INTRODUCTION TO AN INVENTORY OF THE ECOLOGICAL SERVICES PROVIDED BY RANCHERS AND FARMERS IN THE REDBERRY LAKE BIOSPHERE RESERVE

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And of course, thanks to the people of Hafford for being so friendly and generous with us. We really felt like part of the community this summer.

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INTRODUCTION

A. Context of the study

This research is part of the two authors' studies in France, at the Ecole Nationale du Genie Rural, des Eaux et des Forêts (www.engref.fr). It addresses the inventory of ecological services provided by farmers and ranchers in the Redberry Lake World Biosphere Reserve. This large project is one of the medium term strategic actions outlined in the Community's Plan for Sustainability (Sian 2001). It specifically addresses the following action: *Develop compensatory mechanisms for ecological services performed by local farmers and ranchers* (p.15).

B. Objectives

- Explore the concept of ecological services and adapt it to the Redberry Lake Biosphere Reserve.
- Provide a framework to facilitate future studies on the topic in the biosphere reserve.
- Identify and answer the community's main questions before looking for compensatory systems.
- Increase the awareness of farmers, ranchers, and the rest of the community on the role of agriculture in nature conservation in the study area

C. Structure of the report

We first present different definitions of ecological service, and then identify the definition we have used for the study. Because the structure of the report derives from this definition, it is outlined at the end of the discussion of definition.

D. Methodology

Two main sources of information have been used in this study:

- Academic and scientific data, gathered from published research, conservation organisations involved in the area, and interviews with experts
- Local knowledge and concerns: mostly obtained through interviews with farmers and ranchers

We have intentionally given the same weight to each of these two sources, first because ecological service is a concept at least as social as it is scientific, and second because we want this study to provide a starting point from which to take action. Local concerns and desires are indispensable for participation and action. Even if they are scientifically tested, agencies' observations alone cannot instigate local action. To simplify, we restricted the analysis only to the major known environmental impacts of the agricultural practices we have examined.

Identification of ecological services was made on a qualitative basis. According to the definition we selected (see I), we inventoried the agricultural practices of each interviewed farmer or rancher. We then tried to answer the following three questions to classify the agricultural practice analysed in the context of ecological services:

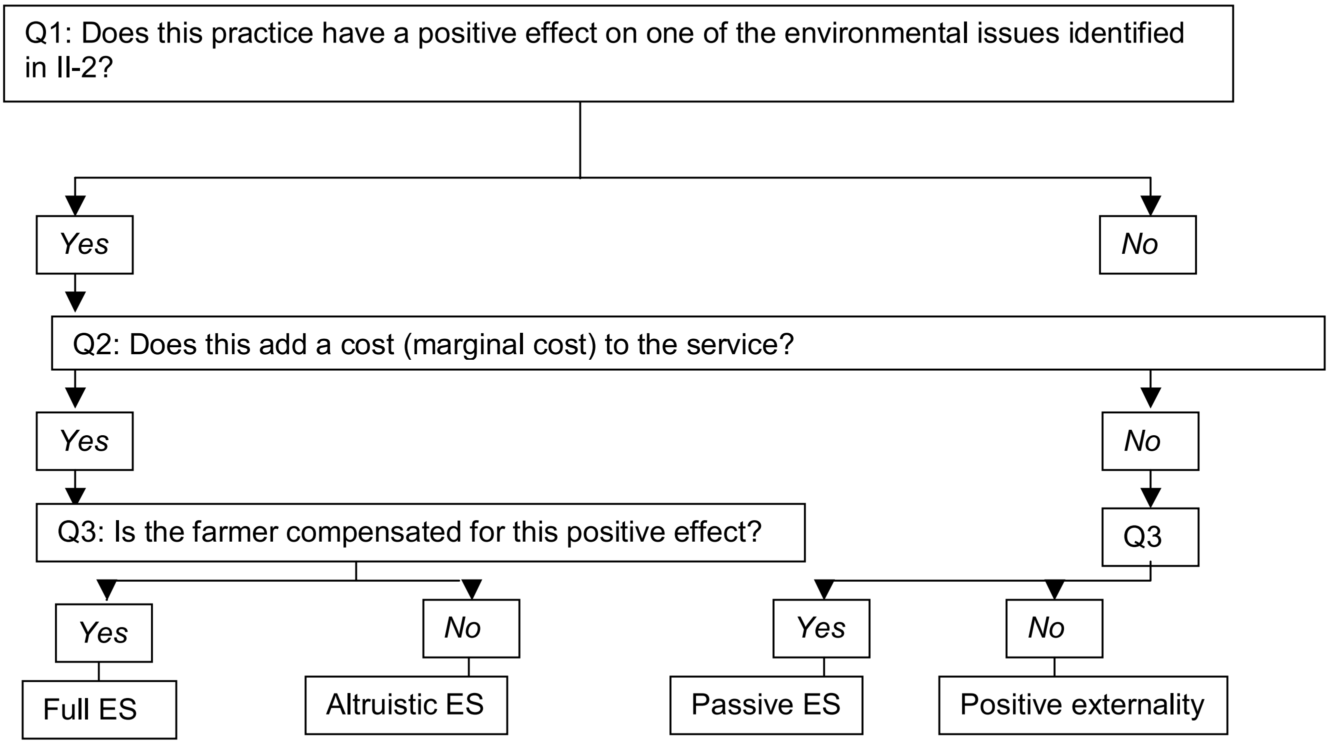

Figure 1: Method for classification of ecological services

E. Sample of farmers and ranchers

Because we identified the ecological services only on a qualitative basis, and because of time limitations, our sample of farmers is not statistically significant.

Farmers were selected for interviews based on the following two criteria:

➔ A need to ensure good geographical coverage of the watershed (avoiding large areas without interviewees)
➔ A need to include farmers or ranchers from each of the three main kinds of farming systems: crop farms, mixed farms, and livestock farms

We were able to conduct complete interviews with 19 farmers and ranchers who farm about 16% of the watershed area. We asked each person interviewed to give his own definition of an ecological service. The answers were diverse and show that few of the interviewees had previously given this concept much thought. Some of the interviewees had no ideas regarding this definition; most of them only gave examples. Appendix 2 gives a list of the various answers we collected.

F. Limitations and need for further researches

Our study originated from the Strategic Actions listed in the Community's Plan for Sustainability (Sian 2001). It consists of an inventory of ecological services provided by farmers and ranchers. This study should be seen as an introduction to a much larger project to take an inventory of the ecological services provided in the Redberry Lake Biosphere Reserve and the economic assessment of these services. The study is not exhaustive, and the classification of ecological services, done without any economic calculation, should be challenged, refined, and eventually modified.

I DEFINITION OF ECOLOGICAL SERVICES

The expression “ecological service” is often used, but there is no official definition of the term. Below we offer some thoughts regarding such a definition. We first give a qualitative analysis of the interviews as they pertain to this topic, followed by a synthesis of the current main definitions of ecological service from Aznar and Perrier-Cornet (2002). Approaches to defining ecological services will be discussed. Next, we propose criteria for measuring ecological services. Finally, we give the definition and criteria we have used during this study.

A. Ecological services as services provided to farmers by ecosystems

The first definition of ecological services considered here comes from the “ecological economics” of English and Scandinavian countries. This approach relies on the notion of natural capital. As stated by Gillis, “the natural capital represents the value of the reserves of natural resources of a country” (Gillis et al. 1998). Ecological services are part of natural capital. “The natural capital consists of all the natural resources … to which must be added all the **ecological services** provided for free by the ecosystems and the biosphere which allow the constitution and maintenance of favourable conditions for life” (Berkes and Folke 1992). Under this definition, farmers and ranchers are not providers, but consumers of ecological services. A good example of an ecological service under this definition is the action of soil microorganisms that enable the release of nitrogen from organic matter.

B. The positive externality of production

A second definition of ecological services derives from the economics of the environment. In this case, an ecological service is perceived as a positive externality of production. This means that the benefits provided by the producer to the environment are not intentional, and don’t add any cost to production. The ecological services are just “sub products” of the agricultural practice, which is environmentally friendly by chance.

C. Definition used for the study: a broad, economically based concept

The third approach to defining ecological services derives from the economics of services. Aznar and Perrier-Cornet (2002) use this last approach to build their own definition of an ecological service. In the economics of services, Gadrey (1996) specifies that: “A service is an operation aiming to transform a reality *C*, owned or used by a client or a user *B*, and realised by a supplier *A* because of the demand of *B* (and often in interaction with *B*), but which does not lead to a final product which can circulate economically independently from *C.*” Gadrey (1996) summed this definition up as “a service constitutes a providing of technical or human abilities, in order to allow the use of a support.

To summarise, Gadrey (1996) gives his “triangle of service”:

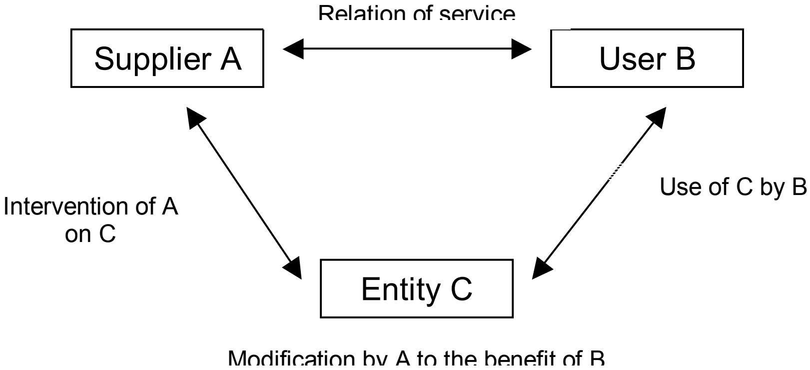

Figure 2: Gadrey’s triangle of service

Aznar and Perrier-Cornet (2002) adapt this triangle to define an ecological service as providing technical and human abilities in order to allow an environmental use of an environmental good. This allows the transformation or conservation of the useful characteristics of the entity *C*, from an environmental point of view. Improvement of the environment is intentional from the supplier’s point of view, and it responds to a demand. The supplier invests time and money to provide the service (marginal cost), and the user pays for this service (compensation). Given this definition, they propose the following classification of ecological services:

	Remuneration of the supplier	Added cost to production due to the ecological service
Full ecological service	yes	yes
Passive ecological service	yes	no
Altruistic ecological service	no	yes
Positive externality of production	no	no

Table 1: Four types of ecological services

In our study, Gadrey’s triangle of service becomes:

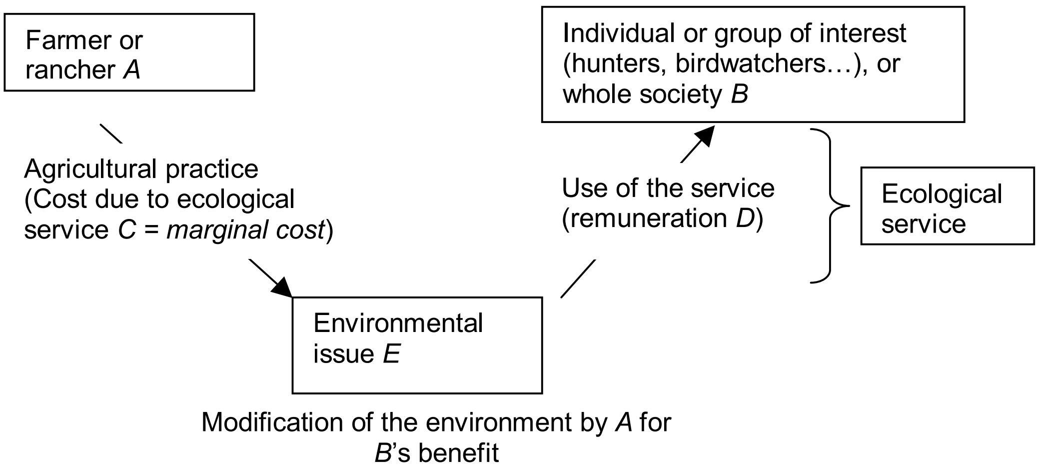

Figure 3: Triangle of service adapted for ecological services

A full ecological service is the ideal service from an economic point of view. The supplier invests money to provide the service and the user pays him in return. For example, we can imagine that a producer plants trees to take carbon dioxide out of the air, and that society pays him for his labour.

