UPPLANDS STIFTELSEN
NATURVÅRD & FRILUFTSLIV

WWF

REPORT 2013/8

WETLAND VEGETATION
as a potential for bio-energy production

Sven-Olov Borgegård

SNOWBAL
Saving the sea from Nutrient Overload by managing grasslands/Wetlands BAltically

CENTRAL BALTIC
INTERREG IV A
PROGRAMME
2007–2013

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
INVESTING IN YOUR FUTURE

CONTENT

AUTHOR
Sven-Olov Borgegård

PHOTOS
S-O Borgegård, T Eriksson & D Gatkowski (fig 15)

ILLUSTRATIONS
Tina Käll

PRODUCTION OCH LAYOUT
Upplandsstiftelsen

CONTACT UPPLANDSSTIFTELSEN
Phone +46 (0)18-611 62 71
E-mail info@upplandsstiftelsen.se
Webb www.upplandsstiftelsen.se

This publication, which is produced within the framework of the EU project Snowbal (Saving the Sea from Nutrient Overload by managing Wetlands/grasslands BALtically), reflects the author´s views. The Managing Authority can not be held liable for the information published.

INTRODUCTION

This study is based on work that has been carried out in Örebro, Sweden by WWF Sweden, the Municipality of Örebro and the County Administrative Board during 2005-2012. By summarising this work and showing what lessons have been learned during the project other organisations, farmers, landowners and others can learn from how this project has worked and what problems and solutions that have been encountered.

Fig 1 and 2 Location in central Sweden and location of Lake Tysslingen in Närke.

BACKGROUND

The county of Närke is situated in the South-Central part of Sweden (Fig.1). The central parts are flat and are used mainly for cereal production and as pastureland. They are surrounded by higher, often forested areas. To the North-East you find the country's fourth largest lake, Lake Hjälmaren – which was drained and lowered during the period 1882-86 in order to generate agricultural land, 15 000 hectares of wetland were transferred to fertile agricultural fields. The bedrock is of Cambro-Silure origin, mainly covered by clay and with occasional "islands" of moraine.

Agriculture has been present in the central parts of the area during thousands of years. The afforestation of the forested parts is of much later origin. Dairy and animal production dominated until the 1960´s often combined with forestry. During present time traditional agriculture has been more and more marginalized except on the plains where cereal production is competing with meat and dairy production. Thus, natural values connected to traditional agriculture are diminishing because of abandonment and over-growth or intensification.

The high natural values in this area are mainly connected to the lakes and wetlands. Lake Kvismaren, Lake Tysslingen, and parts of Lake Hjälmaren around the delta of River Svartån with Oset och Rynninge Bay, are all EU Natura 2000-sites, and included in Birdlife's Important Bird Areas, (IBA). (fig. 2) The area is particularly famous for the large quantities of migrating cranes (*Grus grus*), geese (e.g., *Anser fabalis, A anser)* and whooper swans (*Cygnus cygnus*).

PROJECT CO-OPERATION

The project *Semi-natural grasslands of Närke* started by WWF in 2005 and included meat producing farmers, the Municipality of Örebro and the County Administrative Board. The project was designed to "*strengthen long-term conditions for rural livelihood through viable agricultural enterprises and strengthening of natural and cultural values*"

The municipality of Örebro had already started a spectacular restoration of an old industrial area, a military excersize field and two garbage dump areas, along the mouth of River Svartån, into an "artificial" wetland landscape, giving the project a flying start. The County Administrative board at Örebro are working to establish a nature reserve, which will include Lake Tysslingen and its surrounding wetlands. Since a number of years, various forms of restorations have been carried out to increase the natural values of wetlands. This has lead to a dramatical increase of the number of cattle.

The main concept has been the same as for other WWF grassland projects, including restoration of over-grown land, an increase of grazing animals, establishment of a production ring including farmers, the local slaughterhouse, meat processing company and the local ICA stores. Several innovative ingredients have been introduced in order to reach the project goals.

The farmers Torbjörn and Stefan Eriksson on Gymninge farm, have by their big engagement and big herd of cattle been very active in improving the values of nature and have been a driving force introducing the product "Pasture beef from Närke". These farmers were awarded the "Meat producers of the year in Sweden" during 2008.

