April 27, 2006

Valuating Wetland Benefits compared with Economic Benefits and Losses

Abstract:

The Study Board developed three options for regulating the Lake Ontario-St. Lawrence River System. Each of the three options provides overall economic and environmental benefits, but differs in its distribution of benefits and losses across the sectors and regions. The IJC must now decide between these three plans, something the Study Board did not have to do. No plan can create significant benefits to all sectors without some losses somewhere in the system. A key tradeoff that has emerged is between environmental gains and economic losses. The question facing the IJC as they consider each plan is, "how much economic loss is tolerable to achieve environmental gains?" To better understand the implications of this question, IJC staff asked for more information about the wetland services gained by the various regulation plans. A small team who had worked on the LOSLR study prepared this summary of:

1. *The scale of wetlands affected by a regulation plan (in terms of an estimated average annual acreage of meadow marsh and emergent marsh)*
2. *The nature of the benefits in terms of wetland services*
3. *An indication of the economic value of those benefits relative to the status quo*

This paper is meant to provide preliminary insights on wetland benefits. There is a high degree of uncertainty about the dollar values. Not every team member agreed with all sections of the evaluations. The paper does demonstrate that the wetland improvement estimates of the three candidate plans are conceptually sound and that Americans and Canadians have shown that they value these types of improvements.

1. Introduction:

The Study Board developed three options for regulating the Lake Ontario-St. Lawrence River system. The majority of the Study Board felt that each of the options is better on the whole than the current plan as administered. However, despite their best attempts, plan formulators were unable to develop a plan that was significantly better than 1958DD for all three of the Board's three key competing decision guidelines – to maximize net benefits; to support the ecological integrity of the system; and to minimize disproportionate losses to any sector or region. Each option tilts slightly towards one goal; Plan A+ has the largest net economic benefits, Plan B+ contributes most to the ecology integrity of the ecosystem, and Plan D+ has the smallest overall sectoral losses.

Given that the charge to the Study Board was to present a set of options, they were never forced to choose between the plans, something the IJC will be required to do in selecting one option. The Study Board left an explicit, understandable, objective basis for their consideration of disproportionate losses necessitated by the realization that losses (or a reduction in current benefits) could not be avoided, but that disproportionate losses could be (refer to Study Board final report – pg 56).The Study Board clearly rejected plans that maximized net economic benefits if they created significant losses to any one sector. So in terms of economics, the Board seemed content to accept fewer overall gains in favor for minimal losses with respect to the current level of benefits. This was not necessarily the case for environmental net benefits where many of the Study Board seemed intent on pursuing maximum environmental benefits, even if it meant some losses to other sectors in order to redress environmental losses as a result of the current regulation plan. But the Study Board left no clear guidance for trading environmental outcomes with economic outcomes which are presented as different metrics (dollars and ratios).

Early on in the study process, the Board rejected the idea of conducting an economic valuation of the environmental performance indicators because they were not convinced of its usefulness in the decision-making process. So the question remains, how much economic loss is tolerable to achieve environmental gains? The goal of this paper is to begin to construct a basis for IJC use that is meaningful, and consistent with the LOSLR Study. This effort does not reflect a thorough investigation, but rather is an initial attempt to collate some preliminary information on the value of wetland services to help inform the process.

There was a limit to what the Study Board would give up to restore the pre-regulation environment. The Board rejected Plan E (pre-project except for ice control regulation) as a candidate plan, because Plan E caused $16.36 net annual disbenefits, and created large annual Lake Ontario coastal ($28.5 million) and above dam boating ($5.31 million) losses. Figure 1 shows that Plan B+ would create almost 80% of Plan E's meadow marsh area after low water years, but at a much lower cost. Plan E increased Lake Ontario coastal living costs by about 33%, but Plan B+ increased them only about 3%.

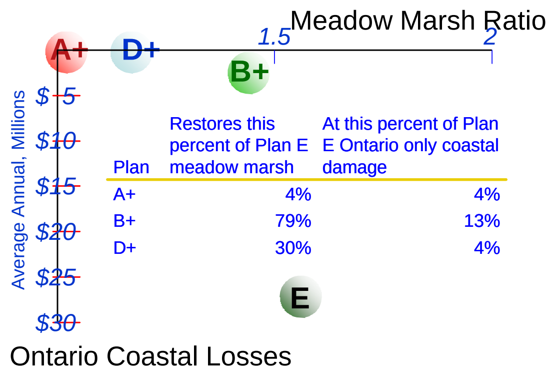


Figure 1: Meadow marsh gains (ratio) vs. Lake Ontario coastal losses (average annual $ millions)

While not apparent from the environmental performance indicator ratios, the Study Board's Environment Technical Work Group (ETWG) did explicitly estimate the scale and nature of the wetland improvements. Based on this analysis, Plan B+ does not create new wetlands, but it restores a more natural division of wetland areas. It does this by increasing the meadow and emergent marsh portions and the services they provide, which are the most valuable, by shifting cattail dominated zones downslope during low water supply years and thus increasing the transitional zone between uplands and submerged vegetation. Changes in area are dynamic for all plans because no plan completely controls water levels. But we estimate that in some years a third of the total Lake Ontario wetlands will become much more productive, adding to meadow marsh or emergent transition to meadow marsh. In an average year, the affected area will be about 2,500 hectares or over 6,200 acres.

Once the scale and nature of the services provided by wetland improvements can be identified, the value or importance of the improvements could be estimated. A post-study estimate of the economic benefits from these wetland changes is not likely to make the choice among the three plans more obvious, but it will provide one measure of the importance of the wetland improvements. There are economic studies that estimate **benefit** values in the range of $200-$500 per year per acre for the habitat services provided by wetlands, although there is substantial uncertainty associated with attempts to apply these estimates to Lake Ontario. Using these indicators of a single service, and allowing some value for the habitat provided now, without counting other possible benefits (such as recreation benefits) from improved wetlands, Plan B+ wetland improvements might produce between $0.6 and $3 million per year in annual benefits. A discussion on the current state of knowledge on wetland valuation is provided in section 4. A survey of the **costs**, services and areas of wetland projects built by the U.S. Army Corps of Engineers and Government of Canada is presented in section 5. This investigation shows an average annual cost per acre of about $2,900. At that rate, the cost to build the wetlands restored by Plan B+ would be about $18 million per year. There are caveats on both sides of this value; economists warn that these are costs, not benefits, and biologists warn that constructed wetlands are generally thought to be less valuable than natural wetlands.

Additional information is provided in the following sections:

2. Discussion points

a) There are much higher per acre values for wetlands in the literature, but they represent a wider array of services than we are claiming for the improvements of Plan B+, though in reality wetlands act as bundles of goods and related ecological services. A study by Ducks Unlimited in 2004 estimated an upper range of $17,712 per acre (2006 U.S. dollars). There may be benefits from Plan B+ that we have not demonstrated. Restoration of bird species might well provide recreational benefits (bird watching and hunting) and improvements in coastal fisheries could improve fishing along the coast and in deeper waters, since game fish feed on prey fish that depend on these marshes. Some of these benefits are more likely to accrue to the residents suffering shore protection damage. Bird watching in particular has a very high per acre value; $1,836 according to a study (Woodward and Wiu, 2001).

b) The importance of the economic valuation of environmental benefits depends to a large extent on the magnitude of the values assigned and on the weight given to the distribution of benefits.

If we assume that the environmental improvements provided by Plan B+ could be completely captured in an economic analysis (and some would dispute that) then the "complete capture" argument means the magnitude of the value assigned becomes extremely important. For example, in our preliminary analysis of economic studies (see Section 4), benefit values for wetlands were found to range from $200-$500 per year per acre for habitat services. The difference in this range could have an important influence on the decision as shown in Table 1 below.

