A Benefit Transfer Tool for Valuing Nature's Benefits to Society from ALUS Farmlands

Study undertaken for
Delta Waterfowl Foundation

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Executive summary

The study develops a tool that can generate sound estimates of the value of benefits to society arising from the restoration of ecosystems and habitats on working farmlands in Canada. Estimates of the monetary value of restoration project sites are an important step for ALUS (Alternative Land Use Services) to market its unique program approach and will support initiatives in terms of communication, funder engagement, project assessment and program efficiency, and in the marketing of unique products and services.

The tool uses the benefit transfer technique and represents a first attempt that will further be improved. It adapts corresponding values of ecological services already estimated for sites other than ALUS land, to the specific context of ALUS projects in the Norfolk and Vermilion River counties, based on three variables, namely net primary productivity (NPP), population density and scarcity of ecosystems.

The tool developed by ÉcoRessources Inc. is an innovative step toward the valuation of ecological benefits in Canada. Due to limitations of data and literature, it cannot capture the full extent of the benefits that can be envisioned in the project areas; however, it provides a conservative, first approximation of those benefits using state of the art approaches to benefit transfer that minimize bias and address issues of value aggregation.

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1. Context and objectives

The goal of this research is to develop a first approximation for a tool that can generate sound estimates of the value of benefits to society arising from the restoration of ecosystem and habitat types on working farmlands in Canada. First estimates of the monetary value of restoration project sites are an important step for ALUS (Alternative Land Use Services) in the marketing of its unique program approach and will support initiatives in terms of communication, funder engagement, project assessment and program efficiency, and in the marketing of unique products and services.

ALUS (Alternative Land Use Services) is a developing agricultural ecological goods and services initiative in Canada currently operating as a network of pilot projects and regular programs. With the exception of PEI, where ALUS services are delivered as a program of the provincial government, each ALUS project is implemented on a community basis and governed as a community collaborative effort, overseen by the Delta Waterfowl Foundation and/or a locally lead organization (i.e. legal entity).

ALUS has been testing the concept of payments for ecological goods and services in Canada on a pilot project basis since 2007. While the PEI ALUS program is delivered by the provincial government with both provincial and federal funding, a private foundation, the W. Garfield Weston Foundation, has funded other ALUS projects in Canada. The Foundation has funded the Norfolk ALUS project beyond the pilot phase, in addition to funding the expansion of ALUS through new pilot projects in Ontario and in the western provinces of Alberta, Manitoba and Saskatchewan (eight new communities in total over the 2012-2015 period).

To develop into a permanent program offering services to various market segments, ALUS must develop sustainable revenue streams by demonstrating value to a range of potential investors, communities, and customers, and by providing a feasible means by which investors, communities, and customers alike can pay for ecological services that they benefit from. ALUS will undertake development and marketing steps to achieve this end. It is toward this end that the tool developed by ÉcoRessources Inc. and this report describing the tool were commissioned.

The objectives of this work are, on the one hand, to develop a tool that estimates the economic values of suites of ecological services from five restoration project types by using accepted benefit transfer approaches, and, on the other hand, to prepare an accompanying technical report describing this tool. These restoration project types refer to wetland, streamside vegetation, grassland, savannah and forest restoration. Due to the lack of existing studies estimating the economic values associated with the restoration of savannahs, this ecosystem type could not be included within the scope of the tool at this stage.

2. The benefit transfer tool

2.1 Main challenges

In a context where the Delta Waterfowl Foundation needs to know the value of ecological services provided by each portion of land that is conserved under the Alternative Land Use Services (ALUS) program across Canada, a tool that estimates this value based on studies already realised for other sites may provide answers rapidly and with limited informational needs. Such a tool is based on the benefit transfer method, which allows adapting values estimated for other sites to the specific context of a given ALUS project.

