Measuring the Economic Benefits of America's Everglades Restoration

An Economic Evaluation of Ecosystem Services Affiliated with the World's Largest Ecosystem Restoration Project

Prepared for The Everglades Foundation
18001 Old Cutler Road, Suite 625
Palmetto Bay, Florida 33157

www.evergladesfoundation.org
305.251.0001

by

Mather Economics
43 Woodstock Street,
Roswell, Georgia 30075

www.mathereconomics.com
770.993.4111

Bobby McCormick, Ph.D., Principal Investigator
Robert Clement, MA
Daniel Fischer, MBA
Matt Lindsay, Ph.D.
Reed Watson, JD MA

with assistance from

Danielle Alderman
Kristina Catani
Joanna Fister
Gabi Huber, Ph.D.
Exley McCormick
Arvid Tchivzhel
Emily Wood, MA

Summary of Results

Everglades restoration will have important and significant economic impacts on several basic services provided by this massive and complex ecosystem. We have split these services into six distinct divisions. For each of these categories, we conservatively estimated, using best available data and economic methods, the increase in economic value of a restored Everglades ecosystem.

Summary of Ecosystem Services Valuation of Everglades Restoration			
	Service	**NPV Best Estimate**	
1	Groundwater purification	$	13,150,000,000
2	Real Estate	$	16,108,000,000
3	Park Visitation	$	1,311,588,000
4	Open space	$	830,700,000
5	Fishing		
	Commercial	$	524,100,000
	Recreational	$	2,037,000,000
6	Wildlife Habitat and Hunting	$	12,539,900,000
	TOTAL Value of Services	**$**	**46,501,288,000**
	Initial Investment	$	11,500,000,000
	Benefit-Cost Ratio		**4.04**
	All calculations are based on discount rate of 2.1% .		

Our analysis strongly suggests that restoration of the Everglades as described and planned in CERP will have large economic benefits. **Our best estimate is that restoration will generate an increase in economic welfare of approximately $46.5 billion in net present value terms that could range up to $123.9 billion**. The return on investment, as measured by the benefit-cost ratio, assuming a cost of restoration of $11.5 billion, is also high and significant, 4.04, which means for every one dollar invested in Everglades restoration $4.04 dollars are generated. Everglades restoration will also have an incremental impact on employment of about 442,000 additional workers over 50 years. In addition, the Corps of Engineers estimates there will be 22,000 jobs created as a result of the actual restoration projects. Throughout our analysis, we have taken a very conservative approach to estimation. Accordingly our best estimates almost surely understate the return on investment of Everglades restoration.

Summary of Jobs Results	
Sector	**Incremental Jobs**
Commercial Fishing	6,798
Recreational Fishing	36,868
Residential Construction & Real Estate Services	273,601
Tourism (Lodging, Eating & Drinking, Transportation, Retail, Entertainment)	48,552
Agriculture	(3,724)
Wildlife Habitat & Hunting	80,569
TOTAL	**442,664**

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Preamble and Executive Summary

We have been commissioned by the Everglades Foundation to place an economic valuation on Everglades restoration. The Everglades are sub-tropical wetlands – a "River of Grass" and much, much more. In order to catalogue the huge array of potential products and services flowing out of the Everglades, we envision this vast natural cauldron as a firm. Ponder General Electric. Among many other things, General Electric produces medical imaging, jet engines, and financial services. Each of its product lines has revenues and costs. GE manufactures and creates the products, and buyers purchase them. In almost every case, the buyer places a higher value on the product than the purchase price. The Everglades system is like GE, except that buyers do not directly pay for the products they consume. Instead, consumption is enjoyed in large measure without any compensation to the owner or producer, because there is no well-defined owner and nature is the producer.

We approach our job as if the Everglades were a multi-product firm like GE, and we task ourselves with estimating the values that consumers place on its products and services. In that taxonomy, Everglades restoration is akin to a business opportunity, and the Comprehensive Everglades Restoration Plan, CERP, is a detailed business plan. Our job is to produce a set of pro forma financial statements to complement and complete that plan. As with all pro forma projections, we have made assumptions about the future. We have attempted to make our assumptions as reasonable, visible, and transparent as possible so that readers can adjust our findings based upon their own assessment of the proper assumptions. As in any analysis of this type, the best assumption is not always obvious. Therefore, in many cases, we have provided a range of estimates, but we also offer what we think is our best estimate. In all cases where there was no clear choice regarding an assumption, we took the conservative approach. Accordingly, in the analysis you see below, we believe that our estimates are at the lower end of the range (lower bound) and follow best practices in economic methodology.

We have broken this multi-product firm, the Everglades, into six distinct divisions and a seventh catch-all branch. These are:

- $ Groundwater purification and aquifer recharge
- $ Real estate
- $ Park Visitation
- $ Open space
- $ Fishing
- $ Wildlife habitat and hunting
- $ Water quality, biodiversity, and carbon sequestration

Take groundwater purification and aquifer recharge as the first of many services produced by the

Everglades. CERP, if enacted as planned, will restore Everglades sheet flow. Restored sheet flow will, in turn, provide additional fresh surface water and groundwater. Consequently, water available for municipal and private use will be less saline, that is, ground water extracted for use by South Floridians will be less saline and require less electricity to become usable and potable. Because it costs money to desalinate water, one service that a restored Everglades would provide is reducing the cost of desalinating increasingly brackish groundwater. In order to assay this revenue stream, we have assumed that restoration will return South Florida groundwater and surface water to its 1970 levels.[1] Using data from that period, and assuming that restoration would create water of similar salinity to that period, we can project how much money the people of South Florida will ***not*** have to spend desalinating groundwater as restoration unfolds. In other words, Everglades restoration means that groundwater will not be as salty and that less energy will be required to prepare it for human use. Salty water must be treated to remove chlorides. As the groundwater is more salty, it takes more electricity to purify the water for humans. Restoration reduces the amount of electricity required and thus is a direct benefit in terms of energy cost savings. We estimate these restoration savings to come primarily from reduced expenditures on energy which would otherwise be used to filter out more saline pushed through membranes to create usable water.[2]

In Table A below, we report in summary format our results of computing the value of services for all the product lines listed above. In our detailed document that follows, we provide thorough insight into our methods, sources, and our exact assumptions. They are only sketched and summarized here. Each division has associated with it a table detailing the best estimates and a range of estimates that we deem plausible. Again, for parsimony of presentation here, we have not included all the details of our calculations. They are available in the full document below.

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[1]Our empirical analysis of ground and surface water supports this assumption. Salinity levels appear relatively constant in ground water test wells up until the early 1970s when they began to grow commensurate with Everglades flow reduction.

[2]While it might be argued that fewer plants will have to built for water purification after restoration, this is not accurate according to our models. Population and income growth will likely necessitate the construction of new plants, but restoration will not preclude these investments. Hence, the virtue and benefit of restoration on groundwater purification comes only from the lower expenditures required to clean the salt from the less briny water not from less capital investment in plants. Plants will have to be built to accommodate increased demand for water, which will not be impacted by restoration.

Table A Summary of Ecosystem Services Valuation of Everglades Restoration			
	Service	NPV Best Estimate	
1	Ground Water Purification	$	13,150,000,000
2	Real Estate	$	16,108,000,000
3	Park Visitation	$	1,311,588,000
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	Initial Investment	$	11,500,000,000
	Benefit Cost Ratio		**4.04**
	All calculations are based on discount rate of 2.1% .		

Our analysis strongly suggests that restoration of the Everglades as described and planned in CERP will have large and important economic benefits. Our best estimate is that restoration will generate an increase in economic benefits of approximately $46.5 billion in net present value terms.[3] The range of this estimate can be as high as $123.9 billion.

The return on investment, assuming a cost of restoration of $11.5 billion, is also high and significant. Our best estimate is that the benefit-cost ratio is 4.04 with a range as high as 9.78. The bottom line, as our analysis strongly suggests, is that the rewards of restoration far outweigh the economic costs. It is important to note that these are the *changes* in value to a restored Everglades. Our valuation does not represent the total value of services that flow from this ecosystem, currently or in its restored state. It is the incremental or marginal increase in value from implementing restoration.

To provide perspective, Table B below reports computations on (1) the total value of services per person in the 16-county South Florida region, (2) the ratio of total services to total income in 2007, and (3) the present value of total income in 2007.[4] These calculations say that the total value of ecosystem services from a restored Everglades amount to an increase in wealth for each person in the region of about $5,129 on a one-time basis, which is approximately a 0.3 percent increase in their wealth (narrowly defined for purposes here as the present value of income over

[3] We believe that the overall welfare impacts, as distinct from the simple benefits, are even larger. Details on this economic distinction are provided later in this report.

[4] Using the 2007 Census data on population and income.

the next 50 years or an 12.9 percent wealth increase when compared to their annual income). These computations suggest that the impacts of restoration are not only real and economically meaningful, but also reasonable.

TABLE B Relevance and Impact of Restoration with respect to Income and Wealth		
Value of Services per capita		$ 5,129
Value of Services per dollar of annual income		12.9%
Value of services per npv of income		0.30%

Details

Groundwater Purification and Aquifer Recharge Valuation

Avoided Groundwater Desalination Costs

Groundwater in the coastal counties of the South Florida Water Management District (SFWMD) is growing increasingly brackish. It will have to be desalinated before most uses. The capital cost of desalination, given the current state of reverse osmosis (RO) technology, is driven by the volume of fresh water that must be produced, which in turn is driven by population growth and perhaps other factors (for instance, climate and income).[5] The operating cost of desalination, on the other hand, is a direct function of the salinity of the water input. Saltier water must go through the RO membranes at a higher pressure, which requires more energy. The restoration of sheet flow according to CERP can be expected to decrease groundwater salinity, because the additional fresh water filtered into the aquifer from above will displace seawater seeping into the aquifer from below. So, conservatively, restoring the Everglades can be expected to result in at least the energy cost savings from desalinating less saline groundwater. We ignore any capital cost savings that might come from possibly having to build fewer desalination plants in the first place. We also ignore labor and maintenance cost savings from using less saline input (instead of assuming, for instance, that RO membranes fail at higher rates when higher-pressure, more saline water is pushed through). This is in keeping with our desire to be ultra-conservative with respect to our estimates. It is reasonable to subjectively estimate that our metrics of benefits are biased on the low side because of this conservative approach.