Table 1: Example Table of Overall Net Economic Benefits

Candidate Plan	Net Economic Benefits	Acres meadow marsh gained	Wetland Net Benefits at **$200**/acres ($)	Net Benefits based on **$200**/acre ($)	Wetland Net Benefits at **$300**/acre ($)	Net Benefits based on **$300**/acre ($)	Wetland Net Benefits at **$500**/acre ($)	Net Benefits based on **$500**/acre ($)
Plan A+	$6.43	90	$0.02	$6.45	$0.03	$6.46	$0.05	$6.48
Plan B+	$4.63	6200	$1.24	$5.87	$1.86	$6.49	$3.10	$7.73
Plan D+	$4.48	800	$0.16	$4.64	$0.24	$4.72	$0.40	$4.88

In the first case using $200 per acre per year, Plan A+ is the clear economic winner. Using $300 per acre per year it becomes harder to distinguish between Plan A+ and B+, and in the third case, using $500 per acre per year, Plan B+ would appear to be the winner. So the importance of having very accurate economic valuation is clearly important.

But even if there was complete confidence in the economic valuation and the magnitude of the values, many would still argue that this table does not adequately reflect the tradeoffs because it does not address the distribution of the benefits and losses.

The two key tradeoffs between Plan B+ and the other plans are environmental gains versus coastal losses. Table 2 uses two measures of impact to coastal residents to show how the new plans shift the balance between the environment and coastal residents (both above and below the dam). Plan A+ returns 4% of the environmental benefits (measured by meadow marsh ratio) lost because of regulation, and takes away 0.4% of the protection benefits landowners gained with regulation, which decreases the current value of coastal living by less than half a percent (rounds to zero). Plan B+ returns 79% of pre-regulation environment, takes away 10% of the protection afforded under 1958DD, and reduces the value of coastal living by about 3%. Using the $300 per acre net value as an example, we could say that Plan A+ restores environmental value worth $30,000 per year at a cost of $100,000 (B/C = 0.3) while Plan B+ restores value of $1.86 million at a cost of $2.84 million (B/C = 0.65) and Plan D+ restores $240,000 per acre at a cost of $100,000 (B/C = 2.4). Based on an incremental loss analysis, Plan A+ is inferior to Plan D+ (since D+ provides more wetland value at the same loss), but B+ is the only way to "buy" a substantial improvement to wetlands.

Table 2: The costs of readjusting the balance between wetlands and coastal structures

Candidate Plan	% Meadow Marsh after low water years restored relative to Plan E	Coastal Losses ($ million U.S.)	% of (total) Coastal losses relative to Plan E*	Coastal "Disproportionate loss %" (Table 7, Board Report)*
Plan A+	4%	-$0.10	0.4%	0%
Plan B+	79%	-$2.84	10%	-3%
Plan D+	30%	-$0.10	0%	0%

* - estimates on page 1 were given in terms of just Lake Ontario coastal costs, this table considers all coastal losses upstream and downstream.

So while the economic valuation certainly helps to inform the process, and a number of those involved in developing this paper feel that a more thorough investigation beyond what is possible in this paper is warranted, it will not necessarily help provide a definitive answer.

c) The timing of these benefits might be important, but these economic estimates do not reflect timing. Plan B+ would probably help the environment soon after it was implemented by flooding more wetlands during the spring breeding and nesting period, but the signature benefit, which is the replacement of cattails stands with more diverse meadow and emergent vegetation, will not happen until the region experiences a relatively rare four year dry period. That might not happen for decades or it could start next year, so discounting the economic benefits from these services becomes problematic. We took unprecedented efforts to calculate the expected coastal damages in each year after implementation. We could do somewhat the same thing with wetland benefits.

d) We are not sure how to interpret per acre importance on this scale. One argument might be that costs per acre taken from small projects don't apply because we may not want to buy this large an improvement at that rate (even if I will pay $1 for a loaf of bread doesn't mean I'll pay $500 for 500 loaves). On the other hand, it may be that to restore birds at risk large projects are much more effective (I may not pay 1 cent for one piece of M&M candy, but I'll pay 50 cents for a bag full of 50 M&Ms). So scale effects in production, consumption, and ecosystem services can go both ways.

3. Scale and nature of the impact

Regulation plans significantly influence the watering and dewatering cycle for coastal wetlands. The banks of Lake Ontario prove that the types of plants found at any given elevation are strongly correlated to how recently that elevation has been flooded or left dry. This relationship has never been challenged by any wetland scientist. The NAS/RSC criticisms were aimed at the assumptions used in the quantification of the impact, and those are addressed later in this section.

Cattails grow near the waters edge because they can survive for only a few years under drier soil conditions. Historic aerial photos show that since regulation began, cattails have slowly spread up the bank, replacing the natural variety of meadow marsh plants found at higher elevations. The reason is clear; regulation improves the odds that cattails moving into the higher bank will get the water deliveries they need. We believe that more than half of Lake Ontario's meadow marsh wetland area has been displaced by cattail-dominated emergent marsh since the mid 1960s. At many study sites, the loss in area of meadow marsh vegetation since the 1960s exceeds 80%.

The more natural water level variation of Plan B+ will partially restore the dynamic diversity of Lake Ontario wetlands by adding low lake-level years when supplies are low, thus increasing the area of meadow marsh and by expanding the transition between meadow and emergent, pushing cattails back down the bank. Figure 2 shows 1958DD meadow marsh (green line) and transition to meadow marsh area (blue line) superimposed on a graph of B+ wetland areas.

There is no inarguable formula for estimating the area of wetland "restored" but a simple approach would be to credit the exchange from upland, cattail and submerged to meadow marsh and the emergent transition to meadow marsh areas. This is the area between the blue area and blue line and the dark green area and dark green line in Figure 2. For Plan B+ this amounts to an average annual value of 2,800 hectares or roughly 6,800 acres. As the NAS/RSC pointed out, the 32 wetlands may not be representative of all wetland areas, and areas affected by pollution or development may not respond as well. Our study wetland experts believe that about 90% of all Lake Ontario wetlands will respond like the sample wetlands, which would reduce the area improved by Plan B+ to 2,500 hectares or about 6,200 acres.