The design of the tool faced four main challenges. First of all, it had to deal with the issue of **aggregation of the value of several ecological services** provided by the same unit of land. In particular, if the value of each ecological service is estimated through a different study, using different methods and in different contexts, the aggregation of the values is a complex issue and cannot be calculated simply as the sum of individual values because, generally, people associate decreasing values to additional ecological services. In order to resolve this issue, we looked for studies that estimate the value of a bundle of ecological services associated with an ecosystem.

Three such studies were identified, namely Pattison *et al.* (2011), Loomis *et al.* (2000) and Christie *et al*. (2011). Pattison *et al.* (2011) considers a bundle of five ecological services provided by wetlands (water quality, flood control, erosion control, wildlife habitat and carbon storage), Loomis *et al.* (2000) a bundle of three ecological services provided by streamside vegetation (water quality, erosion control and wildlife habitat) and Christie *et al*. (2011) a bundle of seven ecological services provided by grasslands and forests (wild food, non-food products, climate regulation, water regulation, sense of place, charismatic and non-charismatic species). No such study was found on savannahs.

The second challenge was to find **original studies at a county-level scale** as it is the scale that characterizes the ALUS program. Among the three original studies identified, one was undertaken at a county level, namely Loomis *et al*. 2000, which estimates the value of a conservation easement that touches four counties. The other two have a much larger scale, namely a provincial (Pattison *et al*. 2011) and a country-level scale (Christie *et al*. 2011). In a context where ALUS plans to increase the area of implementation of its projects, a higher scale is better than a lesser one as it eliminates the risk of overestimating the value of ecological services. Indeed, the value per acre estimated through a large scale valuation is generally smaller than the value per acre estimated through a small scale valuation because people's willingness to pay for ecological services decreases with each additional acre.

The third challenge was to find **studies undertaken in Canada** in order to keep the socio-economic and environmental contexts as close as possible to the one in the Vermilion River and Norfolk counties. Because there are few environmental economic valuation studies in Canada, a second best solution is to find studies in the United States or Western Europe. We found one study in Canada that estimates the value of a bundle of ecological services for an ecosystem that is targeted by ALUS (Pattison *et al*. (2011), in Manitoba) and one study in the United States (Loomis *et al.* (2000) in Colorado). Unfortunately, for forests and grasslands no original study was found in Canada or the United States that estimates the value of a bundle of ecological services.

The fourth challenge was to keep an equilibrium between the number of variables that are used to adjust the values provided in the original studies to the context of the Norfolk and Vermilion River counties and the need to have a **user-friendly tool** that is not too demanding in terms of data input and time consumption. Three categories of variables were identified as having an important influence on the value of ecological services, these are: 1) the intensity of ecosystem functions, 2) the socio-demographic characteristics and 3) the scarcity of the ecosystem.

As mentioned by Ingraham and Foster (2008), the intensity of ecosystem functions may be represented by the net primary productivity (NPP), which indicates the net carbon absorption rate by plants and which is correlated with the value of some ecosystem services in populated areas with similar demographics (as shown by Costanza *et al.* (1998)). They also mention that the value of ecosystem services also depends on socio-demographics and scarcity.

In order to keep the model as user-friendly as possible, only one indicator is used for each of the three categories. The intensity of ecosystem services is captured by the NPP, socio-demographic characteristics by population density and scarcity by the share of the ecosystem within the county.

2.2 How the tool works

The benefit transfer model is composed of three variables that adapt the original value to the specific context of the Norfolk and Vermilion River counties, namely 1) the NPP, 2) the population density and 3) the proportion in which an ecosystem is found in the overall county surface area. The first two variables have a linear impact on the original values. More precisely, the original value is multiplied by the ratio between the value of the variable in Norfolk or Vermilion River and its value at the original site (Manitoba, Colorado or UK).

The share of the ecosystem in the overall area has an indirect impact, namely through the model estimated by Borisova-Kidder (2006) for wetlands that captures the impact of scarcity on the value of wetlands. The ratio between the values estimated by this model for Norfolk or Vermilion River and for the original study is multiplied by the two other ratios and by the original value, as shown in the formula below. The result is the value associated to the Norfolk and Vermilion River ecosystems.