[5] Our use of the phrase desalination might be confusing to some people. Here we are *not* talking about taking salt out of ocean water instead we are referring to the act of removing salt from brackish or slightly salty fresh groundwater.

Under assumptions detailed below, we estimate that these energy cost savings would be substantial and vary by county within the region. Growing energy costs would increase these estimates. Improvements in desalination technology would decrease them. One assumption that affects our cost savings estimates is whether all the groundwater withdrawn must be desalinated. We have made two different assumptions: first, that all groundwater is to be desalinated, and second, that only the groundwater currently classified as saline must be desalinated.

General Approach and Data Sources

Our model has three steps. First, we used the volume of groundwater withdrawn and its salinity as observed over time to infer the change in salinity over the next 50 years without Everglades restoration. Next, we inferred the yearly desalination cost over the same period using regression analysis and engineering data published by the Texas Water Development Board (TWDB). Finally, we repeated the cost calculations assuming that, if the Everglades were restored, groundwater salinity would return to its 1970 level and stay there even as the volume of water withdrawn grows as population and demand grow.[6]

In other words, we assumed that implementing CERP would result in a new steady state, where the aquifer would be replenished with fresh water to a sufficient extent that it could sustain increased withdrawals with no increase in its salinity. The difference between the discounted streams of yearly groundwater desalination cost with and without the Everglades restored is our estimated economic benefit in the form of avoided desalination costs that can be credited to CERP. In the next 40 or 50 years, south Floridians will still need to desalinate their water, but it will cost them less because after restoration, the water will be less saline.

We collected data on ground and surface water use in SFWMD, by county and by year, from the US Geological Survey (USGS). We collected salinity data from DBHYDRO, the official SFWMD data repository of water research results, and from the National Water Information System (NWIS) maintained by the USGS.

Technical Details on Water Supply Calculations

The USGS collects county-level data on water withdrawals every five years. We are interested in

[6] We have *not* made any adjustment to our predicted levels of ground-water salinity based on any sea-level rise that might accompany global climate change. Restoration is a marginal adjustment to ground-water salinity. If climate change increases sea level and that leads to higher salinity of ground water, it will cost more to clean the water, but that impact is separate and independent of our estimate of any changes in salinity that occur as a result of restoration of sheet flow.

data for the 16 counties in the SFWMD. The earliest available records are from the 1985 data set. The latest available are from 2005. Using these data and yearly population figures by county over the same time span, we extrapolated water use 50 years into the future. Details are provided in the full report below.

One of the DBHYDRO measurements is chloride concentration in milligrams per liter. Each measurement comes with the location of the station and the date it was taken, so it is straightforward to combine them into yearly averages per county. The USGS maintains the National Water Information System (NWIS), a similar online database with its own chloride records, with the same unit of measurement, also with locations and time stamps. Both DBHYDRO and NWIS record salinity separately by groundwater and surface water. In the case of groundwater, we are interested in measurements taken in wells no deeper than 500 ft. Below this depth, the water is saline. Southern Florida's fresh groundwater comes from surficial aquifers, with water withdrawn from depths well above 500 feet.

Groundwater in the 16 counties has been growing increasingly brackish over time. This result occurs even after discarding any samples taken from depths either unknown or greater than 500 feet (Figure 1). It is reasonable, then, to assume that desalination will be needed for all

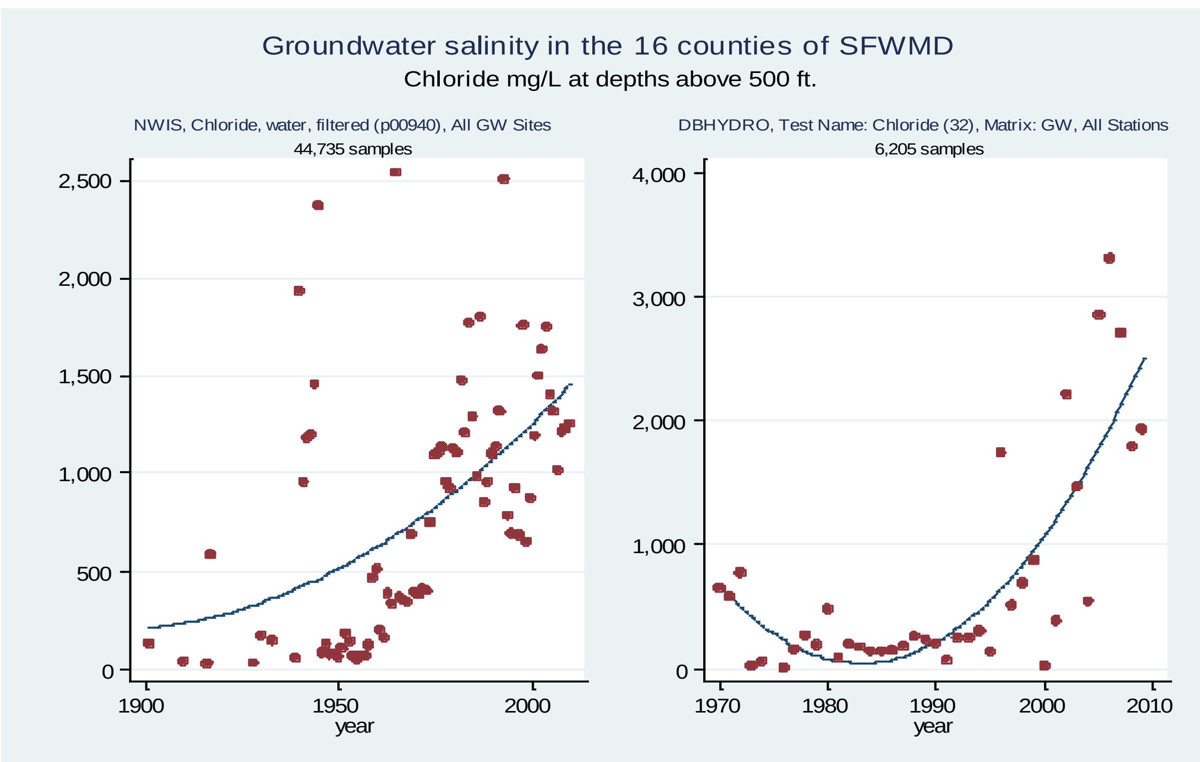

Figure 1 Groundwater Chloride Levels

groundwater withdrawn in SFWMD in the future, whether by private or public water supply systems. Restoring the Everglades will help decrease the expected cost of desalination to the extent that it will succeed in reversing the trend of increasing groundwater salinity. We conservatively assume that surface water will not be affected.

The exercise assumes that CERP would result in groundwater salinity restoring to its steady state 1970 level and have no effect on surface water salinity. Without CERP, we assume that salinity would continue to grow along its current path as shown in the right panel of Figure 1.

The Cost of Desalination

Desalination requires a capital investment (building the plants) and an ongoing operating cost (energy used, materials, maintenance, and labor). As the water input becomes more saline, it must be pushed through RO membranes at a higher pressure. Though the baseline of this relationship is dropping as RO technology improves, it remains true that the higher the pressure, the higher the energy expended, and there are no economies of scale in this process. This is of interest to us, because everything else is subject to either scale effects or factors depending on local characteristics. For example, larger plants, as well as plants designed to operate at a higher baseline pressure, have some efficiencies built-in. The cost of disposing of the brine via deep-well injection depends on local geographic options for doing so. The same goes for the cost of disposing of the concentrate (sludge saturated with impurities other than salt).[7] We have not imputed any benefits-estimate to the expected lower cost of brine disposal that will follow from restoration and less desalination. We are uncertain what these cost savings might be, and hence our conservative approach is to note this fact and move on until further information is available.

We estimated the annual cost of energy as a function of water input salinity assuming an energy price of $.08 per kW/h, based on the average electricity price in Florida for industrial use ($.0767 in 2007). Then we projected this annual desalination cost for each SFWMD county--given its projected water withdrawals (ground and surface) and their respective salinity levels given their current path (groundwater salinity expected to rise at a growing rate as shown in Figure 1; surface water salinity, not shown, expected to remain unchanged). Then we repeated the calculations with salinity levels held at their 1970 level.

[7] We assume that it takes 200 psi to treat 3,000 mg/L of chloride water, and it takes about 1,000 psi to treat 30,000 mg/L seawater. Therefore we assume that as salinity grows by a factor of 10, the pressure required grows by a factor of 5. Filling in a few intermediate values, we estimated, via linear regression, the functional relationship between and pressure and salinity.

Water Supply Results

Our avoided desalination cost estimate is the difference between projected desalination costs given the current path of rising salinity versus projected desalination costs holding salinity constant at its 1970 level (our expected environmental effect of CERP). We performed this calculation under two assumptions regarding water withdrawn by public and private parties in the SFWMD over the next 50 years. First we assumed that all water will have to be desalinated; second we assumed that only the water classified as saline will have to be desalinated. Details are provided in the full report below. Though the latter sounds obvious and results, as expected, in a lower estimate, the former is also deemed plausible. Current readings show that all groundwater in SFWMD tested at depths above 500 ft. is saline, to some extent, and growing more saline on average. If not all of it is treated now, it might need to be in the future. Net present values of the yearly savings between 2010 and 2060 are shown in Table 1.

Assuming lowered desalination resulting from restoration of the Everglades, the cost savings from energy-use reduction will be substantial. For purposes here, we made some additional assumptions. First, we accumulated the cash flows over 30-, 40-, and 50-year periods. Second, we discounted the dollar amounts by the current real cost of capital to municipalities in South Florida, 2.1 percent.[8]

We next report our calculations in pro forma format for the other services and products listed above. While we have gone to some length in this section to give a sense of our methods, in the summary sections below we are more succinct and parsimonious, however, complete discussion of all our methods and technical details are provided in each relevant section of the main document.

[8] Details on our use of this particular discount rate are discussed later in the document.