PROBLEMS

To maintain its attractiveness for staging or nesting birds the nutrient-rich bird lakes have to be managed in order to avoid over-growth. Disturbance such as grazing is necessary to halt invasion of bushes and shrubs. In the past 15 years the number of cattle has been increased together with various kinds of restoration activities. Grazing alone is not enough to create a management of the wetlands that is sustainable. Before midsummer the production of biomass is too fast for the cattle to graze it all. In addition to this the fluctuation of the water table causes problems for the cattle to graze when water is high some years. It is also impossible to cut these wetter parts of the vegetation with traditional farm machinery.

These difficulties cause big economic problems for the farmers. The economy of the farm is dependent of subsidies from the agro – environmental scheme. Wet years the cattle cannot graze the wetland good enough to meet the requirements of the subsidies, still the farmer has expenses for the cattle during the winter. There is a possibility for the county administrative boards to give an exemption from the requirements of grazing during single years of flooding, but this is not always practiced, such as in this case.

WETLANDS FOR NUTRIENT REDUCTION, FOR HARVESTING BIOMASS AND FOR NATURE

Wetlands are centres of biodiversity, performers of multiple ecological roles of value to society, climate change moderators, and potential locations for profitable green enterprise.
With – by definition – abundant water and nutrient-rich soils, wetlands are amongst the world's most productive natural systems. This high level of metabolism stimulates rapid growth in plants, including fibrous wetland vegetation such as reeds and rushes. Harvesting and processing this vegetation – as biomass – performs many valuable functions e.g.

1. Wetlands will be managed in a better way by removing vegetation that is not eaten by cattle.

2. Vegetation leading to overgrowth can instead be processed and used in various ways, such as:

   a. Composting and converting to garden soil
   b. Green fertilizer on fields
   c. Making pellets for heating and electricity production
   d. Processing into biogas

   In this report the focus will be on biogas

3. The vegetation can be processed in to bio fuel such as biogas, to replace fossil sources of petrol and diesel.

4. Nutrients (especially nitrogen) are concentrated into an accessible and useable form in the vegetation for removal from the water cycle.

5. The rest product from the biogas plant is a valuable fertilizer for use on arable fields which reduces the use of artificial fertilizers. The rest product has a much lower C/N – quota compared to the original substrate. C has been converted to CO^2 and methane. The rest product has a high content of mineralized nitrogen, which is easily accessible for plants. Beside this the content of potassium and phosphorus has been concentrated. Until now it is not clear how rich in nitrogen, potassium and phosphorus the rest product is because there has not been any evaluations done.

6. Farmers feel safer when authorities inspect the wetlands to see that the requirements for the subsidies are met, as the wetlands are well managed.

Innovation and evolving technological developments are moving extremely fast. New equipment for harvesting and new conversion facilities are continually appearing, driving down the cost of this "green energy" compared to conventional sources. Today the project harvests wetland grass and was supposed to deliver the grass to a fermentation plant in the city of Örebro for the production of biogas. Due to various problems it is not possible to ferment the wetland grass in the Örebro plant today.

TESTS AND EVALUATION OF SPECIAL EQUIPMENT FOR HARVESTING GRASS FROM WETLANDS IN LAKE TYSSLINGEN

The starting point for the biogas track was to evaluate if wetland vegetation could be used as a substrate to make biogas. Therefore some samples of grass were harvested and sent to Swedish Biogas international to have them analyzed for fermentation.

Substrate	Dry %	Organic part %	Potential of methane Nm3 CH4 /ton wet subst. Mean between days	CH4 –concentration % Mean between days
Potatoes	18	95	456 (29-43)	57 (29-43)
Silage	38	91	373 (36-57)	56 (36-57)
Grass from Wetland	38	93	316 (43-71)	52 (43-71)

Table 1 Result from analysis of wetland grass done by Swedish Biogas international 2008.