The main steps of the calculation are presented in the following paragraphs. They are similar for all ecosystems present on ALUS farmlands, namely grasslands, wetlands, streamside vegetation and forests. There are no specific computations for savannahs because we didn't find any original study that estimates the value of ecological services associated to this ecosystem in North-America or Europe. Because savannah characteristics are halfway between those of grasslands and forests, the value of savannah ecosystem services could be estimated as an average of the estimated values of grassland and forest services.

1) Estimation of the **value per acre** for the original site

Generally, studies estimating the value of ecological services provide a value per household because the methods that are used are based on surveys asking people how much they are willing to pay to conserve or enhance an ecosystem. In order to transform this value into a value per acre, some calculations are needed, as shown in the table below. The value per household is multiplied by the number of households in the region of the study and divided by the area of the ecosystem.

The user of the tool doesn't have to change anything at this step.

TABLE 1 : ESTIMATION OF THE VALUE PER ACRE (WETLANDS)

WTP for the retention of small pothole wetlands in Manitoba	A	269$/household/year
Number of households in Manitoba in 2011	B	466 138households
Area of pothole wetlands in Manitoba	C	1 044 102acres
Area of Southern Manitoba (hypothesis: 1/3 of Manitoba's area)	D	45 494 462acres
Value of the ecological services of wetlands (per acre)	E = A * B / C	**120**$/acre/year

2) Adaptation of the value based on the **NPP**

The value per acre obtained at step 1 is multiplied by the ratio between the NPP in Norfolk or Vermilion and the NPP of the original site, as shown in the table below. This means that a higher NPP increases the value of the ecosystem proportionately. This relationship is based on the finding that ecosystems with higher NPP generally provide enhanced ecological functions and was applied by Ingraham and Foster (1998) when they estimated the value of ecosystem services provided by the U.S. National Wildlife Refuge System.

If a region other than the Norfolk and Vermilion River counties is valued, the user of the tool should find the NPP value for the new region. If the region is located in North America, the study of Costanza *et al.* (2007) should be used as a source of data because it estimates the NPP using the same methodology for all the ecozones in North America.

TABLE 2 : IMPACT OF NPP ON THE VALUE OF WETLANDS

Vermilion River County		
NPP of the ecozone of Vermilion River County (Canadian Aspen Forests and Parklands)	F	380g C/m^2/year
NPP of the ecozone of Southern Manitoba (Northern Tall Grasslands)	G	289g C/m^2/year
Value of the ecological services of wetlands (per acre)	H = E * (F / G)	**158**$/acre/year
Norfolk County		
NPP of the ecozone of Norfolk County (Southern Great Lakes Forests)	I	354g C/m^2/year
NPP of the ecozone of Southern Manitoba (Northern Tall Grasslands)	J	289g C/m^2/year
Value of the ecological services of wetlands (per acre)	K = E * (I / J)	**147**$/acre/year

3) Adaptation of the value based on the **density of the population**

The value per acre obtained at step 2 is multiplied by the ratio between the density of the population in Norfolk or Vermilion and the density of the population in the original region, as shown in the table below. This means that a higher population density increases the value of the ecosystem in proportion. This relationship is based on the fact that the value of the ecosystem at a regional level is proportional to the number of households in the region. The density is used instead of the number of households because the area of the region of the original study could be much larger or much smaller than that of the Norfolk or Vermilion River counties.

If a region other than the Norfolk and Vermilion River counties is valued, the user of the tool should find the number of households and the area of the new region. This information is generally provided by census reports.

