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Introduction

Wetlands can be found in all continents of the world except for the Antarctica. They function as a vital part of the ecosystem even though their importance is often overlooked. It has been a problem defining wetlands with great accuracy. One definition is that "*wetlands occupy the transitional zone between permanently wet and generally dry environments, yet cannot be classified exclusively as either aquatic or terrestrial*" (Finlayson and Moser, 1991). This problem with definition arises from the enormous variety of wetland types, their highly dynamic character and difficulties defining their boundaries with any precision. The key is to describe the nature of wetlands is the presence of water for a significant period of time. Water changes the soil, the micro-organisms and the animal and plant communities so that the land functions in a different way from either aquatic or dry habitats.

In recent decades wetlands have become sparser mostly due to the fact that all over the world they have been drained for agriculture and other uses of the land such as construction. Iceland is no exception to this and in the last century a large part of Iceland's lowland has been drained.

***The purpose and scope of the study***

This study is a part of a larger project called "*Policy measures for the preservation of biological diversity in forests and wetlands*". The project is funded by the Nordic Council of Ministers and the Norwegian Ministry of Environment. The main purpose of the study is to give an overview of the current conditions of forests and wetlands in the Nordic countries. This part of the study deals with wetlands in Iceland. A changing attitude towards the importance and usage of the wetlands has been increasing among nations. Wetlands are a very important factor in the ecosystem and its importance has often been undervalued.

The study should give knowledge on the main issues concerning wetlands in Iceland, both the history and the future of wetlands.

***The focus of the study***

The main focus of this study is:

- The history of wetlands in Iceland. The usage of the Icelandic wetlands is mainly divided into tree periods; when it was left unattached, the drainage and irrigation period and most recently the recovery of the wetlands. Government funding of drainage will be addressed and a summary of the government spending for improvement of the land from 1924-1989. The main purpose and consequence of the drainage will be discussed along with two of the main studies that have been made on the extent of the drainage in the Icelandic lowlands.

- The Icelandic laws and regulations concerning wetlands. The Icelandic government has established a special committee to recover disturbed wetlands and Iceland is a participant in the Ramsar treaty. The Ramsar treaty is an international cooperation for the conservation of and wise use of wetlands and their resources and Iceland has named some of its wetlands to the Ramsar list of internationally important wetlands.

- This study also focuses on the lake Mývatn which is an extraordinary wetland area in Northern part of Iceland that has many special qualities. Lake Mývatn was the first wetland to be appointed by Iceland to the Ramsar list of internationally important wetlands. The usage of the lake itself and its surrounding area has been a hot debate in Iceland. Special laws are in effect concerning the lake and the entire borough it is located in and there may be a change in them impending. Brief discussion will be on the Skútustaðir-borough where the lake is located and the diatomite factory located by the lake. Some debates have been about the diatomite factory and its influence on the lakes wildlife and ecosystem. The factory is the areas larges employer and has mining-permission in one of the lakes basins until 2010. The future of the diatomite factory is uncertain but some ideas have evolved and will be discussed. The area surrounding the lake Mývatn includes a meadow called Framengjar (“Front Meadow”) and the river Laxá will be addressed.

Framengjar is a wetland area that was drained around 1950 and than recovered late summer of 2003. The river Laxá runs from the lake Mývatn and is one of Iceland's most popular fishing rivers, a hydro power plant is also located in the river. The future perspective of the Mývatn area will also be addressed.

- Economic studies on environmental issues can often be complex but are very necessary. When valuing wetlands and other environmental recourses it is very important to look at every aspect of its products and services. Large part of the products and services provided by wetlands are non-marketable and therefore harder to value than the ones that are priced on the market. Techniques used to valuate environmental recourses will be discussed mainly the *willingness to pay* /*willingness to accept* with *direct method* and *indirect method*. Suggestion is made for the strategy of further recovery of wetlands in Iceland and a review of the cost of a recovery made in Northern-Iceland in the late summer 2003. Finally there is taken an example of a valuation study made in the UK.

## Wetlands in Iceland

### *Short overview*

Iceland is a volcanic island located in the North Atlantic, midway between Europe and North America. It is approximately 103.000 $km^2$ but with a geography that differs very much from the other Nordic countries. It consists largely of highlands and a considerable part of the highlands is covered with glaciers, among them Europe's largest glacier, *Vatnajökull*. Lowlands are quite sparse with most of these areas being occupied for agriculture and industry. In Iceland there are now hardly any forests but wetlands on the other hand are quite common in the landscape. Iceland has an oceanic climate with one of its distinctive features being a lot of precipitation and little evaporation. This makes Iceland rich with water *(Malmquist, 1998)*. It is not fully known how large a part of Iceland the mires and marshy ground cover but it is believed that they cover at least between 8 to 10 thousand $km^2$ which is approximately 1/10 of Iceland. Some even believe that these figures underestimate the real coverage and believe it to be about 9-12 thousand $km^2$. [1]

It is believed that from the settlement of Iceland, in the 9$^{th}$ century, until the mid 19$^{th}$ century, wetlands in Iceland were essentially undisturbed. The settlers were farmers working the land providing only for their own families. They lived on small farms and used the wetlands without corrupting them in any way. This changed shortly after the mid 19$^{th}$ century with advancing technique in agriculture. This agricultural revolution made Icelanders become interested in making irrigations and growing meadows. Farms grew bigger and farmers made products for trading instead of just for their own use. This led to the appearance of drainage in Iceland, though not very widespread at first. This new technique remained in balance until 1930 when growing large hayfields became increasingly popular with concurrent increase in drainage of the wetlands.

[1] This is an verbal source form Óskarsson, Hlynur a wetland expert for the Agricultural research station in Iceland (RALA).

*Impact of mechanical labour*

Early in the drainage period the ditches were manually dug and were both narrow and shallow. In the years preceding the First World War ditches were made by digging holes in the ground, not far from each other, and then explosives were put in the holes. The explosions dashed the soil and the ditches were than completed by shoveling what was left of the soil to make an unbroken ditch.

In lowlands, mires were drained and turned in to hayfields. In the year 1942 a breakthrough in draining occurred when the first excavator was imported to Iceland. From that year on drainage of wetlands grew considerably until reaching its peak in the year 1968.

Furthermore the growing import of excavators made the process of digging ditches much easier and manually dug ditches became very rare. An overview of ditches and drainage in Iceland can be seen in *Table 1.* [2]