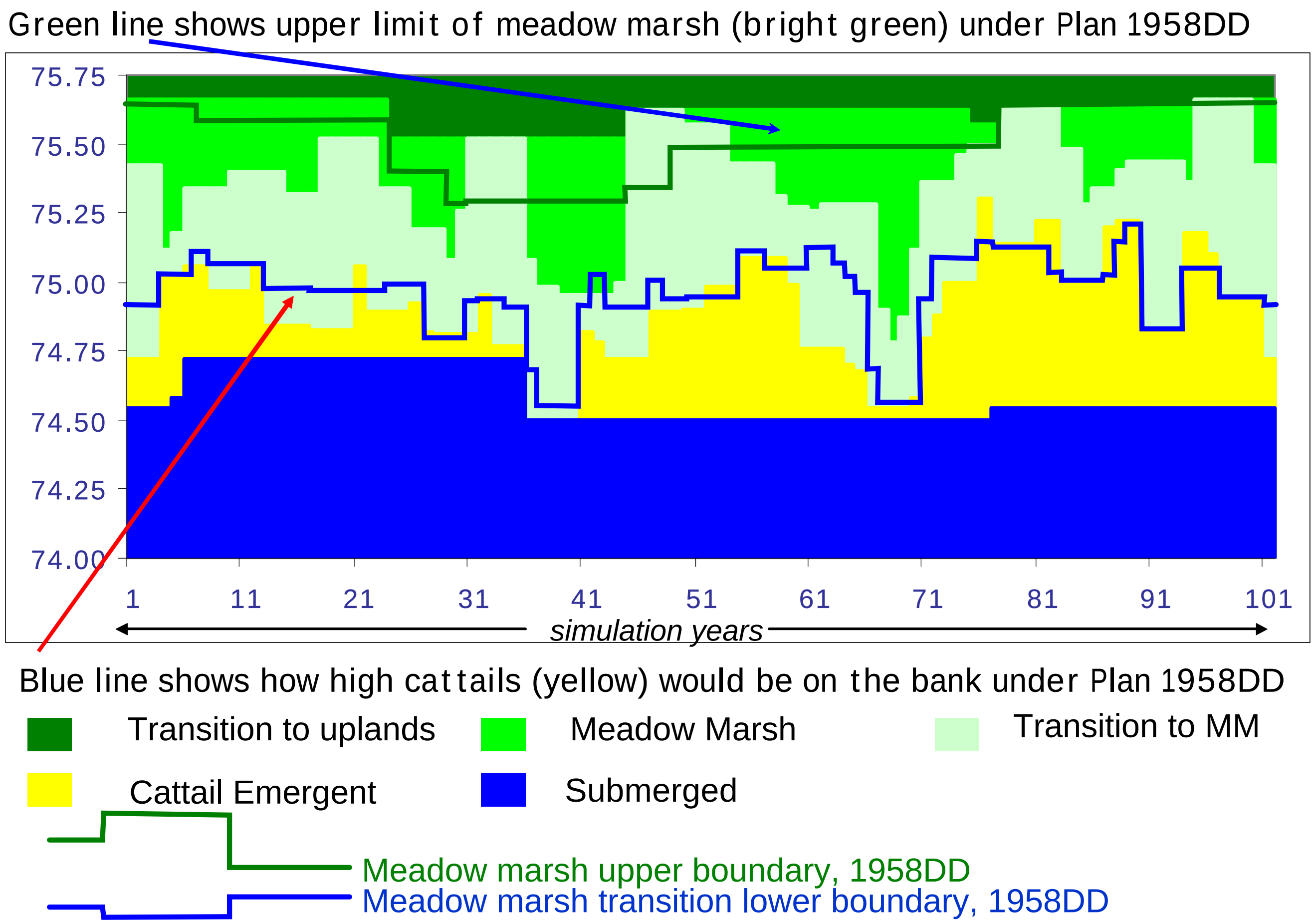


Figure 2 – Plan B+ Historic Simulation Wetland Zones

These are average annual areas. More natural regulation does not cause a migration to a new, but static division of wetlands. The area of Lake Ontario meadow marsh will change over the years with any plan because the range of water supplies will create high and low water years and wetland zonation is driven by water levels. In fact, the division of wetlands is much more dynamic without regulation, and Plan B+ will restore some of that variation. The standard deviation of the annual areas is a measure of variability. Figure 3 shows the standard deviation in the annual areas associated with each wetland type below for plans 1958DD, Plan B+, and Plan E. The standard deviation distills what would be a remarkable physical difference under each of the three plans.

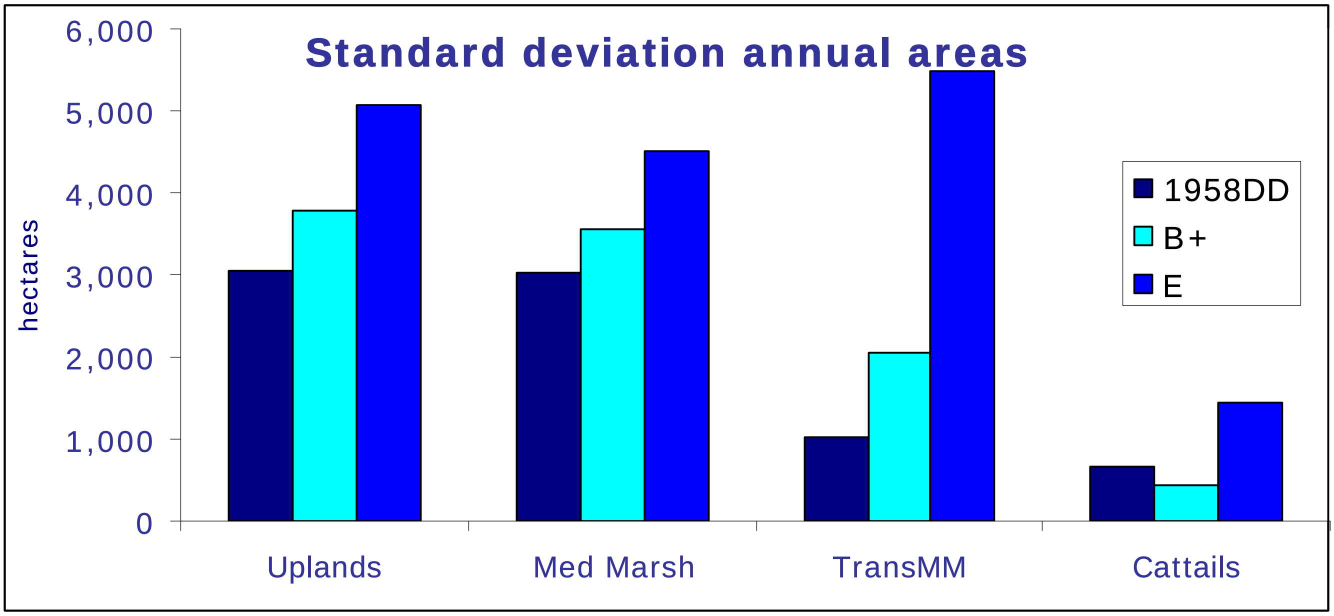


Figure 3: The standard deviation in the annual areas associated with each wetland type for Plans 1958DD, Plan B+ and Plan E.

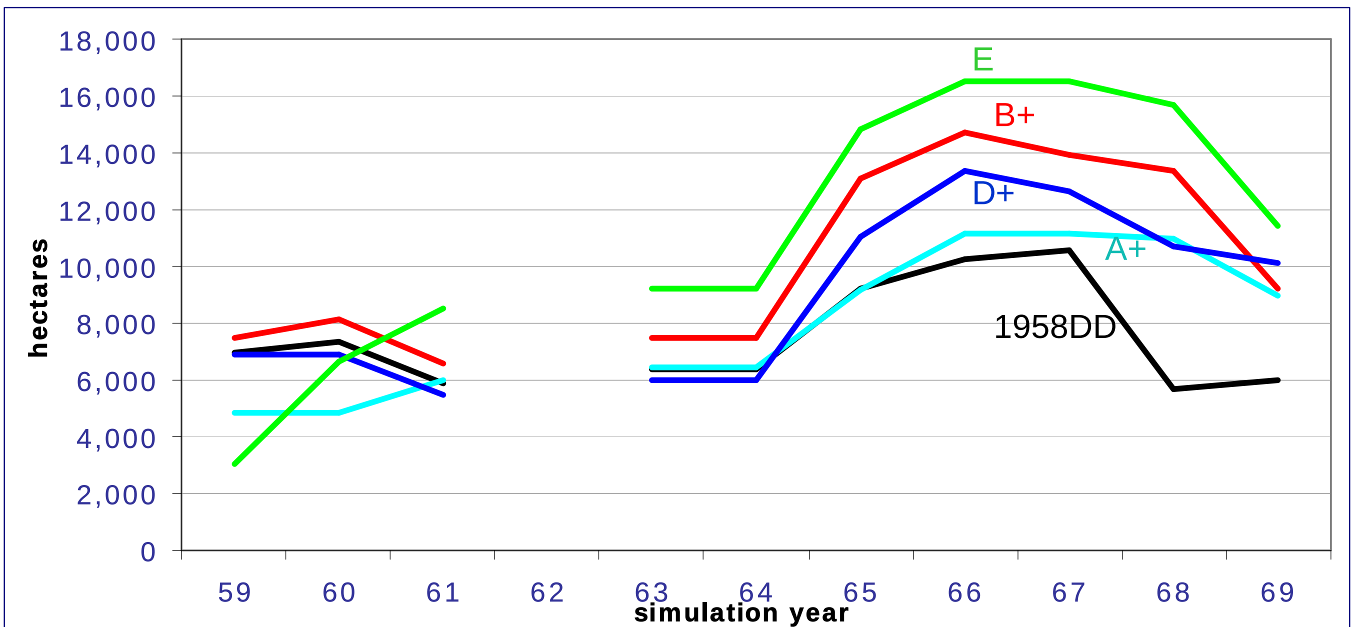


Figure 4 – Meadow marsh area after low water years, five plans (IERM results)

We know a more diverse environment will better resist impacts from environmental threats in the Great Lakes, such as toxins and invasive species (Tilman and Downing, 1987; Schindler, 1998). There is proof of this in our performance indicators (see Table 3, below) for Black Tern, King Rail and Virginia Rail. Two of these three bird populations are considered at risk by both Ontario and New York State and all three represent habitat preferences for many other species. All of these species are expected to improve under Plan B+. The model for the net productivity of Northern Pike on the Upper St. Lawrence River also shows a substantial improvement over Plan 1958DD both because of the wetlands providing better habitat and the water level variations from quarter month to quarter month being substantially smaller.