TABLE 3 : IMPACT OF POPULATION DENSITY ON THE VALUE OF WETLANDS

Vermilion River County		
Number of households in 2011	L	2 800households
Area of the county	M	1 363 570acres
Population density of the county	N = L / M	2households/1000 acres
Population density in Southern Manitoba	O = B / D	10households/1000 acres
Value of the ecological services of wetlands (per acre)	P = H * (N / O)	**32**$/acre/year
Norfolk County		
Number of households in 2011	Q	25 046households
Area of the county	R	397 246acres
Population density of the county	S = Q / R	63households/1000 acres
Population density in Southern Manitoba	T = B / D	10households/1000 acres
Value of the ecological services of wetlands (per acre)	U = K * (S / T)	**904**$/acre/year

4) Adaptation of the value based on the **share of the ecosystem**

The value per acre obtained at step 2 is multiplied by the ratio between the values for Norfolk or Vermilion River and the values for the original study as estimated by the Borisova-Kidder (2006) model, as shown in the table below. This model captures the impact of scarcity on the value of wetlands. The difference between the two values estimated with this model is due only to the difference in scarcity.

The Borisova-Kidder (2006) model is applied to all ecosystems even if it is specific to wetlands because, according to our knowledge, a model that captures scarcity doesn't exist for the other ecosystems. On the other hand, because only the relative change in the values estimated by this model is used in the benefit transfer tool, the specific values of wetlands don't influence the values estimated by the tool.

If a region other than Norfolk and Vermilion River counties is valued, the user of the tool should find the share of the ecosystem in the new region. This information is generally provided by geographic information system (GIS) data. In the case of streamside vegetation, a 5-mile buffer on each side of the river should be designated and the area of all polygons that have a different vegetation cover than annual crops and that are part of this buffer area should be calculated. This procedure follows the design of the conservation easement valued in the original study (Loomis et al. 2000).

TABLE 4 : IMPACT OF SCARCITY ON THE VALUE OF WETLANDS

Vermilion River County		
Share of wetlands in the county	V	0,04%
Share of wetlands in the Manitoba	W = C / D	2,3%
Change in value because of change in scarcity	X = See page "Share of wetlands", N38	113%
Value of the ecological services of wetlands (per acre)	Y = P + X	**36**$/acre/year
Norfolk County		
Share of wetlands in the county	Z	3,3%
Share of wetlands in the Manitoba	a = C / D	2,3%
Change in value because of change in scarcity	b = See page "Share of wetlands", I38	95%
Value of the ecological services of wetlands (per acre)	c = U + b	**857**$/acre/year

2.3 Assumptions and limitations

The design of the benefit transfer model is based on several assumptions and limitations, described as follows:

- The value of ALUS farmland is estimated based on the assumption that the ecosystem is fully functional and with respect to a situation where the ecosystem is completely destroyed;
- The NPP and the density of the population influence the value in a linear way;
- The model used to estimate the impact of scarcity on the value of ecosystems (Borisova-Kidder, 2006) is specific to wetlands but will also be used for the other ecosystems, considering the lack of such a model for the other ecosystems;
- Christie et al. (2011), the study used for estimating the value of grasslands and forests, provides values specific to improvements of ecosystems associated with the Biodiversity Action Plan (BAP). Because the present study estimates the value of a fully functional ecosystem, we had to add to this value the value of the ecosystem as they existed before the implementation of the BAP;
- Perennial crops and pastures were included into the category of grasslands because some of ALUS farmlands allow grazing. Christie et al. (2011), the study used for estimating the value of grasslands, uses the term "improved grasslands" to designate this type of grassland;
- The value estimated by Loomis et al. (2000) for streamside vegetation also includes the value associated to the effect of increasing the water flow in the river through the decrease of water

diversion to agriculture. Therefore, associating the whole value estimated by Loomis et al. (2000) to streamside vegetation areas, overestimates the value of this ecosystem.

2.4 Implications as a marketing tool

This tool is a primary step in ALUS' marketing strategy. ALUS has demonstrated an innovative farm community engagement model and generated increasing interest from farming communities across the country. This was made possible through funding from private foundations.