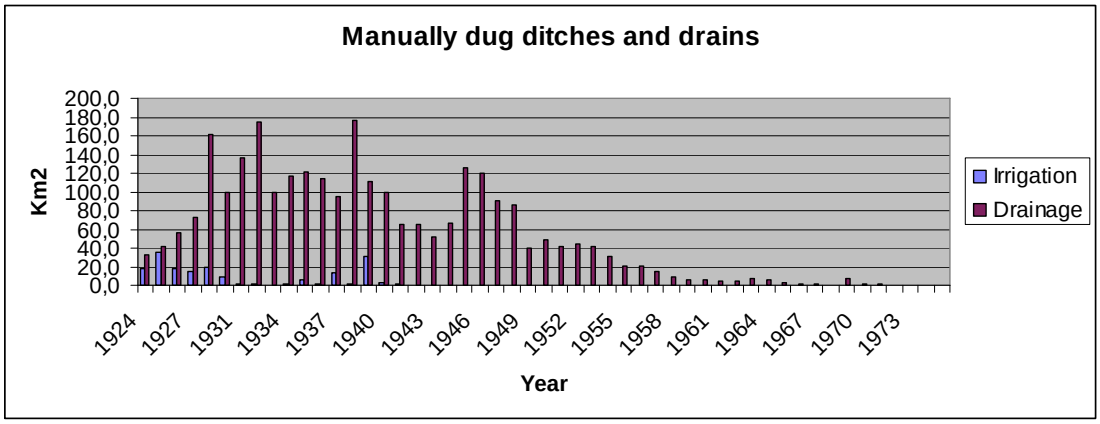
[2] Source: Statistics Iceland

## *Table 1 - Owerview of ditches dug for drainage and irrigation 1924-1989*

| | *Drainage and irrigation* | | | |
|---|---|---|---|---|
| | *Ditches and drains dug manually* | | *Ditches and drains dug by excavators* | |
| | *For irrigation* | *For drainage* | | |
| | 1.000 m³ | 1.000 m³ | km | 1.000 m³ |
| 1924 | 17,3 | 33,0 | – | – |
| 1925 | 35,4 | 42,0 | – | – |
| 1926 | 17,1 | 55,9 | – | – |
| 1927 | 14,4 | 72,7 | – | – |
| 1928 | 19,1 | 161,9 | – | – |
| 1929–30 | 8,3 | 99,0 | – | – |
| 1931 | 2,0 | 136,1 | – | – |
| 1932 | 1,8 | 175,3 | – | – |
| 1933 | 0,3 | 99,3 | – | – |
| 1934 | 1,0 | 117,2 | – | – |
| 1935 | 5,4 | 121,4 | – | – |
| 1936 | 2,2 | 114,8 | – | – |
| 1937 | 13,5 | 94,8 | – | – |
| 1938 | 0,9 | 177,0 | – | – |
| 1939 | 31,3 | 111,6 | – | – |
| 1940 | 2,9 | 98,6 | – | – |
| 1941 | 2,1 | 64,5 | – | – |
| 1942 | – | 64,9 | 6 | 34 |
| 1943 | – | 52,1 | 12 | 64 |
| 1944 | – | 66,4 | 33 | 124 |
| 1945 | – | 126,2 | 64 | 280 |
| 1946 | – | 120,1 | 86 | 343 |
| 1947 | – | 90,4 | 216 | 743 |
| 1948 | – | 85,4 | 413 | 1.456 |
| 1949 | – | 40,7 | 474 | 1.773 |
| 1950 | – | 49,3 | 575 | 2.178 |
| 1951 | – | 42,2 | 506 | 1.967 |
| 1952 | – | 45,0 | 657 | 2.540 |
| 1953 | – | 41,9 | 721 | 2.978 |
| 1954 | – | 30,7 | 801 | 3.406 |
| 1955 | – | 20,5 | 694 | 3.104 |
| 1956 | – | 21,2 | 948 | 4.179 |
| 1957 | – | 14,8 | 942 | 4.194 |
| 1958 | – | 8,4 | 966 | 4.184 |
| 1959 | – | 5,3 | 937 | 4.023 |
| 1960 | – | 6,3 | 778 | 3.344 |
| 1961 | – | 5,0 | 659 | 2.875 |
| 1962 | – | 4,5 | 596 | 2.549 |
| 1963 | – | 6,7 | 813 | 3.515 |
| 1964 | – | 6,3 | – | 5.391 |
| 1965 | – | 2,6 | – | 4.076 |
| 1966 | – | 2,1 | – | 3.968 |
| 1967 | – | 1,4 | – | 5.729 |
| 1968 | – | 0,4 | – | 6.493 |
| 1969 | – | 8,0 | – | 4.455 |
| 1970 | – | 1,1 | – | 5.340 |
| 1971 | – | 0,8 | – | 5.573 |
| 1972 | – | 0,5 | – | 5.241 |
| 1973 | – | 0,1 | – | 3.985 |
| 1974 | – | 0,4 | – | 5.131 |
| 1975 | – | 0,1 | – | 4.142 |
| 1976 | – | – | – | 4.477 |
| 1977 | – | – | – | 3.858 |
| 1978 | – | – | – | 4.900 |
| 1979 | – | – | – | 2.916 |
| 1980 | – | – | – | 3.192 |
| 1981 | – | – | – | 2.417 |
| 1982 | – | – | – | 4.724 |
| 1983 | – | – | – | 4.638 |
| 1984 | – | – | – | 6.446 |
| 1985 | – | – | – | 4.943 |
| 1986 | – | – | – | 1.996 |
| 1987 | – | – | – | 2.835 |
| 1988 | – | – | – | 2.240 |
| 1989 | – | – | – | 1.703 |

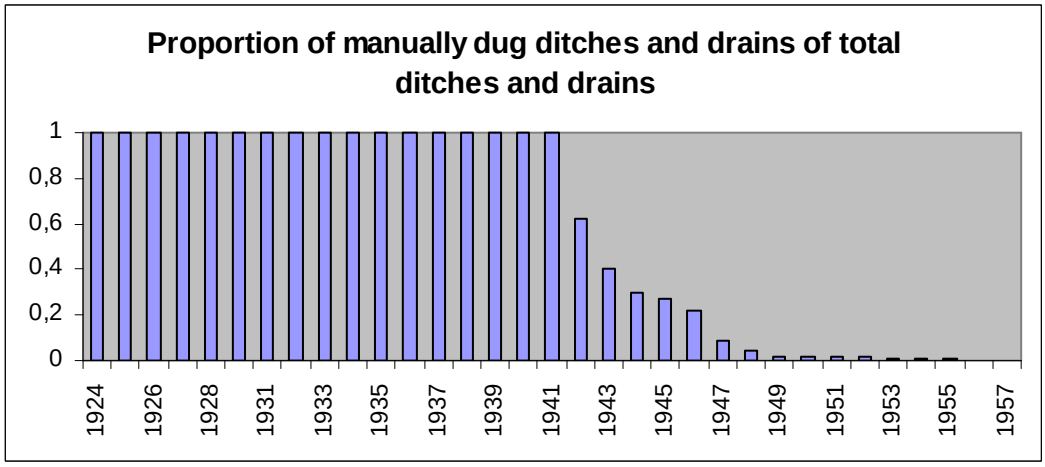
*Table 1* shows that until the first excavator was imported to Iceland, in the year 1942, ditches and drains were all manually dug. Since the arrival of excavators, manual labour for digging ditches for irrigation became almost non-existing. Manually dug ditches for drainage on the other hand did not disappear as rapidly as the ones for irrigation, although their proportion became less and less.
After the year 1975 records indicate that manual labour for drainage ditches ceased.

*Figure 1-Manually dug ditches and drains*




The year that the first excavators were taken in use (1942), manually dug ditches and drains still were about 60% of the total number of ditches. In the year 1947 that number went below 10% and a few years later in 1954 records show that the number went below 1%.

*Figure 2-Manually dug ditches and drains in proportion of total ditches and drains*



After 1965 another period of a rapid increase in drainage occurred. This was largely because of a growing demand for more land for livestock grazing. This led to the import of more highly developed machinery that made drainage of mires especially easy.

***Government funding***

Advances in technological development are not the only things believed to have had a great impact on the drainage of the lowland mires in the years after the Second World War. Another vital issue was the approval of laws favouring drainage of the mires. Some type of government agricultural support system had existed in Iceland for a long time. Until Iceland became independent and was ruled by the Danish monarchy the Danish King offered grants for improvements of the land to the Icelandic people. In the year 1923 the establishment of special agricultural laws included generous governmental support for draining the land for agricultural purposes. Naturally this played a part in the increase in drainage that occurred in Iceland in the twentieth century.

Government grants for drainage have not been constant over the years. *Table 2* gives some overview of the government participation in the cost of drainage with open ditches.

*Table 2 - Government participation in drainage cost*

| Year | | Govenment participation in drainage cost (%) | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| 1942-1949 | | | 33,3% | | | |
| 1950-1954 | | | 50% | | | |
| 1955-1963 | | | 65% | | | |
| 1964-1987 | | | 70% | | | |

*(Source: Geirsson, 1975)*

As can be seen in *Table 2* the grants for the drainage were about 65-70% for most of the twentieth century. In the beginning the main reason for the support of the government was that it was believed that drainage and the different usage of the land that followed would improve welfare in Iceland, especially for the Icelandic farmers.

There is no doubt that in the areas that were in large part mires, the drainage did improve agricultural production in Iceland.

*Table 3* is a summary of the government cost in land improvement for a period of 65 years, from the year 1924 to the year 1989. As already mentioned the government has over the years participated in various so-called improvements of the land. In the years that the government participated in the cost of drainage it was considered among land improvement cost. Many other factors that are considered as an improvement of the land are included in this cost.

*Table 3* [3] *- Government spendings on land improvements 1924-1989*

| | *Government spending on improvements* | | | *Government spending on improvements* |
|---|---|---|---|---|
| *Year* | *Thous. new ISK* | | *Year* | *Thous. new ISK* |
| | | | | |
| 1924 | … | | 1958 | 273 |
| 1925 | 2 | | 1959 | 269 |
| 1926 | 3 | | 1960 | 272 |
| 1927 | 4 | | 1961 | 263 |
| 1928 | 5 | | 1962 | 263 |
| 1929–30 | 6 | | 1963 | 390 |
| 1931 | 7 | | 1964 | 656 |
| 1932 | 6 | | 1965 | 685 |
| 1933 | 6 | | 1966 | 688 |
| 1934 | 7 | | 1967 | 942 |
| 1935 | 7 | | 1968 | 201 |
| 1936 | 6 | | 1969 | 935 |
| 1937 | 5 | | 1970 | 1.017 |
| 1938 | 6 | | 1971 | 1.193 |
| 1939 | 6 | | 1972 | 1.798 |
| 1940 | 3 | | 1973 | 2.350 |
| 1941 | 3 | | 1974 | 3.967 |
| 1942 | 6 | | 1975 | 5.761 |
| 1943 | 7 | | 1976 | 7.731 |
| 1944 | 14 | | 1977 | 10.571 |
| 1945 | 24 | | 1978 | 14.713 |
| 1946 | 35 | | 1979 | 16.540 |
| 1947 | 39 | | 1980 | 23.326 |
| 1948 | 52 | | 1981 | 40.400 |
| 1949 | 45 | | 1982 | 65.800 |
| 1950 | 72 | | 1983 | 99.500 |
| 1951 | 90 | | 1984 | 145.200 |
| 1952 | 107 | | 1985 | 169.500 |
| 1953 | 115 | | 1986 | 162.500 |
| 1954 | 140 | | 1987 | 217.500 |
| 1955 | 171 | | 1988 | 164.000 |
| 1956 | 207 | | 1989 | 126.100 |
| 1957 | 229 | | | |

[3] Source *Statistics Iceland*

*Grants for ditches and drains dug by excavators 1942–44 excluded. Grants to hay-drying systems 1964–70 included.*

*Only one record was published for farm improvements 1929 and 1930. Some of the 1929 returns are included in the 1928 figures.*

.

Government funding of draining continued until the year 1989 when it was revoked. Government funding has since been confined to maintenance of previously drained land. It has been a commonly held view that the drainage stopped serving its purpose as to increase the productivity of the agriculture in Iceland in the seventh or eighth decade of the twentieth century but because funding was still available the draining period carried on longer than it should have. In fact the drainage did not stop until a few years ago when most part of the Icelandic wetlands in the lowland had already been drained.