Table 3. PI's affected by wetland changes above the dam

	A+	B+	D+	E	PI
Least Bittern *	0.88	1.04	0.95	1.13	Reproductive index
Virginia Rail	0.96	1.11	0.99	1.15	Reproductive index
Black Tern *	1.03	1.12	1.01	1.16	Reproductive index
Yellow Rail *	0.96	1.01	0.98	1.01	Preferred breeding habitat
King Rail *	1.05	1.1	1.03	1.27	Preferred breeding habitat
Northern Pike **	1.05	1.03	1.01	1.06	YOY Recruitment
Northern Pike **	4.02	2.08	1.17	4.08	YOY Net Productivity

* - specie at risk
** - based on two studies using different methods, one by Minns and Doka, the second by Farrell, Mead and Murray. The Farrell study includes a measurement of survival of one year old fish (hence "net" productivity) and is calibrated and validated with a portion of the field data used to develop the PI algorithm. The Minns study measures the number of new fish born each year. Both produce the same plan rankings, and indicate that higher Spring water levels are even more important than wetland changes (hence the good score for Plan A+)

The wetland performance indicator is a ratio; it scales the improvement and clearly shows that under Plan B+ or Plan E, the wetlands will become more like they used to be – but it begs the question, "why is that good?" The species at risk indicators help to answer that question but they are not as definitive as the wetland indicator because our studies could establish only part of the influence on the populations of these species - we didn't measure predation or competition with other species – so we can say these species will have a better chance under Plan B+ or E, but we can't prove those plans will allow the populations to recover.

Statistics on plans:

Table 4. Simulated areas of meadow marsh and emergent transition to meadow marsh, corrected for 90% effectiveness, in acres, relative to Plan 1958DD.

Plan	Best Year	Average Year	Worst Year	Avg. After Low Water Years	Depinto Index	Meadow Marsh Ratio
A+	10,485	89	-14,358	3,700	1.06	1.02
B+	17,283	6,152	-7,119	10,063	1.35	1.44
D+	11,113	760	-9,677	4,031	1.10	1.17
E	24,041	5,375	-23,053	15,782	4.04	1.56

Statistics on wetlands

Figure 5 – Counties and reaches in the wetland database

Wetland studies were done at 32 of the nearly 900 wetland sites identified in the Lake Ontario - Upper St. Lawrence Coastal Wetland Database, which was developed as part of the LOSLR study. Sampling was done at wetlands that cover more than 10 thousand acres, while the total area of coastal wetlands above the dam totals over 80 thousand acres. About 60% of the wetlands are on the Canadian side, and while no mapping exists by county, the similarity between the reaches used to group wetlands and county shorelines (Figure 5) allows an estimate of the approximate wetland areas on each county's coast. The National Academy of Science review committee asked what percentage of randomly selected sample sites would have included wetlands compromised by development or pollution (and thus not as responsive to water level changes). The ratio to Plan 1958DD we reported as a performance indicator was not affected by this argument, but it is relevant if we try to estimate economic benefits based on acres affected. Joel Ingram, a wetland scientist working on the LOSLR study, estimates that 90% of the wetlands would respond as the sample sites did, and we used that percentage to calculate the average areas used in the economic analysis.

Table 5. Wetland area by county

Geographic place	Percent	Acres
Niagara-Orleans	1%	700
Monroe	5%	4,300
Wayne	0%	<100
Cayuga	8%	6,100
Oswego	1%	800
Jefferson	14%	11,000
Frontenac-Addington	5%	4,400
Hastings†	37%	30,000
N. Umberland	1%	1,000
Durham	3%	2,700
Toronto	0%	<100
Peel-Halston	0%	200
Hamilton	1%	700
Niagara	1%	600
River	23%	18,600
Total wetland area		80,700

† *The Hastings total includes Prince Edward wetlands.*

The areas of different wetland zones (uplands wetlands, meadow marsh, emergent transition to meadow marsh, cattail dominated emergent and submerged) simulated for each plan using historic water supplies are shown on the following two pages. The vertical extent modeled ranges from 73.0 to 75.75 meters (the 100 year high and low annual peak levels under Plan 1958DD are 75.61 m and 74.56 m), the range for which area-elevation curves were developed during sampling. Note that about 45% of the 80,700 acres of wetlands are submerged and this portion is reduced only during long droughts. During very wet periods, the upland wetlands will probably extend above 75.75 m, increasing the total area of wetlands, but that increase is not measured in our modeling. Note also that meadow marsh exists at 75.75 m under Plan E for much of the century (the ten year flood elevation for Plan E is 75.83 m), which suggests that there would be upland wetlands above 75.75 m during those periods.

Plan Simulations

Figures 6 through 10 below show plan results in terms of area of wetland by type over the 101 year historic supply simulation. It is clear from these figures that the wetlands zones are constantly in flux. What differs is the range in the transitional zones between upland vegetation and submerged vegetation. The greater the range in the transitional zone, the better the plan in terms of wetland habitat.