Potatoes have a good potential to produce gas and already after 13 days 85% of methane potential was reached. *Silage*, compared to grass from wetlands, turned into gas quicker. This may be due to the fact that the silage was prepared with acid and therefore more accessible for bacteria. *Grass from wetlands* was the poorest of these three substrates, but it is still not a bad substrate. It is a substrate which can be of economic value if it is possible to get it at good price. (Technical report by Swedish Biogas international in Linköping, 2008).

The conclusion is that wetland grass is good enough to use for biogas production although it takes longer time to produce the gas, compared with grass from arable fields. The wetland grass can be used as a resource for biogas production. The content of energy is at its highest point around midsummer and decreases after this. But it is not possible to harvest the grass before the nesting period for birds is over and the chicks are out of their nests. In Lake Tysslingen this is about the 1st of July. With this result a plan for harvesting wetland grass was started.

Tests of different equipment for restoration and harvesting

Primarily restorations were carried out where bushes and tussocks were cleared away from the wet meadows. Piste machines were used as a carrier of a cultivator giving a very low pressure on the ground. The cultivator pulverizes the wooded material as well as its roots and organic material and soil in the tussocks (Fig. 3 and 4). It was not possible to use tractors, even with double wheels, on the wetter parts of the wet meadows.

Fig 3 Cultivator on a piste machine

Fig 4 Cultivator, detail

The year following the first restoration a trial to harvest the grass was carried out, without success. The reason was that the ground has to be very flat and that there were still roots, branches and twigs causing problems when collecting the biomass. The quality of biomass was too low because of contamination of soil and wooded material. The conclusion from this was to use the two first

Fig 5 On dryer parts of the wetland a tractor, equipped with double wheels, is used to prepare the ground.

years to prepare the ground without collecting any biomass at all. On dryer parts it may be possible to use an ordinary tractor with double wheels to prepare the ground (Fig 5).

If the wetland is to be grazed then it is not necessary to prepare the ground during two years.

One important requirement when starting the restoration is that the water table is low enough, minimizing tracks on the ground from the machines. In Lake Tysslingen it is possible to lower the water table by lowering the water a few weeks before management.

On wetter parts of the wet pasture it may be necessary to trim the vegetation with machines more or less every year. Still, some years it is not possible to trim the vegetation because of a too high water level. Therefore it is even more important to trim the vegetation all the years it is possible (Fig 6, 7 and 8).

Fig 6 A flail mower was used to prepare the ground.

Fig 7 A towed disc mower is efficient before collecting the grass.

Fig 8 A cutter also can be used.

After the restoration period mowing of the grass was started (Fig 9, 10 and 11). To mow the grass a period with low water and no rain is required. The time for cutting the grass will be different every year depending on the water table. It is not possible to hire a company under these circumstances. The county administration board in Örebro has included machinery for mowing in a LIFE project that started 2012.

Fig 9 On wetter parts a piste machine cuts the grass and strings it together.

Fig 10 A big baler collects the grass

Fig 11 A piste machine with spears in front moves the bales from wet areas to the edge of arable fields.

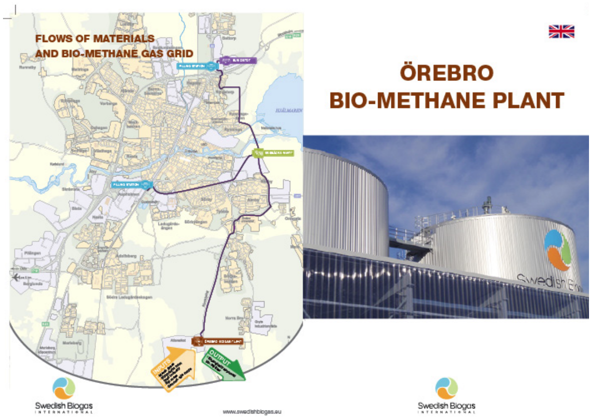

Fig 12 Plan of the biogas plant in Örebro. The biogas is used for busses running in the city.


Fig 13 Cutting down the straw to a length of 10 mm with an exact cutter.

Fig 14 Tractor with track units, which reduce the pressure on the ground.

The next step was to deliver the bales to the biogas plant (Fig 12). From the beginning of the cooperation there were no restrictions concerning the size of the straw or how to deliver it to the biogas plant. It was even possible to deliver bales.