Next table is an overview of the ditches dug in the lowlands by the Icelandic farmers in the years between 1942 and 1986. Since most of the ditches dug in the Icelandic lowlands after the year 1942 were indeed mechanically dug by farmers, this overview should be a good indicator of what was dug altogether during this period. The table also shows an overview of the average cost in Icelandic kronas on the volume ($m^3$) of the ditches for every year. As mentioned earlier the Icelandic government participated in the drainage cost and the figures of the total cost of the drainage are also shown in the table.

*Table 4 – Mechanically dug ditches by farmers 1942-1986*

| *Year* | *Ditches in m* | *Ditches in m³* | *Average cost in ISK on m³* | *Total cost* in ISK |
|---|---|---|---|---|
| 1942 | 5.553 | 34.164 | 1,44 | 49.196 |
| 1943 | 12.218 | 64.030 | 1,59 | 101.808 |
| 1944 | 32.536 | 124.053 | 1,78 | 220.814 |
| 1945 | 63.936 | 279.733 | 1,48 | 414.005 |
| 1946 | 85.346 | 342.653 | 1,56 | 534.539 |
| 1947 | 216.245 | 743.084 | 2,01 | 1.493.599 |
| 1948 | 431.380 | 1.455.458 | 1,93 | 2.809.034 |
| 1949 | 482.264 | 1.783.403 | 1,92 | 3.424.134 |
| 1950 | 579.765 | 2.187.663 | 2,27 | 4.965.995 |
| 1951 | 501.054 | 1.980.951 | 2,96 | 5.863.615 |
| 1952 | 660.885 | 2.754.955 | 3,13 | 8.623.009 |
| 1953 | 718.769 | 2.962.353 | 3,18 | 9.420.283 |
| 1954 | 803.206 | 3.413.011 | 3,23 | 11.024.026 |
| 1955 | 674.820 | 3.013.403 | 3,30 | 9.944.230 |
| 1956 | 866.617 | 3.925.472 | 3,65 | 14.327.973 |
| 1957 | 908.901 | 4.041.675 | 3,98 | 16.085.867 |
| 1958 | 940.882 | 4.092.703 | 3,97 | 16.248.031 |
| 1959 | 904.451 | 3.893.272 | 4,15 | 16.157.079 |
| 1960 | 743.854 | 3.272.643 | 4,80 | 15.708.686 |
| 1961 | 620.120 | 2.979.877 | 4,88 | 14.541.800 |
| 1962 | 580.961 | 2.481.885 | 5,46 | 13.551.092 |
| 1963 | 806.055 | 3.488.397 | 6,08 | 21.209.454 |
| 1964 | 1.255.858 | 5.375.418 | 6,31 | 33.918.888 |
| 1965 | 962.707 | 4.057.141 | 6,98 | 28.318.844 |
| 1966 | 959.028 | 3.967.985 | 7,85 | 31.148.682 |
| 1967 | 1.376.755 | 5.715.713 | 7,89 | 45.096.976 |
| 1968 | 1.632.928 | 6.422.100 | 9,11 | 58.505.331 |
| 1969 | 1.066.807 | 4.455.432 | 8,76 | 39.029.584 |
| 1970 | 1.243.317 | 5.339.530 | 9,07 | 48.429.537 |
| 1971 | 1.276.246 | 5.573.064 | 11,22 | 62.529.778 |
| 1972 | 1.072.909 | 5.241.194 | 11,09 | 58.124.841 |
| 1973 | 737.414 | 3.991.427 | 13,90 | 55.480.835 |
| 1974 | 973.672 | 5.131.281 | 17,48 | 89.694.792 |
| 1975 | 719.988 | 4.121.741 | 30,15 | 124.270.491 |
| 1976 | 749.219 | 4.477.372 | 37,25 | 166.782.107 |
| 1977 | 641.281 | 3.858.160 | 48,30 | 186.349.128 |
| 1978 | 837.928 | 4.900.285 | 72,43 | 354.927.643 |
| 1979 | 485.885 | 2.915.633 | 103,74 | 302.467.767 |
| 1980 | 452.071 | 3.193.267 | 175,00 | 558.821.725 |
| 1981 | 355.842 | 2.412.013 | 2,75 | 6.633.036 |
| 1982 | 537.074 | 4.724.101 | 3,67 | 17.337.451 |
| 1983 | 570.994 | 4.557.995 | 6,68 | 30.447.407 |
| 1984 | 819.955 | 6.444.727 | 9,00 | 58.002.543 |
| 1985 | 566.407 | 4.942.884 | 10,50 | 51.900.282 |
| 1986 | 159.459 | 1.995.508 | 11,30 | 22.549.240 |
| | **31.093.562** | **153.128.809** | | |

*(Source: Bjarnason p.24-33)*

This table shows that over 31 million meters of ditches covering more than 153 million $m^3$ were made in order to dry the land in the years between 1942 and 1986. The table shows that the cost per $m^3$ rises from year to year until the year 1981 when the cost falls considerably. The explanation for this is that two zeros were taken off the Icelandic krona in the beginning of 1981 so that 1000 ISK became 10 ISK. This should be kept in mind when comparing the cost figures.

***Studies on wetland draining in Iceland***

A number of studies have been made on wetlands in Iceland. Most of them deal with biological ecosystems, i.e. research on various bird species or changes in the Icelandic flora. Studies have also been done to try to evaluate the proportion of the Icelandic lowlands that has been drained over the years. Studies on that particular topic have been carried out both in the western and southern parts of Iceland.

In the western part the research focused on Borgarfjarðarsýsla (Borgarfjardar-county) and Mýrarsýsla (Myrar-county). It is believed that the extent of wetlands in that region prior to drainage was 703 $km^2$ (Óskarsson, 1998). The results of the study on these particular areas showed that only 18% of the original wetlands (703 $km^2$) remain intact that is the total of 128 $km^2$. Intact wetland in this area was mainly found in Mýrarsýsla (106 $km^2$), which is close to 83% of the intact wetland. The conclusion of this particular study is that drainage of wetlands in Iceland could be about 55-75% of the total wetland area in lowlands of Iceland. *Table 5* sums up the results of this study.

*Table 5 - Extent and status of wetlands in Western Iceland*

| | Estimated area of wetlands 1930 ($km^2$) | Drained wetland areas 1994 ($km^2$) | In % | Altered wetland areas in 1994 ($km^2$) | In % | Intact wetland areas 1994 ($km^2$) | In % |
|---|---|---|---|---|---|---|---|
| **Borgarfjardarsysla** | *238,8* | *198,5* | *83%* | *18,1* | *8%* | *22,2* | 9% |
| **Myrarsysla** | *464* | *177,1* | *38%* | *180,7* | *39%* | *106,2* | 23% |
| **Total** | **702,8** | **375,6** | **53%** | **198,8** | **28%** | **128,4** | 18% |

(Source: Óskarsson, 1998)

Another study was done on wetland drainage in lowlands in the southern part of Iceland. The study covered an area from Ölfus in the west, eastwards to Markarfljót river and Geysir in the inland. It is believed that that this particular area

was covered with 1.100 $km^2$ of wetlands in the early 20th century. When the Icelanders started making irrigations as mentioned earlier, the lowlands in the southern part of Iceland were especially under attack. The study mentioned above which dealt with wetlands in the south indicates that most part of wetlands in that area has been drained in the last decade. The focus of the study was only on the wetlands that still remain. The remaining wetlands were divided into three groups depending on the state of the wetland. *Table 6* shows the results of the study.

*Table 6 – status of wetlands in Southern part of Iceland*

| Class | Description | Number of sites | Total area ($km^2$) |
|---|---|---|---|
| A | *Completely intact or lightly disturbed, water table high, natural boundaries but some sights with ditches at edges or inside.* | 9 | 26,7 |
| B | *With ditches slightly drained: water table high on land and in ditches* | 25 | 117,2 |
| C | *With ditches, clear indication of drainage* | 13 | 26,7 |

*(Source: Thorhallsdottir,1998)*

The table shows that the remaining wetlands in this area cover about 170.6 $km^2$ and 144 $km^2$ of these wetlands have been disturbed in some way. Of the 1100 $km^2$ of wetlands believed to have existed in the lowland in the southern part of Iceland in the early 20th century, only about 26.7 $km^2$ are still intact or lightly disturbed. This particular study therefore indicates that about 97% of wetlands in this area have been substantially disturbed or drained.

The major conclusion of these studies is that the vast majority of the wetlands in the Icelandic lowlands from the early 20th century have either been drained or at least disturbed in some way.

***The purpose and consequence of drainage***

The main purpose of drainage is to get rid of any excess water from the soil. Various physiological and chemical changes occur in the soil with drainage. The most important are lowering of the ground water level, shorter circulation period of water through the soil and less amount of organic nutrients. Also there is increased erosion in connection with the edges of the ditches. When the wet soil has not been drained it carries low oxygen content and the organism living there are mostly anaerobic. Decay in such conditions is very slow. By draining the soil two fundamental changes takes place that alter the living conditions of the soil. Air, rich in oxygen, enters the soil and secondly the temperature of the soil changes. The temperature of wetlands is dependant upon the temperature of its water. Water acts as an insulator for the wetlands, making temperature changes less rapid. This means that that wetlands heat up very slowly in the springtime which is unfavorable for the growth of plants. When the wetlands are drained the soil also becomes oxygen rich which is an environment favoring growth of aerobic microorganisms. Aerobic microorganisms are more efficient in decomposing organic materials than anaerobic organisms. The result is that once the decomposition is on its way, the soil becomes more fertile.