In order to identify investment opportunities for the private sector and launch unique products and services to a range of potential markets, ALUS must undertake comprehensive development and marketing steps to build on the strengths of its delivery approach.

The approach ALUS aims to market is designed both to cultivate nature's potential benefits to society that can be derived from farmlands, and to continuously verify the realization of those benefits in a transparent process. This developing verification model is the basis of the ALUS value proposition, and it includes five levels:

1. Community-engagement collaborative process: oversight, program delivery, and participation
2. Verification of project work on farmlands: third party verification
3. Measurement of the benefits: research, modeling and valuation
4. Use of the best applied science: continual improvement
5. Leadership in verification: provide leadership and create partnerships

Through this process, ALUS aims to market the full suite of benefits from ALUS projects by developing vehicles to match the demand (both private and public) for restoration with ALUS' offer of land restoration efforts. For example, the ecological services arising from ALUS farm projects can be marketed to meet the demand for a specific ecological service, habitat type, or mitigation requirement, such as may arise in sectors that are submitted to regulatory constraints for having negative impacts on specific habitat types or wetlands. The vehicle in this instance is a protocol or set of government regulations that ALUS can help comply with.

On the other hand, these ecological services can be marketed to a broader scale by offering the whole suite of ecological services provided by an acre of ALUS project land to the voluntary market. An example of this would be a voluntary credit for offsetting a personal or corporate environmental footprint. The set of services designed to match the supply of, and demand for ecological services from farmlands is designated by ALUS as an ecological credit. The credit can be seen as being based on a set of existing and developing protocols for ecological services with each unit of the credit corresponding to verifiable, additional and transparent data on ecological services originating from a given project.

The tool developed by ÉcoRessources Inc. will be used internally to compare the costs and benefits of ALUS projects in different contexts across Canada. As the model is tested for different cases, it can be compared with benefit transfer estimates from new studies made by other parties. In this way, the model can be extended to incorporate the most up-to-date estimates of the value of those ecological services that are relevant to ALUS, and, over time, it will generate better approximations of the value of ecological services provided to society by ALUS projects.

The ultimate purpose of the tool is to demonstrate value for investment. Demonstrating value to communities and new markets involves identifying the costs (i.e. outreach, project start-up, annual service payments) and valuating the benefits (e.g. value of carbon removed at project sites, estimated value of habitat for species at risk, etc.). While cost information is readily measurable, the economic value of benefits still lacks a reliable method for estimation.

3. Data used for valuation

Data used to estimate the economic value of the ecological services provided by ALUS farmlands come from four sources, namely i) original studies that estimate the value of ecological services provided by ecosystems similar to those found on ALUS farmland, ii) census data, iii) geographical data and iv) NPP values. The table below presents these sources for each of the four ecosystems.

The original studies that estimate the value of ecological services provided by ecosystems similar to those found on ALUS farmlands and which are used in this study are Pattison *et al.* (2011), Loomis *et al.* (2000) and Christie *et al.* (2011). The first of them estimates the value of wetlands in south Manitoba, the second one the value of streamside vegetation land in Colorado and the last one the value of grasslands and forests in the UK. They provide information on the value that households associate to ecological services, as well as other information useful in adapting these values to the Norfolk and Vermilion River counties.

The census and geographical data is useful when transforming the value per household into a value per acre. Census data is easily available at no cost through the Statistics Canada website. Geographical data is more difficult to obtain and manipulate but, fortunately, several free sources exist. Most of the geographical data for the Norfolk and Vermillion River counties was downloaded from the GeoBase portal, a geospatial data base for the Canadian territory. Files containing municipal boundaries data for the Vermillion River County were purchased from AltaLis Ltd, an Alberta-based enterprise. As for the U.S. data, geospatial data of the county boundaries was found on the official Colorado state web portal and hydrological and land cover shape files were downloaded at no cost from the Southwest Regional Gap Analysis Project (SWGAP) website.