But once it was time to deliver the biomass it was not possible to deliver bales as the biogas plant could not handle bales. The biomass had to be unwrapped and the straw also had to be cut.

During the winter of 2011 an experiment was carried out with the aim of seeing if it was possible to use an exact cutting machine to cut down the straw to a length of 1 cm. The feeder feeding the grass into the fermentation tank could not transport material bigger than 1 cm.

A great number of bales were unrolled on a frozen field by a mixer wagon. A precise cutting machine cut the biomass and blew it into containers to be transported to the plant (fig 13). The result was negative. The capacity of the machine was too low, possibly because there were too few knives.

Swedish Biogas International has contracted farmers to deliver grass from grass lays to the biogas plant in Örebro. The harvest is done by a company, which has machines with the capacity to cut the grass down to less than 10 mm. These machines are not possible to use on wetlands because they are too heavy. There are not any machines of this kind on the market therefore smaller, lighter and less expensive solutions have been sought.

The summer of 2011 a traditional tractor with track units was tried out (fig 14). The idea was to see if it is possible to use less expensive machinery for harvesting the wetland grass. A tractor can be used in farming when it is not used for work in wetlands. The experiment failed because the tractor broke through the root layer. It was very hard to lift the tractor up on more solid ground due to the track units digging the tractor deeper and deeper into the ground.

During 2012 an inventory was done to see what kind of machinery is available in different countries.

There are various ways to harvest and transport the wetland vegetation to the bio-energy plant. Some ways are presented below.

A. A piste machine cuts the grass. The next machine collects the grass and makes it into big bales which are transported to solid ground where the bales are wrapped in plastic and stored before they are converted in to bio-energy. The bales can also be used directly. In this case it is not necessary to wrap them. This method is used in Tysslingen in Sweden. It is also used in Poland in Bierbza national park. The project is run by OTOP.

B. A piste machine cuts the grass, which is collected in a container behind the piste machine. The container is unloaded on solid ground. The grass is then loaded into bigger containers and to the bio-energy plant. This technique is developed in Poland and is used in Bierbza national park. The same idea is used in Germany, but with the difference that the container is on the back of the piste machine. (fig 15 and 16).

C. Tractors with adequate equipment cut the grass. A second tractor makes big bales. This technique, using a tractor with low pressure in the tires was used already in the late 1980-ies in Nötmyran in Västmanland, Sweden. This technique is also used in Poland and Denmark.

D. Special machinery is constructed for management of wetlands, mostly for reed cutting. Such machinery is available in eg. Holland, Great Britain and Estonia.

Fig 15 Retrak in Poland

Fig 16 Piste machine with cutter and collector

Refining the harvested grass

Shredder mill

An investigation was done of the market, both on the Internet and through contacts with people working with connected problems. Sjöstrand is specialized on cutting and sorting materials of quite different kinds, from pulverizing cars into chips and wastes from private households. Together with this company we did experiments with wetland grass. A mill was used for all their fragmentations, a shredder mill. This mill can work by its own or can be linked together with one or two more of the same kind, cutting the material in smaller and smaller pieces. The result of the experiment was that the first shredder mill could not cut the grass to an efficient size. A lot of straw was more than 100 mm long. The capacity seems also be too low for our purpose.

Conventional cutting equipment

At Odensviholm and at Hagelsrum farms the biogas plants uses manure and used straw beddings for cattle together with straw and unused silage. The reactor is not sensitive to the length of the straw. The silage is fragmented with a mixer feeder wagon.

In Toula close to Turku in Finland one fraction for biogas production is reed that has been harvested in early autumn. It is fragmented with an American Haybuster with sufficient result.

In Estonia the Rotogrind is used to fragment silage or dry straw. It does not seem be efficient enough to fragment wetland grass.

Making pellets for burning

A study tour was made to a factory that makes pellets for burning, Låttra gård, Ving Bio Energi Mälardalen AB. The raw material is Reed Canary grass (Phalaris arundinacea). The grass is harvested in spring and the water content is about 15 %. The grass was collected in big square bales, dry enough to be stored under roof.