With all the drainage going on for years in Iceland, little research has been done on the influence of the drainage on the environment. The consequence of the drainage depends partly on factors of the surroundings such as hydrology, water quality, salinity, chemistry, seasonality and soils. The low temperature in Iceland makes the decomposition in the drained wetlands slower than in countries with higher average temperature. This fact makes the recovery of drained wetlands easier because the soil might not be completely dry and therefore could still have some traces of wetland flora in it.

**Laws regarding the wetlands**

A large part of the world's natural wetlands have been tempered with. It is, for example, believed that in the USA humans have caused the loss of over 50% of natural wetlands and in many countries in Europe the loss is around 30-90%. (Malmquist, 1998)

It can be said that in recent years a change of attitude has occurred regarding wetlands and their use. Nations around the world are starting to sense the importance of undisturbed wetlands and have started issuing laws concerning their protection.

The Ministry for the Environment is Iceland's youngest ministry and was established in the year 1990. Since its establishment the Ministry has worked on formulating and enforcing an integrated policy for environmental affairs, with sustainable development as a guideline.

Many recent legislation concerning environment and nature conservation have been enforced. The main nature conservation law is *The Nature Conservation Act* (no. 44, 1999), other important law concerning that field are *The Planning and Settlement Act* (no. 73, 1997) and *Environmental Impact Assessment Act* (no. 75, 2000). Now there are stricter laws regarding drainage of wetlands and a special permission from the authorities is needed if drainage of wetland is to take place. If wetlands are disturbed when roads are made, a recovery of the disturbed wetland is mandatory. A special committee has been established to focus on the recovery of drained wetlands and Iceland is also a participant in an international wetland treaty called the Ramsar-treaty.

The ministry has published its first nature conservation plan, which covers the period between 2004 and 2008. This plan is a step in the Ministries determination to establish an organized net of areas that are protected in Iceland. The goal is to define these areas using scientific databases that exist on Iceland's nature.

The plan that has now been introduced for the years 2004-2008 suggests the conservation of 14 areas, considering their importance, the imminent threat they face and the wishes of local residents. The goal is to establish a method concerning regional nature conservation, which fulfils Iceland's international obligations. This proposal awaits the approval of the Icelandic parliament.

***The wetland committee***

In the year 1996 the Icelandic Minister of Agriculture appointed a committee on the recovery of drained wetlands. This committee, often called *the wetland committee,* is still at work and its main goal is to suggest where and how drained wetlands can be recovered. The wetland committee is also supposed to manage and follow the progress in recovered areas. The committee emphasizes the need for the recovery of drained wetlands is to be done in cooperation with the farmers and landowners. Even though the drainage of wetlands in the lowlands is thought to have played a key role in the improvement of agriculture in Iceland, it is now thought that further drainage is unnecessary. Farmers and landowners are therefore encouraged to recover drained wetland wherever possible. No government support is available for the recovery.

***Why recovery of the wetlands?***

Wetlands have been considered to play a crucial role in the biological diversity of any given area. The circulation of water and nutrients are largely dependant on its existence. The committee has classified three important aspects of wetlands:

- *Hydrological value*: Wetlands keep an even flow in brooks and rivers, by collecting water in heavy rains and donating water in the dry periods. This is important for many living organism such as the salmon.
- *Nutritive elemental value*: When plants grow they collect carbon dioxide from the atmosphere. When plants decay the carbon dioxide is returned. Because of high ground water level of mires this decay is much slower than it would be in dry habitats. This results in the piling up of a large amount of plant remnant, which subsequently forms layers of peat. Therefore mires are loaded with carbonic material and any ecological changes in these areas have a global significance. Thus any change in factors such as average temperature and ground water level can have substantial influence on these ecosystems and even lead to net loss of carbonic material. A large part of the drained wetlands have already gone through these changes resulting from lowered water level.

- *Ecological value*: Wetlands are an important habitat for birds, plants and a lot of other species base their existence on these areas. They therefore enormously increase the biological diversity of any territory.

*(Source: www.rala.is/votlendi)*

In light of a decline in the importance of agriculture in Iceland, some previously drained wetland areas are now of no use for agricultural production. This has further increased the opportunity to recover drained wetlands. With wetlands playing a large role in the ecosystem and being the habitat for birds, insects and flora, this recovery in considered very important. Since the carbon dioxide is a greenhouse gas the recovery and even creation of wetlands will increase the storage of carbon and therefore decrease global warming.

When the drained wetlands are recovered it is tried to regain as much of the former wetland quality as possible. The recovery of drained wetlands can sometimes be very difficult. When drained wetlands have lost all traces of the wetland flora and wildlife the recovery can be extremely difficult and costly. It is, however, believed that the drained wetlands in Iceland are in a better condition than in many other countries since cultivation is rather limited and the wetland flora has in many places not completely disappeared.

***The Ramsar convention***

The Convention on Wetlands of International Importance Especially as Waterfowl Habitat is known as the Ramsar convention. The Ramsar convention is named after the place it was adopted in Ramsar, Iran 1971. It is an intergovernmental treaty, which provides the framework for international cooperation for the conservation of wetlands and wise use of wetlands and their resources. Eighteen nations signed the treaty in 1971 and among them three Nordic nations, Denmark, Sweden and Finland.

The Ramsar mission statement is as follows *"The Convention's mission is the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world"*. (*Source: www.ramsar.org*)

In the beginning of 2004, 138 nations had joined the Convention and the number has been steadily increasing since it was first introduced in 1971. 1328 wetlands have been registered to the Ramsar list of wetlands of international importance, covering about 112 million hectares.

In 1978 Iceland became party to the Ramsar Convention. The Lake Mývatn and the river Laxá were the first wetland area that Iceland appointed to the Ramar list as internationally important. By joining the treaty the Icelandic government is obligated like other contracting parties to undertake four main activities, which are:

- *to designate wetlands for inclusion in the 'List of Wetlands of International Importance' and to maintain their ecological character*
- *to develop national wetland policies, to include wetland conservation considerations within their national land-use planning, to develop integrated catchment management plans and, in particular, to adopt and apply the guidelines for implementation of the Wise Use Concept, which is the sustainable utilisation of wetlands for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem*
- *to promote the conservation of wetlands in their territory through establishment of nature reserves and to promote training in wetland research, management and wardening*
- *to consult with other Contracting Parties about transfrontier wetlands, shared water systems, shared species and development aid for wetland projects.*

*(Source: www.ramsar.org)*

Iceland has since appointed two other wetlands to the Ramar list of important wetlands, Grunnifjörður and Þjórsárver (Thjorsarver). Being a part of the Ramsar treaty is important for wetland conservation and wise use. The appointed wetlands have to fulfil certain conditions regarding, i.e., ecological system, wildlife and hydrology and every three years the participant nations meet and introduce the state of the listed wetlands.

## Lake Mývatn and surrounding areas

### Lake Mývatn

The Lake Mývatn is one of Iceland's largest and best-known lakes. The lake is located in the neo-volcanic zone of North-Eastern Iceland. The main characteristic features of the lake are its irregular shape and shallowness. The lake is 37 $km^2$ and the maximum depth of the lake is about 4 meters, though the average depth is only 2.05 m (*http://www.hi.is/HI/Stofn/Myvatn/engframe.htm*). The lake is 278 m above sea level. Lake Mývatn has two basins, the northern one, which is smaller (8,2$km^2$) and shallower called *Ytri Flói* (Outer Bay), and the bigger and deeper northern basin (29,1$km^2$) called *Sydri Flói* (Southern Bay). There are around fifty small islands in the lake. It is believed that the first lake in this basin was formed by a lava dam around 3800 years ago. The latest lava flow into the lake occurred after five years of volcanic activity in the years around 1729 witch also affected the biology of the lake. (Ólafsson, 1979).

Most of the inflow into the lake is from submerged cold and warm springs along the eastern shore, the only surface flowing stream into the lake is from a small river called Grænilækur. Water from the lake is than discharged in the western part into the River Laxá. The submerged water, especially the warm water, is extremely rich in nutrients and supports ideal conditions for aquatic life. (Gudmundsson, 2002) Trout fishes can be found in the lake, and the lake is famous for its bird life, especially the many species of ducks.

The name of the lake is derived from the enormous amount of midges that can be found there. About 50 types of midges can be found by the lake. In the springtime and several other periods during the summer the banks and the islets of the lake are covered with (adult) midges. The midges are vital for the wildlife, because its larvae constitute the essential food for fishes and some species of the ducks. Biologically the lake Mývatn is the most studied place in Iceland, and a research station is located by the lake.

**Skútustaðir-borough and the diatomite factory**

The borough that covers the area of Lake Mývatn and surroundings is called Skútustaðir borough (Skútustaðahreppur) and is Iceland's highest altitude borough and also one of the largest covering 4,926 $km^2$. Despite its size there are only about 450 inhabitants in the borough. Through the centuries people living in the borough made a living mostly by agriculture and fishing. In the past few decades the scenario has changed quite a lot following a decline in agriculture, with increasing technology and tourism. A diatomite factory is now run by the lake Mývatn and since it was put in use it has played a vital role in the local industrial activity and is now the largest single employer of the area. Now there are 55 employees and all of them are residents of the Skútustaðir-borough.