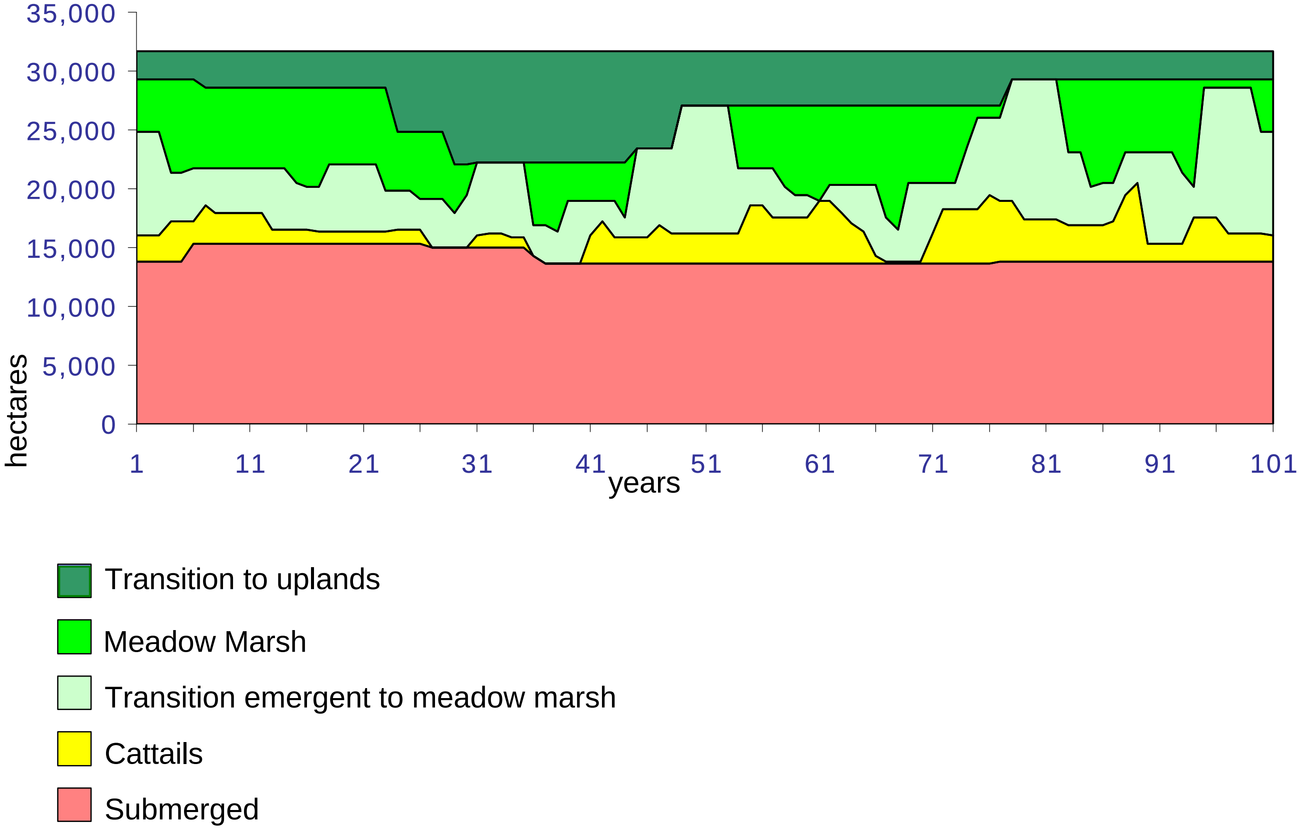


Figure 6 – Plan 1958DD, areas of wetland by type, historic 101 year simulation

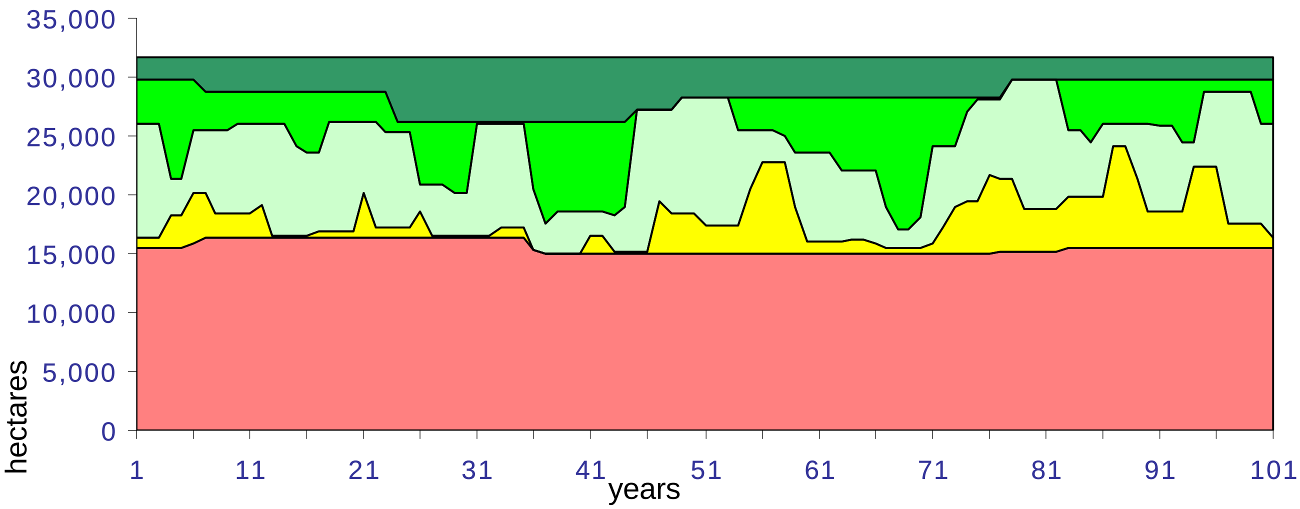


Figure 7 – Plan A+, areas of wetland by type, historic 101 year simulation

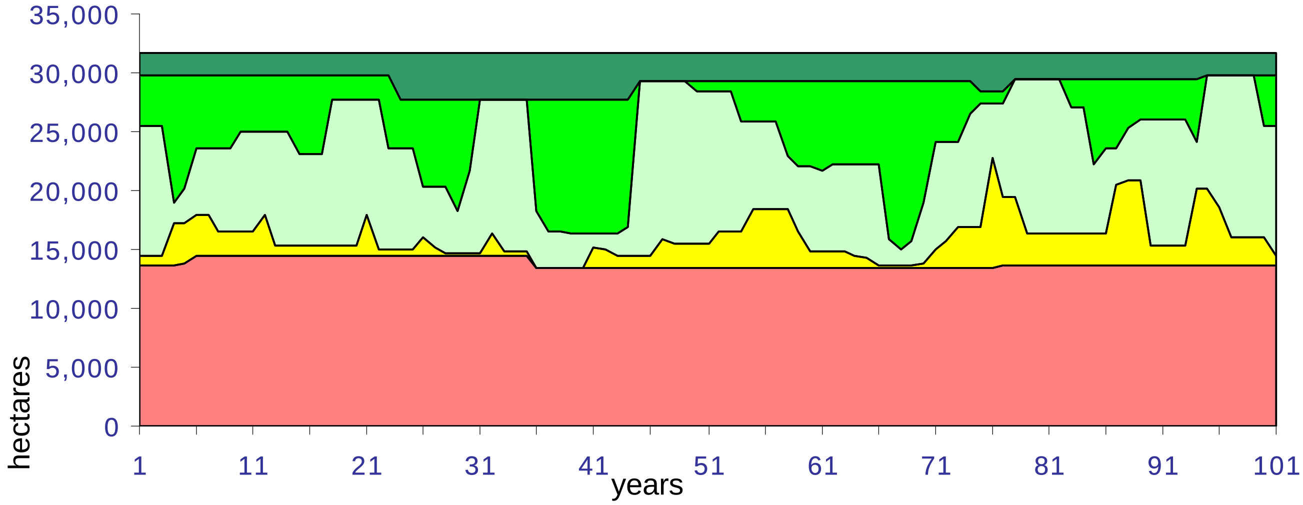


Figure 8 – Plan B+, areas of wetland by type, historic 101 year simulation

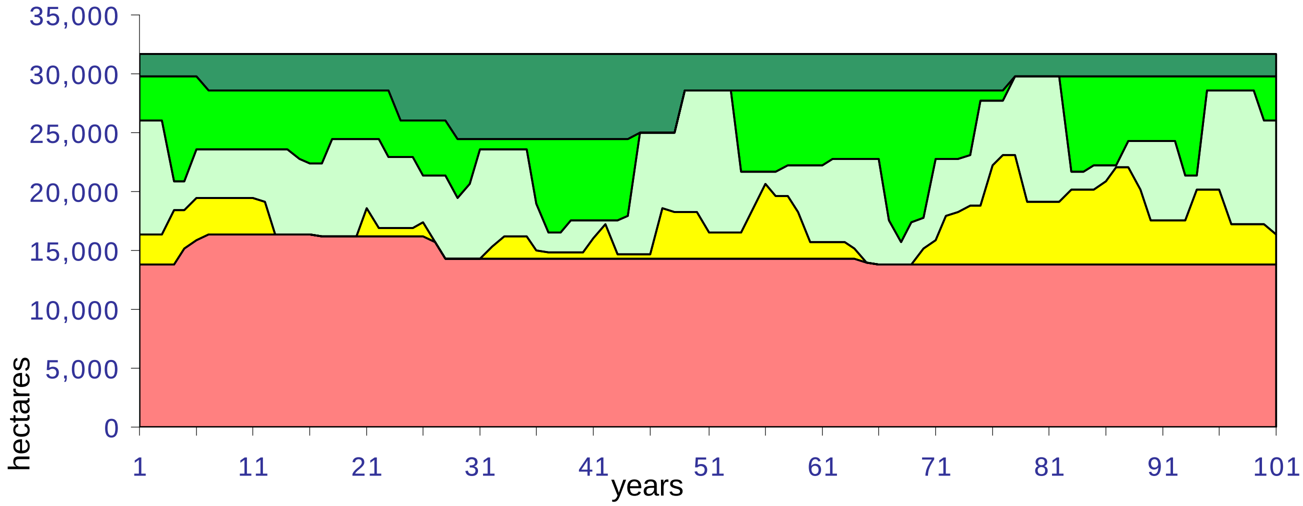


Figure 9 – Plan D+, areas of wetland by type, historic 101 year simulation

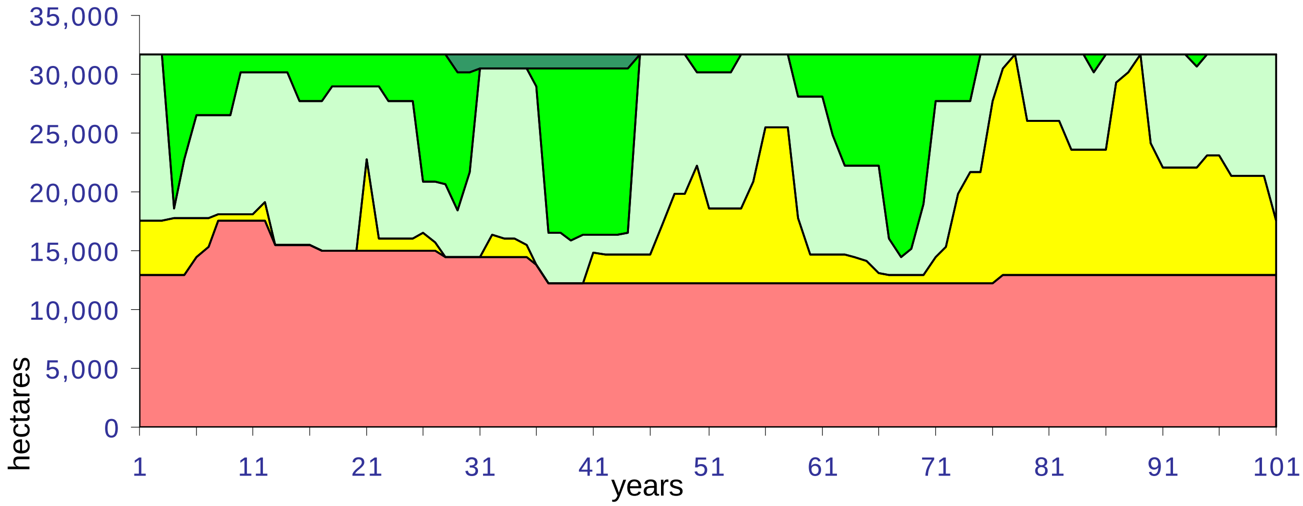


Figure 10 – Plan E, areas of wetland by type, historic 101 year simulation

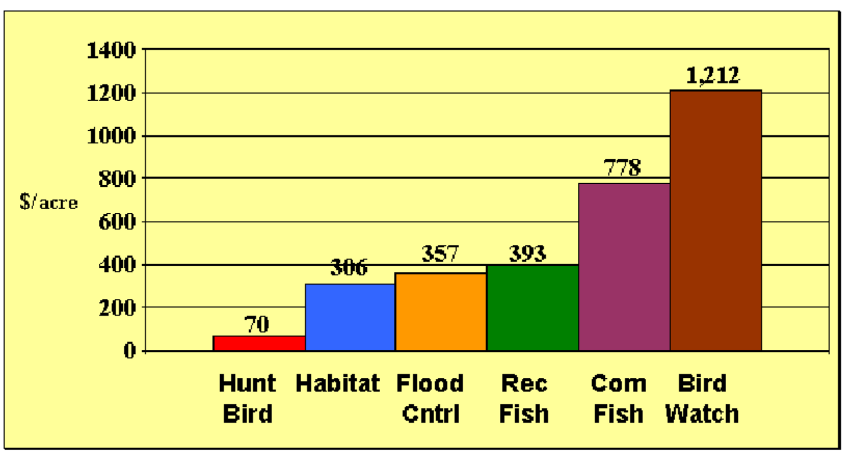
4. Valuation of wetland services:

Do Changes in Wetland Habitat Services have Economics Value?

It is well established in the literature that wetlands provide services to humans and have economic values not captured in the market (Agardy 2005). Moreover, it is well established that the habitat wetlands provide are a key and valuable service (Agardy 2005). These non-market economic values are real, and they are conceptually valid for use in comparing the costs and benefits of policies affecting wetlands.

In the Lake Ontario regulation plans, the quantity of wetlands is not hypothesized to change with Plan B+, but the habitat services are expected to improve. There are studies of the economic value of such services that we can draw upon. Perhaps the most widely cited example of wetland services values is the meta-analysis of Woodward and Wiu (2001). The authors examined numerous wetland valuation studies and determined mean values by service types as well as values per acre (see figure 11). As outlined below, there are numerous other types of evidence that strongly support the notion that there can be significant economic values associated with improvements in habitat. Clearly then, the quality of wetland habitat matters to the general public. Never-the-less, putting reliable dollar values on wetland habitat services remains challenging, especially if one must rely on transferring values for existing studies.

Figure **11** Value of Wetland Services



Woodward and Wui, 2001

Making generalizations about wetland values is difficult because wetlands are not a homogeneous commodity. Different types of wetland provide very different services. Similarly, where a wetland is located in relation to people will affect its value. Moreover the demographic characteristics and tastes of the people whose values are being measured will affect wetland values. Consequently, and in contrast to some types of non-market values, the wetland values per acre reported in the literature vary widely (Woodward and Wiu 2001, Kazmierczak 2001a,b).