NPP values for North American ecoregions are available in Costanza et al. (1997), as they are for the UK and five other countries in Krausmann *et al.* (2012).

TABLE 5 : SOURCES OF INFORMATION USED

Source	Information used
Specific to wetlands	
Pattison *et al.* (2011)	• WTP/household/year • Area of pothole wetlands in Manitoba
Specific to streamside vegetation	
Loomis *et al.* (2000)	• WTP/household/year • Area of the streamside vegetation cover that is valued • Number of households within the four Colorado counties that are covered by the streamside vegetation project
Wikipedia (2012a)	• Area of the four Colorado counties
State of Colorado (2012) (GIS data)	• Boundaries of the four Colorado counties
Southwest Regional Gap Analysis Project (2007) (GIS data)	• Area of streamside vegetation in the four Colorado counties
Specific to grasslands and forests	
Christie *et al.* (2011)	• WTP/household/year • Area of grasslands and forests in the UK • Number of households in the UK
Wikipedia (2012b)	• Area of the UK territory
Krausmann *et al.* (2012)	• NPP value for the UK
Common to all ecosystems	
Costanza *et al.* (2007)	• NPP values for the ecoregions of the two counties, of south Manitoba and of the four Colorado counties
Statistics Canada (2012)	• Number of households in Manitoba, Vermilion River county and Norfolk county • Areas of Manitoba, Vermilion River county and Norfolk county
Borisova-Kidder (2006)	• The meta-model is used for estimating the impact of scarcity on the value of wetlands, streamside vegetation, grasslands and forests
GeoBase portal (GIS data)	• Area of wetlands, streamside vegetation, grasslands and forests in the Norfolk and Vermilion River counties
AltaLis Ltd (GIS data)	• Administrative boundaries of the Vermillion River County

4. Valuation results for Norfolk and Vermilion River counties

The values of ecological services provided by the ALUS farmland projects in the two different counties show significant discrepancies. Indeed, the values in Norfolk County are 8 to 49 times higher than they are in Vermilion River and this is mainly due to the difference in population density, which is 31 times higher in Norfolk. When the values for Norfolk are less than 31 times higher, as is the case in forest areas, it is the scarcity that comes into play to scale down the discrepancy. The share of forest areas in Vermilion River is much smaller than in Norfolk (0.1 % of county area, compared to 25 %). Table 6 presents the values for the two counties and for four of the five ecosystems present on ALUS lands. The value for savannahs may be estimated as an average of forest and grassland values because savannah characteristics are a mixture of the characteristics of both.

The estimated values also vary across ecosystems. In Vermilion River they range from 1 $/acre/year for grasslands to 36 $/acre/year for wetlands and in Norfolk they vary from 37 $/acre/year for grasslands to 857 $/acre/year for wetlands. The values per territorial unit vary more than the values per household because they are influenced by additional factors, such as the area of the ecosystem and the density of the population.

TABLE 6 : VALUE OF ALUS FARMLAND IN NORFOLK AND VERMILION RIVER COUNTIES ($/ACRE/YEAR)

	Norfolk	Vermilion River	Original study
Wetlands	857	36	120 (Manitoba)
Streamside vegetation	134	2	236 (Colorado, US)
Grasslands	37	1	298 (UK)
Forests	42	6	793 (UK)

Compared to the estimates provided by the original studies used for the benefit transfer exercise, the values for Norfolk and Vermilion River are lower in the case of streamside vegetation, grasslands and forests because of either a lower population density or a lower scarcity. Population density in the UK is 7 times higher than in Norfolk County and 202 times higher than in Vermilion River County. As for Colorado, its population density is quite similar to the one found in Norfolk but 30 times higher than in Vermilion. Scarcity of streamside vegetation, forests and grasslands is also lower (more abundant ecosystems) than in the UK and Colorado.