The smooth bottom of the lake Mývatn is made of thick diatomaceous sediment. The sediment in the northern basin, *Ytri flói*, is industrially utilized. Mining of sediment from the bottom of the lake started in 1967. The sediment is used to produce diatomite that is exported to most countries in Europe, also to Asia and even Africa. The 36 years of mining in the lake has had some influence on it. The visible effects are the deepening of the lake in the mining area and the loss of nutritious sediment, plants and organism living at the bottom of the lake. Also a considerable part of the organic sediment produced in *Ytri flói* moves to the deeper mined area, leaving the area around it less nutritious and sandy.

Research in the lake indicates fluctuations in the ecosystem but these fluctuations are not fully explained. One research was made to evaluate the effects of the mining factory on the ecological system of the lake and whether causal relation existed between these fluctuations and the mining. Even though the mining in the lake is the main human impact on its wildlife the researchers could not state in their conclusions if the fluctuations were linked to the mining. Fluctuations in the basin that is not mined are in some aspects more than in the mined basin and it is therefore considered unlikely that the mining is the main cause of the fluctuations in the lakes ecosystem. This does not mean that the mining has adverse effects on the ecosystem, just that more research is needed. This especially concerns the comparison of the two basins. In the above mentioned research, which was made by an international research group for the Ministry of Industry and Commerce, it is suggested that all further mining should be ceased and the mining area should not be expanded.

The diatomite factory has permission to mine until the year 2010. This permission is limited to 48% of total area of the *Ytri flói* basin. The future of the factory after that is very uncertain. Since the diatomite factory is the largest employer in the Mývatn area a lot of interests are at stake. This issue is a conflict between the regional developmental policy and forces encouraging conservation of the nature.

**Framengjar ("Front meadows")**

*Framengjar* (front meadows) are a 14 $km^2$ area south of Mývatn, with the river Kráká in the West and Grænilækur in the East. Framengjar is a meadow that is or at least used to be a wetland area. In the earlier days when people living in the Mývatn area were farmers and made their living mostly from agriculture and fishing, the meadows were used to collect hay for feeding the livestock during the winter. In the years around 1950 the meadows were drained with many ditches in order to make it easier to mow the meadows with tractors for hay collection. The drainage was not as successful as had been expected. The land lowered and became uneven and in the end stopped being the area's main supplier of hay and is now mostly used for grazing.

In the late summer of 2003 constructions started to recover part of the drained wetland in the *Framengjar* area. The plan is to recover 21.8 hectares by filling up all or part of some old ditches and also by making dams in some of them. The recovery and its cost will be reviewed later in this paper.

**The river Laxá**

The river Laxá is one of Iceland largest spring-fed rivers. Its length is 58 km and the drainage area is 2150 $km^2$ (Rist, 1979). The river runs from the Lake Mývatn and drains into the Arctic Ocean. The river is famous for its good stocks of salmon and trout and is one of Iceland's most bountiful and sought after fishing rivers. Even though Mývatn is covered by ice for approximately 190 days a year during the winter time the flow to the river is stable. This stable flow and other favorable conditions made the river a suitable place for a hydro power plant. The first power plant was completed in the year 1939, the second in 1953 and third in 1973.

All three existing power plants use low dams, the first and the third use the same one. Plans were made to make a large dam in the river Laxá which would have

resulted in the virtual disappearance of the upper part of the river, large fluctuation in the water level and discharge in the lower river causing the reduction of the wild salmon. Many protested against this construction, especially the local population, which resulted in the cancellation of the construction and the agreement for special conservation laws for the area.

### *Laws regarding the lake Mývatn and the river Laxá*

*Current laws*

The lake Mývatn and the river Laxá are protected by a special law aimed to protect the lake, the river and the surrounding areas. The conservation law was enacted in June of 1974 after, the above mentioned, long and harsh debate about plans of building a large hydro power plant in the river Laxá, which were eventually cancelled. In fact it is not only the lake and river itself that are protected, all the Skútustaða borough falls under the law so the protected area is quite large.

In the area that the law covers, any construction is prohibited without a special approval from the Nature Conservation Council. The law also prohibits any manipulation with the lake levels and flow of rivers for other purposes than conservation or cultivation. Exceptions from this are constructions on farms given the fact that they do not harm the environment in any way. The Nature Conservation Council is responsible for the conservation of the area, and bases its management on advice from the Mývatn Research Station.

Since the approval of the current law regarding protection of Mývatn and its surroundings, thirty years have passed. During this time, many changes have occurred in the Iceland's general policy and awareness for the preservation of the nature. Laws concerning other areas and some general environmental laws have been approved during these three decades. This is one of the reasons it is considered suitable to rewrite the legislation regarding Myvatn. The main criticism regarding the current law has been twofold. Firstly the local government of Skútustaðar-borough believes that having the legislation cover the entire borough leaves them no control of the area in matters such as issuing building permits and so forth, which other local

governments' control. Their attitude is that the area that the law covers is too vast and includes land that need not to be protected by special legislation. Secondly they also think that the legislation is too complicated and therefore difficult to put into effect.

Other reasons have also been mentioned when discussing the need to rewrite laws concerning Mývatn. Among those are the many requirements Iceland has agreed to meet when signing various international treaties over the years. Some of those agreements at least partly cover environmental issues. Having Mývatn added to the Ramsar list also obligates the national government to issue a preservation plan for the area which emphasizes sensible usage and control.

Thirty years of experience of managing Mývatn and its surroundings as environmentally important area is considered valuable and now is thought to be the right time for rewriting the legislation.

*New law proposal*

The Ministry of the Environment has for quite some time been working on a change in the current nature conservation law of Mývatn and Laxá. The new law proposal has been introduced in the Icelandic parliament but has not yet been approved.

The new proposal assumes that the protected area will be considerably smaller than in the current laws. Instead of protecting the whole borough the main goal of the new law would be to concentrate on the protection of the lake Mývatn itself and the river Laxá to the estuary of the river by Skjálfandaflóa, including 200 m. bench surrounding the lake and also 200 m. bench on each side of the river. The new law proposal also includes the protection of wetlands in that area and 200 m. of benches surrounding them. The aim of the law is the sustainable development of Mývatn and that the ecological system of the area will not be endangered with human actions.

The main difference in the new legislation proposal opposed to the current law is the following:

- The vastness of the protected area is decreased in order to create room for the usage of areas in the borough that are not considered ecologically important

and instead pinpoint the exact areas that are thought the most vulnerable and valuable.

- A special act in the new law proposals suggests that the groundwater of Mývatn and Laxá is to be protected from any damage or pollution. Industrial companies in the area must satisfy strict requirements regarding the protection against pollution.
- Another new act in the proposals discusses the need for a special preservation plan tailor maid for the Mývatn area. This plan should be issued by the *Environment and Food Agency* in collaboration with the local government of Skútustaðir borough and the local farmers.
- Provisional clause in the new law proposal that is effective until the end of 2014 allows the *Environment and Food Agency* to authorize further raise of the dam in the river Laxá. The authorization has to be agreed also by the Mývatn and Laxá landowner-association and environmental impact analysis has to be made for the construction.

The provisional clause about possible authorization of raising the dam in the river has caused the most public conflicts. The Skútustaða-borough administration has rejoiced the new law proposal and has encouraged the parliament to approve the proposal as soon as possible. If an agreement is not reached between conflicting parties about the provisional clause the borough' administration suggests that the laws will be approved without the clause. The local nature protection organisation called SUNN has protested against the provisional clause but is positive towards other changes, especially the provision of the protection of the lakes and the rivers water area and a protection plan for it. The organisation has though made some remarks on the new law proposal besides the on one the possible permission of raising the dam in the river Laxá. Mainly:

> If the new law should replace the old one it is vital that the protection plan (as stated in article 6 in the new law proposal) should be fully finished. Also decision has to be made on special areas that are supposed to be under conservation before the new law replaces the old one. In the new law proposal there are three different dates for the finishing of the protection plan for the area, the proposals for the special conservation areas and enact of the new law. The protection plan is

scheduled to be finished one year after the new law comes into effect and two years later the list of special conservation areas should be finished. The nature protection organisation wants this all to be set on the same date and sees no reason why this has to bee tree separate dates. The organisation thinks that if these requirements are fulfilled the new law would offer better nature protection than the older one.

**The future of the lake Mývatn and its surroundings**

In Iceland there has been a reduction in the manufacture of agricultural products in the last decades and the area surrounding the lake Mývatn is no exception. It is clear that with changing lifestyle, employment opportunities also change. The future of the area depends largely on the opportunity of the locals to get work. Now the diatomite factory in the lake Mývatn is the largest single employer in the borough and it is clear that if its mining permission is not extended or the production changed in some way, many jobs will be lost. To keep a secure job environment it is absolutely essential to keep full awareness and constantly assess the situation and seek new opportunities. Many think tourism to be the most exciting and promising field for the area. Tourism has become an increasing part of the local economy. A study made by the Icelandic Tourist Board in the period from September 2001 – August 2002, shows that 51.7% of tourists that came to Iceland during the summertime (June-August) also visited the Mývatn area. During the fall, winter and spring time 10.4% of the tourists that visited Iceland went to the Mývatn area. The number of tourists that visits Iceland is increasing from year to year, in 2002 **277.900** tourists came to Iceland and in 2003 they were **320.000**[4]**,** it is believed by many that there are many unexplored opportunities in that field for the Mývatn area.