High variability limits the confidence that can be placed in any attempt to transfer values from one study context to another area. This differs from other types of resources for which benefit transfers are often performed. For example, even though recreation values per day of activity vary across recreation studies, across activities and across locations, there remains a fair amount of consistency in these values and many practitioners are comfortable using these values in a benefit transfer to establish reasonable ranges for recreational values (Rosenberger and Loomis 2001; Hoehn 2005). While it may seem that converting wetland values to a common unit (e.g., $/acres or $/acre/service type) would reduce the variation in values, substantial variation remains in these numbers even after such transformations. In part this may be due to the fact that there is no natural numeraire for converting ecosystem services to values (Hoehn 2005) as there is for recreation values which can be compared on a per day basis.

Evidence that Habitat Provided by Wetlands has Economic Value

Improved habitat associated with Plan B+ might be expected to contribute in some ways to recreation activities such as wildlife viewing and to fishing and hunting. Looking across recreation studies, Rosenberger and Loomis (2001) show that for the Northeastern US region that includes Lake Ontario, average recreation values per day of activity are about $26 for wildlife viewing, $32 for waterfowl hunting, and $36 for small game hunting. Similarly, for improvements to threatened or endangered species, the literature suggests there are significant values associated with protection and enhancement of endangered species (Loomis and White, 1996).

Wetland services related to and including habitat are valuable. Woodward and Wui (2001) conducted the above mentioned meta-analysis to estimate the value of wetland services. The estimated values of services per wetland acre are shown in Figure 11. The estimates indicate that consumptive services such as bird hunting (Hunt Bird), commercial fishing (Com Fish), and recreational fishing (Rec Fish) created significant derived demand for wetland protection. Non-consumptive services were also highly valued (Habitat, Flood Cntrl, and Bird Watch). For example, bird watching (Bird Watch), for instance, had the highest value per acre of all the wetland services examined in the study. (See also Table 6 for these values in current dollars).