Table 1 Value of Groundwater Purification and Aquifer Recharge Services from Everglades Restoration

Assumptions:	
Total Growth	3%
Income Growth	0%
Population Growth	1%
Energy Cost Growth	2%
Technology	0%
SF Muni Bond Rates	4.50%
Inflation	2.40%
Discount Rate	2.10%
Initial Investment	$ 12,100,000,000

Total Benefits: Adjusted for Growth	Total Benefits: Unadjusted		Return on Investment, water supply only: Adjusted	Return on Investment, water supply only: Unadjusted
$ 27,974,488,275	$13,150,812,909	50 Years	131%	9%
$ 18,671,662,550	$10,306,678,952	40 Years	54%	-15%
$ 11,222,040,888	$7,408,688,810	30 Years	-7%	-39%

County Estimates, Adjusting for Growth

Years	Broward	Charlotte	Collier	Glades	Hendry	Highlands	Lee	Martin
NPV 50	$4,609,492,133	$1,753,556,508	$3,037,706,282	$1,919,983,244	$1,162,162,385	$698,345,814	$424,886,022	$1,914,496,540
NPV 40	$3,109,313,065	$1,269,883,770	$2,155,116,915	$939,722,627	$853,459,336	$481,608,784	$267,666,580	$1,268,848,876
NPV 30	$1,896,237,894	$857,682,344	$1,407,512,215	$266,441,931	$571,550,030	$298,391,864	$145,288,674	$759,955,278

Years	Miami-Dade	Monroe	Okeechobee	Orange	Osceola	Palm Beach	Polk	St. Lucie
NPV 50	$1,007,782,981	$844,489,817	$445,303,896	$1,933,953,018	$968,626,070	$5,004,265,681	$1,120,046,038	$1,129,391,846
NPV 40	$725,449,099	$592,881,240	$280,842,498	$1,157,340,508	$624,711,897	$3,478,682,745	$701,642,250	$764,492,361
NPV 30	$478,860,798	$377,843,554	$151,122,484	$587,782,360	$361,506,661	$2,205,447,197	$384,229,243	$472,188,362

Impact of Improved Water Quality

We anticipate that a restored Everglades will improve the quality of surface water in the 16-county South Florida Water Management District.

Water plays an important role in the determination of residential real estate values. Proximity, type (ocean, bay, lake, river, etc.), view, size and quality are among the water attributes that are valued by real estate buyers. For example, lakeside or seaside properties sell at a premium to properties located away from bodies of water. A home on a clear stream trades at a premium to a similar home on a polluted stream. Of course, water and its attributes are only a small part of the bundle of attributes that determine a property's value. House size, quality of finish, proximity to a city, and a great many other factors also play important roles. But imagine a thought experiment of taking a given house and property on some body of water and changing nothing but the quality of the water. Now observe the change in property value associated with that one single environmental change. That thought experiment describes our method.

Economists have developed techniques to quantify the incremental value of environmental attributes. One of the often used and robust techniques employed is hedonic pricing. This method estimates the price people are willing to pay for individual product characteristics, such as a swimming pool or air conditioning, and environmental goods, such as air and water quality, holding other attributes constant. Studies consistently show that the water quality effect is positive; that is, property located on or around high quality water is more valuable, *other things the same,* than property located on or around lower quality water. The magnitude of this effect is generally in the 0.5 percent to 7.0 percent range. That is, some level of water quality improvement can have up to a 7 percent impact on real estate values. The same techniques also find, for example, positive effects on air quality and negative effects on proximity to toxic waste sites. These results are both intuitively and scientifically robust.

For the purposes of this study, our role is to estimate the impact on residential real estate values that will derive from a restored Everglades due to improvements in water quality. The aggregate owner-occupied residential real estate value in the 16-county SFWMD is approximately $976.217 billion. Based on a survey of hedonic estimates of water quality effects, the elasticity of real estate values with respect to water quality is .07054.[9] Assuming that water quality, as

[9] A 100 percent improvement in water quality will produce a 7.054 percent increase in real estate values.

measured by dissolved oxygen, can be returned to 1970 levels as a result of restoring the Everglades, this implies that there is a potential 23.4 percent improvement in water quality.

Combining these estimates, we estimate the incremental value of a restored Everglades on real estate across all 16 counties as:

$976.217 Billion H.07054 X .234 = **$16.08 Billion**

This change represents a 1.65 percent increase in the aggregate value of real estate, which is well within the range of typical studies on water quality effects. However, we have also done what-if analysis, to examine the impacts based on different levels of water quality improvements. The results of that analysis are reported in Table 2, which also lists the county-by-county best estimates of additional ecosystem services forthcoming from cleaner surface water via a restored Everglades. We also estimated the increased value of real estate by assuming that nitrogen levels would not achieve the high levels of 2004 and 2005 hurricane years. These estimates are also reported in Table 2.

Next we discuss the additional change in value of services relating to recreation and park visitation that we expect will flow from restoration of this teapot we call the Everglades.

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Table 2 Value of Everglades Restoration on South Florida Real Estate via Improved Water Quality

Real Estate Value Improvement - Best Estimate

County	Incremental Real Estate Value
Broward	$ 3,032,000,000
Charlotte	$ 261,000,000
Collier	$ 974,000,000
Dade	$ 4,379,000,000
Glades	$ 7,000,000
Hendry	$ 21,000,000
Highlands	$ 96,000,000
Lee	$ 1,058,000,000
Martin	$ 333,000,000
Monroe	$ 307,000,000
Okeechobee	$ 21,000,000
Orange	$ 1,561,000,000
Osceola	$ 340,000,000
Palm Beach	$ 2,807,000,000
Polk	$ 557,000,000
St. Lucie	$ 353,000,000
Totals	$ 16,108,000,000

Years Until Water Quality Goals Met	Potential Increase in Real Estate Value at 2.1% Discount Rate
1	$ 15,777,000,000
2	$ 15,452,000,000
3	$ 15,134,000,000
4	$ 14,823,000,000
5	$ 14,518,000,000
Discount Rate	2.10%

Sensitivity Analysis

	Potential Real Estate Value Improvement Using Various % Change in Water Quality					
Basis	**1%**	**5%**	**23% - Best Estimate**	**25%**	**50%**	**100%**
Suspended Solids Model	$ 536,000,000	$ 5,357,000,000	$ 16,108,000,000	$ 13,392,000,000	$ 26,785,000,000	$ 53,570,000,000
Nitrogen Model	$ 689,000,000	$ 6,887,000,000		$ 17,216,000,000	$ 34,433,000,000	$ 68,865,000,000

Recreation and Park Visitation Valuation

The Everglades are one of South Florida's main tourist and recreational attractions. The rivers, lakes, and wetlands unique to the Everglades invite sightseeing, photography, bird watching, manatee watching, camping, cycling, boat tours, sailing, airboat tours, canoeing, nature hikes, kayaking, hunting, shelling, saltwater fishing, and freshwater fishing. Logic dictates that Everglades restoration would increase the quality of these activities and, consequently, the number of resident and non-resident visitors to the Everglades. This increase in recreational and tourist activity translates to an economic value that we estimate here.

In economic studies similar to this one, sometimes, tourism is seen as a catch-all category. Here we have tried to use a more laser-like approach and break tourism down into smaller categories of recreation, park visitation, bird watching and wildlife habitat, hunting, and fishing. Thus, we have no overall category called "tourism" per se. However, our approach is deemed superior because it subsumes all the sub-categories and avoids the temptation or problem of doubling counting.

To estimate this economic value, we employed the travel-cost method. The basic premise of the travel-cost method is that expenses people incur while traveling to a recreation site or tourist destination represent the price of admission in the economic sense of opportunity cost. This outlay of expenditures reflects the traveler's willingness-to-pay, that is, the value that a recreationist or tourist places on accessing a particular site. By aggregating the travel expenditures of all visitors to an unrestored Everglades, then projecting a marginal increase in those expenditures attributable to Everglades restoration, we estimated the recreational and tourism component of CERP's economic value.

Our approach has five stages. First, we collected historical data on park visitation in South Florida.[10] Because many recreationists and tourists who travel to the Everglades visit the area's national parks, preserves, state parks, and sanctuaries, we assume changes in park visitation reflect changes in overall tourist and recreational demands. Second, we used data from National Park Service visitor surveys to determine the ratio of residents to non-resident visitors for each park. Third, we estimated county-specific, per-person, per-day travel expenditure figures for both residents and non-residents who visit the Everglades parks, preserves and sanctuaries.[11]

[10] For the Everglades National Park, Big Cypress National Park, Biscayne National Park, The Dry Tortugas, Loxahatchee National Wildlife Reserve and Corkscrew Swamp Sanctuary, we obtained data specific to the total number of annual visits by their recreational activity. For the state parks, we obtained county-specific visitor data.

[11] There were ten counties with specific data on the average daily expenditure for non-resident tourists. For counties that did not have a non-resident per day expenditure, we used an average daily expenditure of $104.00, calculated by the Fish and Wildlife Conservation Commission for wildlife-viewing in Florida. To estimate resident travel expenditures, we used the National Park Service visitor survey data to calculate an average per day resident expenditure for counties that overlap with a national park: Collier, Monroe and Miami-Dade. For counties that did

In our fourth stage of analysis, we established a baseline of recreational and park visitation expenditures by multiplying the county-specific resident and non-resident expenditures by the number of resident and non-resident park visitors. Finally, in our fifth stage, we estimated the marginal increase in recreational and park visitation expenditures under a 2 percent increase in park visitation projected out 50 years. Preliminary regressions of water quality and tourist expenditures confirm this to be a likely scenario. See Table 3.1.[12]

Table 3.1 Recreational and Park Visitation Expenditures 2 Percent Increase over 50 years

County	NPV Incremental Increase
Broward	$103,206,003
Charlotte	$58,458,420
Collier	$178,150,740
Lee	$122,795,151
Martin	$13,306,731
Miami-Dade	$201,075,047
Monroe	$518,206,430
Okeechobee	$987,239
Orange	$25,849,076
Palm Beach	$49,055,665
Polk	$5,519,029
St. Lucie	$34,978,795
Total	**$1,311,588,326**

Our best estimate of the change in tourism valuation is based on a 2 percent increase over 50 years. This amounts to an increase in economic well-being of $1.311 billion in net present value terms.

Open-Space Valuation

If completed, CERP will produce approximately 157,555 acres of preserved open space in South Florida. In the absence of CERP, this land would likely be inaccessible to the public and or developed as Florida's population grows. But with Everglades restoration pursuant to CERP, this land will provide enhanced recreational opportunities and aesthetic benefits to the residents of

not have specific data on the per day expenditure for residents, we used the same FWCC wildlife-viewing report which estimated an average daily expenditure of $58.00 for residents.