To expand the service for tourists and to strengthen business activity in the area, some locals have been spending several years preparing the opening of outdoor baths, using the areas many geothermal resources. Constructions are already underway and are scheduled to be finished in May 2004. The baths will be located

[4] The statistics of the number of tourists and how many of them visisted the Mývatn area come from the Icelandic Tourist Board. See webpage, www.ferdamalarad.is.

about 4 km. from the lake Mývatn in an area rich of geothermal resources. The bath-lagoon itself will cover about 2000 square meters. In addition to that there will be facilities for various services including reception, shop, locker rooms and a public steam bath and hot tubs. The government is the largest owner of the new baths and has put 20 million ISK into this project, but the owners are around 30 in total and the scheduled cost for the first stage of the construction is 40-60 million ISK. The government of the Skútustaðir-borough is very positive towards the opening of the baths. Hopes are that the baths will be a valuable addition to the tourist attractions in the area, especially, during the wintertime and can also be a first step in further development of health related tourism.

Other opportunity for the local community can also be found in further strengthening of research and academic studies in the unique nature of the area.

The Icelandic government used to be the largest owner of the diatomite factory in the Lake Mývatn but in the year 2001 the government sold its share in the factory. Suggestions have been made that the payment obtained for the share in the factory should be used to further support the local industry and the creation of new jobs in the area and the investment in the baths is a part of that plan.

To be prepared for the possibility that the mining permission of the diatomite factory will not be extended after the year 2010, a corporation has been established with the intention to explore opportunities in financing a diatomite powder factory in the area. Both the local government and some local companies are participating in this project. The goal is to get as much as 150 million ISK to get the factory started. Hopes are that the construction can start in the year 2004 and the production the following year (2005). The diatomite powder would be manufactured from imported material. This innovation has already been developed in Norway and now the goal is to use their technology in the Lake Mývatn area. It is thought to be possible to use the machinery of the old diatomite factory. The continuing operation of the factory is believed to be very important for the future of the community. The change in the production of the diatomite factory from mining to using imported material is considered less harmful for the Lakes ecosystem. If the new legislation proposal for the Lake Mývatn will be approved that will lead to stricter rules concerning the protection of the Lakes ecosystem for local industry.

The area that the Skútustaðir-borough covers, especially the lake Mývatn and the river Laxá is thought to be very sensitive in an ecological sense. There are many issues to consider when planning the future of the area's industry. A balance needs to be established between the conservation of the nature and the growing tourism on one hand and on the other hand the need for a more advanced industry. Currently there is some debate about the future of the river Laxá. *Landsvirkjun* runs the power plant in the river Laxá and is an enterprise jointly owned by the State Treasury, the City of Reykjavík and the Township of Akureyri. *Landsvirkjun* wants to make another dam in the river to insure safer working environment and prevent damage to the machinery caused by sand and stones in the river. Many people object to this proposal and believe that it would not be a wise move when the disturbance that the dam would make on the environment is considered.

As in many other communities there is a conflict concerning the balance between environmental and economic viewpoints. Among these conflicting issues are the following:

| | | |
|---|---|---|
| *The preservation of the Lake and its nearest surroundings* | | *Further industrial development in the area* |
| | **Versus** | |
| *Keeping the river Laxá in its current state* | | *Raising the dam in the river for security reasons* |

As already mentioned the local community sees opportunity in further strengthening the areas tourist industry. More tourists are good for the local economy but what would be the influence on the nature? Increasing number of tourists can lead to more strain on the nature. In the nearest future that is not considered a large problem for that area but it must always be taken in to consideration that the nature can be sensitive towards increasing number of tourists. The Lakes' diverse bird-wildlife attracts many tourists to the area every year. The creation of more wetland area could lead to:

*More wetland area → More diverse bird-wildlife → More tourists → More human impact on the nature*

If the new law proposal concerning the Mývatn area will be approved, preservation plan has to be made for the area. That plan would have to include some rules about the public traffic rights and tourists accessibility.

**Economic studies on environmental issues**

The services that environmental resources provide are in some sense non-tangible and are therefore often complicated to value. In economics it is usual to value resources through prices that are decided by the market supply and demand. But since environmental recourses are not commonly on market it is harder to put a price tag on them than on other marketable assets. Environmental issues are therefore not well captured in established monetary indicators and that leads to the fact that services, that environmental resources provide, are often un-priced or wrongly priced.

Many environmental resources are complex and multifunctional, and it is not obvious how the goods and services provided by these resources affect human welfare. Even though decisions concerning these resources can be very difficult they are in most cases inevitable. Many questions are raised and have to be answered when considering environmental issues and their future role. Questions that need to be answered are for example: *Is it better to deplete or change the usage of the environmental resources? Is it necessary to conserve these resources?* Economic valuation provides us with a tool to assist in making the difficult decisions involved when dealing with environmental issues.

To valuate non-marketable environmental resources implicit and explicit trade-offs between conservation and development are used. One of the economic assumptions made to value wetlands and other environmental resources is that people make rational choices. Based on the rational choice assumption, valuation on non-marketable things is made possible.

In the last few decades more and more interest has been in valuation of non-marketable assets resulting in advancing techniques. The main economic measures on these non-marketable assets are *willingness to pay* and *willingness to accept*. The willingness to pay reflects the economic valuation of improved environmental services, and willingness to accept stands for the compensation people are willing to accept for making changes that make them worse off. Popular methods for valuing these non-marketable environmental issues are *direct method* and *indirect method*. In the direct methods individuals are asked directly about their preferences for environmental quality. Indirect methods on the other hand try to estimate the individual preferences towards environmental quality by observing their behaviour in other related markets.

In light of the difficulties mentioned above, the valuation of the wetlands is therefore not clear-cut, and has some inbuilt difficulties. Wetlands act as water filtration for the land. In the rain periods the wetlands collect the water and during the dryer periods the wetlands donate water to the nearest environment. Therefore wetlands in some sense work as a sponge and that is very vital for the ecosystem in order to keep stability in the environment such as even water flow in rivers that is important for the many fishes that live there. When valuing wetlands the marketable products and services provided by the wetlands are much easier to measure than the often hidden services obtained from the ones that are not as common on the market. Even though wetlands play a vital role in many aspects, their valuation is often difficult, but it is thought to be vital to identify economic value of wetlands to increase worldwide awareness of the need for and benefits of wetland conservation. It is therefore vital to take in to consideration all aspects of the wetlands, both the non-marketable and the marketable ones and direct and indirect usage of it, in order for policy makers to make wise decisions concerning the wetlands.

***The future of wetland in Iceland***

As mentioned before a substantial part of the wetland area in the Icelandic lowland has been drained and there could be many opportunities to recover. Since most of the drainage was done for agricultural purposes the drained land is mostly privately owned by farmers. Information from the Ministry for the Environment and

the Ministry of Agriculture in Iceland state that there is no direct support for recovering the drained wetland areas. The only form of support is through the *wetland committee* mentioned earlier. It could be taken in to consideration to increase the support to recover drained wetland areas. The diminishing agricultural production in Iceland can lead to more interest on behalf of the landowners to recover some of the drained wetland.

One of the things that benefit all is the way wetlands fight the so-called *greenhouse effects*. The balance of the radiant energy that the earth gets from the sun and the energy re-rated back into space from the earth keeps the temperature of the Earth's surface roughly constant. The heat in the lower atmosphere is trapped with many gases that absorb the infrared radiation that is re-radiated from the Earth's surface. These gases are called *greenhouse gases* and one of them is carbon dioxide ($CO_2$). Increase of greenhouse gases in the atmosphere results in more concentration and that will make the Earth warmer. Carbon dioxide is one of the gases that have been increasing in the atmosphere and since wetlands store carbon, creation or recovery of wetlands will play a part in the attempt to reduce the greenhouse effects that carbon dioxide creates. (*Source: www.eia.doe.gov*)

As part of the United Nation climate change the Kyoto protocol it could be taken into consideration to offer landowners a support to recover wetland that the voluntary want to recover in order to store carbon dioxide. The Kyoto protocol goal is to maintain the stabilization of the atmosphere and in 1996 the Icelandic government took an effort in binding carbon dioxide by forestation. The government put 450 million ISK to the project from 1997-2000 and the results were better than hoped for. The projects goal was to store around 22.000 tons of carbon dioxide a year but it is believed that approximately 27.000 tons were stored each year.

If decided to combine efforts in recover wetland areas and store carbon dioxide an idea for carrying out the project could be in similar way as in the agricultural district of South-West Scania in Sweden where wetland was created manly in order to reduce nutrient load to the Baltic Sea and also to increase the biological diversity. There the local municipalities largely fund the project. The most vital thing in the process is good co-operation with the landowners of the drained area because the making of the wetland depends on the landowners voluntarily convert

some of their land. If an agreement is to create wetland a lease contract is made between the landowner and the municipal.

The process of execution of the programme

1. Dissemination of information
2. Replies from interested landowners
3. Evaluation of potential places for wetland creation
4. Visits to selected places
5. Preparation of draft wetland design
6. Discussions with landowners and the Country Board
7. Preliminary leasing agreement
8. Invitation for tenders for construction
9. Construction work
10. Examination of the constructed wetland
11. Signing of final leasing contract
12. Payment to landowner
13. Creation of vegetation cover

(Source: Söderkvist, p.20)

The term of the lease is 30 years and the leasing agreement does not change the property right to the land. Public access may be applicable to the converted land, which means that the general public is allowed to visit the wetland for recreation. The rent that the landowners get for the converted land is the cost of constructing the wetland plus opportunity cost of the land. The opportunity cost is measured as the market value of the land subject to conversion. If the landowner is judged to benefit financially form the creation of the wetland (which is in this case mainly by irrigation), the policy is to pay no more than 60% of the construction cost. To construct the wetlands, tenders are invited and the most favourable tender is selected. When the construction of the wetland is completed the final leasing contract is signed. The landowners are responsible for the vegetation cover but are provided seeds and seedlings.