Kazmierczak (2001a,b) provides a thorough review of wetland valuation studies linking them, where possible, to the portions associated with habitat and fish/wildlife recreation services. In most cases, these later services amount to a small fraction of the total ecosystem services provided by the wetlands. In the case of Plan B+, it is this net change in services that must be measured. Since the total acreage of wetlands does not change across plans, the total value is not relevant for comparing plans. Thus, the information in Kazmierczak suggests it would be inappropriate to transfer total values when only some of the ecosystem services are changing, and for habitat and recreation services these can be a relatively small part of the total values that are reported in the literature.

Costanza et al (1997) provide a well known example of benefits transfer in which wetland values play a key role. The breakdown of values from the Costanza study also support the finding of Kazmierczak that the habitat & recreation services are likely a comparatively small part of the total value (see Table 6).

In a recent application of benefits transfer not covered by the above studies, Breunig (2003b, p44) reported that, using benefits transfer data based on 16 studies, the total value of all ecosystem services from Massachusetts freshwater wetlands was assessed to be $15,452.30/acre (2001 dollars). Note that this is for the total value and no breakdown by services is provided.

Evidence in support of the notion that habitat matters to people is also found in Hoehn et al (2003) who conducted focus groups with randomly chosen members of the general public to discuss wetland services. This inquiry revealed a general public understanding of habitat services and revealed habitat to be as important as flood control services. In the context of considering trade-offs between wetland mitigation projects, habitat-based services of wetland have a clear affect on the amount of additional acreage a mitigation project must provide to compensate people for the loss of a wetland. Here lower quality habitat significantly increases the acreage demanded by the public as compensation for loss (Lupi et al, 2002; Hoehn et al, 2004). While these findings support the notion that habitat quality matters to people, they do not provide guidance as to the fraction of the total value of wetlands that is accounted for by habitat services.

Few studies are specific to Great Lakes coastal wetlands. One recent exception is the survey-based investigations of Lupi et al (2004) and Arreola (2006). In Lupi et al (2004) a mail survey elicited public preferences for alternative wetland programs that would “restore and preserve” Michigan’s coastal wetlands. The study used stated choice approaches to identify trade-offs the public was willing to make between attributes of alternative programs, and the results indicated that programs focusing on biodiversity and on water quality/flood control were most preferred by respondents when compared to other services such as providing open-space. This finding adds evidence to the importance of biodiversity services of wetlands.

In a follow-up to the Lupi et al (2005) survey, Arreola analyzed contingent valuation information from the same surveys. The mean value per household was $163 for the programs to protect and preserve Michigan’s coastal Great Lakes wetlands. Extrapolating this value to the statewide population and dividing by the acres in the proposed program yields an implied present value per acre of $19,110 in 2006 dollars. Converting this to an annualized flow of benefits at 5% yields $955.50 per acre per year for the willingness to pay for preservation and restoration of coastal wetland services. However, when queried about how certain they were about their answer, fewer than half of the survey respondents who had indicated they would vote yes to pay, indicated they would “definitely vote for it.” Thus, caution is warranted in interpreting these results.

Hushak (2001) performed a benefit transfer for wetlands in Saginaw Bay, Michigan using the results of de Zoysa (1995). The main finding is that the benefit transfer results vary tremendously depending on the assumptions made about the relevant population of people willing to pay for the wetland services and the method used to translate per acre values to the program being evaluated.

Relation with Plan B+

As a summary, Table 6 reviews total values for wetland ecosystem services and also provides some evidence of how these values vary by services. It seems likely that the portion of wetland total values per acre that can be attributed to changes induced by Plan B+ will constitute a modest portion of the total value of wetlands. Never the less, there are demonstrated economic values for these habitat services. Given the broad range of value estimates, it is not recommended that benefits transfer be used to quantify the economic benefits of Plan B+ at this point.

What steps would be needed to develop a more accurate indication of the value of the wetland improvements provided by Plan B+? As a start, it would be useful to know what happens to the full array of ecosystem services provided by wetlands under alternative regulation plans. While this is a tall order, better information linking plans to services known to be valued by people would help. For example, how do birdwatchng opportunities change; how is waterfowl hunting affected; what happens to recreational fishing quality? If these recreational service changes were articulated they could be reasonably valued using benefits transfer based on the large body of recreation valuation studies in the literature. Regardless, clear information about what wetland ecosystem services are likely to change with regulation plans is a necessary precursor to improved environmental valuation of these changes. Finally, primary valuation studies that are specific to the human populations and resources of interest are preferred to reliance on benefits transfers such as the ones discussed in Table 6.

Table 6: Summary of Freshwater Wetland Valuation Studies

Study	**Services**	**Reported Values In Acres/ Yr.** (Converted to 2006 $US)
Woodword and Wiu*	Flood	$595
	Quality	$632
	Quantity	$192
	Recreational fishing	$541
	Commercial fishing	$1,179
	Bird Hunting	$106
	Bird Watching	$1,836
	Amenity	$5
	Habitat	$464
	Storm	$359
Kazmierczak	Habitat and species protection	$287
Costanza et al	Habitat/refugia	$235
	Recreation	$263
	Total ecosystem services	$10,482
Arreola	Preserve/restore total services	$956
Breunig	Total ecosystem services	$17,307
Olewiler	Total ecosystem services (Low)	$4,217
	Total ecosystem services (High)	$17,712

* Woodward and Wiu note that these values should not be treated as additive since in any one example, studies primarily providing one service type also provide other services.

Note: Additional studies can be found in the EVRI database but they are drawn from grey literature that was not readily available, and the summary information in EVRI suggests they would not change the overall message presented here.

5. Examples of what government pays to improve wetlands

Our review of Environment Canada and U.S. Army Corps of Engineers wetlands projects shows that the costs of providing wetland habitat can be much less or much more than the values reported from the economic benefit studies. Several economists reviewing this paper suggested strongly that this section be deleted because it reports costs, not benefits. There could be several causes for the differences:

- Wetland services are bundled and even projects whose objective is listed as just habitat may provide other services. For example, the Corps of Engineers is not required to estimate potential recreation services, yet the costs of some of their projects are shared by Ducks Unlimited, a private organization that supports habitat projects that enhance duck hunting. Similarly, for the Canadian wetland restoration projects on Lake Ontario we believe that there are recreational benefits, but these were not the key objective of these projects.
- The projects may be too expensive. The Corps is now required to do an incremental cost analysis that shows that there was no cheaper way to get the same wetland area or wetland service, but it does not have to estimate a benefit-cost ratio, which could still be less than one.
- The reasons for building wetlands may not be completely reflected in the perceived value of the wetland services.
- Most of the benefit values that were summarized in Table 7 reflect averages from benefits summaries, but actual benefits for any specific site will vary and they depend on many factors including proximity to people, scarcity of the services being provided, etc.
- The range in project costs can be a reflection of the effort required for restoration. This can range from very simple efforts such as planting of key vegetation species to major excavation efforts. The U.S. projects, for example, are categorized by Clean Water Action Plan categories, and include establishment, re-establishment, rehabilitation, enhancement and protection of wetlands.

The table on the following pages shows sixty projects built for habitat with no stated recreation or water quality goal. The average and median cost per acre of wetland habitat for all sixty projects is $2,902 and $323 per acre per year, respectively, using a 4% discount rate and 30 year repayment period. The minimum cost is $2 per acre; the maximum is nearly $25,000 per acre. The Canadian projects are Great Lakes Sustainability Fund projects funded through the Government of Canada and its partners and administered through Environment Canada.