The processing starts with cutting the bales with a cutter. The grass is then transported to a FRP mill (Lars Fransson) (fig 17), which can fragment the straw to various sizes depending on the size of the grid. After fragmentation the straw is transported to the pellet machine and made into pellets. The pellets for burning are ready to use. The process has been working for many years and works very well as far as the manager of the factory told us. The constructor of the mill later concluded that it is important that the straw is dry, otherwise the material will fill up the grid and the process will stop.

Fig 17 A Fransson FRP mill

In Poland there is an ongoing LIFE-project, "Conserving Aquatic Wabler in Poland and Germany", in Biebrza Valley. The Polish Society for Protection of Birds (OTOP) has set up a pelleting facility that will allow production of pellets from the biomass derived from mowing wetlands. The vegetation contains about 35% water and needs to be decreased to a 15-18% water content. The grass can be dried by heating it up, but this will cost a lot of energy. An alternative is to mix the wetland vegetation with straw which contains very little water. The size of the grass blades is not critical, therefore an ordinary cutter used in agriculture has been used.

Extruder technique

Örebro municipality is looking for alternatives to get more biogas for the town busses. Therefore contacts have been taken with the nearby municipality Karlskoga. They are in the process to building a biogas plant where they are going to use manure from farms and grass from grass lays. This plant will use a different technique to fragment the material that will feed the biogas plant. The farmers are contracted to deliver grass up to 40 mm of length. When feeding the plant all material will be fragmented in an extruder. The machine works with a high pressure and high

temperatures. This makes the cells collapse making it easier for the plant to utilize the energy content in the grass. This technique is used for preparation of maize etc in Germany with good results. It is said that the extruder is sensitive to sand and gravel. The Hanze Wetlands Company in Holland and Clean energies in Germany have experiences of the extruder being too sensitive and easily braking when the wetland grass is contaminated. It is not possible to harvest wetland vegetation without any contamination. It is therefore wise to investigate this further.
The use of an extruder in the Karlskoga biogas plant will be the first time this technique is used in a biogas plant Sweden.

In Århus they have harvested vegetation from wetlands since 2009 as a part of the BIOM-project. 2012 they started to use the grass for production of biogas and ecological manure. They are using an extruder for fragmentation of the grass and are using big bales. It is not necessary to cut the grass when harvesting.

Suggestions to make the mowing more efficient

The piste machines are constructed for winter use. When used in summer they have to be converted with an efficient cooler system and with summer belts that cause less damage to the ground. This alteration has already been done. Now we are looking in to the possibility of reconstructing a piste machine so that it can cut the vegetation and pick it up at the same time so that the driving on the wetland is reduced.

The bales should be wrapped with netting instead of with string. This causes much less work when preparing the bales. In the longer run there is a need for netting which is made of organic matter which can be cut together with bales or can be eaten by cattle.

The bale machine has to be equipped with cutting knives, which cut the collected vegetation in small pieces.

Usually there are no roads going down to wetlands. This causes problems with transportation of bales from the wetland to ordinary roads. Therefore there are plans to construct simple "roads" which can be used by tractors with lorry trailers or lorries.

There are various ways to solve problems with the length if the straw, one is to cut the material down to a size of less than 1 cm. Another is to look for some other biogas plant with an alternative and less sensitive technique. We are taking both ways into consideration and are working with both of these scenarios. If this problem can be solved in an inexpensive way then lots of other biomass, e.g. from public gardens, roadsides and leftover bales from farms, can be used for bio energy purposes.

Summary of experiments and costs for restoration, mowing and collecting of grass from wetlands

Logistics:

a. Restoration of wetland. Mowing of bushes and tussocks during 1-2 years to get the surface as flat as possible. Machines used; Piste machine with cultivator on soft soils and tractor with adequate wheels and mill on more solid soil. Photo 3, 4, 5.

b. Cut and string the grass. Machines used; Piste machine with a grass cutter which strings the grass. Photo 9, details 6, 7, 8.

c. Make bales of the grass. Machines used; Piste machine with baler. Photo 10.

d. Lift the bales from wetland to solid ground. Machines used; Piste machine with spears. Photo 11.

e. Wrap the bales with plastic if they have to be stored. Machines used; tractor with plastic wrapper.

f. Move the bales with a lorry to a storage place close to the biogas plant. Machines used: lorry or tractor. Photo 12.

g. Cut the bales before the grass is loaded in to the fermentation tank. Photo 13.