[12] The counties not listed in this table have tourism benefits in other categories, hunting, wildlife viewing, and fishing.

South Florida. In this section we quantify these values.

To estimate the value of open-space preservation, we employed a multi-stage process. First, we used data from the Trust for Public Lands to estimate type-specific and county-specific willingness-to-pay (WTP) values per acre of preserved open space.[13]We estimated type-specific WTP values because open space preservation projects of different scale and proximity produce different bundles of aesthetic and recreational benefits.[14] Specifically, we grouped the open space and conservation projects into three types: local open-space bond initiatives, state-wide conservation projects and federally funded wetland preservation projects.

We estimated county-specific WTP values because the marginal value of open-space preservation depends on numerous geographic and demographic variables such as population density and proximity to population centers. Everglades restoration under CERP will encompass restoration projects throughout South Florida, so using geographically specific values adds precision to the open-space valuation.

Averaging across all counties, we estimated WTP values per acre of open-space preservation of $12,133 for county projects, $4,505 for state projects, and $740 for federally funded wetland projects. These figures comport with economic rationale; voters are willing to tax themselves at a higher rate for open space that they can enjoy more often and more easily, that is, local open space.

In the second stage of our analysis, we estimated county-specific open-space value ranges for each CERP project. We did this by multiplying the county, state and federal WTP values by the number of acres yet to be acquired under each specific CERP project. For instance, the "Lakes Park Restoration" project is in the "Lower West Coast" CERP region and has a remaining 40 acres yet to be restored. Because the "Lower West Coast" CERP region overlaps Hendry, Glades and Lee counties, we multiply an average of those three counties' local ($12,133)[15], state ($2,716) and federal ($740) WTP values by 40 to estimate a range of open-space values attributable to that particular CERP project. Our open-space value estimates for that project range from $485,331 (local WTP) at the upper bound to $29,600 (federal WTP), with our best estimate being $108,652 (state WTP).

In the final stage of our analysis, we aggregated the range of open-space values across the remaining acres of each CERP project. We report these aggregations for county, state and federal

[13] We gathered acreage and expenditure data by cross-referencing the Land Almanac and other conservation databases reported by the Trust for Public Land.

[14] For instance, a municipal park in Broward County generates significantly different open space values than does a federally funded wetland restoration in Glades County.

[15] Because we did not have data for local open space bond initiatives in these counties, we used the state-wide average of $12,133.

WTP values. These type-specific value estimates define the range of possible open-space values from Everglades restoration. Because CERP most closely matches the kind of open-space preservation projects used to calculate the state-level WTP value, the state-level WTP estimate is our best estimate of the total open-space value attributable to Everglades restoration under CERP. That estimate is **$830,733,000** in net present value terms.

Table 4.1 Open Space Valuation Increase from Everglades Restoration

CERP Region	Counties	Open Space Value Increase
Everglades Agricultural Area	Palm Beach and Hendry	$31,187,000
Everglades, Florida Bay, and Keys	Broward and Miami	$318,739,000
Lake Okeechobee Watershed	Okeechobee, Glades, and Highlands	$30,509,000
Lower West Coast	Hendry, Glades, and Lee	$41,611,000
Miami Dade County	Miami-Dade	$115,507,000
North Palm Beach County	Palm Beach	$5,752,000
Upper East Coast	Martin and St. Lucie	$215,220,000
Water Preserve Area	Palm Beach, Broward, and Miami	$72,208,000
	Total	**$830,733,000**

Table 4.2 summarizes these calculations, our assumptions, and our sensitivity analysis.

Table 4.2 Changes in Value of S. Florida Open Space Associated with Everglades Restoration

Lagged Response	
Years Until Increase Begins	**Present Value of Delayed Increase**
1	**$813,646,000**
2	**$796,911,000**
3	**$780,520,000**
4	**$764,467,000**
5	**$748,743,000**

Possible Range of Values		
Various WTP/Acre of Open Space		
Local	**State**	Federal
$2,763,345,000	**$830,733,000**	$116,593,000

Fishing Valuation

Everglades fishing is a big business, and it stands to be even bigger business if the Everglades are restored along CERP guidelines. Florida is fishing. To best catch the changes in fishing associated with restoration, we have broken our analysis into commercial and recreational components. There is little difference, however, in the analysis or the methods used.

Commercial Fishing

We obtained data on commercial catch per species for each of the relevant South Florida counties for the years 1986 through 2008.[16] Earlier data are considered unreliable. We assumed that restoration will enhance commercial fish catch, owing to increased sheet flow. We estimated the change by comparing current levels to peak levels in the late 1980s. To be conservative, we assumed that a restored Everglades would provide 75 percent of the difference between current catch levels and catches in 1989, the first year in which there are reliable data.

The estimates for expected post-CERP value (75 percent of 1989) and total future dockside value depend on the length of time it takes the fishery to recover after the Everglades project is completed.[17] We calculated future dockside value by summing catch in all Everglades counties for each species, multiplying this by .75, then multiplying these estimated numbers for future catch by the per-pound 2009 price for each species.[18] We summed these values to obtain the expected future dockside value post restoration. We estimate that there will be an increase of $23,271,221 per year in catch, after the fishery is fully restored. This is a 43.3 percent increase from current (2008) value. Table 5.1 shows the present value of commercial fishing value increases over a 50-year period assuming a 0, 20-, and 30-year fishery restoration timetable.

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[16] Commercial catch data obtained from Steve Brown at the Florida Fish and Wildlife Research Institute; this data can also be viewed at http://research.myfwc.com/features/view_article.asp?id=19224.

[17] It is plausible that there will be a short period of diminished catch after Everglades restoration as salinity levels adjust in Florida Bay and elsewhere.

[18] This method may slightly overestimate the impact of recovery as fish prices may fall as larger quantities are brought to market. At this point in our analysis we have not determined the geographic scope of the relevant fish markets and hence cannot determine whether the increased catch will impact price.

Our best estimate is that commercial fishing catch will increase, in present value terms with a 2.1 percent discount rate, by a total of $524 million (assuming a 20-year time to full recovery for the fishery).[19]

Table 5.1 Estimates of Commercial Fish Catch Increase From Everglades Restoration					
			Time for Fishery to Recover After Everglades Restoration		
Discount Rate			Immediately	**20 Years**	30 Years
2.1%		NPV Increase	$716,129,276	**$524,131,653**	$441,139,562

[19] As a check on our estimates, we also estimated the change in fishery catch using data from the net ban that went into effect in Florida in 1995. This method suggests that Everglades restoration will increase catch by about 57 percent. To be conservative in our forecasts, we use the earlier, lower estimates already discussed.

Recreational Fishing

Largemouth bass is the most common freshwater fish targeted in the Everglades region.[20] Thus, we chose to use increase in recreational catch of bass as a proxy to estimate the increase in economic benefits for recreational anglers due to CERP restoration.

On average, each recreational angler catches 59 bass each year in Southeast Florida, with an estimated marginal value per fish of $4.32.[21] The FWC 2006 survey of Fishing, Hunting and Wildlife estimates that each angler in Florida spends 17 days fishing (this is an average of residents and non-residents). Therefore, we estimated that on average, anglers currently catch 3.47 bass per day fishing.

We again assumed that restoration will restore 75 percent of total fish population, as used to estimate the changes in commercial fishing catch. The estimates for commercial fishing suggest that there is potential for a 49 percent to 56 percent increase in commercial fishing catch post-CERP. It is assumed that this percent increase in commercial catch can likewise be applied to recreational fishing.

We conservatively used the minimum estimate of a 49 percent increase in commercial fishing catch for our estimate of increased recreational fishing catch. This provides a potential estimated increase in catch per angler per day of 1.7 bass. The total number of fishing licenses sold[22] in 2008 in the 16 Everglades counties was approximately 362,300.[23] However, the FWC states, "It is important to note that only about half of Florida anglers actually have to purchase a license due to various exemptions, so these numbers do not reflect participation."[24] Therefore, we multiplied angler licenses in Everglades counties by two in order to estimate the number of anglers fishing in these counties. We assumed this number (724,600) is an appropriate, though likely low-end, estimate for the number of anglers fishing in Everglades counties in a given year.

The FWC estimates the average number of days spent fishing per angler at 17, which leads to an estimated 12,318,200 angler-days fishing in the Everglades. We multiplied this estimated number of angler days by the estimated increase in Everglades recreational bass catch (per day, per angler) post-CERP (1.7) to get an estimated increase of 20,940,940 bass caught each year. The estimated increase in value due to restoration (based on a marginal value per bass of $4.32)

[20] A survey of Everglades anglers by Fedler provided this information; 40 percent of saltwater angler days are spent targeting largemouth bass.

[21] http://myfwc.com/CONSERVATION/FishingBassConservationCenter_Value.htm.

[22] This includes both residents and nonresidents for freshwater licenses, saltwater licenses and combination licenses.

[23] Stronge, W.B. *The Economics of the Everglades Watershed and Estuaries: Phase 2 - 2010 Update of Data Analysis* (March 2010). Prepared for the Everglades Foundation.

[24] http://myfwc.com/CONSERVATION/Conservation_ValueofConservation_EconFreshwaterImpact.htm.

is then $90,464,861 for each year after restoration is complete.

Table 5.2 shows the present value of recreational fishing value increases over a 50-year period using this estimate of a $90,464,861 increase in value each year after CERP is completed. This is calculated for both a 20- and 30-year restoration period (assuming catch increases linearly over those years), as well as for instant restoration.[25]

Our best estimate is that Everglades restoration will increase the value of recreational fishing by a total of $2.04 billion in net present value terms.

Table 5.2 Estimates of Recreational Fish Catch Increase From Everglades Restoration				
Discount Rate	**Time for Fishery to Recover After Everglades Restoration**			
		Immediately	**20 Years**	30 Years
2.1%	**NPV Increase**	$2,783,890,688	**$2,037,516,539**	$1,714,891,823

Wildlife Habitat and Hunting Valuation

While fishing is a major recreational activity in Florida, hunting and wildlife viewing are popular pastimes as well. In this section, we detail our estimates of these economic impacts.