The three other definitions derive from that of the full ecological service by variation of its two main elements: the cost inherent to the service and the remuneration from the user. In the environmental field, because of the absence of market, these variations are very common. In our study there are few links between producers and consumers. There is no explicit demand, and therefore no remuneration (*D*=0 in Fig. 3); furthermore, because the original purpose of a farm is not to produce environmental goods, there is often no tool to measure the cost added to production to provide the service (*C* unknown in Fig. 3).

A passive ecological service is a service for which the supplier is paid, but which costs nothing for him to provide (*C*=0 and *D*>0 in Fig.3). For example, farmers are sometimes paid to delay cutting their hay until the 15^{th} of July each year, but in fact they would do so even if they were not paid.

An altruistic ecological service is a service for which the supplier invests time and/or money to provide a service for which he is not paid (*C*>0 and *D*=0 in Fig.3). An example would be a farmer buying a flushing bar without any subsidies.

The last kind of ecological service, given this classification, is called a "positive externality of production." Such a service costs the farmer nothing, and he not paid to provide the service. This is the definition of an ecological service according to the economics of environment.

In all the previous definitions, it is assumed that the services provide a benefit to the environment. However, these definitions are insufficient to determine whether or not an agricultural practice has a true benefit at the ecological level. We need to compare this practice to a criterion (*E* in Fig.3) existing in the area where the service is performed. The ecological service exists only if this practice improves the condition of the environment in comparison with the standard chosen.

Clearly, choice of the criterion strongly influences the assessment (and even the existence) of an ecological service. We now present some examples of potential standards.

Improvement, or maintenance in the same state, of the environment can be measured in comparison with the actual state of the environment. For example, a regular sampling of soil in a given area can provide a basis for such a measurement. In this case, the criterion of reference is the actual state.

Another example would be to choose a native plot of land, one never used for farming, and compare it to a farmed plot. In this example, the criterion is the native ecosystem and its original characteristics. In our study area, the native ecosystem consists of the mix of native grassland, wetlands, and bushes acted upon by three main driving forces: seasonal moisture changes, fire, and bison grazing (which probably used to occur in the fall).

The standard may also be the most common practice (or average practice) used in the area. A farmer provides an ecological service if he applies a practice that is more environmentally friendly than the average practice applied in his neighbourhood to do the same operation. This may be determined by:

- asking the local agronomic specialist, or local agronomic adviser
- studying statistics (quantity of chemicals used by acre, percentage of farmers using conventional summerfallow , etc…)
- conducting a local survey about the practice under consideration

Economic constraints, governmental policies, and local habits generally govern which practices are most commonly used.

It is also possible to use standards given by laws (or by organisms) (see appendix 1). For example, if a farmer uses less chemicals per acre than the law allows, or the chemical company prescribes, he is considered to be providing an ecological service.

In this study, we considered the four kinds of ecological services potentially provided by farmers and ranchers, given Aznar and Perrier-Cornet's (2002) analysis: full ecological service, passive ecological service, altruistic ecological service, and positive externality of production. We have not restricted our study to include only full ecological services because to do so would preclude the objective to take "inventory of ecological services provided by farmers and ranchers in the Redberry Lake Biosphere reserve" (Sian 2001). Consequently, we thought it better to begin with a broad approach to address the benefits that local agriculturists provide to the environment.

Our report is structured according to the four-part framework of ecological services. Because this study focuses on ecological services provided by farmers and ranchers, the next three chapters present the three elements of the definition that interest us here: environmental concern and support of the service (chapter II), the local agriculture and providers of the service (chapter III), and the ecological services identified (chapter IV). Finally, the fifth chapter is a synthesis of our reflections about ecological services in the Redberry Lake drainage basin, presented as a strategy to develop them in the Biosphere Reserve.

II GENERAL ENVIRONMENT: A CLOSED WATERSHED WITH TRANSITION CHARACTERISTICS

A. General description

1. A closed watershed with …

Redberry Lake watershed is a closed watershed that encompasses four rural municipalities: Redberry Lake (435), Great Bend (405), Meeting Lake (466) and Douglas (436).

Rural Municipality	Number of acres in the watershed	Percentage of the Watershed
466	68,320	24
405	11,040	4
436	5,280	2
435	197,970	70

Table 2: Estimation of each RM's share of the Biosphere Reserve

The watershed is composed of two sub-units: Marshy Creek watershed and Oscar Creek watershed.

The boundaries of the watershed are shown in Figure 4[1].

Figure 4: Topographic map of the watershed: see appendix 3

The degree to which Redberry Lake derives from groundwater that originates from outside the watershed is unknown. It may be connected to both shallow and deep aquifers. J. Schmutz (1999) proposes the following scenario for water connections in the watershed and for the declining lake level:

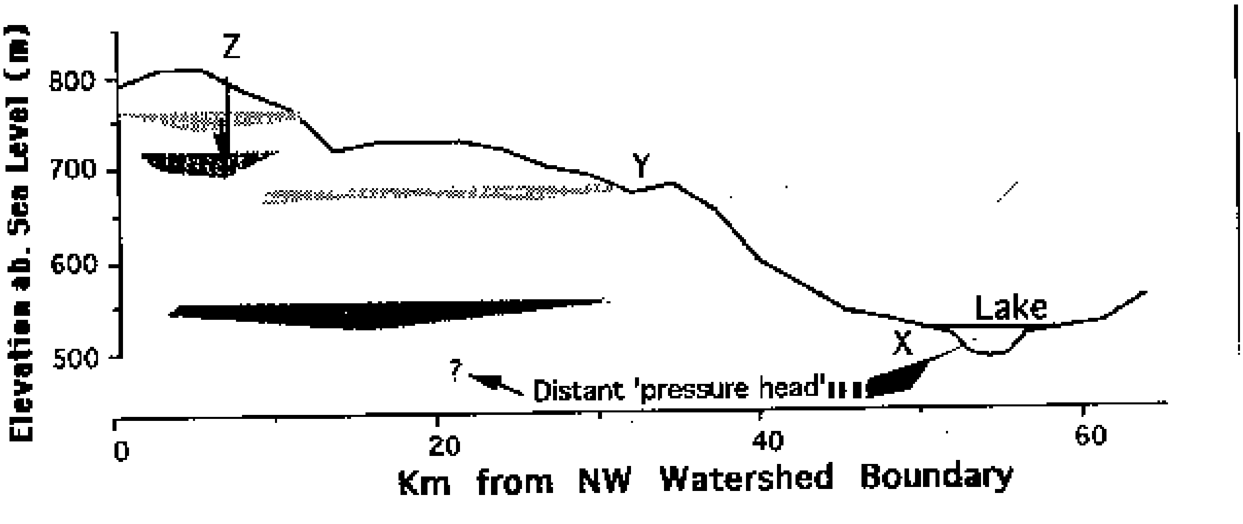

Figure 5: Hypothesis of connections between the watershed and underground water sources

"One branch of a group of salty aquifers, the Battleford Valley aquifer, is located very close to Redberry Lake. It is possible that such a deep salt water channel may have an upward

[1] Map realized by S.McNally from PFRA, derived from 1994 WGTP Program.

connection, and water under pressure can flow upward, as in an artesian well. The deeper the aquifer, the longer it takes to recharge (scenario X).

Shallow aquifers can have a large or a small extent, and as a result can have local or far-reaching effects. In scenario Y, a shallow aquifer into which surface water percolates from relatively flat lands can feed a creek, and thus have an impact on lake level.

In scenario Z, a water well, or seismic exploration hole is bored through one aquifer and into another. Water wells are meant to prevent drainage, but if the seal breaks or the pipe disintegrates, this would allow exchange of water between the two aquifers."

Redberry Lake is the hydrographic core of the area, and it is also the core of the Biosphere Reserve. It is important both symbolically and socially.

2. …a diversified land cover, …

The total area of the watershed is 1,150 km^2 (284,000 acres) (mean of various estimates). The land is mainly comprised of crops, grass, forage, trees, and shrubs as shown on the land cover map[2].

Figure 6: Land cover map: see appendix 4

The following table results from this map[3].

	Acres occupying the watershed	Extent of area %
Cropland	133,860	46
Grass and forage	63,785	22
Trees and shrubs	57,837	20
Water and wetlands	32,990	11
Other lands	3,380	1
Total	291,852	100

Table 3: Land cover in the watershed

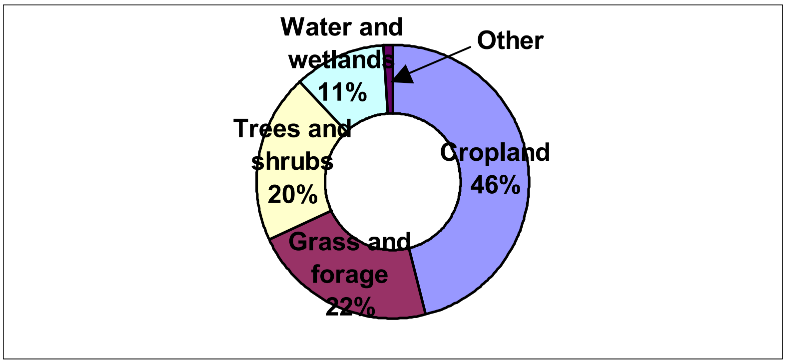

Figure 7: Land cover in the watershed

The watershed also has numerous patches of dominant native prairie vegetation.

[2] Map realized by S.McNally from PFRA, derived from 1994 WGTP Program.
[3] Data furnished by S.McNally from PFRA, derived from 1994 WGTP Program

Analysis of a land cover map from 1997 shows patches of dominant native prairie vegetation, many of which are larger than a section:

- One is the community pastures' patch.
- One surrounds the lake. This patch is linked to one located around Swystun Bay, one northwest from Swystun Bay, and one that stretches in the direction of Oscar creek in the north part of the lake.
- One is between Swystun Bay and the community pastures.
- One is located northeast from the community pastures, and is linked with another patch that stretches along the highway after Hafford in the direction of Krydor.

Other patches, between one quarter of a section and one section large, include:

- two northwest from Oscar Creek
- one southwest of Gordon Lake
- four or five at the centre of Oscar Creek

A lot of smaller patches can also be found in the watershed. They are located between larger patches and act as corridors. Corridors allow for the exchange of seeds between patches. The following sketch is a simplified drawing of those corridors in the watershed based on the land cover map.

3. …an important biodiversity and a diversified landscape,…

The southern part of the watershed of Redberry Lake is part of the Aspen Parkland ecoregion, which, in its native state, is characterised by a mosaic of aspen groves and fescue grasslands. From north to south, grassland replaces forest in response to an increasing moisture deficiency as the balance between precipitation and potential evaporation becomes increasingly negative. In the north, grassland covers the warmest and driest slopes. At the southern edge, aspen are restricted to depressions and steep north-facing slopes. Aspen Parkland comprises more tree cover than it did in the 19^{th} century. Aspen stands reach heights of 10 m at the south edge, and 15 to 20 m at the north edge of the watershed. Shrubs appear in depressions or on the margins of aspen stands. The wettest sites have the tallest shrubs.

Glacial till landscapes, characterised by short, steep slopes and numerous undrained depressions or sloughs, are prevalent and provide an ideal habitat for ducks and other waterfowl. White-tailed deer is the most prominent wildlife species. Coyote, hare, fox, and Richardson's Ground Squirrel are also prevalent. Typical birds include the House Wren, Least Flycatcher, Western Kingbird and Yellow Warbler. Due to the favourable climate and fertile, loamy black soils, most of the land is cultivated, producing a diversity of crops including cereals and oilseeds, as well as forage crops and several special crops.