Benefits from mowing wetland grass

The amount of nitrogen, which can be taken out from the wetland, has not been calculated. Until now the yield per ha is about 2 tons in one cut. That means when mowing 50 ha then 100 tons of biomass is moved from the wetland including nitrogen and phosphorous. The content of nitrogen from silage is about 10 kg/ton. If we estimate that the content of nitrogen in silage from wetlands is 50%, then 500 kg nitrogen is removed from the Tysslingen wetland back to the fields every year.

Economy

To cut the grass, harvest it and carry the bales to solid ground has, during the test period, cost about 5 500 SEK/ha. If the costs for investments can be solved in a positive way for entrepreneurs or farmers the cost for this job can be as low as 2 500 SEK/ha.

This can be compared with the cost of harvesting silage on an arable field, which is 1000 - 1200 SEK/ha.

The yield of grass from wetlands varies between 2 – 4.2 tons/ha.

Income from the grass can be 1200 – 2520 SEK/ha depending on the yield. This is estimated on a payment from the biogas plant of 1 SEK/kg of silage from arable fields and an outcome of biogas from wetland grass of 60% of that from arable fields.

If agro-environmental payments are added to this income, wetland grass can be of economic interest to use as a substrate for producing biogas.

CONTACTS DURING THE PROJECT.

Agripro. Tomas Nilsson. www.agripro.se
Andersson, Michael. michael.andersson@lansstyrelsen.se
Bergkvist, Tomas. tomas.bergkvist@orebro.se
Dalme, Bengt, Hammars säteri.
Enoksson, Håkan. PURAC. he@purac.se
Eriksson, Torbjörn, Gymninge gård. torbjorn@gymninge.se
Fransson, Lars. Franssons recycling machines. www.franssons.com
Gatkowski, Dariusz. OTOP, Poland. dariusz.gatkowski@otop.org.pl
Hanze Wetlands, Arnold van der Post, Holland. arnoldvdp@gmail.com
Hanze wetlands, Marcel Oomen, Holland. marsceloomen66@gmail.com
Hedberg-Fält, Peder, LST västra Götaland. Peder.Hedberg.Falt@lansstyrelsen.se
Jan Lundegrén. Lundegren.axvall@telia.com
Karlskoga energi. jorgen.lundblad@karlskogaenergi.se www.karlskogaenergi.se
Kässbohrer, Germany. www.pistenbully.com
Lehmann Maschinenbau GmbH. j.zorn@lehmann-maschinenbau.de
MERA, Jürgen Rabeler. www.mera-rabeler.de
Older Grupp in Saku, Estonia. siim.older@oldergrupp.ee
Swedish Biogas International, Erik Florell. www.sbilantbruk
Sjöstrand. www.contact@sjostrand.se
Skogstjänst, Bengt Pettersson. bengt@pe-te.se
Svensson, Fredrik. Odensviholm
Turunen, Aimo. www.kiteenmatojamulta.fi
Vafab, Västerås. www.vafabmiljo.se
Ving Bio Energi Mälardalen AB. goran@vingbioenergi.se
Winn marketing, Glenn Bergström. www.winnmarketing.com
Jalli, Veli-Matti. veli-matti.jalli@livia.fi
Vang Jørgensen, Thomas. Økologichef. tvj@lmo.dk

Wetlands are centres of biodiversity, performers of multiple ecological roles of value to society, climate change moderators, and potential locations for profitable green enterprise. With – by definition – abundant water and nutrient-rich soils, wetlands are amongst the world's most productive natural systems. Is it possible to use wetland vegetation as substrate to make biogas?

In this report you can read about lessons that have been learned concerning harvesting wetland grass for biogas production in Tysslingen, outside of Örebro, during the period of 2005-2012.

UPPLANDS STIFTELSEN
NATURVÅRD & FRILUFTSLIV
Box 26074, 750 26 Uppsala
SWEDEN
info@upplandsstiftelsen.se
www.upplandsstiftelsen.se