There are two important hunting groups in the Everglades: deer and waterfowl (primarily ducks). Restoration stands to impact hunting, it turns out, both positively and negatively. Deer have moved into and flourished in the drained wetlands of the Everglades, and ducks have been driven out. Restoration will reverse these recent trends.

Using data for 17 statewide Wildlife Management Areas, we computed the ratio of the economic value of hunting in the WMAs located within the Everglades to the economic value of hunting in WMAs statewide. From the lower-bound estimates for each WMA's value, we calculated the ratio of hunting expenditures in the Everglades to the entire state. We then multiplied this ratio by the U.S. Fish and Wildlife Service's estimate of the total economic value of hunting in Florida, $377,394,000 annually. This method leads to a baseline estimate of $175,000,000 per year that hunting in the Everglades contributes to the Florida economy.

Fluctuations in water levels are partly responsible for current high mortality rates among deer in

[25] We also estimated the total number of anglers in Everglades counties using the ratio (number Everglades counties)/(number counties in Florida) and multiplied this by the estimated 2.8 million anglers fishing in Florida. We then used this ratio to estimate the number of anglers in the Everglades to recalculate the increase in bass caught and increase in value. The results are numbers that are similar and suggest that either assumption is appropriate.

South Florida. CERP estimates that, with the restoration of the Everglades, white tail deer populations will be reduced to pre-drainage numbers, but that deer mortality due to drowning and starvation will decrease. CERP estimates suggest that deer hunting in Big Cypress National Preserve should not be impacted in either direction, but that deer hunting in Everglades WMA will be adversely affected. For purposes of this model, we assumed no net change in deer hunting in Big Cypress and a decrease of 75 percent in Everglades and Rotenberger WMAs. The decrease is due to lower deer populations and more difficulty in accessing huntable areas. While CERP does not make the Holey Land or Rotenberger as wet as the Conservation Areas, we assumed that the Rotenberger deer hunting would respond similarly to the Everglades. In effect, as the discussion below reveals, we believe that this is a worst-case scenario for deer. We further assumed that Holey Land would undergo half the total effect of Everglades or Rotenberger, because it is already partially rehydrated. It has already seen a notable transition from deer hunting to waterfowl hunting as a result of these higher water levels.

The Everglades occupy the western portion of the Atlantic Flyway in Florida. Increasing year-round water levels in Everglades and Rotenberger WMAs would provide more ideal habitat for waterfowl. It would also induce a shift in hunting patterns in these areas from primarily deer hunting to primarily duck hunting, as seen in Holey Land WMA after its restoration.

We used the rehydration of Holey Land WMA as a measure of the consequences of restoration on hunting in the Everglades. This rehydration, which began in 1991, drastically changed hunting patterns within the Holey Land WMA, and we expect a similar shift in the overall Everglades. We used days of hunting to estimate percent changes.

While the marginal impact of Everglades restoration on hunting expenditures might be negative, the expected change in wildlife-viewing expenditures is almost surely positive and far larger than the potentially negative impact on hunting expenditures. The expansion of habitat produces additional services, primarily through viewing of birds and other wildlife. We have already computed the additional value of viewing by tourists. Here, we estimate the habitat impact on resident viewings in and around their homes, local bird and wildlife watching. The increased demand from restoration will also be reflected in increased expenditures on bird watching equipment such as feeders, food and binoculars.

The U.S. Fish and Wildlife Service estimates that the State of Florida generates more than $3 billion in annual expenditures by wildlife watchers.[26]Of the 1.5 million people who engage in away-from-home wildlife watching each year, more than 1.1 million engage in waterfowl

[26] Table 31; page 39; FWS – FHWAR. We conservatively excluded from our calculations the "special equipment expenditure" category because we are attempting to measure the habitat-only demand and not travel or tourism-related demand. If we had included this effect, overall impact of restoration would be calculated to be much higher. "The special equipment" category of expenditures is large, as it includes RVs, travel trailers and the like. Our intent here was to capture local viewing, not tourism. This avoids a potential double-counting problem.

watching and 1.29 million watch other non-game water birds. In comparison, only 421,000 engage in viewing of large land mammals.[27] Using data for 17 statewide Wildlife Management Areas, for purposes of scaling the state total to the region, we used as a proxy the ratio of the economic value of hunting in the WMAs located within Everglades to the statewide value. We then multiplied this number by the U.S. Fish and Wildlife Service's estimate of the total economic value of wildlife watching in Florida, which was $3.08 billion annually. This leads to an estimated value of $1.43 billion per year that non-consumptive wildlife recreation in the Everglades contributes to the Florida economy.

The primary source of wildlife-watching value in Florida comes from bird-watching, primarily of wetlands species, either waterfowl or wading birds.[28] CERP estimates significant habitat improvement for water-reliant bird populations, specifically waterfowl and wading birds. The Everglades occupy the western portion of the Atlantic Flyway in South Florida. Consequently, a large portion of migrating waterfowl pass through the Everglades on their way from Canada to the Caribbean. Increasing year-round water levels in Everglades and Rotenberger WMAs along with Everglades National Park will provide more ideal habitat for waterfowl and non-game wetlands birds. It will also induce a shift in wildlife watching demand in these areas due to increased quality relative to other areas.[29]

CERP estimates improved habitat for the following endangered species:

- West Indian Manatee
- American Crocodile
- Snail Kite
- Wood Stork
- Cape Sable seaside sparrow

We estimated the baseline value of habitat and non-consumptive wildlife appreciation in the Everglades. We used wading bird populations as our indicator metric for habitat value in the Everglades. The University of Florida estimates that, just prior to drainage, there was a stable population of approximately 70,000 mating pairs of wading birds. This is our reference benchmark for restoration. Using 2006 bird populations, our conservative best estimate is that restoration will return these numbers to 75 percent of the 70,000 mating pairs reference benchmark. We then estimated the marginal impact of changes in species populations on demand for viewing, providing an annual improvement in habitat value of approximately $424 million.

Though we have estimated a portion of these values in our recreation and park visitation model which measures park visitation changes, wildlife viewing generates additional values not

[27] Table 26; page 35; FWS – FHWAR.
[28] Table 26; page 35; FWS – FHWAR.
[29] CERP Sections 8.7 and 8.8.

captured by our park visitation model. These values should be considered when evaluating Everglades restoration, particularly to local residents who derive pleasure from the increased number of animals residing around their homes. To fully capture the value of the impact of restoration on wildlife habitat and hunting, we summed the values from habitat and hunting calculations. Our best estimate is that Everglades restoration will increase wildlife habitat and hunting services by $407.4 million annually.

As a final word about habitat and hunting, it is important to note that the impact on hunting will only be negative if significant numbers of deer hunters do not transition to duck hunting as duck populations expand. The experience with Holey Land restoration suggests that it is complicated to forecast the impacts on hunting associated with expansive additional CERP restoration. On the one hand, it appears that additional duck populations attract people to duck hunting, and this is reasonable from the point of view of economic theory. It may also be true that existing duck hunters will chose to hunt locally more often and forego trips to distant duck hunting areas such as Louisiana, but we cannot estimate these shifts with any precision. In order to be conservative, we have assumed a very low elasticity of substitution between deer and duck hunting and a low elasticity of new duck hunters. Accordingly, our negative estimate on hunting is probably biased, and the likely outcome is not so dire. Additional information on hunter switching could refine this estimate.

Other Everglades Valuations, Miscellany

There are four broad areas of ecosystem services that, at present, we have not conclusively valued that might be forthcoming or enhanced as a result of Everglades restoration: the potential for carbon sequestration, potential fire-damage reduction, the potential for enhanced water purification, peat accretion and soil build-up, and the option value of unknown compounds and life forms living in the Everglades. While these values stand to be real and to change in important ways as the Everglades are restored, we are not prepared at this point in time to offer estimates of the pro forma financial calculations for two reasons. First, the science of these services is somewhat unsettled and unclear, compared to the other services, and second, the markets for these services are immature and undeveloped. Hence, while there is rampant speculation about how these services might be highly valued and special, we are not presently prepared to put hard numbers to these theories, regardless of what they might turn out to be.

We can note that if the world moves to a market for carbon sequestration, and such markets are developing, the amount of carbon sinking in the Everglades could be important. Our best estimate at this time is that the amount of carbon sequestered is small, but we have low confidence in that assessment. Moreover, the future of these markets is highly uncertain. So basically, while we acknowledge the potential for important values of carbon sequestration services and changes that might flow from restoration, in order to maintain our conservative stance, we will not add any hard numbers. As time proceeds, we will revisit our position on this topic.

Another topic for further study is the potential for Everglades restoration to improve South Florida's water quality in ways not captured by our real estate and recreation value estimates. Because wetland ecosystems are known for effectively filtering nutrients, we suspect a restored Everglades would produce significant cost savings in water treatment and create opportunities to improve poor water quality. In particular, we have researched the potential for CERP to reduce water quality treatment costs, beach closures and health impacts in South Florida. However, we have chosen to omit the corresponding valuations from this report because there exists significant disagreement in the scientific community over the connection between nutrient reductions and such water contamination cost drivers as harmful algal blooms, beach clean-ups, and shellfish poisoning.[30] Like carbon sequestration, this topic should receive additional attention as this research continues and progresses.

A third topic we might investigate further is the potential value of unknown compounds and life forms in a restored Everglades. These are commonly called "biodiversity values," and we have found evidence of nascent markets in biodiversity. Michele Zebich-Knos reports on a contract between Merck Pharmceuticals and INBio, an NGO in Costa Rica for biodiversity development.[31] The amounts of money at play in this market are not fully public. We are confident that there are others, and this appears to be a fertile area for further analysis. At present, however, given the high levels of uncertainty, we are not prepared to put hard and fast estimates to these option values. Given the scientific and policy uncertainty over these topics, our omission makes our valuation estimates more robust. However, future work should probably pay close attention to developments here.

There is speculation that the current Everglades is more fire prone because of reduced sheet flow. Fire has been a part of life throughout the nature history of the Everglades, but the real issue here is: How might one go about modeling the reduction of fire and then estimating the economic impact of fewer and less severe fires? According to our principle of a conservative approach to estimating benefits, we refrain from including any air quality or other impacts that a restored Everglades might have on fire duration, intensity or frequency. With that said, we suspect that a restored Everglades might likely have fewer fires or ones of less severity. And, we know that fire can create negative economic impacts. Fires in the Everglades, as they do elsewhere, cause air quality issues via smoke, plus they stand to destroy valuable property. Thus, reduced fires, if they were to be a result of Everglades restoration, would count as an additional benefit. Clearly,

[30] See Chapter 7 in the main document for additional discussion on this topic.