The north part of the watershed is in the Boreal Transition ecoregion. This ecoregion is characterized by a mix of forest and farmland, marking both the southern limit of the boreal forest and the northern limit of arable land. Gray soils, supporting tall stands of aspen, are characteristic of the hilly upland area. Spruce and Jack Pine occur but are less common than in the northern ecoregions. The lowlands are plains, mostly cultivated. In fact, the black and dark gray soils are some of the most fertile and productive in the province, producing a wide range of forage crops, feed grains, cereals, and oilseeds. The wildlife population is diverse, with white-tailed deer, moose, elk, and black bear being most prominent. Other mammals include the beaver, northern flying squirrel, and short tailed shrew. The Gray Jay, Boreal Chickadee, Black and White Warbler, and Great-crested Flycatcher are typical birds.

The transition between these two ecoregions can be observed in the watershed. In the southern portion, bush is scarce and less prominant than crops and pastures. The northern part of the watershed has more moisture, and bush is very common. Moose, along with bears, are commonly observed in the northern part of the watershed. Furthermore, we observed a wild spruce in a native patch of bush in the northeast part of the watershed, which is a good indicator of this northern influence.

Another important difference between the northern and southern parts of the watershed is the topography. The difference can be seen clearly when driving from south to north, or when looking at land cover and topographic maps. The southern part is generally flat, while the northern portion contains rolling hills and some steeper slopes. The difference in the presence of bush probably results from this difference in topography.

Redberry Lake is also considered an Important Bird Area (IBA) and a Migratory Bird Sanctuary (MBS) because of the presence of migratory birds such as the American White Pelican, White-Winged Scoter, and other shore birds. Some of the species that inhabit or use this area are endangered.

In summary, the watershed not only provides an important variety of landscapes, but is also rich in biodiversity.

4. *…and soils generally suitable for agriculture.*

The Redberry Lake drainage basin overlaps two dominant soils units. The Black Chernozemic group in the south and the dark Gray Chernozemic group in the north. They are separated approximately by the north boundary of township 44. The following table lists the main soil associations that can be found in the watershed. (For more detail about these associations, see the Saskatchewan Institute of Pedology, The Soils of the Saskatoon Map Area 73-B SASKATCHEWAN, 1978 and the Saskatchewan Land Resource Centre, University of Saskatchewan, The Soils of the Meeting Lake Rural Municipality No.466 Saskatchewan, November 1, 1997.)

Soil Associations	Main surface texture	Approximate location
BLACK SOILS		
Craigmore Oxbow Krydor Meota	Loam Loam (+sandy or sand loam) Loam-Clay loam Loamy sand-very fine loamy sand	AROUND THE REDBERRY LAKE
Blaine Lake Whitesand	Loam (+Silt loam) Gravelly loam-Loam	OUEST OF HAFFORD
Hamlin	Loam-Fine sandy loam	South west corner of watershed
Mayfair	Loam	West-North west of watershed
DARK GRAY SOILS		
Lorenzo Meeting Lake	Loam Loam	NORTH OF WATERSHED

Table 4: Main Soil Associations of the Redberry Lake drainage basin

In general, these soils are well suited for agriculture (see III-C). There are, however, some low water holding limitations, water erosion risks due to steeper slopes (see II-B-2), and wind erosion risks southwest of the lake.

The soil texture of the southwest part of the watershed is Sandy Loam, while the rest of the watershed is Loamy.

The main characteristics of the watershed as regard agriculture are detailed in the second part of this report, which deals with agriculture.

The lake level is constantly decreasing, which indicates that it might dry out completely. This will affect the choices people make regarding local projects. The lake has already been well studied; now efforts should be concentrated on the entire watershed, and the Biosphere Reserve provides an opportunity to do so. The fact that Redberry watershed is a closed watershed represents a huge opportunity for local people to manage the quality of their surface water.

The diversity of habitats of the watershed is an interesting feature of the area, and results in rich biodiversity and a diversified landscape. Moreover, the area still comprises native prairies, which have become scarce and must be protected and managed in order to be maintained. In some parts of the watershed, soils may be threatened by erosion and need particular attention.

B. Environmental concerns in the watershed: similarities and differences between academic and local approaches

1. Definition of an environmental concern

Environmental issues pertaining to the watershed, which we have identified through literature reviews and interviews, fall under to two broad definitions:

- environmental components that are considered to be important, threatened, or endangered
- actions or phenomena that are considered to be capable of affecting the integrity of one or more environmental components

To identify the environmental issues of the Redberry Lake watershed area, we used the following two resources:

- ➢ scientific knowledge including available scientific data that outline the main ecological stakes of the area (gathered from documents and expert interviews), and conservation objectives of agencies, non -governmental organisations, or corporations implementing programs in the watershed
- ➢ local knowledge from local farmers and ranchers

For more information about the biological and ecological mechanisms linking these environmental concerns to agricultural activities, see chapter III-E.

2. *Environmental concerns in the watershed according to scientific data and conservation objectives*

Environmental concern *Sub group of environmental concern*	Acreage managed for this issue through programs, land reservations, or conservation easements, or number of wells	Percent of Watershed	Agencies involved
Biodiversity *Habitat for aquatic birds and other wildlife* *Native habitat*	Programs with farmers: 2,400 Land with reservations: 35,360	0.85 12	Ducks Unlimited, Sask. Ag. and Food, Sask. Environment, Canadian Wildlife Service, Sask. Wildlife Federation
Soil erosion	2,774	0.98	PFRA[4]
Water *Quality* *Quantity*	n.a. 650 wells (data Sask. Water)	n.a.	Sask. Water

Table 5: Synthesis of environmental issues outlined by scientific data and agencies' involvement (n.a. = Non available)

While there are many conservation programs available to farmers, it is important to note that more than 85% of the watershed remains cultivated (or idled) without any explicit objective for environmental conservation. This shows that the landowners, and therefore farmers and ranchers, have a great deal of control over the watershed environment.

- Habitat for aquatic birds, other wildlife, and native habitats

Three main groups of habitats can be identified in the study area: native grassland, bush, and wetlands (including ponds, sloughs, low spots, potholes, riparian areas, and creeks). Several factors threaten these habitats in the Biosphere Reserve (see Chapter III).

Native grassland:

Since the area was settled, this habitat has been widely degraded as land was broken to plant crops or seeded grass. As a result, few patches of native grasslands can be found (see I-1).

The main factors threatening the remaining native grasslands in the watershed are:

- Fragmentation – As shown above, most of the native meadows are small and isolated from one another. This fragmentation may weaken the species complex by reducing genetic exchange. Also, the meadows are much more vulnerable to accidental destruction because they are isolated from the pioneer plant species stocks. Without these pioneer plants, it is much more difficult for the meadows to recover from disturbances.

(Image not available)

Figure 8: Invaded native prairie

[4] PFRA = Prairie Farm Rehabilitation Administration

- Colonisation – Domesticated forage plants, such as Brome Grass, are invading native grasslands located near seeded pastures or hay fields. These plants compete with native species and may take over. The native species are also threatened by shrub invasion when not pastured. Grain prices or policies may encourage farmers to break new land to make greater profits. (See section IV-B)
- Overgrazing – Particularly during droughts, ranchers tend to overgraze both native and seeded meadows, which weakens the grass.

(Image not available)

Figure 9: Overgrazed prairie

- Gravel exploitation.

(Image not available)

Figure 10: Gravel exploitation in a native prairie

Wetlands

Wetlands, meaning bodies of water of all sizes, including low spots, potholes, sloughs, and creeks with their riparian areas, have a particular importance in the watershed. There are many wetlands, comprising about 33,000 acres (more than 11% of the watershed, see II-A-2), which provide essential wildlife habitat. In fact, for many waterfowl species, these wetlands are more important for nesting and breeding than Redberry Lake itself.

The main threats to the remaining wetlands are:
- Drought – As the smallest wetlands been drying out over the last few years, farmers have been more likely to break and seed them, or even to drain or plug them.
- Degradation by cattle stamping and manure (erosion and water pollution)
- Contamination by chemicals, fertilisers, and pesticides, especially when crops are located at the edge of the water body

Bush

Bush comprises the third type of land cover in the area (about 58,000 acres, or 20% of the watershed).
Bush provides shelter for wildlife, as well as breeding and nesting areas for birds. It is particularly important for big game animals, such as deer and moose, as well as songbirds. Cattle also use bush areas as shelter and for protection from wind. Areas of bush and shrubs in the Biosphere Reserve are not decreasing at present. Some measurements indicate that their surface area may even be increasing.
Drought appears to be the only threat to bush in the Biosphere Reserve. It weakens the trees and makes them vulnerable to diseases and parasites such as caterpillars, as well as

potential development of lumber exploitation (for pulp) in the northern part of the watershed (some quarters have already been cut).

- Soil erosion

Soil erosion is considered to be a serious threat all across the prairie region. Redberry Lake Biosphere Reserve is on the northern edge of this region, where soils are less vulnerable to erosion than in the south. However, local sandy soils appear to be prone to erosion in the southern and southwestern parts of the watershed (south and southwest of the lake). Also, because of the watershed's hilly topography, soils on steep slopes are more likely to be eroded during heavy rainfalls (such as the 6 inches of rain that fell in the southern part of the lake during spring 2002) or by snowmelt. In these sensitive areas, the risk ranges from moderate to extremely high.

(Image not available)

Figure 11: Soil erosion

- Water

Quantity:
Decreasing quantities of water in the drainage basin are affecting all of the bodies of water in the study area. According to local observations, many sloughs and creeks have dried out in the last two years. The level of Redberry Lake, the final destination of the surface water, is also decreasing. Lake level has dropped from 26 metres in the 1930s to 18 metres today.
Environmentally speaking, lower water levels threaten the islands' nesting bird populations by transforming isolated islands, which were relatively protected from terrestrial predators, into peninsulas. For example, Old Tern Island became the Old Tern Peninsula as a result of dropping lake levels. In the rest of the watershed, the disappearance of wetlands destroys nesting, breeding, and feeding areas for waterfowl and other wildlife species.

Quality:
Over the past several years, water quality monitoring has shown high levels of phosphorus, nitrogen, and dissolved organic carbon. However, the lake's chemistry (salinity and pH, among other factors) reduces the negative consequences (eutrohpic development and turbidity) usually observed in these cases (Khanna, 2001). There is also an indication of contamination by triallate, an herbicide commonly used in the region. The numerous wells spread throughout the watershed represent "vulnerable points" where pollutants can contaminate ground water.
While all these factors, which likely originate from agricultural activities, have a potential negative impact on the environment, and even on human health, there is no real evidence of that in the Biosphere Reserve. If Redberry Lake is contaminated, we can assume that other bodies of water in the watershed may also be affected.

Table 5 highlights the large area protected through land purchasing in comparison with the area managed by farmers. This observation brings to mind the original strategy of organisations involved in environmental preservation: to buy and "secure" land. This strategy keeps the farmers and ranchers away from areas of environmental concern. However, it seems to generate bad feelings among farmers against these organisations (and so also a bad image of environmental actions) and it reduces the potential of ecological services performed by farmers and ranchers (see IV and V).

3. Environmental concerns in the watershed according to local knowledge

Through local interviews and examination of community produced documents, several environmental concerns emerge. Some merge with the scientifically identified concerns but others do not. The answers obtained through local interviews are given in appendix 2.

We have prioritised the environmental concerns their apparent importance to local people (assessed based on how often they appear and how important they seem to people). **This prioritisation is not a statistical one**, it is simply our qualitative interpretation of the importance of these environmental concerns for the community.

