regions and the red (dark) areas are invisible, from point A). Upper left is scenario “today”. Upper right shows “business as usual” (3 m higher trees than today, about 20 years from now). The lower left picture shows the “cut” scenario, where a zone is cleared from viewpoint A to the lake. Finally the lower right picture shows the view if all trees at Salunäset are cut, scenario “all cut”.

Results

In the area there are a few suitable solutions to produce bioenergy and simultaneously prevent the landscape from becoming more overgrown. Areas classed as farmland entitle agricultural subsidies, and it is therefore profitable to keep these areas as farmland; thus growing barley, reed canary grass etc. for energy production. At abandoned farmland that already lost the agricultural subsidies it is necessary to find other ways to profitability. One possibility is to restore an area for touristic or historical reasons, which is supported by the EU. Otherwise bioenergy production and the wish for openness have to be the driving forces.

One way to work is to choose one zone that is always kept open, as scenario “cut” above suggests (Management system 1). In the rest of the area either alder/birch short-rotation forest can be used or it can be left to become full grown forest. In an enlarged version a little more can be opened up (Management system 2). Figure 7 shows a suggestion of three zones that could be cleared. The green areas include a lot of abandoned farmland and are therefore desirable to open up again.

Figure 7. Suggestion of three zones (two in line with the viewsector and one at right angle to the others) that could be opened up (Management system 2) or used in a rotation system (Management system 3).

If the farmer nevertheless chooses to afforest the land, it is strongly recommended to use broadleaves instead of spruce around Siljan as it gives a lighter and more attractive appearance. Based on this and earlier studies a good choice is to use grey alder or birch already present at the site as base for a short-rotation forest system. The short-rotation forest should be harvested every 15 years at a height of about 10 meters (see table 2). If a number of zones like the ones presented in figure 5 and 7 are identified, it is possible to make sure that Lake Siljan is always visible in at least one of the zones. It is possible to use a rotation system with, for example, five zones of broadleaved short-rotation forest. The idea is to manage the system so that the zones are harvested in different years; if there are five zones one zone could be cut every 3rd year. Then there would always be one zone with maximum three-year-old short-rotation forest of about 1,5-2 m height and Lake Siljan would always be visible (Management system 3).

If the green zones in figure 7 are used either for Management system 2 or 3 Lake Siljan will be visible from different angles. Three viewpoints (A, B, C) are marked in figure 3. Two of them (A & B) are placed in the corners of the measured viewsector, close to road 70 and the railroad. Small rest stops could be prepared in spot A and B, presenting nice views of the lake for bypassing tourists. To get to viewpoint C you need to take a little detour on smaller roads which is something not everyone will do but a possible way to experience the landscape even better for the enthusiastic tourist.

Discussion

Evaluation of the method
The method used in this study to illustrate how different landuses influence the landscape has shown to be useful. When the landscape analysis as in this case is restricted to investigation of the views the chosen technique was found to be sufficient. The model could be further developed to give a more realistic representation of the landscape if it is to be used as base for decisions concerning landuse in a sensitive landscape. It is possible to include more detailed landuse alternatives. Only height has been analyzed in this study, but evidently there are other aspects of the experience of different landuses, for example color and degree of variation [19].

It is important to note that even if one height is given to a big area in this study it does not mean that the whole area should be one big field of the same crop, but rather a mosaic of fields with different crops or grazing. The reason for this is that not only an open landscape is requested, but also the small scale experience should be preserved. For many people the wish for an open cultural landscape is based on the wish to keep qualities and to reach sustainability. To keep the Siljan area open and well kept is to maintain the cultural heritage in one of Sweden's most famous and appreciated landscapes.

Except for the emotional historical and cultural aspects there is also the financial side. As the tourism is such an important income source in the area there should be strong incentives to please the tourists and to keep an open, living cultural landscape and scenic views. Together with the profit from the bioenergy production and maybe EU funding it should be possible to maintain the suggested management systems.

In this specific case the method was used to illustrate the view from a scenic road over a lake. The method could also be used in more urban areas, for example to illustrate what crops is suitable in the near surroundings of big cities. Frequently there are areas around cities that are kept open by the municipality without any yield or income, which could be used for bioenergy production.

Development possibilities
Landscape management is considered an agricultural issue and is by that means regarded a regional interest. Consequently every member country of the EU can relatively freely work out their objectives and instruments. The political and administrative system and people on local level have a common interest to preserve the traditional agrarian landscape and to promote a living countryside. Therefore there is a need for development of a suitable system for landscape management.

The different landuses discussed in this article demand land preparation of different extent. This of course has to be considered when calculating the actual cost/profit of the landuse alternatives. The cost of preparing abandoned farmland for energy crop cultivation have been studied by Larsson and Nilsson [46].