[31] "Preserving Biodiversity in Costa Rica: The Case of the Merck-INBio Agreement." *The J. Of Environment and Development*, 6(2)(1997).

additional work is warranted here.

Impact On Job Creation And Earnings

Restoration of the Everglades through the implementation of CERP will impact jobs in the state of Florida. Changes to the different ecosystem services in the Everglades will impact the number of jobs in a variety of industries and the economic activity they generate. In addition, the Corps of Engineers estimates there will be 22,000 jobs created as a result of the actual restoration projects.[32]

It is very important to understand that jobs are *not* an additional benefit above and beyond the present value calculations we have already presented. Instead, they are an alternative way of representing the overall change that is likely to be forthcoming from restoration. Economists often speak of a circular flow of economic activity where firms purchase inputs (land, labor, capital and the like) from households in order to engage production. As compensation for the release of these inputs, households are paid income (sometimes broken into finer gradients called wages, interest, rents and profit). Firms then sell the outputs made from the inputs to households in exchange for money. According to this logical truism, one may count the sales of the goods and services as one measure of the output of the firms, but one might also count the value of the inputs consumed. They have to be equal by the accounting identity. Jobs then are a loose or casual way of talking about the extent of economic activity being one of the primary inputs to production (and hence consumption). Most academic economists would prefer to discuss the sales of the output of the firms rather than the jobs used in production, but for some reason or another, policy makers, pundits and politicians seem to prefer the jobs numbers approach. For sure, jobs are easier to calculate and perhaps easier for lay people to appreciate. Our point here is to respond to that latter audience, but it would be a *big* mistake for anyone to interpret our discussion here as additive. The jobs are *not* in addition to the calculated benefits. They are an alternative way of visualizing the impact of Everglades restoration. We urge the reader to be careful and cautious on this point.

Our approach to estimating net job creation relies on an input/output model that uses data generated by the key components of this study (inputs) to estimate the number of incremental jobs and earnings as a result of CERP (outputs). We calculated outputs using jobs and earnings (or total economy) multipliers from different sources. Unless otherwise specified, we used total economic output multipliers to reflect the impact on the broader economy (direct, indirect and induced jobs). In some cases, we used only direct multipliers to avoid overlap (double counting) among the different sectors. We used the following key inputs and multipliers:

Commercial Fishing

[32] See Kopecky report, January 22, 2010.

- Input: Incremental dockside value of commercial fisheries (finfish, invertebrates and shrimp).
- Multipliers: Fishing producer employment multiplier (jobs/$ billion export value) from the USDA Economic Research Service and Total Economy multiplier.

Recreational Fishing

- Input: Incremental saltwater and freshwater anglers and expenditures in the Everglades region. We used a modified (50 percent) tourist (visitor) yearly growth-rate to determine the increase in anglers to the region (using the 2 percent tourist growth scenario). The incremental number of anglers (over a growing base) due to a restored Everglades was multiplied by average yearly "fishing-only" expenditures (to avoid overlap with tourism—shopping) to calculate incremental expenditures.
- Multipliers: Employment (jobs per $ million) and earnings (not total economy to avoid overlap with tourism) from Tony Fedler's report: "The Economic Impact of Recreational Fishing in the Everglades Region."

Residential Construction & Real Estate Services

- Input: Incremental value (from the "Potential Value Increase based on 23 percent Improvement in Water Quality" scenario) and subsequent activity in residential construction and real estate services. Elasticity between "increase in real estate value" and "increase in construction activity" was set at 0.5.
- Multipliers: Residential construction and real estate multipliers (Direct + Indirect + Induced) we calculated from "Shimberg Center for Affordable Housing; THE IMPACT OF RESIDENTIAL REAL ESTATE ON THE FLORIDA ECONOMY; 2005 update (Using Roll Year 2004 Property Appraiser Data)."

Park Visitation

- Input: Incremental visitors and expenditures in local park visitation by specific NAICS sector:
  - Hotel and lodging
  - Eating and drinking establishments
  - Transportation
  - Retail trade (shopping)
  - Entertainment
- Multipliers: Total effects multipliers from the REMI II model (from the MGM2 model, the University of Michigan). We utilized Large Metro, Small Metro and Rural multipliers depending on the specific county.

Agriculture

- Input: Decrease in crop acreage (mostly sugar cane = 88%) due to repurposing for stormwater storage and treatment. We used the EAA Water Retention Scenarios –

Agricultural Income Loss model (Marcel Aillery, et al) to determine the present value of income loss in an STA+RS (Stormwater Treatment Area + Reservoir = 83,500 acres) scenario. We used a 2.5 adjustment factor to include other crops and potential further land acquisitions.

- Multipliers: We used the USDA Economic Research Service "Sugar Cane and Sugar Beets) producer employment multiplier.

Table 8.1. Summary of Jobs Impact Results

Sector	Incremental Jobs
Commercial Fishing	6,798
Recreational Fishing	36,868
Residential Construction & Real Estate Services	273,601
Tourism (Lodging, Eating & Drinking, Transportation, Retail, Entertainment)	48,552
Agriculture	(3,724)
Wildlife Habitat & Hunting	80,569
TOTAL	**442,664**

In addition to the jobs created by the impacts restoration, there will be jobs created to do the actual work of restoration. The Corps of Engineers estimates that there will be approximately 22,000 jobs created in the construction projects detailed below in Table 8.2 as reported in Kopecky (2010). Table 8.2 is reproduced, unaltered, from that report.

Table 8.2. Direct Job Creation as a Result of Construction, COE Estimates[33]

Appropriation requests were run through IMPLAN (Minnesota IMPLAN Group) software. This is an input-output analysis that attempts to project employment, output and earnings for a given change or event in the economy's activity. This model is typically set up to run at regional levels, but contains a National function as well and this is what was analyzed. There are three types of effects

- **Direct effects** take place only for the industry immediately affected:
- **Indirect effects** concern inter-industry affects
- **Induced effects** measure the effects of the changes in household income. These changes effect the related industries employment.

The category of construction used was Sector 36 (Construction of other new non-residential). This is the closest to our construction technique.

[33] See Kopecky (2010) which is reproduced here exactly.

South Florida Water Management District
Job Creation in Everglades Restoration
AS RUN BY COE USING IMPLAN
February 1, 2009

Project	Appropriation Request	Direct	Indirect	Induced	Total
Herbert Hoover Dike Rehabilitation **(3)**	$77,000,000	645	382	510	**1538**
C-44 Reservoir and STA	$363,000,000	3042	1801	2406	**7249**
C-43 Reservoir **(1)**	$473,000,000	3963	2347	3135	**9446**
Kissimmee River **(3)**	$31,000,000	260	154	205	**619**
Picayune Strand /FAKA Union Pump Station Works and Road Removal	$57,000,000	478	283	378	**1138**
Picayune Strand /Merritt Canal Pump Station Works and Road Removal **(3)**	$52,000,000	436	258	345	**1038**
C-111 Spreader Canal	$35,000,000	293	174	232	**699**
C-51/STA1E	$8,000,000	67	40	53	**160**
L31 North Seepage Pilot Project **(3)**	$5,000,000	42	25	33	**100**
Seminole/Big Cypress **(3)**	$3,000,000	25	15	20	**60**
TOTALS(SFWMD PROVIDED)	**$1,150,000,000**	**9636**	**5707**	**7623**	**22966**

On Restoration Costs

Since CERP was ratified 10 years ago, it has become obvious that certain aspects of it were either unreasonable or inappropriate. Accordingly, for this analysis, the original CERP storage projects have been replaced with an alternative storage approach. This adjustment was made due to reasonable doubts that have been raised regarding the feasibility of the original storage options and their estimated costs. In addition, there exists a viable alternative storage method with sound cost estimates. CERP's original cost estimate included costs for the Lake Okeechobee ASR, In-ground reservoirs, and the EAA reservoir. In 1999 dollars, these three projects cost $2.6 billion, which represented 33.2 percent of the total $7.8 billion CERP cost. Since the original plan was completed, the feasibility and costs of these storage options have been reconsidered, and it is likely these costs were underestimated by a considerable amount. For our cost estimate, we have removed these costs from the CERP estimate and replaced the three storage projects with the River of Grass Reservoir storage option that has an estimated cost of $3.2 billion in 2010 dollars. The net effect of these changes is to adjust the total Everglades restoration costs to $11.5 billion in 2010 dollars.

Notes

Diamonds and Water

Economics has a conundrum called the diamond-water paradox. This conundrum ponders why diamonds, which are so unnecessary to life, are so valuable while water, so necessary, is so cheap. The paradox is resolved by noting that the prices of diamonds and water are *marginal* valuations to society of an additional unit of each, *not the total or average value*. The implication of this line of reasoning is profound. For instance, professional football players earn a much higher salary than do high school teachers, yet it is almost surely true that the value of high school teachers to the world exceeds the total value of football players. Marginal values do not reveal total values.

So it is with ecosystem services (or any other product for that matter). Accordingly, if we were to capture the *total* value of Everglades restoration, we would have to engage a more complicated and detailed process. Suffice to say here, our estimates are not total estimates. They only capture a portion of the total value of restoration. There is considerable consumer surplus, to use economic jargon, that is not captured by our methodology. Thus, our approach understates the total value to society of spending resources to restore the Everglades. Indeed, based on other studies, our gut feeling is that the true total benefits are several times larger than our marginal valuation estimates.

Consider Figure 2. Our calculations reported here effectively estimate the shaded area labeled E. There is potentially a much larger area, labeled CS, that represents economic well-being, or willingness to pay, which buyers or consumers of services obtain without paying for them. We call this consumer surplus. It is the unrequited or unpaid-for happiness that a consumer gets from a purchase, *above and beyond the purchase price.* We have not attempted to estimate this component of economic system services, but as the graph suggests, the area of CS can be substantially larger than the area of E, depending upon the price elasticity of demand for the particular service. As our work progresses, we will attempt to assay and estimate these valuations. They are important to any properly conceived analysis of economic wellbeing or welfare.