Environmental concern *Sub group of environmental concern*	Qualitative assessment of importance for the community +++: most frequently mentioned; ++: given by a large majority of people, often first or second; +: commonly given, but not as the main concerns;°: mentioned few times
Pesticides	+++
Biodiversity	++
Native habitat	++
Wildlife	++
Water	++
Quality	++
Quantity (dropping of lake level)	+
Intensive Livestock Operations (ILOs)	++
Soil erosion	+ / ++
No concern	+
Air quality	°
Beavers	°
Lake salinity	°
Awareness of people about environment	°

Table 6: Environmental concerns of interviewed farmers and ranchers

It is interesting to note that local farmers and ranchers have a greater variety of environmental concerns than official (government and non-governmental) organisations. Consequently, only some of these issues are considered important by both organisations and local residents. The issues that are considered important by both groups include native habitat for wildlife, soil conservation, and water quality and quantity. Therefore, these are ideal issues to work on first. All the other environmental issues identified by local residents are not currently addressed by organisations. This is particularly true for pesticides and Intensive Livestock Operations (ILOs). This disparity between the concerns of residents and outside organisations should be examined and resolved (see discussion and proposals in chapter V).

Note from the authors: One environmental concern we consider to be important that was not mentioned in interviews or documents about the watershed is the landscape. We use a broad definition of landscape, including the visible organisation of both human and natural elements and their interactions. We consider this to be an environmental concern because the landscape is very vulnerable to human activities (particularly agriculture) and is a unique feature of this part of the world. It also reflects the diversity of local wildlife habitats. Often, the many elements of the landscape are considered individually, not as a global entity. However, we have not included our personal opinion in the identification of ecological services.

III OVERVIEW OF THE VARIOUS REDBERRY LAKE BIOSPHERE RESERVE AGRICULTURE

A. General description of local agriculture

This section outlines the key components of agriculture in the watershed, in comparison with Saskatchewan as a whole. The data are given at the Biosphere Reserve level, but most come from a special treatment by Statistics Canada of the 1996 Census of Agriculture (1996 Census of Agriculture, Selected Data for Saskatchewan Rural Municipalities). The change trends indications (↓↑) mainly come from the Atlas of Saskatchewan (2000) or expert observations. Here again, extrapolation from the RM level to the watershed scale is only an estimate. Each table is followed by a short interpretation.

1. The farms

	Number of farms	Total area of farms in acres	% of the total area owned by farmers	% of farms smaller than 400 acres	% of farms having cattle
Biosphere Reserve	213 (0.4% of Sask.)	217,552 ↓	70	31 ↓	55 ↑
Saskatchewan	56,995	65,653,588	71	28	44

Table 7: Farms of the watershed

This table illustrates the small size of the watershed and the resultant smaller amount of agricultural land compared to Saskatchewan as a whole. In the northern part of the Reserve (Meeting Lake RM), small farms are more numerous and often have cattle. On the contrary, the western part of the watershed (Douglas RM) has more crop farms.

While the area of occupied farmland has decreased in the last several decades, the area of improved land has increased significantly (Fig 12).

(Image not available)

Figure 12: Change in improved land (1931-1996) in the Redberry Lake watershed

2. The farmers

	% of people in primary production	% of farm operators older than 55	% of farm operators under 35	% of farm operators with another source of income
Biosphere Reserve	56 ↓	38	17	8
Saskatchewan	16	35	16	13

Table 8: Data about farm operators

Despite the fact that agriculture is decreasing, farming activity is still an essential element of local economy and employment. The relatively large percentages of older and younger farmers may indicate a locally strong period of retiring and installation. This is consistent with the decreasing number of small farms and the reduction of total occupied farmland.

B. Local agri-environmental indicators

Since 1991, new questions in the Census of Agriculture allow for evaluation of some environmental indicators such as soil conservation practices or use of chemicals. Without pointing precisely at the ecological services provided in the Biosphere Reserve, these criteria reveal some important agricultural behaviours.

	% of farmland in natural land for pasture	% of farmland in all other land	% of farmland in summerfallow
Biosphere Reserve	18	11	12
Saskatchewan	19	5	17

Table 9: Biodiversity and availability of wildlife habitat on farm land

This table gives the amount of land under three census categories. These categories can be classified according to their value for wildlife. The two with the highest value for wildlife are “all other land,” which contains wetlands and woodlands not grazed, and “natural land for pasture.” The category with the lowest value for wildlife is “summerfallow.”

We can see that within the watershed, there is a significant amount of land in the category “all other land.” On the contrary, the percentage of “summerfallow” is lower in the Biosphere Reserve than in Saskatchewan as a whole. Land categorized as “natural land for pasture” is about the same in both. As a result, we can assume that Biosphere Reserve farms provide a good quantity of valuable habitat for wildlife compared to average Saskatchewan farmland.

	Use of commercial fertiliser		Use of herbicides		Use of insecticides	
	% of total farm acreage	% of number of farms	% of total farm acreage	% of number of farms	% of total farm acreage	% of number of farms
Biosphere Reserve	36	70	34	69	2	5
Saskatchewan	38	66	41	71	5	19

Table 10: Use of chemicals

The average amount of fertiliser and herbicides used in the area is the same as used in Saskatchewan as a whole, perhaps even a little lower. But farmers in the study area appear to use less insecticide than in the province as a whole. Some recent publications report a possible link between bird abundance and damage to crops by insects. For example, gulls, which are common around Redberry Lake, are very efficient insect predators.

	Crop rotation	Grassed waterways	Strip-Cropping	Contour cultivation	Windbreaks	Permanent grass cover
Biosphere Reserve	81	4	2	9	8	20
Saskatchewan	78	9	10	7	16	21

Table 11: Soil conservation practices: farms reporting these practices (% of the total number of farms)

According to Table 11, it appears that certain soil conservation practices are widely used by farmers in the Redberry Lake drainage basin. These include crop rotation, permanent grass cover, and contour cultivation. Conversely, other conservation practices are applied less often in the watershed than in the rest of Saskatchewan.

	Chemical only	Tillage only	Tillage and chemical combination
Biosphere Reserve	7	48	46
Saskatchewan	9	55	37

Table 12: Forms of weed control on summerfallow in percentage of total area of summerfallow

	Tillage incorporating crop residue into soil	Tillage retaining residue on top	No tillage
Biosphere reserve	55	37	8
Saskatchewan	45	33	22

Table 13: Tillage practices used to prepare land for seeding in % of the total area prepared for seeding

Tillage is still a widespread practice in the area, used for controlling weeds in areas of summerfallow, or for preparing land before seeding. Use of chemicals is common, but mostly in combination with tillage (Table 12). This may be because many farmers are wary of chemicals (see Environmental concerns in part II-B), and because they may not consider soil erosion and degradation to be a major concern in the area.

C. Agricultural capability of soils

Based on the Canada Land Inventory, the CLI map (see appendix 5) highlights the capability of the watershed's soils for agriculture. Effectively, around 52% of the watershed contains class 2 or 3 soils, which are good for agriculture, but may require some conservation practices (see appendix 5). Twelve percent are very poor soils (classes 5 and 6). These are located in the northeast corner of the watershed, which is mostly covered by bush, wetlands, and native grasslands (see land cover map in appendix 4), in some areas around the lake (strong slopes and light texture), and in the southern portion of the watershed.

CLI class	% of the watershed area
2	15
3	37
4	33
5	11
6	1
Non arable land (lake)	3

Table 14: Percentage of each CLI class in the watershed

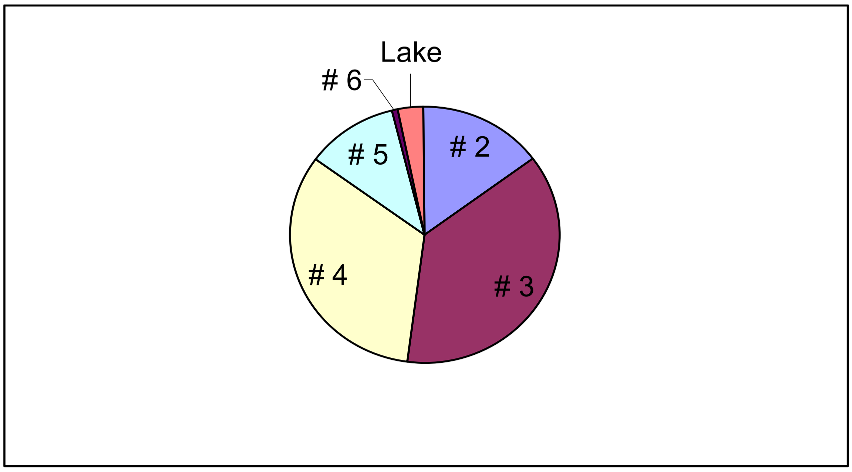

Figure 13: Percentage of each CLI in the watershed

Most of these classes, however, may require particular conservation practices (see erosion risks in part II-2).

D. Agriculture and landscape in the watershed

This short section is intended to give our point of view of the farming system and organisation, and its visible elements in the Biosphere Reserve landscape.

As we move from south of the lake (RM 405 of Great Bend) to the north (RM 466 of Meeting Lake), different agricultural landscapes are visible. South of the lake we see a wide open landscape of large crop fields with homesteads. Windbreaks and grain bins characterize the view. Closer to the lake, there are steeper slopes, covered by a mix of grasslands, bush, and shrubs, forming a natural strip surrounding the water. This strip, which varies from a few meters to about a kilometer wide, marks the crop limits around the lake.

Further north, as we cross highway 40, more hills and bush are present, making the landscape wilder and less open. Pastures and grazing animals emphasize the presence of livestock, and homesteads tend to be hidden by bush or topography.

In the western part of the watershed (west of Hafford and RM 436 of Douglas), we again find large open fields on relatively flat land.

E. Links between agriculture and the environment: basic background to illustrate the biological and ecological basis of ecological services

In this section, we give a simplified explanation of examples of the different biological mechanisms of interactions between farmers and their environment. These mechanisms enable the farmer to either destroy the environment or to provide an ecological service. Conversely, some of these mechanisms allow the services to be provided by the ecosystem to the farmer, and help us understand how protecting the environment can be beneficial to a farmer or rancher. This section is mainly based on a review of the relevant literature.

1. Agriculture, water, and wetlands

Running water carries many different particles, including sediments eroded from the soil, or dissolved fertilisers and chemicals (pesticides, herbicides, fungicides). If the quantities carried are significant, ground or surface water may become contaminated, which can have a negative impact on humans, livestock, and wildlife.

Nitrogen is an essential nutrient that becomes available for crop use when it is in a soluble form such as nitrate. Nitrate can be leached into ground or surface water that may be used as drinking water for humans, livestock, or wildlife. When highly concentrated, it can reach levels harmful to humans or livestock. According to Canadian law, the safe limit for nitrate in human drinking water is 10 milligrams per litre. Excess nitrate and phosphorus, when they enter surface water, may cause eutrophication - the overgrowth of algae and aquatic plants.

Other chemicals, when concentrated in water, can also pose a threat to humans, livestock, wildlife, and aquatic life.

Turbidity of water, resulting from suspended sediment, affects both the quantity of light entering the water and to what depth the light can penetrate. This affects aquatic ecosystems and negatively impacts drinking water sources.

There are several kinds of water circulation that essentially depend on the physical properties of the soil, and on the slope. Water can infiltrate the soil or run off along the ground surface. A steep slope, or hard crust at the surface, favour runoff, while flat and porous soil allows water to infiltrate easily.