Table 7. U.S. and Canadian Wetland Restoration Projects

Project	Country	Wetland area (acres)	Project cost	Annualized project cost	O&M cost	Total annual cost	Annual cost per acre
Turning Basin Number 3 Restoration	U.S.	6	$2,603,900	$150,584	$3,000	$153,584	$24,772
Coastal Wetlands Rehabilitation	Canada	10	$4,057,200	$234,629	$0	$234,629	$24,357
Puget Creek Estuary Restoration	U.S.	1	$182,000	$10,525	$0	$10,525	$21,050
Re-Introduction of Southern Wild Rice Into Cootes Paradise	Canada	1	$188,400	$10,897	$0	$10,897	$17,646
Ocean Pines	U.S.	9	$2,289,000	$132,373	$0	$132,373	$15,573
Rooster Island	U.S.	5	$988,000	$57,136	$0	$57,136	$11,660
Toronto Islands Habitat Restoration: Franklin Garden Demonstration Wetland	Canada	1	$235,700	$13,629	$0	$13,629	$11,035
Munyon Island Wetland Restoration	U.S.	11	$1,460,000	$84,432	$0	$84,432	$7,676
Potters Marsh Rehabilitation and Enhancement	U.S.	32	$3,050,000	$176,382	$6,100	$182,482	$5,703
Hidden Lake Restoration/Great Marsh Restoration Project	U.S.	47	$2,725,000	$157,587	$6,000	$163,587	$3,481
Youth and Community Greening the Rouge River Watershed	Canada	21	$1,192,700	$68,973	$0	$68,973	$3,285
Galilee Salt Marsh Restoration, Narragansett, Rhode Island	U.S.	34	$1,548,000	$89,521	$10,000	$99,521	$2,927
Humber Bay Shores Butterfly Meadow	Canada	2	$79,900	$4,621	$0	$4,621	$2,495
Rouge Watershed Wetland Creation Initiative: Phase 3	Canada	17	$682,400	$39,462	$0	$39,462	$2,282
Peoria Lake Habitat Rehabilitation and Enhancement Project	U.S.	168	$4,419,000	$255,551	$19,800	$275,351	$1,639
Peoria Lake Enhancement	U.S.	168	$4,419,000	$255,551	$0	$255,551	$1,521
Porter Levee Section 1135 Restoration Project	U.S.	8	$223,000	$12,896	$0	$12,896	$1,433
Lower Don River - Habitat Restoration Projects	Canada	24	$604,700	$34,968	$0	$34,968	$1,430
Milne Park Natural and Cultural Heritage Restoration Project Phase III	Canada	3	$70,500	$4,075	$0	$4,075	$1,179
Granger Greenway Habitat Enhancement	Canada	8	$165,600	$9,574	$0	$9,574	$1,147
Spencer Creek Fisheries Projects	Canada	9	$148,000	$8,560	$0	$8,560	$990
Brown Lake, Cameron and Calcasieu Parishes, Louisiana	U.S.	89	$1,504,000	$86,976	$0	$86,976	$977
Toronto Island Sand Dune Restoration	Canada	2	$38,400	$2,221	$0	$2,221	$899
Deepwater Slough Section 1135 Project	U.S.	204	$2,509,000	$145,096	$10,000	$155,096	$760

Project	Country	Wetland area (acres)	Project cost	Annualized project cost	O&M cost	Total annual cost	Annual cost per acre
Yolo Basin, Davis Site	U.S.	268	$0	$0	$185,000	$185,000	$503
Piedmond Lake, Lick Run Reclamation Project Kirkwood Township, Ohio	U.S.	97	$686,000	$39,671	$2,277	$41,948	$432
Sabine National Wildlife Refuge, Louisiana, Wetland Creation and Restoration Project	U.S.	151	$1,076,000	$62,225	$0	$62,225	$412
Hart-Miller Island	U.S.	200	$0	$0	$77,400	$77,400	$387
Humberwood Bird Habitat Enhancement Project	Canada	1	$5,900	$342	$0	$342	$346
Mississippi River - Gulf Outlet Mile 14 to Mile 11, Marsh Creation, Louisiana	U.S.	100	$558,000	$32,269	$0	$32,269	$323
Hamilton Harbour Watershed Stewardship Project	Canada	29	$132,200	$7,646	$0	$7,646	$266
Amazon Creek Wetlands Restoration, Eugene, Oregon	U.S.	181	$0	$0	$46,735	$46,735	$258
Lake Chautauqua Rehabilitation and Enhancement	U.S.	3,250	$12,460,000	$720,563	$29,800	$750,363	$231
Orwell Lake, Otter Tail County, Minnesota	U.S.	67	$224,000	$12,954	$1,500	$14,454	$216
Grindstone Creek & Cootes Paradise Rehabilitation Project	Canada	667	$2,485,800	$143,757	$0	$143,757	$216
Bruce's Mill Dam Decommissioning & Wildlife Habitat Enhancement Project	Canada	7	$20,900	$1,207	$0	$1,207	$163
Old Leon River Channel Wetland Restoration, Proctor Lake, Texas	U.S.	100	$188,500	$10,901	$3,000	$13,901	$139
Trempealeau National Wildlife Refuge Habitat Rehabilitation and Enhancement	U.S.	165	$0	$0	$21,700	$21,700	$132
Fern Ridge Lake Marsh Restoration	U.S.	347	$540,200	$31,240	$13,400	$44,640	$129
Yolo Basin Wetlands, Sacramento River, California	U.S.	2,513	$0	$0	$322,400	$322,400	$128
Calcasieu River and Pass	U.S.	120	$260,000	$15,036	$0	$15,036	$125
Chester River Bodkin Island, Maryland	U.S.	8	$0	$0	$817	$817	$109
Lake Winnibigoshish- Waterfowl Ponds	U.S.	44	$78,300	$4,530	$0	$4,530	$103
Leech Lake Reservation, Lake Winnibigoshish, Cass County, Minnesota	U.S.	44	$78,300	$4,530	$0	$4,530	$103
Sagamore Marsh Restoration	U.S.	50	$0	$0	$5,000	$5,000	$100
Homme Lake Reservoir, Walsh County,	U.S.	20	$29,800	$1,723	$0	$1,723	$86

Project	Country	Wetland area (acres)	Project cost	Annualized project cost	O&M cost	Total annual cost	Annual cost per acre
ND							
Lewisville Lake Wildlife Habitat Restoration Project, Denton County, Texas	U.S.	1,012	$880,000	$50,890	$21,200	$72,090	$71
Somerville Lake Wetlands Restoration	U.S.	312	$235,700	$13,631	$7,000	$20,631	$66
Claireville Natural Area Enhancement	Canada	46	$44,200	$2,555	$0	$2,555	$55
Flag Pond Wetland Restoration	U.S.	350	$211,400	$12,225	$5,000	$17,225	$49
Dead Lake Waterfowl Impoundment	U.S.	96	$75,400	$4,360	$0	$4,360	$45
Barataria Basin Waterway, Marsh Creation, Mile 31 to Mile 24.5, Jefferson Parish, Louisiana	U.S.	200	$150,000	$8,675	$0	$8,675	$43
Willapa River Estuarine Restoration Project	U.S.	351	$0	$0	$11,500	$11,500	$33
Trestle Bay Restoration, Oregon	U.S.	603	$237,600	$13,740	$0	$13,740	$23
Sally Jones Lake Vian, OK	U.S.	650	$100,000	$5,783	$5,000	$10,783	$17
Green Island Headwall Modification	U.S.	1,400	$254,900	$14,739	$1,000	$15,739	$11
Murphy Island, Santee Wildlife Refuge	U.S.	5,500	$0	$0	$18,800	$18,800	$3
Nimrod Waterfowl Levee	U.S.	1,800	$96,300	$5,569	$0	$5,569	$2
Salt Bayou, McFaddin Ranch	U.S.	60,000	$2,339,500	$135,294	$0	$135,294	$2

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