Kumm [47] noted that energy crops are possibly profitable on highly fertile and well-situated fields, but on such fertile land food production might also be profitable. Land that is too poor for profitable food production could also be to poor for production of energy forestry, energy grass or grain for bioenergy production. Therefore energy crops are most likely to be grown on lands which lack a profitable alternative. The abandoned farmland around Siljan may well match this description. As presented above grey alder, birch and reed canary grass can give high biomass yields on abandoned farmland. But which crops are the most suitable at Salunäset needs to be further investigated.

This study does not reveal any drawbacks of bioenergy production in the near surroundings of Lake Siljan, though many aspects have not been taken into consideration; economy, marked possibilities and the many landowners of the fragmented land. There is definitely a need for more research in the field. Could it really be economically profitably to grow bioenergy on abandoned farmland? Which crops are suitable? Are there marketing possibilities in the surroundings? Is it possible to harvest the different crops at reasonable costs? How can the many landowners be brought together in joint projects?

Management systems

This study shows that Lake Siljan would be more visible from the road/railroad on the way to Rättvik if "view zones" were opened up, as illustrated in figure 6. To make the analysis clear and easy to perceive only one zone was used for the viewsheds presented in figure 6. There is a obvious difference between the pictures; in scenario "cut" you can see the water almost all the way to the shore, standing in point A, in contrast to the more distant water glimpses in the "today" and "business as usual" scenarios. With "business as usual" less of the lake is visible than "today", illustrating that less and less of the lake will be visible if nothing is done to prevent it. Scenario "all cut" (the last picture in figure 6) shows the striking difference obtained if all land on Salunäset was cleared. To clear the whole area may be too harsh even if it is tempting to suggest that at least all abandoned farmland should be opened up again. Therefore an attempt has been made to achieve as much views with as little cleared areas as possible. Quite naturally "view zones" is an efficient way to work. To reach the best result all trees should be cut in these zones, at least temporarily. The land in a "cut" zone can be used for grazing or for cultivation of small crops that do not seriously disturb the views of the landscape.

This study shows that if Management system 1 is used there will definitely be an improvement of the view from road 70 and the railroad, at least in viewpoint A where a rest stop could be prepared. This system implies the use of grazing, agriculture and small energy crops in the zone showed in figure 5. The zone accounts for 60 hectares which is only about 8 % of the studied area, Salunäset (760 ha). It should be possible to spare this area from forestry. Instead the zone will produce bioenergy for the local market. The analysis showed that reed canary grass, which grows to about 2 meters height, will not apparently disturb the view and is therefore a good alternative. Agricultural crops like barley and rape are also suitable. The rest of Salunäset could be used for traditional forestry or for growing grey alder and birch as short-rotation forest.

If all three zones illustrated in figure 7 were cut, Management system 2, the view would be even better. The three zones account for totally 160 hectares which is 21 % of the studied area, Salunäset (760 ha). The third solution, Management system 3, is to use a rotation system with broadleaved short-rotation forest. In this case about five zones could be chosen (of about 50 hectare each) and one zone should be cut every three years. In this way Siljan would always be visible in at least one direction. This system is based on grey alder, birch, aspen etc. broadleaves grown as short-rotation forest. The field studies showed that there is plenty of these species present to base the short-rotation forest system on. Reed canary grass, barley and other lower crops would still be a nice feature close to the road but is not necessary for the view.

Conclusion

Which of the three management systems to choose is not obvious as many aspects need to be considered. Nevertheless the most reasonable solution may be to start with clearing one view zone as Management system 1 suggests. This may later be extended to more cleared zones (Management system 2) or some zones with short-rotation forest could be added (Management system 3).

A motive to choose broadleaved short-rotation forest (Management system 3) is that most of the land at Salunäset is not any longer counted as farmland, and hence has lost the agricultural subsidies. Furthermore preparation of the land would be a big cost to be able to grow crops as reed canary grass or barley. On the other hand the harvest costs of the different crops may differ which is not considered in this study. Management system 2 is the one that will have the biggest influence on the view and the experience of the area.

From a landscape perspective it is positive with bioenergy production on abandoned farmland around Lake Siljan according to proposed management systems. If some zones are cleared from trees the impression of Salunäset will be very different from today. There will be some narrow but nice views of the lake between the trees. Probably the landscape would adopt a more old-time appearance as the historical landscape by Siljan is associated with openness and variation [2].

All three management systems discussed above promote both tourism and bioenergy production and therefore support the rural development in the Siljan region. It is thus possible to combine production of bioenergy and creation of an open cultural landscape along Siljan. The different actors could possibly share the land, for example by application one or more of the three management systems proposed in this study.

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