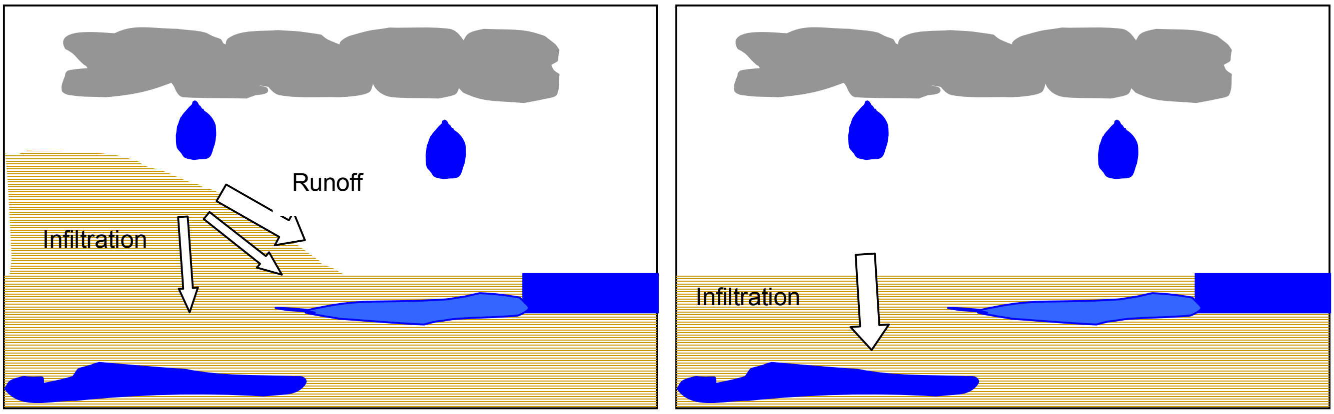

Figure 14: Water circulation

In order to avoid water contamination, farmers can:
- adapt their input to the real need of the crop,
- improve timing of nitrogen application,
- store their manure so that runoff is minimised,
- properly store and dispose of their chemical containers,
- limit soil erosion (this is detailed further),
- avoid spraying pesticides and other chemicals near water sources,
- maintain or seed buffer strips (vegetation around water– natural or seeded)

Given the low level of precipitation in the area, the risk of groundwater contamination is probably less significant than it is in rainy provinces. But runoff, which can easily cause surface water pollution, exists because of the hilly topography.

Adapting input of fertiliser and chemicals helps farmers decrease their costs and maintain drinkable water for them and their livestock.

Wetlands and riparian areas are other important elements for maintaining water quality and, to a certain extent, water quantity. Such areas also contain rich biodiversity. Wetlands, when situated in crop fields, are threatened by contamination and by being drained or seeded. Large riparian areas along creeks or around lakes are also threatened by contamination or degradation when located in pastures or in crop fields. Because a large number of small wetlands or lakes are located in farmers' properties, and because creeks cross these same properties, farmers have the power to preserve healthy wetlands and riparian areas.

Wetlands[5] are low-lying areas covered by water, often enough to promote and support the growth of aquatic plants and animals for part of their life cycle. Theirs soils and plant communities are the result of periodic or continued flooding. The transitional vegetative zones that separate the wetland from adjacent uplands are called riparian areas. Wetlands are functioning dynamic ecosystems.

Natural vegetation near water provides:
- streambank protection, preventing soil erosion,
- trapping and filtration of sediment,
- ground water recharge and streamflow regulation,
- nutrient cycling and storage, as well as trapping and filtration of residue from fertilisers or chemicals, which are deposed because the speed of the runoff is decreased by the

[5] The main sources for information about wetlands and riparian areas are Huel (2000) and Huel (1998).

vegetation. This allows natural processes to remove many of the pollutants, and the fertiliser is then used by the natural vegetation.
- primary biotic production.
- biodiversity.

Sloughs or potholes are sometimes viewed as impediments to crop production because they reduce the farmable acreage, decrease the efficiency of soil operations, and sometimes contribute to crop degradation by waterfowl. Therefore, some farmers drain sloughs or potholes or seed them as soon as they are dry. This can also destroy all the vegetation surrounding the water (sloughs or potholes, lakes, and creeks) in crop fields or seeded pastures, and allows cows destroy it in pastures.

Preservation and management of healthy natural vegetation around bodies of water can benefit farmers by providing healthy water for livestock, recharging groundwater reserves, increasing crop productivity in adjacent areas, providing huge amounts of quality forage, and reducing soil erosion and salinity problems. Wetland vegetation is also very important for wildlife and biodiversity.

Farmers can maintain healthy vegetation around bodies of water by:
- not destroying it in fields crops,
- managing livestock (fencing animals out, providing an alternative watering site, and/or practicing rotational grazing)

(Image not available)

Figure 15: Riparian areas

2. *Agriculture and soils*

Soil quality has both an inherent element, determined by geological materials and soil formation processes, and a dynamic element, determined by farm management practices.
Modification of the prairie ecosystem and agricultural practices have deeply affected the soils of this region. Some of the main environmental problems during the past two decades have been related to:
- soil organic matter
- soil erosion
- soil salinity

Soil is made up of small particles of various sizes; sands are between 0.05 and 2 mm in diameter, silts are between 0.002 and 0.05 mm in diameter, and clays are less than 0.002 mm in diameter. Soil particles may also have different mineralogical compositions, and may be classified as clay, loam, or sand. (Note that even though in some cases the same names are used for both size and mineralogical classification, there is no evident link between the two.)
Soil contains air, organic matter, and micro- and macro-organisms, and is able to fix dissolved particles and water. A particular soil has physical, chemical, and biological characteristics. The physical and chemical properties of the soil are mainly determined by particle size, organic matter present, and the mineralogical composition of the soil. Physical properties of soil important for agriculture are compactness and the soil's capacity for holding moisture. The most important chemical properties are: nutrient levels, pH (acidity or alkalinity), and salinity. Biological characteristics are influenced by moisture and temperature. Biological activity affects the decomposition of organic matter, which releases nutrients. Decomposing organic matter releases nitrogen, improves the soil‘s moisture holding capacity, improves soil texture, and reduces the risk of wind erosion.

Some practices such as bare soil summerfallow (erosion by wind and water results primarily from insufficient litter cover of the soil) or deep tillage enhance natural water and wind erosion. Prolonged drought also contributes to erosion. Organic matter is a major component of topsoil that is removed by erosion. When organic matter is lost, soil structure breaks down and the soil becomes less permeable to air, water, and nutrients. It may compact and show surface crusting. As this happens, the soil becomes more vulnerable to all types of erosion, further compounding the problem by removing even more topsoil. As soil fertility and productivity drop off, greater amounts of inputs (e.g. fertiliser) are needed to produce a reasonable crop, and eventually the soil reaches an unproductive state.

Soil has a natural state of compactness, but compaction can be increased by agricultural practices such as the use of heavy farm machinery, which presses down on the soil, especially when it is wet.

Excessive use of chemical fertilisers can affect the microfauna activity of the soil. For example, it has been hypothesized that the initial decrease in crop productivity during conversion from chemical-intensive to alternative agriculture may be due to the diminished biological potential of conventionally managed soils to efficiently cycle and mineralise organic nutrients. Actually, there is some evidence that repeated applications of inorganic fertiliser can suppress the production of a particular molecule produced by microorganisms which is involved in nutrient cycling (e.g. amidase in the nitrogen cycle) (Dick 1992). On the contrary, the addition of farmyard manure increases the incorporation of organic residues and is reported to increase the amount and activity of microorganisms.

Consequently, to control soil degradation and to improve productivity, farmers should:
- preserve soil organic matter by practicing crop rotation and by adding crop residues
- maintain good soil structure by crop residue addition and careful tillage practices
- protect the surface of the soil against erosion through proper cropping and tillage practices and preservation of soil moisture
- fertilise carefully using soil testing and plant analysis
- use appropriate and not systematic weed and pest control practices to minimise the use of chemicals

3. Agriculture and air

Earth absorbs short wave radiation from the sun and then reradiates it into the atmosphere at a longer wavelength. Certain gases in the atmosphere, such as water vapour, nitrous oxide, methane, carbon dioxide, and ozone, act like greenhouse windows, trapping that radiation. This natural greenhouse effect has warmed our planet for billions of years. These "greenhouse gases" are responsible for maintaining Earth's average temperature of 15°C. Without the greenhouse effect it would be -18°C.

The average concentration of greenhouse gases and the average global temperature are thought to have varied slightly from century to century over the last 10,000 years. However, during the last five decades the concentration of greenhouse gases in the atmosphere has risen dramatically. As a result, more outgoing terrestrial radiation is trapped, warming the atmosphere and Earth's surface even further, causing climate change. This increase in greenhouse gasses comes in part from agricultural and industrial activities.

The three main gases responsible for the greenhouse effect are nitrous oxide, methane, and carbon dioxide (in combination responsible for 90% of the effect). In 1996, agricultural emission of these three gases represented 13% of total Canadian emissions[6].

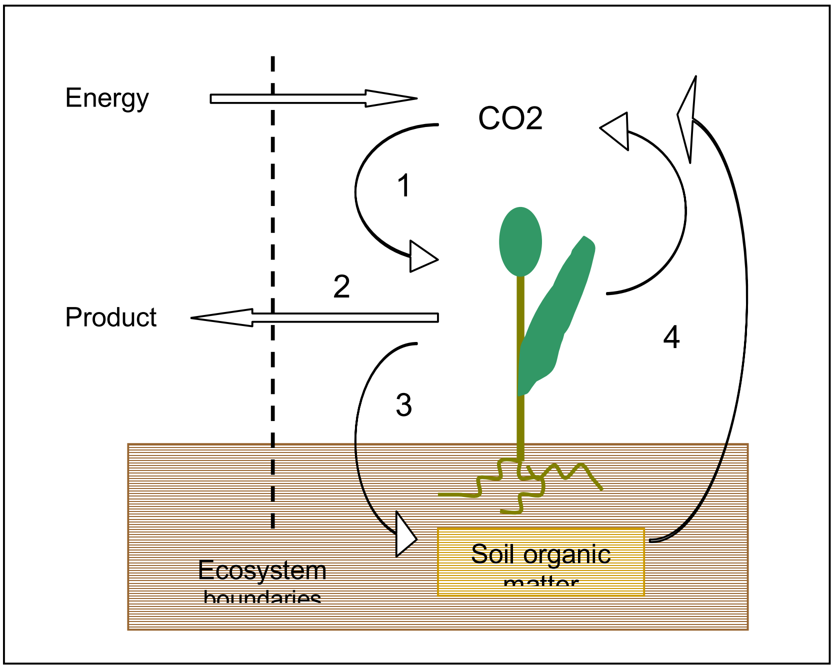

Figure 16: Carbon cycle in agriculture

This illustration and explanation of the carbon cycle in agriculture helps to explain and to synthesise ways farmers can influence the quantity of carbon dioxide released into the atmosphere.

When crop plants carry out photosynthesis (1), they use solar energy to convert carbon from the atmosphere and water from soil into carbon-rich compounds. Those carbon-rich compounds are the main elements of the plant. As a result, when crops are harvested, carbon is removed the agricultural system (2). Crop residues are left to decompose through

[6] Extract from: "Environmental sustainability of Canadian agriculture, report of agri-environmental indicators project," Agriculture and agri-food Canada, 2000.

the action of microorganisms, which convert them into soil organic matter (3). During this decomposition, the microorganisms release the carbon dioxide back into the atmosphere (4). The rate of decomposition depends on the quality of the residues, the type and number of soil microorganisms, and the chemical and physical characteristics of the soil.

Farmers have a lot of influence on this cycle. We have already seen that when they harvest their crops, they remove carbon from the system. When they work the soil or add inputs, they modify the soil composition, affecting both microorganisms and the chemical and physical properties of the soil. Consequently, they influence the rate of decomposition of organic matter. The quantity of remaining crop residues is also decided by farmers, and constitutes part of the soil organic matter. Another good example of the farmers' influence is the kind of cover they choose. If they plant grass or trees, the removal of carbon from the plot will be less significant and more organic matter will accumulate than if they plant a crop or let the soil idle.

Experts believe that carbon storage in the soil can be improved by:
- growing more grass and forages
- using no-till systems
- using methods that increase yields and, in turn, crop residue input
- reducing use of summerfallow
- using soil conservation practices
- replanting marginal lands with grass or trees

Farmers can also reduce their carbon dioxide emissions by cutting down on their use of fuel. This can be achieved by reducing tillage, improving the efficiency of farm machinery, and increasing the use of bio-fuels such as ethanol.