Voluntary participation in programmes for environmental protection is an increasingly important tool for accomplishing environmental policy objectives. The possibility to obtain subsidies has been popular in agriculture. Such subsidies could be an incentive to induce landowners to be willing to participate in the recovery of

drained wetlands. Because the recovery may result in the change in the usage of the land, the willingness of the landowner is very important.

The cost of recovery can divided into:

- Construction cost
- Compensation for land
- Administrative cost
- Capital cost
- Maintenance cost

Construction cost is the cost that comes from recovering and/or creating wetland area. In the areas that have been drained the cost would mainly arise from filling up the ditches that have already been made. The cost of creating a new wetland area would mostly involve excavation, building dams and laying pipes and so on. The construction cost for recovering disturbed wetlands in Iceland will be addressed in next section.

The compensation for the converted land could be the same as in the Swedish wetland creation project that is the full marked value of the land unless the landowner is believed to gain financially from the conversion.

Administrative cost involves supervising the wetland creation and making sure that the official process (like the 13 steps mention earlier) is being taken. It can be presumed that administrative cost will be a substantial part of the total creation cost[5]. The capital cost and maintenance cost must be decided for each project to cover the cost of maintenance of the wetland area that is likely to arise and the decreasing time value of money.

***Recovery of disturbed wetlands***

In light of the importance of the wetlands for the ecosystem, some limited areas of the disturbed Icelandic wetlands have been recovered in recent years. The main goal of the recovery is to try to make the drained wetlands as close to its original hydrological state as possible. If the recovery is successful a life environment for wetland vegetation and wildlife is created. In time the recovered wetlands should also

[5] In the Swedish project administrative cost was 24% of total creation cost.
Total creation cost was considered to be creation cost, compensation for land and administration cost.

bind carbon from the atmosphere instead of getting rid of it to the atmosphere like it does when drained. With increasing awareness of the importance of wetlands and the many unused drained wetland areas, the thought of recovery has become reality. The recovery of drained wetlands started only a few years ago in Iceland. The first recovery under the supervision of the *wetland committee* was made in 1996, and even though not many areas have been recovered it is still a step in the right direction.

One of the most recently recovered wetland is a meadow called *Framengjar* located near the lake *Mývatn.* As discussed earlier the meadow used to be hey collection area for the local farmers. The recovery took place in the late summer of 2003 and the *Public Roads Administration* paid for this particular construction. With a new regulation the *Public Roads Administration* has to make up for the loss of wetlands that occurred some cases when making public roads and therefore the *Public Roads Administration (PRA)* has been a participant in some of the recoveries. The area that was scheduled to recover in *Framengjar* covered around 21.8 hectare and was done by a contractor for the *PRA.* The following table was the reference.

*Table 7 – Recovery in the Mývatn area*

**The recovery of wetland in the Front-meadow in the Mývatn area**

| *Ditch no.* | *Length of ditches (m) that will be fully filled* | *Length of ditches (m) filled in 1/3* | *Length of ditches (m) that will only be dammed* | *Total lenght of ditches* |
|---|---|---|---|---|
| 1 | 915 | | | **915** |
| 2 | 190 | 130 | 300 | **620** |
| 3 | 1266 | 341 | 367 | **1974** |
| 4 | 393 | | 74 | **467** |
| 4a | 171 | | | **171** |
| 11 | 886 | | | **886** |
| 12 | 432 | | | **432** |
| **Total** | **4253** | **471** | **741** | **5465** |

The payment made by the *Public Roads Administration* was 180 Icelandic kronas for every meter in ditches that were fully filled up and 100 Icelandic kronas for the ditches that are filled up by 1/3. Included in the payments are 3-4 dams, so no extra payments are made for the making of the dams. The total payment made to the contractor is therefore:

*Table 8 – Cost of the recovery in the Mývatn area*

| | | |
|---|---|---|
| Cost of fully filled ditches | 4.253m * 180 ISK/m | = 765.540 |
| Cost of 1/3 filled ditches | 471m * 100 ISK/m | = 47.100 |
| **Total cost** | | **812.640 ISK** |

Since it is planed to recover 21.8 hectares of wetland the cost on per hectare is **37.277** ISK (812.640/21.8). As can be seen from these numbers, this covers just the cost of filling up the ditches. There is no other cost included in these figures that could come up like the cost of supervision and further studies on the recovered wetland or the cost of making fences and so on. No prior usage of the land was lost with the recovery so opportunity cost did not have to be considered. If there would have been some loss in the usage of the land resulting from the recovery, the loss would be considered as opportunity cost and would have to be valued in the cost analysis of the recovery.

Even though many of the dried wetland areas in Iceland are no longer used for collecting hey or other agricultural production, it has to be kept in mind that not all drained wetlands can be recovered to its original state. In Iceland, however, it is the general believe that the condition for recovery is good.

The study of the Icelandic wetlands was made difficult by many factors. No maps locating the exact extent wetlands were available, neither before nor after the drainage begun. No records were on the usage of the land that was drained and the usage information is a vital part in the making of some sort of cost analysis. If the land is not used for other things there is no opportunity cost involved in the cost analysis. If on the other hand there is presently some other usage of the land, consideration to that has to be taken in the calculation of the recovery cost. It is also necessary to measure the benefits of the recovery of the drained areas. Benefits of the wetlands are in most cases indirect and are often not visible until a few years after the recovery. From an economic point of view the benefits have to exceed the total cost of the recovery for the construction to be justifiable.

***Economic valuation of wetland in practice***

Since no economic valuation of wetland has been made in Iceland, an example of such valuation can be found in studies made in other counties. One of these studies was made in the Norfolk Broads wetland area in East Anglia in UK. An economic valuation study was made there in order to assess the merits of retaining the wetland areas versus permitting them to be converted to alternative uses or simply to degrade from lack of investment in management and control works. A description of the area, its merits and usage is as follows:

> *The Norfolk Broads constitute a sizeable wetland complex which supports various agricultural activities, such as cropping and grazing, and recreational or amenity opportunities of national significance. Nutrient retention is also an important service provided by the Broads, and the area is an important habitat for numerous species of waterfowl and other fauna. Since the wetlands are of national interest, they might be expected to generate not only important use values but significant non-use values as well. The area has historically been associated with peat extraction and has been subjected to drainage, channelization of watercourses and substantial dyking and flood control works, portions of the latter having been allowed to degrade so that saline flooding is a substantial threat. In recent years, it has been recognized that the area could not continue to provide the same level of outputs and services without some attention to improved management and resolution of key resource conflicts. To protect the integrity of the area, a number of alternatives have been proposed, including the strengthening of flood walls and construction of a tidal barrier.*
>
> *(Source: Barbier,1997)*

Contingent valuation was used to elicit the conservation of recreational and amenity benefits of the area. Contingent valuation uses questionnaires designed to elicit preferences, mostly people's *willingness to pay*. The Norfolk Broad study was made on-site with sample size about 3000 people. In order to find out the *willingness to pay* three different questioning techniques were used. All three of them used an increase in taxes to collect the hypothetical payments. The first question technique used an

open-ended question which involved asking the respondent how much he would be willing to pay annually to conserve the area. The second question technique used an approach called "iterative bidding". In that approach the respondent is asked to choose from a provided range of values what he would be willing to pay annually to conserve the area. The third technique involves a predetermined figure which the respondent must answer with a *yes* or *no* and the figure may be varied between respondents. The information from this approach is then used to determine the probability of the respondents choosing a particular value. This approach is called "dichotomous-choice". The results of the study are shown in *Table 7* and the numbers are in 1991 British pounds (£).

*Table 9 – Results from the Norfolk-Broads study*

| **Question Format** | **Number of Respondents** | **Mean WTP** | **Min bid** | **Max Bid** |
|---|---|---|---|---|
| Open-ended Question | 846 | 67 | 0 | 1250 |
| Iterative Bidding Question | 2051 | 75 | 0 | 2500 |
| Dichotomous Choice Question | 2070 | 140 | -- | -- |

(*Source: Barbier, 1997*)

As can be seen in the table the variance from the highest bid to the lowest bid is substantial, that is often the case when valuating the *willingness to pay*. To try to avoid the bias associated with different level of knowledge of the respondents a considerable care was taken to ensure that a constant flow of information was provided to the respondents.

The *willingness to pay* contingent valuation survey is only a part of a full cost benefit analysis. To complete a cost benefit analysis for protecting the area additional values of the wetland area have to be considered along with the cost. Other values that are not captured by the "on site" survey could include other direct- and indirect uses along with non-use values. The valuation of many environmental functions and

recourses are often subject to data limitations and can often be costly to make. It is however necessary in such circumstances to gather the best information possible to aid decision-making.

**Conclusions**

As has been addressed in this paper, wetlands in Iceland were undisturbed for almost a thousand years, that is from the time of the settlement until the mid 19th century. With the introduction of more complex agriculture, farms grew bigger and more land was needed. . This led to the appearance of wetland drainage. Although the drainage was not widespread at first and relying upon manual labour, this changed considerably after the Second World War. This increase in wetland drainage was made possible by the policy of the Icelandic government, which paid for up to 70% of the cost, and also by the import of heavy machinery, making drainage much easier. This evolution continued for most of the second half of the 20th century and led to the drainage of almost all of the wetlands in the Icelandic lowlands. Two studies made, one in Southern part of Iceland and the other in Western part, confirm the scope of the drainage.