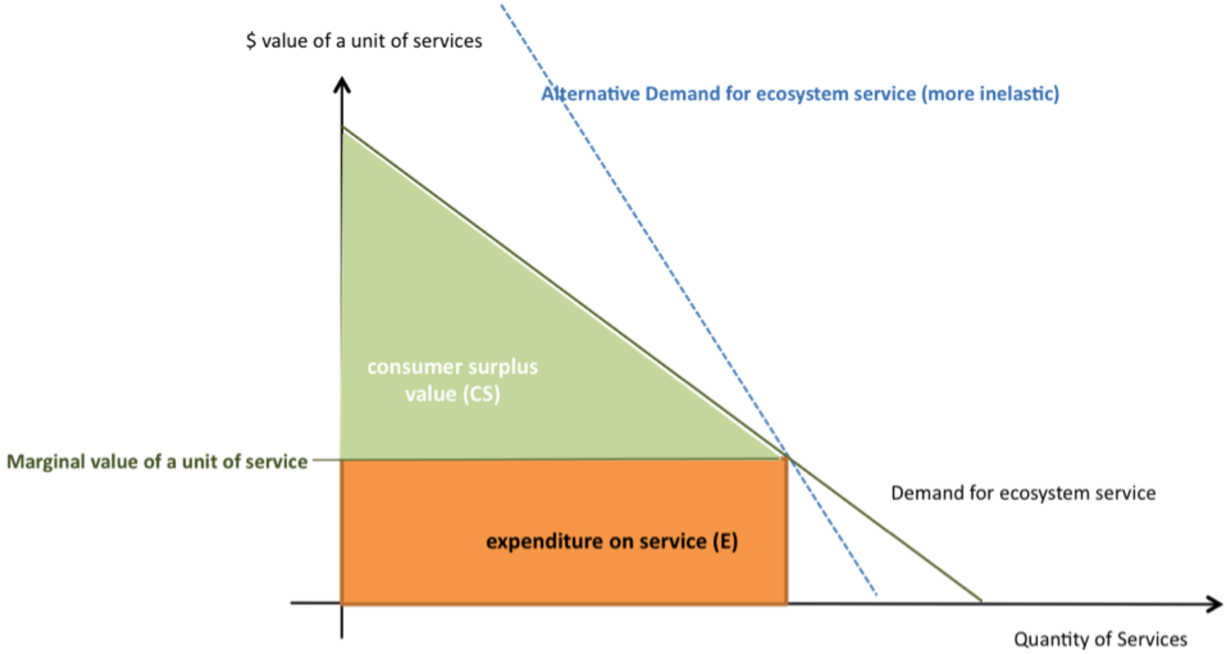

Figure 2 Product expenditure and consumer surplus

Regarding the effect of restoration on jobs, from the point of view of economic well-being or welfare, the important consideration is not total jobs, but incremental welfare above and beyond the opportunity cost of time or leisure. In a way similar to consumer surplus, most workers are paid wages higher than the underlying value of their time. This is called economic rent or producer. This is measured by the triangle above the supply curve of labor. Therefore, while many people view jobs as an economic good, the real increase in welfare comes not from employment, but from wages higher than the lost alternatives of leisure or home production. We have not estimated these additional benefits in our analysis, but suffice to say that, like the uncounted consumer surplus we mention, it stands to be important and non trivial. Our omission of this additional welfare makes our estimate of return on investment even more conservative.

Outrunning the Bear

At the outset of this evaluation, we promised to execute our assignment according to best practices and methods of economic science. We believe we have lived up to this promise, and we invite all readers to evaluate our success. It bears noting that one of the time-honored tenets of economic methodology, owed to Nobel Laureate Milton Friedman (and many others) is the concept that it takes a theory to beat a theory. In this spirit, while readers may criticize or disagree with our assumptions and techniques here, any such complaints will fall on deaf ears unless a superior alternative is proposed. Put bluntly, we will not accept criticism that simply says, “Your assumptions are wrong.” Let the critic propose adequate or superior alternatives. What this means in practical terms is that our work need not be perfect in order to be useful and acceptable. It just needs to be better than the rest. This does *not* mean that we believe we have done our job as well as it can be done. Rather, it is meant to convey that our minds are open to suggestions of better ways to do this project but not to simple statements that our work is wrong or incorrect. The Olympic Gold Medalist need not set a world record to climb to the top of the podium at the medal ceremony. She only need outrun the woman in second place. Of course, we hope that each piece of our work "sets a world record," but we will sleep soundly if our work is better than any other work tendered or suggested.

mather:

Detailed Report Section

Measuring the Economic Benefits of America's Everglades Restoration

An Economic Evaluation of Ecosystem Services Affiliated with the World's Largest Ecosystem Restoration Project

Introduction

The Everglades is a vast ecosystem comprising approximately three million acres, a sub-tropic wetlands covering a significant portion of South Florida. The wetlands system is fed by rain and water from Lake Okeechobee which is filled locally and by the Kissimmee River, which flows into the lake from the North. Figures 3 and 4 show the vastness of the wetlands ecosystem. Note to the obvious, because of the climate and ocean resources, this is a popular place for humans. The population of Miami-Dade County alone is approximately 2.5 million people and has grown by 11 percent over the past decade.[34] According to official documents from the State of Florida:

> The Everglades Ecosystem extends from the Chain of Lakes south of Orlando to the reefs beyond the Florida Keys, an area covering 18,000 square miles. Historically, freshwater moved south from Lake Okeechobee to Florida Bay in a broad, slow moving sheet—120 miles long and 50 miles wide but less than a foot deep—creating the Everglades. Known as the River of Grass, the Everglades is the second largest wetland on the planet. The Everglades is an enormously rich ecosystem, providing habitat to hundreds of species of birds, fish and other wildlife. In the late 1800s, primitive canals were dug to drain the vast wetlands in South Florida. Additional alterations continued throughout the 20th century, as more than 1,700 miles of canals and levees vastly changed the landscape, interrupting the Everglades' natural sheet flow and sending essential freshwater to sea. An astounding 2 million acres, or more than half the Everglades wetlands, were lost to development. Marjory Stoneman Douglas was the first to publicize the problems of the Everglades in 1947, describing an ecosystem that was beautiful yet already clearly suffering. Just one year later, in 1948, a massive project to provide essential flood protection and water management to South Florida was approved. While the Central and Southern Florida Project allowed the region's rapid growth, it worsened the Everglades' problems. The project includes about 1,000 miles of levees, 720 miles of canals and almost 200 water control structures. Much of the drained area became sugar farms or was heavily urbanized.[35]

Everglades National Park sits in the midst of the ecosystem and occupies nearly 1.4 million acres:[36]

> Everglades National Park is a subtle place where earth, water and sky blend in a

[34] Demographic details of each county in the region are reported below in Table 1.
[35] http://www.dep.state.fl.us/ern/restoration/default.htm.
[36] http://www.everglades.national-park.com/info.htm.

> low, green landscape; where mere inches of elevation produce distinct changes in vegetation; and where a great wealth of birds and other wildlife find refuge. For this is almost exclusively a biological park dedicated to the preservation of a complex and precisely ordered living mechanism. It lies at the interface between temperate and sub-tropical America, giving a rich diversity of species, many at the limit of their ranges.
>
> The topography is so subdued that a broad sheet of water slowly flows over and through the porous limestone bedrock on its way to the sea, rather than following well-defined valleys. Most of the park is actually covered with water during normal wet seasons, while dry winters cause fresh water to dwindle to a few open areas crowded with wildlife.
>
> The great floral variety of the Everglades is one of the key resources of the park. Among its more prominent and colorful plants are Bromeliads and epiphytic orchids. As many as 25 varieties of orchids are known to occur in the park, in addition to over 1000 other kinds of seed-bearing plants and 120 species of trees. Over 36 threatened or endangered animal species reside in Everglades National Park, such as the American alligator (*Alligator mississippiensis*) and crocodile (*Crocodylus acutus*), the Florida panther (*Felis concolor coryi*), the West Indian manatee (*Trichechus manatus*), and the Cape Sable seaside sparrow (*Ammodramus maritima mirabilis*). More than 300 species of birds have been recorded, seven of which are rare or endangered.[37]

This is a populated wetland, creating a trove of troubles with many actors occupying what is now little space. Resource conflicts are common in many places on the planet, but this area seems to have more than its fair share.

[37] http://www.everglades.national-park.com/info.htm.

Figure 3 Everglades

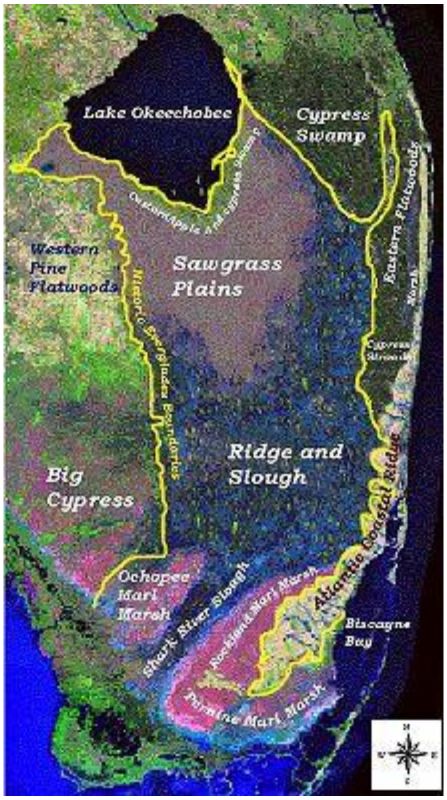

Figure 4 The Details of the Ecosystem

The sixteen county region of Florida that covers the area of the Everglades is economically and demographically diverse. Table 1 reports summary statistics on these counties, and it is noteworthy that, like the biodiversity in the surrounding natural environment, there is rich demographic diversity amongst the people in this portion of Florida.