The use of fertilisers on farms results in nitrous oxide emissions. Some microorganisms, which can only act in the absence of oxygen, convert nitrogen from the soil into nitrous oxide. This nitrous oxide is then released into the air. When farmers use too much fertiliser, those microorganisms can use the surplus of nitrogen under certain conditions. About 50 to 75% of the annual emission of nitrous oxide in Canada occurs in early spring during the snowmelt. Excess water results in anaerobic conditions that, coupled with adequate nitrate, available carbon, and favourable temperature, enable those microorganisms to release nitrous oxide to the atmosphere. These conditions may be encountered in different places at different times of the year.

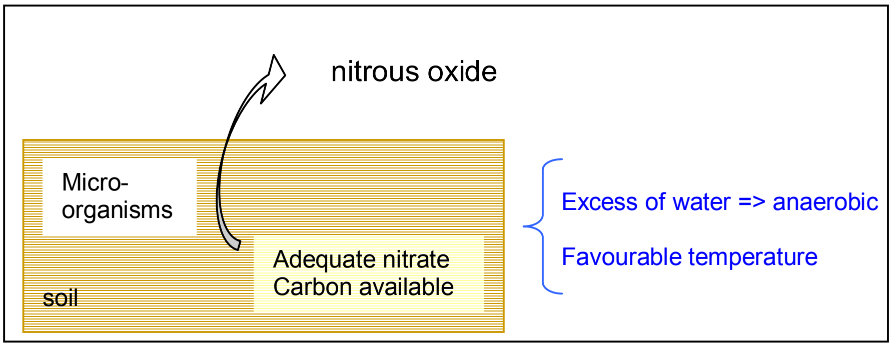

Figure 17: Nitrous oxide release

The release of nitrous oxide from the soil by microorganismsis known as nitrification

Nitrous oxide emissions are often increased by poor soil conditions. Experts believe that the following practices promote a decrease in the release of nitrous oxide:
- the use of controlled-release fertilisers
- the use of nitrification inhibitors
- improved timing of nitrogen application
- better manure management
- refining nitrogen content in animal feeds

The third greenhouse gas that may be released by agricultural activity is methane. Methane comes from manure as well as directly from animals. In the case of manure, the creation of methane results from incomplete decomposition of the organic matter by microorganisms. This incomplete decomposition occurs when there is a lack of oxygen.

In order to reduce these emissions, experts advise farmers to:
- better aerate to the manure
- reduce the storage time

To reduce animal emissions they can:
- use easily digestible feeds like grain, legumes and silage
- harvest forage at an earlier, more succulent growth stage
- chop feed to increase surface area
- minimize the use of coarse grasses and hays
- feed concentrated supplements as required

Agricultural emissions of carbon dioxide decreased by 13% between 1981 and 1996, mainly because of the adoption of conservation farming practices. However, at the same time, emissions of nitrous oxide increased by 21%, and methane emissions remained stable. This was essentially the result of more intensive farming practices and growing use of nitrogen fertiliser. Between 1981 and 1996, emissions increased in Manitoba and Alberta, but remained stable in Saskatchewan.[7]

4. Agriculture and biodiversity

Because of the rapid settlement of North America, agriculture took only two centuries to mimic ecological changes that, in Europe, had taken place over approximately two millennia. These changes have had a significant impact on the biodiversity of North America.

Because a large portion of the Canadian landscape is farmed, agriculture has a significant effect on biodiversity, and the effects of some agricultural management practices go beyond the boundaries of the cropped area. The following paragraph describes interactions between agriculture and biodiversity.

Loss of non-crop and native habitats, use of chemicals, and the increasing homogeneity within the agricultural landscape has resulted in a decline in biodiversity. This decline concerns not only large animals, but also insect species. Diminishing arthropod biodiversity is correlated with the loss of natural pest control (Altieri and Withcomb 1979 and 1982, Altieri and Schmidt 1985, Kevan 1986, Bugg et al. 1987, Russell 1989, Bugg 1992). A reduction in insect pollinators, especially bumblebees, results in the loss of pollination as a fundamental ecosystem process (William 1986, Kevan and Plowright 1989, Kevan et al. 1990, Corbet et

[7] Extract from “Environmental sustainability of Canadian agriculture, report of agri-environmental indicators project,” Agriculture and agri-food Canada, 2000.

al. 1991). There is evidence that decomposition of organic matter is also affected (Morris et al. 1991).

Some research has shown that after a few years, a field in conservation tillage had a higher invertebrate population than in a conventionally tilled field (Schaller 1968, Edward and Lofty 1975, 1982, Hanson 1990, Piller 1999). Conservation tillage is also supposed to be beneficial for vertebrate species, but timing of operations is much more important in this case.

Use of fertilisers decreases overall plant diversity because the resultant high level of nutrients selects for the more competitive plants (Orians and Lack 1992, Mahn 1988). It can also alter the disease susceptibility of plants. Repeated applications of chemical fertilisers reduces the biological potential of soil to efficiently cycle and mineralise organic nutrients (Dick 1992). It has been proposed that this may be the cause of the initial decrease in crop productivity during conversion from chemical intensive to alternative agriculture. Soil fauna tend to benefit from the increased organic matter resulting from manure application. A good level of decomposing organic matter in soils allows farmers to reduce fertilisation costs. The enhanced nutritional qualities of fertilised forage have been found to increase wildlife reproduction and survival rates (Mereszczak et al. 1981). Fertilised forage can also improve habitats for birds and mammals because of increased cover. When fertilisers are carried by run-off into bodies of water they can significantly impact aquatic habitats

Herbicides, the more commonly used pesticides, often have an impact on non-targeted plants. Knowledge of this impact, especially the effects on rare or endemic species, is very limited. Herbicides can also be toxic to some invertebrates. Insecticides are much more toxic to soil fauna. The use of chemicals also influences the vertebrate population. Comparison of conventionally and organically farmed land from various European countries reveals a significant increase in abundance of numerous common birds species on the organic farms (Braae et al. 1988, Denmark).

Non-crop habitats adjacent to cropland maintain plant diversity and are useful for the conservation of beneficial predatory insects. Wildlife habitat is also important to preserve birds. A review of birds as biological control agents (McFarlane 1976) concluded that birds may help bring down local outbreaks of insect pests, but that their main benefit is to have a longer-term depression effect on agricultural pests when these are at low to moderate densities. Like insect predators and parasitoids, birds may reduce the need to apply pesticides, leading to a lower frequency of application and therefore a reduction in cost. Recent research has shown that bird predation is important in limiting grasshoppers in rangelands (Fowler et al. 1991) and cutworms in cereal fields, even in the context of today's intensive agriculture practices. But birds cannot be expected to provide control if there is no habitat nearby to fill their other requirements. Birds tend to be more active on the borders of fields (Best et al. 1990), and it is therefore probable that the larger the field the lesser the impact of bird predation on crop pests. For example, large shelter-belts with several rows of several kinds and sizes of trees are most useful for birds.

While well managed rest-rotational grazing allows for greater coexistence between domestic and wildlife species, overgrazing is detrimental to plant and animal biodiversity. Riparian areas sustain a disproportionately large amount of biodiversity in the prairies. As a result, careful management, for example by fencing out cattle or by applying accurate rotational grazing, can help preserve those areas.

Consequently, farmers can play an important role in helping to maintain biodiversity; in many cases it is in their best interest to do so. For example they can:

- adopt conservation tillage

- manage fertilisers – both organic and mineral – properly to maintain soil biological potential
- limit the use of chemicals, especially at the edge of fields or near water
- manage hedgerow
- preserve bush, riparian areas, and native prairies

Conclusion:
This section illustrates the fact that the link between farming practices and the environment are numerous and complicated. Consequently, farmers have real potential to enhance their environment. However, individual actions are generally not efficient. For example, if one farmer reduces fertiliser run-off, but at the same time his neighbour increases it, there will be no improvement in water quality.

This section also emphasizes that environmentally friendly farming practices often also benefit farmers.

IV FIRST IDENTIFICATION OF ECOLOGICAL SERVICES IN THE WATERSHED: A WIDE RANGE

A. Typology of ecological services found in the biosphere reserve

This section presents the ecological services we have identified in the study area, classified according to definition. However, we have not done a detailed economic assessment of the costs and benefits of those ecological services. As a result, the classification we propose is hypothetical, and careful economic analysis is needed to confirm our findings.

1. *Full ecological services*

Given the definition of full ecological services, the only services present in the area are those provided by conservation programs implemented by agencies, corporations, or NGO's that share an interest in environmental preservation, and by the organic farming system.

- Conservation programs

In this case, the consumer (or the group of consumers) of the service is not directly in contact with the producer. Rather, the consumer is represented by an organisation. In the area, the most involved organisations are:

Name of the organisation	Group of consumers of ecological services it represents
Ducks Unlimited (D.U.)	Waterfowl hunters, birdwatchers
Prairie Farm Rehabilitation Administration (PFRA)	Canadian society

Table 15:Consumers of ecological services

The practices promoted in the area through these programs are:

Agricultural practice	Environmental issues it addresses	Organisations "consumer" (*B* on Fig.3)
Fencing off of riparian areas and wetlands from cattle	Waterfowl and wildlife habitat	D.U.
Alternative water supply	Water quality, bank erosion, and wildlife habitat	PFRA
Conversion of cropland into forage	Soil erosion, wildlife habitat	D.U., PFRA
Rotational grazing with one paddock idle a year	Waterfowl and wildlife habitat	D.U.

Table 16: Full ecological services of the watershed

To see the significance, in acres, of these programs, see II-B.

(Image not available)

Figure 18: Farmers, cows, and riparian areas

FARMERS, COWS AND RIPARIAN AREAS MANAGEMENT
0.14 lb./day is the average weight gain for calves under remote watering as opposed to direct access according to the Western Beef Development Centre Research
73% of ranchers surveyed in a University of Manitoba study have observed an improvement of livestock health with controlled access to water bodies

(Image not available)

Figure 19: Fencing out of a creek

(Image not available)

Figure 20: Alternative water supply (tank and solar pump)

- Organic farming system

In our opinion, organic farmers provide full ecological services because:
-Becoming an organic farmer requires time, knowledge, new skills, equipment, and sometimes labour.
-There is an intentional benefit to the environment.
-The consumer pays the producer a higher price for organic food because these products satisfy his desire for healthy and environmentally friendly produced foods.

This service can de described as follows:

Agricultural system	Environmental issues it addresses	Organisations/consumer (*B* on Fig.3)
Organic farming or ranching (or other systems without chemicals)	Chemicals	Purchasers of organic food

Table 17: Description of the full ecological service provided by organic farming

2. Passive ecological services

We identified very few passive ecological services in the biosphere reserve. They consist of taking advantage of a program to subsidise an agricultural practice that is already occurring. As with a full ecological service, there is consumer (usually represented by an organisation) who pays the producer for the service, but there is no marginal cost added to the practice by the service. Also, farmers or ranchers would provide these services even if they were not compensated (if they continue their current farming systems).

Agricultural practice	Environmental issues it addresses	Organisations /consumers (*B* on Fig. 3)
Delay cutting hay after mid-July	Bird nesting success	D.U.
Planting forage on marginal lands	Soil erosion and wildlife habitat	PFRA, D.U.

Table 18: Description of passive ecological services

This kind of service illustrates the importance of the social aspect to ecological services (see discussion in methodology). When social demand exists, it can turn a normal agricultural practice into an ecological service. Also, these passive ecological services show that some ordinary agricultural practices in the watershed are ecologically friendly enough to provide an ecological service.