In recent years the importance of wetlands has become an increasing issue. Wetlands play a crucial role in the biological diversity of any given area by supporting even flow in brooks and rivers, offering diverse nutritive elements and are habitats of birds, plants and other organisms. Wetlands are also considered important in reducing the so-called greenhouse effect and global warming. This has led to a growing demand for the preservation of undisturbed wetlands and the attempt to recover wetlands were-ever it is possible. In Iceland there are now stricter laws and regulations concerning the drainage of wetland areas. Governmental funding for the draining of new wetlands was stopped in 1989 and a special permission from the authorities has to be granted in order to drain wetlands. Legislations concerning environment and nature conservation have been enforced in recent years in Iceland, like *The Nature Conservation Act (no. 44, 1999)*. The Ministry for the Environment in Iceland has also published its first conservation plan for the years 2004-2008. In 1996 the Ministry of Agriculture appointed a wetland committee to manage the recovery of wetlands across the country. This work is slowly underway but the goal is to work with farmers and landowners and encourage and follow wetland recovery

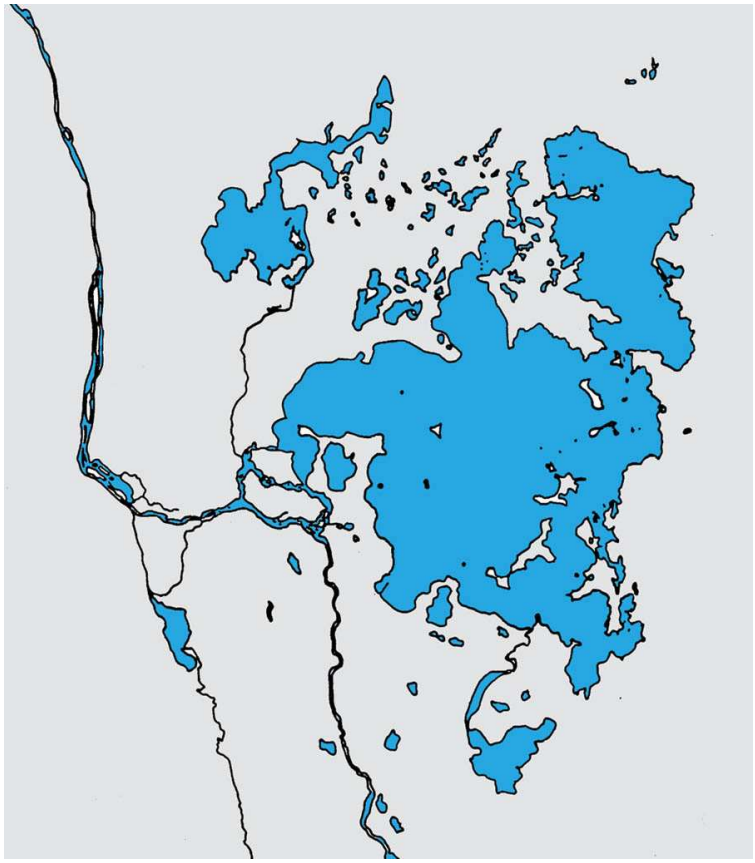
wherever possible. Iceland is a part of the Ramsar Convention, which is an intergovernmental treaty that provides framework for international cooperation for the conservation and wise use of wetlands and their resources. Iceland has appointed three wetland areas to the Ramsar list of important wetlands. One of the appointed wetland areas is Lake Mývatn and the river Laxá located in the North-Eastern part of Iceland.

The Lake Mývatn is one of Iceland's largest and best-known lakes. The lake, which is known for its spectacular bird life is the most studied place in Iceland when it comes to biological research. Both the lake and the river are considered extremely important for the borough they are located in and their past, present and future usage is an everlasting debate. Since 1967 a diatomite factory has been operating in the lake and its products exported to many countries for use in industry. Some scientists argue that the factory has potential adverse effects on the lake's ecosystem but studies that have been done have not been conclusive. This issue is very sensitive because the factory is also the largest single employer of the area. Recently it has been suggested that the factory might close down before the mining licence expires in 2010. If this happens it is considered vital for the local economy to have some new projects started in the area. The Icelandic government has promised to participate in this and among the plans for the future are the building of a diatomite powder factory using imported material and therefore not harming the lake's wild life, and developing health related tourism by using the areas geothermal energy to build a bath lagoon much like the Blue lagoon in the South-Western part of Iceland.

It has already been established that wetlands are an important part of our nature and environment. It is also important to do an economic valuation on environmental issues such as wetlands when deciding their future. Both the marketable and the non-marketable recourses should be taken in consideration. For many years wetlands in Iceland had to give in to the growing need for farmland but recently this evolution has been reversed and recovery of previously drained areas have been started. Many unexplored opportunities are to recover drained wetland areas in Iceland and the government and the municipalities could consider putting more funding into recovery projects.

## Appendix

*Figure 3 - Lake Mývatn and the river Laxá and surrounding lakes and ponds*



*(www.hi.is/HI/STOFN/MYVATN)*

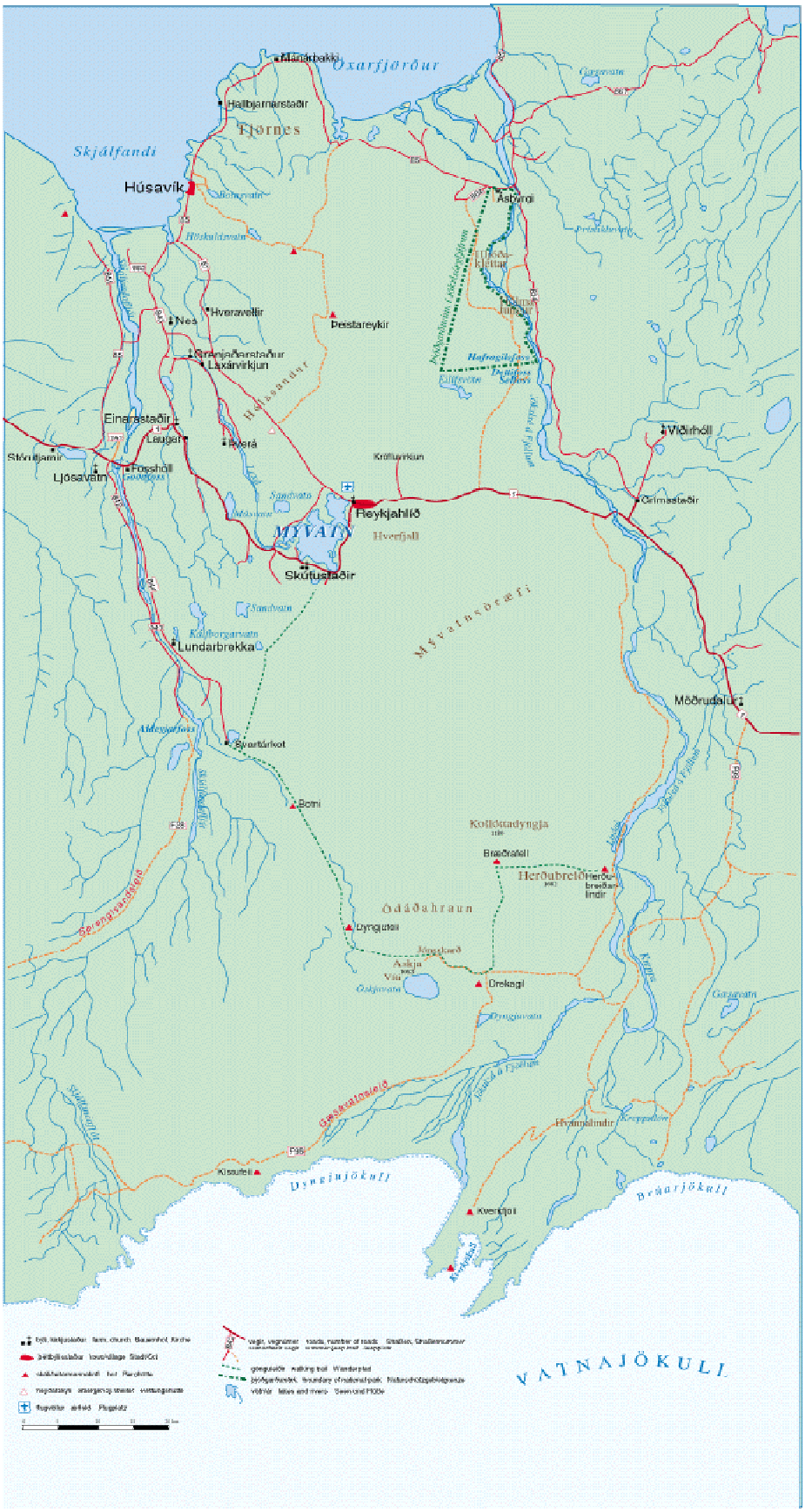
*Figure 4 – Lake Mývatn*

*(www.hi.is/HI/STOFN/MYVATN)*

*Figure 5 - Ditch in the Framengjar area in Mývatnssveit*

*Figure 6 - A ditch that has been closed*

*Figure 7 – The location of Lake Mývatn in N-A Iceland*



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*www.eia.doe.gov/oiaf/1605/gg98rpt/emission.html*

www.ferdamalarad.is

*www.hi.is/HI/STOFN/MYVATN - Source for Figure 3*

www.hi.is/HI/Stofn/Myvatn/engframe.htm

www.myv.is

www.rala.is/votlendi

ww.ramsar.org