In the case of wetlands, the estimated value is higher in Norfolk County (857 $/acre) than in the original study (120 $/acre) but lower in Vermilion County (36 $/acre). The variation is due to differences in population densities which are 30 times higher in Norfolk County and 5 times lower in Vermilion County. As for the other ecosystems, scarcity of wetlands in the two counties is lower (more abundant wetlands), which has a decreasing impact on the estimated value.

If the value per acre in the original sites differs from that in the Norfolk and Vermilion River counties, the value per household however remains constant. For example, in the case of forests, if a UK household is willing to pay 83 $/year to maintain ecological services of forests at their present level, the benefit transfer model considers that a household in Norfolk or Vermilion River counties has the same willingness to pay. Changes in the value per acre are influenced only by the differences in NPP, population density and scarcity of ecosystems.

Among the three variables that influence the value estimated with this model, population is the one that has the highest impact in the specific case of the two counties under investigation because population is the variable that varies the most. For example, there are 2 households per 1000 acres in Vermilion County, 63 households per 1000 acres in Norfolk County, 10 households per 1000 acres in southern Manitoba and 415 households per 1000 acres in the UK.

Scarcity comes second because, even if it varies significantly (from 0.04 % to 25 % in terms of a given region's area), its influence on the value follows a much less than proportional relationship. For example, in the case of forests, the proportion of the total surface area occupied by forests is 6 times smaller in the UK than in Norfolk but the decrease in value is only 3 times as large. Finally, the NPP has the least impact even if it entirely transfers the differences in values. This is because it doesn't vary much from one to another of the regions considered.

5. How to interpret the results

The estimated values of the four ecosystems represent the value of a bundle of ecological services, such as water quality, flood control, erosion control, wildlife habitat, and carbon storage. They capture one aspect of the total value of an ecosystem, namely its non-use value. Use values, such as the value associated to recreational activities (wildlife viewing, hunting, boating) or pollination services for agricultural production, are excluded from these estimated values.

The results are comparable to other estimates that capture non-use values for the same ecosystems. For example, Anielski and Wilson (2009) estimate the value of ecological services of the Canadian boreal forest at 21 $/acre/year (51.24 $/ha/year), while the estimates of the present study range between 42 $/acre in Norfolk County and 6 $/acre in Vermilion County. In the case of wetlands, Anielski and Wilson (2009) estimate the value of their ecological services at 481 $/acre/year (1,189 $/ha/year), while the present study estimates them at 857 $/acre in Norfolk and 36 $/acre in Vermilion County.

Compared to total economic values such as those estimated by Troy and Bagstaad (2009), the results of this study seem very low. There are two factors that can explain this difference:

- Values estimated by Troy and Bagstaad (2009) include use-values such as recreation and pollination services to agriculture, which are not accounted for in the present estimates;
- Values estimated by Troy and Bagstaad (2009) are the result of a summation of values estimated in separate studies, which induce double-counting problems (some ecological services being counted twice) and considers that people will give the same value to a service when it is estimated separately as they will when this service is associated to other services (which is not true because generally people have a decreasing willingness to pay for additional services)

6. Potential improvements and extensions

As the analysis of the results shows, the model is a great tool to analyse the variation in value across ecosystems and regions. At the same time, the model can be improved so that estimated values better reflect the socio-economic and environmental contexts of the Norfolk and Vermilion counties. Among the following proposed improvements, the first one is the most strongly recommended:

- The benefit transfer tool would be much improved if the original studies that were used to build the model had been realised at county level and in Canada. One study covering all ecosystems found on ALUS farmland and making use of experimental economics or contingent valuation methods would provide a solid basis for the benefit transfer tool. The precision of the estimations that the model provides would be much improved;
- More indicators could be added to each of the three categories of variables that are used to adjust the values of the original studies to the characteristics of the Norfolk and Vermilion River counties. For example, the income could also be part of the socio-demographic characteristics category in order to adjust the value per household, which is presently kept constant across the original study areas and the Norfolk and Vermilion cases;
- The application of the indicators on the original values could depart from a strictly linear relationship, if more information were available. The model used for the impact of scarcity on the value of wetlands is an example of a non-linear impact;
- The impact of scarcity on the value of grasslands, streamside vegetation and forests has so far been based on a model that is specific to wetlands. If such a model were developed for grasslands, streamside vegetation or forests, it should replace the one developed specifically for wetlands;