3. Altruistic ecological services

Again, as with a full ecological service, an altruistic ecological service is performed through a certain agricultural practice by a producer. It adds a marginal cost to the practice, but contrary to a passive ecological service, there is no explicit consumer, and therefore no remuneration to the producer. Although there is no identified consumer of the service, many individuals or groups may take advantage of it.

Agricultural practice	**Environmental issues it addresses**	**Main origins of the marginal cost**
Use of an alternative water supply from farmers' or ranchers' own funding	Water quality, bank erosion, and wildlife habitat	Investment for pumping system, fencing, and time for maintenance
Keeping native habitat (bush or grassland) on good soil in cultivated fields	Wildlife habitat	Difficulties working the field (time, gas)
Returning chemical jugs to the seller	Chemicals	Time, gas
Disposing of oil waste appropriately	Water quality	Time, gas
Using less spray than recommended by chemical companies	Chemicals	Lower yields
Providing buffer strip around wetlands in crop fields	Chemicals and water quality	Time and lost crop acreage

Table 19: Description of altruistic ecological services inventoried in the Biosphere Reserve

(Image not available)

Figure 21: Buffer strip in a crop field

These altruistic ecological services show the importance of aesthetic and emotional components of the decision making process at the farm scale. When a farmer or rancher organises his or her farming system, s/he may take into account aesthetic arguments (bush patches for example), even if s/he can't assess their economic value and s/he knows that it is going to increase costs.

4. Positive externalities for the environment

Agricultural practice	Environmental issues it addresses
Rotational grazing	Wildlife habitat and soil erosion
Keeping bush in pastures	Wildlife habitat
No or minimum tillage	Soil erosion
Injected fertiliser	Water quality
Fertilising after planting	Water quality
Spreading manure in summer	Water quality
Precision spraying	Chemicals
Continuous cropping with direct seeding	Air quality (carbon sequestration)

Table 20: Description of positive externalities inventoried in the Biosphere Reserve

These externalities, which have a positive effect on the environment, show that despite what people usually think, artificial farming systems in the area provide important ecological services. However, in these cases, the ecological services have evolved with the farming systems. In particular, they have followed the movement from local (practices adapted to local environmental conditions, locally sold products) to global (open systems with externally made inputs and outputs sent great distances). Similarly, the ecological services provided by these farms can be very significant, but are often distant from local issues. They are not necessarily less valuable than others; they are simply less beneficial at the local level.

ROTATIONAL GRAZING
80.5% of ranchers have experienced greater weight gain on rotational pastures over traditional grazing (Faculty of Agricultural and Food Services, U of Manitoba)

Figure 22: Rotational Grazing

(Image not available)

Figure 23: Rotational grazing: two paddocks

Some ecological services are contradictory. For example, using chemical summerfallows has a positive effect regarding soil erosion, but a negative impact on the environment because of the use of chemicals. The contrary is true with tillage summerfallows. So, to determine which practice provides a real ecological service, one must prioritise environmental concerns at a local level.

Another important point regarding ecological services is the level of analysis. In this study, we have focused on the agricultural practice level. The farm level is the next important scale for analysis. Actually, a farmer may provide an ecological service by using a certain agricultural practice and damage the environment by using another one. In this case, the global farming system may cause more environmental damage than it provides ecological services.

As mentioned at the beginning of this chapter, this classification of ecological services is not justified by economic calculations of marginal costs, which would be necessary to convert our simple hypothesis into more solid assertions. We invite the readers to challenge this typology. However, we believe that several ecological services are provided in the watershed, even if farmers and ranchers (at least those we have met) have varying levels of awareness about ecological services and the environment. Many provide ecological services without realising it.

This first attempt to classify ecological services is not comprehensive enough to report or explain the complex local link between agriculture and the environment.

Figure 24: Producers' experiences (next page)

FARMERS' EXPERIENCES

FARM

Acreage	7 quarters
Livestock	60 cows and 80 sheep
Crops	only to feed the livestock, 3 quarters
Pasture and hay	4 quarters

Note: no other income, has had several children

ECOLOGICAL SERVICES

- Rotational grazing (12-13 acres each paddock)
- No chemical fertiliser at all, only manure
- Infrequent use of chemicals in crops (control of weeds by delay till and early cut)
- Minimum till
- One paddock idled each year for wildlife, over 10 years

COST

In exchange for the ten-year contract ensuring one paddock be set aside each year, Ducks Unlimited paid for the fencing of the paddocks.

BENEFITS AND DISADVANTAGES MENTIONNED BY THE FARMER

✧ Rotational grazing :
  - need to re-seed the grass less often (one is 15 years old and still productive)
  - it doubles the production of grass
  - carrying capacity: the system could support 80 pairs (cows + calves)

✧ The contract with Ducks Unlimited was profitable economically

OTHER COMMENTS OF THE FARMER (QUOTATIONS)

" I believe in wildlife habitat necessity."
" I watch my grass carefully and it's easy [the rotational grazing]."

PROJECTS

Would be interested in working again with Ducks Unlimited to protect wildlife habitat

FARMERS' EXPERIENCES

FARM

Acreage	24 quarters
Livestock	500 cows + calves
Crops	oats for cattle, 600 acres
Pasture and hay	1 000 acres of alfalfa

Note: one external income, but not really necessary, several children

ECOLOGICAL SERVICES

- Rotational grazing (minimum paddock one quarter)
- Alternative water supply and fencing out of the creek
- No spray on hay silage (control of weeds by re-seeding)

COST

One mile fence for the creek paid by Ducks Unlimited
Solar pump system $3,000 CDN ($1,000 paid by Ducks Unlimited, $500 by SaskEnergy, and the rest by the farmer)

BENEFITS AND DISADVANTAGES MENTIONNED BY THE FARMER

✧ Rotational grazing => better carrying capacity
✧ Alternative water supply => clean water and no erosion

✷ The alternative watering site takes more time than the previous system

OTHER COMMENTS OF THE FARMER (QUOTATION)

Rotational grazing is "pretty easy"
"I am already satisfied with the alternative watering site even if it is quite new."

PROJECTS

He would be interested in fencing out his sloughs and ponds

FARMERS' EXPERIENCES

FARM

Acreage	3 500 acres
Livestock	90 pairs cows / calves
Crops	1 600 crops for sell (wheat and canola), 200 acres oats for cattle
Pasture and hay	
Chemical summerfallow	

Note: two families, only one has children, one other income but not really necessary

ECOLOGICAL SERVICES

- Always use half the recommended amount for chemicals
- Use some organic products to spray
- Keep some bush even if it is in good lands

COST

??

BENEFITS AND DISADVANTAGES MENTIONNED BY THE FARMER

- Using less chemicals is less expensive
- Bush = good for wind erosion, wildlife, water

OTHER COMMENTS OF THE FARMER (QUOTATION)

" I am really wondering what we are doing to our environment with all those chemicals."

B. Why farmers may not have an interest in preserving the environment

We have described a large range of ecological services provided in the watershed, but it is interesting to briefly examine the major factors that hinder sustainable agriculture (and therefore hinder the production of ecological services).

Government policies and programs, big firms' policies, and market conditions have largely influenced the decisions of farmers and ranchers.

For example, the increase in conversion of wetlands and marginal lands into croplands since the 1970s is said to have been mainly a response to high grain values (Environmental Management Associates 1993). However, some studies show that there is, in fact, a lack of connection between farmers' behaviour and economics (Girt 1990). Given these studies, farmers appear to be influenced more by government policies and programs than by economics.

For example, policies and programs encouraging wheat production for export as a bulk raw commodity may have encouraged development of technology based only on increasing production, cultivation of marginal lands, lack of crop production supporting the livestock industry, and lack of incentives to establish value-added food industries. The national transportation policies have encouraged farmers to grow grains for exportation in huge quantities, discouraging diversification.

Another example of the kind of policy that discourages diversification is the Canadian Wheat Board policies, which penalize producers who have more than one third of their annual seeded acreage devoted to special crops.

The Crop Insurance Program has also been criticized. A report from 1991 (Saskatchewan's Conservation Strategy Agricultural Sector Report) said that: " In the past, the crop insurance program has promoted grain production without consideration for soil conservation, reduced the incentive to diversify farming operations, at times encouraged different farming practices that would not have been the case with no program, and have encouraged the cultivation of marginal lands better suited to forage production and permanent cover under vegetation."

A more recent report states that after the 1992 modification, the GRIP was still penalizing farmers who adopted soil conservation practices such as crop rotation or conservation tillage by differentiation between stubble and summerfallow yield coverage levels. It was also still guaranteeing a minimal return for marginal lands.

Many other policies and programs have been unfavourable to wildlife habitat. The Canadian Wheat Board quota system, for example, is based on cultivated acres. This allows farmers to possibility to use the conversion of land into crops as a tax write-off. In addition, the government subsidises farmers to drain wetlands on private lands. Governments have also been contradicting themselves by simultaneously promoting the Permanent Cover Program and the National Soil and Water Conservation Program.

Farmers who have followed government demand to increase wheat production may now be caught up in a vicious circle. Debts from the purchase of equipment, for example, oblige them to maintain high maximum yields through the use of chemicals and fertilisers, and to farm a significant amount of land. They are also encouraged to maintain high maximum yields because of their cost per acre. Those farmers may make a lot of money, but they also face a permanent risk of bankruptcy.

There is also another factor that can influence farmers' decisions regarding land use. Today, children seem to be less inclined to take over their parents' farm; the life of a farmer is often seen as very difficult. You may have to live in a very remote area, you have to work a lot for a little money, and you get no real thanks from society. Moreover, the farm may be too small to be viable. Farmers are likely to take better care of their land when they will be turning the farm over to their children, as opposed to when they are going to sell it.

There is likely also a lack of knowledge among the farmers. Research on farming practices has evolved significantly in the last few decades, and it is difficult to communicate new technologies and new ways of thinking to farmers who have worked the land for years. A good example of this lack of knowledge is the expression "clean soil." Some farmers have a strong work ethic and feel that they have to keep their soil "clean" to be good farmers. For example, they feel that they must eliminate all the weeds. However, a clean appearance is not always a good indicator of soil health, especially if it requires the use of a lot of chemicals or ploughing. As indicated in III-E-2, trying to clean a soil can cause more harm than good.

C. Compensation

Compensation is part of the notion of ecological services (see definition in I-C). Compensation refers to the remuneration paid by the consumer (or his representative) to the producer (in our study, a farmer or rancher). Compensation is often a main concern when people discuss services. Moreover, compensation of farmers and ranchers is the goal of the Community's Plan for Sustainability research project we are trying to begin with this study.

In this section, we intend to show that before finding ways to compensate farmers, some questions must be answered. Most of these questions can (must?) be answered by the community itself.

Three main questions are the focus of this discussion; below we outline issues surrounding each question.

<u>Question 1</u>: Should farmers or ranchers always be compensated for the ecological services they provide?

It is not necessary to ask this question in the case of full and passive ecological services, because they are already compensated.

We saw that farmers perform altruistic ecological services because they believe that the aesthetic or emotional benefit they get in return is worth the marginal cost the service adds. Because other people (neighbours, visitors, tourists) can benefit from these services, we believe it would be fair for them to contribute to cover the cost.

Altruistic ecological services + compensation ➔ full ecological services

For the positive externalities, there is no marginal cost. So:

Positive externalities + compensation ➔ passive ecological services

It seems more effective to focus on altruistic ecological services to try to assess the marginal cost they add and find ways to remunerate the producers.

There are some negative aspects to the compensation issue, including:

- loss of autonomy for some decisions at the farm scale
- potential degradation of the innate pleasure resulting from providing the service (apparently important for many farmers and ranchers)

Question 2: If yes, how much should they be compensated?

The assessment of the value of environmental goods is the preoccupation of numerous research teams throughout the world. To our knowledge, there is no satisfying solution, despite the abundant literature on the topic. In reality, the most common method of compensation for full and passive almost ecological services is through negotiation and experience. The consumer (often an organisation representing a group of consumers) decides on compensation acceptable to him and attractive to the producers.