References

Anielski, M. and Wilson, S. (2005). *Counting Canada's Natural Capital: Assessing the Real Value of Canada's Boreal Ecosystems.* Prepared for Pembina Institute. Commissioned by the Canadian Boreal Initiative. Online at http://www.borealcanada.ca/documents/Boreal_Wealth_Report_Nov_2005.pdf

Borisova-Kidder, A. (2006). *Meta-analytical estimates of values of environmental services enhanced by government agricultural conservation programs.* Dissertation presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University. http ://www.ohiolink.edu/etd/send-pdf.cgi?osu1141755971

Christie, M., Hyde, T., Cooper, R. Fazey, I., Dennis, P., Warren, J., Colombo S. and Hanley, N. (2011). Economic Valuation of the Benefits of Ecosystem Services delivered by the UK Biodiversity Action Plan. Final report to the UK Department for Environment, Food and Rural Affairs (Defra). Online at http://users.aber.ac.uk/mec/Publications/Reports/Value%20UK%20BAP%20FINAL%20published%20report%20v2.pdf

Costanza, R., Fisher, B., Mulder, K., Liu, S. and Christopher T. (2007). Biodiversity and ecosystem services: A multi-scale empirical study of the relationship between species richness and net primary production. Ecological Economics, volume 61, pages 478 – 491.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R., Sutton, P., van den Belt, M. (1998). The value of ecosystem services: putting the issues in perspective. Ecological Economics, volume 25, pages 67–72.

Ingraham, M. W. and Foster, S. G. (1998). The value of ecosystem services provided by the U.S. National Wildlife Refuge System in the contiguous U.S. Ecological Economics, volume 67, pages 608-618.

Krausmann, F., Gingrich, S., Haberl H., Erb, K.-H., Musel, A., Kastner, T., Kohlheb, N., Niedertscheider, M. and Schwarzlmüller, E. Long-term trajectories of the human appropriation of net primary production: Lessons from six national case studies. Ecological Economics, volume 77, pages 129–138.

Loomis, J. Kent, P., Strange, L., Fausch, K. and Covich, A. (2000). Measuring the total economic value of restoring ecosystem services in an impaired river basin: results from a contingent valuation survey. Ecological Economics, volume 33, pages 103–117.

National Atlas of the United States. (2012). National Atlas Data Download. Online at http://nationalatlas.gov/atlasftp.html?openChapters=chpagri#chpagri

Pattison, J., Boxall, P. C. and Adamowicz, W. L. (2011). The Economic Benefits of Wetland Retention and Restoration in Manitoba. Canadian Journal of Agricultural Economics, volume 59, pages 223–244.

State of Colorado. (2012). Political boundaries. Online at http://www.colorado.gov/cs/Satellite?c=Page&childpagename=DOLA-Main%2FCBONLayout&cid=1251595720253&pagename=CBONWrapper

Statistics Canada. (2012). 2011 Census Profile. Online at http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/index.cfm?Lang=E

Troy, A. and Bagstad, K. (2009). Estimating Ecosystem Services in Southern Ontario. Prepared for the Ontario Ministry of Natural Resources. Online at http://www.mnr.gov.on.ca/stdprodconsume/groups/lr/@mnr/@lueps/documents/document/279512.pdf

Wikipedia. (2012a). List of counties in Colorado. Online at http://en.wikipedia.org/wiki/List_of_counties_in_Colorado

Wikipedia. (2012b). United Kingdom. Online at http://en.wikipedia.org/wiki/United_Kingdom