Theoretically, many problems must be solved and choices have to be made to assess the value of ecological services.

- Should the basis for assessment be potential benefit for consumers, or costs to producers? The same ecological service can be compensated either given its costs to the producer or according to the benefit consumers think they have. In each case the assessment would be different.
- If the chosen basis for assessment is the consumer‘s benefit, then the choice of a standard to measure the value of an ecological service is essential, and will determine its value.

(See discussion about the standards in I-C)

ENVIRONMENTAL GOODS VALUE…
$2.7 and $6.5 Million CDN/year are the estimated benefit provided by the 2,295,512 acres of PFRA community pastures to society through waterfowl hunting and carbon sequestration, respectively.

Figure 25: Environmental goods value

For example, lets look at a farming practice that protects soil from erosion. To compensate the farmer, the consumer of the service (let’s say society) needs to assess the ecological benefit (X) provided by this practice.

In this example, the indicator used to measure the benefit is the depth of the soil in centimeters, and the compensation rate is $1 per centimeter added in the soil above the standard at the end of the contract. At the beginning of the operation, the soil had a depth of 100 cm; at the end of the contract it reached 110 cm.

If the standard is the depth of the soil at the beginning of the contract then X = 10cm*$1=$10
If the standard is the average depth of soils in the area (95cm) then X = 15 cm*$1 = $15
If the standard is the native soil before the settlement (120cm) then X = 0 cm*$1=$0

In this example, the same ecological service, carrying the same cost for the producer, can be compensated at different amounts depending on the choice of the standard.

Question 3: Who compensates the provider?

- final consumers through the price of food?
- government by direct subsidies for farmers and ranchers?
- the ecosystem by improving its ability to produce in response to the environmentally friendly practices used to perform ecological services?

Of course, the most sustainable possibilities seem to be the first and last choices, but they probably take the longest to realise.

V STRATEGIC ACTIONS TO DEVELOP ECOLOGICAL SERVICES

In this last section, we present the strategy we favour for increasing the ecological services provided by farmers and ranchers, and propose as a tool for local development. Finally, we give an example of a project that applies this strategy, and that could be started quickly.

A. Strategic actions

According to the classification in IV-A, the best strategy would be to increase the number of full ecological services and positive externalities.

Moreover, given our analysis of environmental concerns in the watershed, it would be more efficient to concentrate first on the environmental concerns shared by both organisations and local residents: wildlife and habitats, water, and soils (see II-B)

B. Potential and conditions to develop this strategy

To maximize the positive externalities provided by agricultural practices, knowledge about agronomy and links between agriculture and environment is critical. Conferences for farmers or field trips with agronomic advisers could fulfill this need.

To increase the number of full ecological services, compensation, and therefore a demand, is needed. We have seen in part IV-A that the current potential customers were organisations (agencies, NGOs) involved in environmental conservation, and consumers. The Redberry Lake watershed has real potential to attract funding for land management programs, rather than for buying land. This potential can be divided in four groups of assets: the territory, the people, the Biosphere Reserve, and the agencies' interest.

1. *The territory*

- The closed watershed makes it easier to have an impact on water quality.
- There is still a significant amount of diverse wildlife habitats.
- The biodiversity is remarkable.
- The number of mixed farms is significant and allows a broader range of new agricultural practices.

2. *The people*

- There is increasing awareness of environmental problems. Farmers want a change and are becoming more conscious of the environmental problems. For example, many are frightened by chemical use. They consider the lack of education, information, and interest of consumers about their food and the way it is produced to be a problem.
- The three years of drought have made them think about different ways of farming to conserve moisture. They have also reduced chemical inputs.
- They already provide diversified ecological services, in a broad sense, in the area.
- There is a trend of installation of young farmers (III-A-2).

3. The Biosphere Reserve

- It is the first official designation in the area that recognises and encourages people to take action. The other designations (IBA, MBS) only have an interest in natural and ecological values (birds mostly).
- The biosphere reserve is based on three principles: conserving biological and cultural diversity, providing models of land management, and providing experimental sites for sustainable development. Biosphere reserves aim to enhance sustainable interactions between people and their environment. Moreover, agriculture is still the economic and social core of the watershed. As a result, agriculture is the pillar of the biosphere reserve. The ranchers and farmers have the power to maintain, improve, or destroy the watershed.
- The biosphere reserve is more than a symbolic designation that highlights one territory among the others. It also provides an opportunity to be clearly identified as an entity, and a potential partner for government or other agencies and consumers.

4. The agencies' interest

- Most of the organisations we have encountered stated that they would be interested in working (or doing more work) in the watershed, and they have proved this by helping us in our study.
- The drainage basin is a good size to be a "laboratory" for public policy experimentation in the agri-environmental field. It contains enough farmers and acres to be representative, yet is small enough for studies to be financially feasible and to enable the results of experiments to be seen within a reasonable amount of time.

5. Conditions that must be fulfilled to exploit this potential

Other factors that play a role:
- A significant number of farmers must be involved.
- Collective projects are necessary because ecological systems, especially in a closed watershed, are closely linked in a continuous web, individual actions are very significant, and because the agencies express an interest in working with groups of farmers as opposed to with individuals. This aspect is important both at the farmers' level and at the Rural Municipality level.

To reach potential customers and make them consumers of ecological services, it is necessary to take advantage of the Biosphere Reserve's image and the full ecological services provided through programs conducted by various agencies. This image must be converted into a marketable and reliable product. That would probably require a marketing and education plan to educate consumers about the ecological value of "made-in-the-Redberry Lake Biosphere Reserve" products. Unfortunately, this ideal consumer does not yet seem to exist, and this is probably a long term goal.

C. What can such a strategy offer farmers?

Based on the farmers' own observation that farming "cannot goes on like this," and the fact that farmers are looking for ways to improve their condition, it is clear that they will have to choose from a few different solutions.

In the search for new ways of farming, ecological services can represent a first step. Of course, they won't replace traditional production. They can, however, help solve some of the biggest problems, among which is the lack of understanding and respect from urban society, the first obstacle to the recognition of environmental costs of agricultural products. In Redberry Lake watershed, farmers are in a good position to choose to provide ecological services. Because they have avoided Intensive Livestock Operations (ILOs) in the watershed, they have a choice regarding their future farming practices. Furthermore, their current farming systems would not require breaks or complete changes, just some continuous soft modifications to increase the number of full ecological services and positive externalities they provide.

THE ILOs' COST IN FRANCE
$2 Billion CDN is the total cost of public investments in 58,000 farms to try to remove ILO generated nitrate from water

Figure 26: The ILOs' cost in France

Lastly, conservation organisations are moving away from their original strategy of buying and securing land to protect it. In this strategy, farming was considered a danger to the preservation of natural lands. Ecological services provide a good framework to support this change. The intention is to turn farming into a partner for nature conservation, and divert the money used to purchase land to help farmers manage their land in an environmentally friendly way. A good example of this new strategy is the use of livestock grazing to maintain native prairies in the watershed.

APPENDIXES

1 Example of standards (Canadian and Saskatchewan water quality guidelines)

2 Answers collected in the interviews

3 Topographic map

4 Land cover map

5 CLI classes map

APPENDIX 1

Examples of standards to assess ecological services: Canadian and Saskatchewan water quality guidelines[8]

Canadian Water Quality Guidelines

Parameter		Drinking Water	Aquatic Life	Recreation and Aesthetics	Irrigation Water	Livestock Water
Phosphate	Ortho-Phosphate	--	--	--	--	--
	Total Phosphate	--	--	--	--	--
Nitrate	Nitrite	3.2 ppm	0.06 ppm	--	--	10 ppm
	Ammonia	--	1.37 – 2.20 ppm	--	--	
	Nitrate	45 ppm	Concentrations that stimulate weed growth should be avoided	--	--	100 ppm (nitrate and nitrite concentration combined should not exceed 100 ppm)
Dissolved Oxygen		--	5.5 ppm	--	--	--
PH		6.5 – 8.5	6.5 – 9.0	5.0 – 9.0	--	--
Total Dissolved Solids		500 ppm	--	--	500 – 3500 ppm	3000 ppm
Turbidity		1 NTU	Not to increase more than 8 NTU above background	55 NTU	--	--
Bacteria	Fecal Coliforms	Not to exceed a count of 0/100mL	--	The average of at least 5 samples over 30 days should not exceed a count of 200/100mL	100/ml	--
	Total Coliforms	Not to exceed a count of 10/100mL	--	--	1000/100mL	--

[8] Keena N. 2002. The water quality of the Redberry Lake watershed, University of Saskatchewan thesis

Saskatchewan Water Quality Guidelines
(Saskatchewan Environment)

Parameter		General Surface Water	Aquatic Life	Contact Recreation	Irrigation Water	Livestock Water
Phosphate		Concentration should not be enough to encourage nuisance growth of algae or aquatic weeds (0.1 ppm)	--	--	--	--
Nitrate	**Ammonia**	Concentration should not be enough to encourage nuisance growth of algae or aquatic weeds	0.06 – 2.06 ppm, exact value depends on pH and temperature of water	--	--	--
Nitrate	**Nitrate + Nitrite**		--	--	--	100 ppm (nitrate and nitrite concen-tration combined should not exceed 100 ppm)
Dissolved Oxygen		5 ppm	5.0 ppm	--	--	--
PH		6.5 – 8.5	--	--	--	--
Total Dissolved Solids		--	--	--	700 ppm	1000 ppm
Turbidity		Not to increase more than 25 NTU above background	--	Secchi disc is visible to a depth of 1.2m	--	--
Total Suspended Solids		Not to increase more than 10 ppm above background	--	--	--	--
Bacteria	**Fecal Coliforms**	Not to exceed a count of 1000/100mL	--	Not to exceed a count of 200/100mL in more than 20% of samples taken in a 30 day period	100/100mL	--
Bacteria	**Total Coliforms**	Not to exceed a count of 5000/100mL	--	--	1000/100mL	--

APPENDIX 2

ANSWERS GIVEN FOR THE FOLLOWING QUESTIONS:

1. WHAT ARE THE MAIN ENVIRONMENTAL ISSUES IN THE REDBERRY WATERSHED?

Abandoned wells
Storage and handling of pesticide, herbicides, and fuels
Livestock relocation in sensitive areas
Clearing of native habitat, fragmentation of native ecosystems
Overgrazing
Chemicals linked with water
Chemicals
Water
Water disappearing
Lack of bush for moisture and wildlife
No problem
Cropped land that should not be farmed
Intensive Livestock Operations (ILO's)
Increasing salinity of Redberry Lake
Birds
Water quality and quantity
Diversity of habitats
Erosion
Manure
Too much cropland, lack of pasture
Bush destruction and consequent wind erosion
Lack of environmental education of farmers
Beavers
Wildlife

The answers are not prioritised. Several people may have given the same answer.

2. COULD YOU GIVE US YOUR OWN DEFINITION OF AN "ECOLOGICAL SERVICE?"

Most of the interviewed farmers and ranchers had no answer to this question.

Whatever society sets as a goal
Agricultural practice with benefit to the community other than just economical
Supplying land to government or organisations for wildlife
Carbon sinks
Elimination of chemicals
To manage land in a sustainable way
To practice mixed farming

3. WHAT DOES THE BIOSPHERE RESERVE REPRESENT FOR YOU?

POSITIVE ANSWERS	NEUTRAL OR NEGATIVE ANSWERS
Opportunity to educate farmers to the environment	Useless
Opportunity for a sustainable development	Only for pelicans and tourism
Interesting tool	No benefit for farmers
Opportunity for farmers to attract tourism	I don't know what it is
There is no regulation, only benefits	Way to freeze your land if they find an endangered species on it
	Since the creation two years ago, nothing has be done
	They should pay for water quality preservation

APPENDIX 3
(Image not available)

APPENDIX 4

(Image not available)

APPENDIX 5

(Image not available)

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