Table 1
Demographic and Economic Facts, 16 county South Florida Region

County	Land area in acres	Population in 2009	Population Density, persons/sq mi.	Percentage Change in Population Since 2000	Housing Units, 2008	Median Value of Owner Occupied Housing, 2000	Total Retail Sales in 2002 (in 1000s)
Broward	1,205.4	1,766,476	1,465	8.8%	805,772	$128,600	$ 22,012,210
Charlotte	693.6	156,952	226	10.8%	101,223	$ 97,000	$ 1,434,629
Collier	2,025.3	318,537	157	26.7%	193,808	$ 168,000	$ 4,196,902
Miami-Dade	1,946.1	2,500,625	1,285	11.0%	979,082	$ 124,000	$ 24,568,286
Glades	773.6	10,950	14	3.5%	6,079	$ 72,400	$ 7,812
Hendry	1,152.5	39,594	34	9.3%	13,359	$ 71,500	$ 297,216
Highlands	1,028.3	98704	96	13.0%	55,377	$ 72,800	$ 737,104
Lee	803.6	586,908	730	33.1%	364,932	$ 112,900	$ 6,365,752
Martin	555.6	139,794	252	10.3%	75,920	$ 152,400	$ 1,921,445
Monroe	996.9	73,165	73	-8.1%	53,813	$ 241,200	$ 1,183,949
Okeechobee	773.9	40,241	52	12.1%	16,731	$ 77,600	$ 335,976
Orange	907.5	1,086,480	1,197	21.2%	460,600	$ 107,500	$ 12,403,154
Osceola	1,321.9	270,618	205	56.9%	120,997	$ 99,300	$ 1,751,198
Palm Beach	1,974.1	1,279,950	648	13.2%	640,851	$ 135,200	$ 16,480,821
Polk	1,874.4	583,403	311	20.6%	280,609	$ 83,300	$ 4,522,310
Saint Lucie	572.5	266,502	466	38.3%	132,341	$ 86,100	$ 1,886,487
TOTAL	18,605.23	9,218,899.00	7,212.98		4,301,494	$ 1,829,800	$ 98,218,764
AVERAGE	1,162.83	576,181.19	495.50	17.5%	268,843.38	$ 114,363	$ 6,256,578

Source: US Department of Census at http://quickfacts.census.gov/qfd/states/12000.html

For example, Glades County is rural and basically unpopulated, 14 people per square mile, as compared with Broward County, which has over 1,400 people per square mile. The owner-occupied housing in Monroe County is worth more than $241,000 per home (year 2000) compared with Hendry County where the median owner-occupied home was worth $71,500 in 2000. Some of the counties are bustling metropolises, Miami-Dade, Broward, Palm Beach, and Orange counties as examples with billions of dollars of retail sales per year (2002), while others are small, remote, and rural with miniscule total retail sales of less than $10 million for the year 2002. Against this backdrop and landscape we have been commissioned to estimate the economic impacts of the proposed Everglades restoration plan.[38]

There is a well-vetted plan to restore the Everglades to which we reference all our work. This is the Comprehensive Everglades Restoration Plan (CERP).[39] There are many folk who have proposed alternatives and additions to this plan.[40] We have not, at this point, evaluated any of these alternatives, save one.[41] With that said, the proposed rewards of this investment, somewhat surprisingly, have not, until now, been measured with any degree of scientific or economic rigor. The benefits of Everglades restoration, according to CERP, while arguably noble and substantial, are not precise:

> The Plan's focus has been on recovering critical ecological features of the original Everglades and other parts of the ecosystem. The Plan will restore natural flows of water, water quality and hydroperiods. The removal of more than 240 miles of internal levees and canals will improve the health of more than 2.4 million acres of the South Florida ecosystem, including Everglades and Biscayne National Park. The restoration of hydrologic conditions of the original natural areas of the South Florida ecosystem will result in Lake Okeechobee once again becoming a healthy lake. Major benefits will be provided to the Caloosahatchee and St. Lucie estuaries and Lake Worth Lagoon. The Plan will also improve fresh water deliveries to Florida and Biscayne bays. The greater

[38] "In 2000, Congress passed the Water Resources Development Act, authorizing the Comprehensive Everglades Restoration Plan. The State of Florida and federal partners—the U.S. Environmental Protection Agency, Army Corps of Engineers and Department of Interior—are deeply committed to Everglades restoration. The primary state agencies charged with carrying out the restoration are the Department of Environmental Protection and the South Florida Water Management District. Since 2000, Florida has invested more than $2 billion to restore water quality and flow in America's Everglades." (http://www.dep.state.fl.us/ern/restoration/default.htm).

[39] http://www.evergladesplan.org/index.aspx.

[40] The many details of CERP are outlined in a number of fact sheets which are viewable online at http://www.evergladesplan.org/facts_info/fact_sheets.aspx.

[41] Our project is based on an adjustment to the original CERP which replaces artificial injection of water into underground aquifers with the River of Grass concept. We offer details on this adjustment in more detail below.

> Everglades ecosystem will be much healthier than it is today. Improvements to native flora and fauna, including threatened and endangered species, will occur as a result of the restoration of the hydrologic conditions.[42]

Essentially, we do not argue or take any position on any aspect of the proposed restoration. We view ourselves as appraisers or estimators, not engineers or policy makers. We do not engage the job of deciding how the Everglades should be restored, whether it should be restored, who should pay for it if it is, when it should be done, or on what schedule. Instead, we approach our assignment from the perspective of the benign economic scientist, asked to render a fair, but conservative, estimate of the overall impact of the proposed restoration. Nothing more, nothing less.

Our Assignment

In February of 2010, we were asked by the Everglades Foundation if we could provide an economic analysis of the ecosystem service changes that would be associated with the Comprehensive Everglades Restoration Plan.[43] We took this task literally. This means that we *do not* do any of the following:

1. We do not evaluate or estimate the costs of restoration. We take these as a given, per se. Some have suggested that the estimate of costs is not accurate or appropriate. Be that as it may, we were not assigned that task and have not engaged it in any important way. Rather, we have relied upon cost estimates provided by the Corps of Engineers to the Congress and to the public.
2. We do not estimate the marginal or step-wise benefits of any particular portion of the CERP plan. Our approach is total. We look at the entire project as a whole.
3. We do not evaluate the scientific certainty or appropriateness of any of the CERP plan. Again, we take the plan as others have prepared it and estimate the benefits of it with the plan as a given.
4. We do not estimate any probabilities of the plan actually going into effect. We assumed that CERP will be implemented as described and planned.

[42] http://www.evergladesplan.org/about/rest_plan_pt_08.aspx.

[43] http://www.evergladesplan.org/index.aspx provides information on this project. The information that follows in our discussion here was taken primarily from this source.

Our Methods, Approach and Assumptions

There are many ways to estimate the value of an asset. We take the revealed preference approach, which means we only use data from actual transactions of people buying things. Other methods include contingent valuation and survey techniques. These methods have their place, but not in our work. We approach the problem of valuation using market data and real transactions and we do not use survey data or other methods to approximate what people might pay for a good or service. There is significant literature on these methods, but we are dedicated to avoiding speculation as much as possible, and hence we only use actual market transactions as metrics of people's willingness to pay. For a starting point on this discussion, consult Harberger (1971).[44]

For instance, when it comes to valuing cleaner water, we estimated the increase in value of real estate associated with water quality improvements caused by Everglades restoration. While we or others could ask people how much they might pay for an increase in water quality in their neighboring streams, we believe that method is fraught with issues that we seek to avoid. For instance, it is very hard for people to estimate how much they might pay for an environmental service, particularly when they cannot perfectly visualize what it is they are being asked to price hypothetically. On a related note, if survey respondents don't *actually* have to pay for the environmental service, they might artificially inflate their response so that they appear and feel more environmentally conscious. Our technique avoids these issues by only using prices actually paid by real people for real goods and services.[45]The benefits that will flow from a restored Everglades are a capital asset in that the services will accrue over time. In order to compute a net present value of these flows of services, it is necessary to discount the future returns or services to the present. We made no adjustment for inflation; all our calculations are in 2010-dollar terms, discounted to the present. As such, we make no assumption about the adjustment of relative prices over time. In effect, we assume that relative prices remain constant at 2010-dollar levels. We used the current municipal bond rate in South Florida, minus the current inflation rate to discount the future expected flows of services. This rate as of spring 2010 was 2.1 percent. We

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[44] Harberger, Arnold C. "Three Basic Postulates for Applied Welfare Economics: An Interpretive Essay." *Journal of Economic Literature*, *9*(3), (1971): 785-97.

[45] For additional information on contingent valuation and criticism of that method, see Glenn Harrison. "Valuing public goods with the contingent valuation method: A critique of kahneman and knetsch." *Journal of Environmental Economics and Management*, (November 1992): 248-257 among a host of others. See also Peter Diamond and John Hausman. "Contingent Valuation: Is Some Number Better than no Number?" *Journal of Economic Perspectives*, 8(4), (Autumn 1994): 45-64.

note that the current U.S. Treasury inflation adjusted bond rates, depending upon maturity date, span our choice of discount rate. The 10-year TIPS bonds issued on July 15, 2010 have a yield of 1.295 percent. The 30-year TIPS bonds issued on February 26, 2010 are currently carrying a yield of 2.229 percent. Accordingly, we suggest that our discount rate of 2.1 percent is appropriate and conservative.[46]

As economists, in any attempt to measure value there is always a tension which arises from something we call the diamond-water paradox.[47] Essentially, there are two ways to measure the value of a product. One is the expenditures paid by consumers and received by sellers. This is the price of the product or service times the quantity purchased. In economic jargon, this is called the rectangle of expenditure or simply the rectangle. This metric is simple, straightforward and easy to calculate under most circumstances. More meaningful in many situations, however, is the concept called consumer surplus, which measures the additional or unrequited joy that a buyer gets, *above and beyond the price paid*, which is also a measure of economic welfare. This additional value that consumers place on their purchases is sometimes called the triangle of consumer surplus (as opposed to the rectangle of expenditure). In fact, most economists take the position that the total value of an asset is not just what the buyer might have paid for it, but the price paid plus the additional amounts that buyers *would be willing to pay*. Note carefully that this is not the same as contingent valuation.

Contingent valuation is ascertaining or estimating what something might be worth in the absence of a market or transaction or budget constraint. Consumer surplus is the value that a buyer receives above and beyond the purchase price of a good or service that is transacted in the marketplace.[48]

Why is this important? We discuss consumer surplus in more detail below, but for now suffice to say that the actual benefits from Everglades restoration, according to standard economic theory, include not only the direct expenditures, which we measure, but also the consumer surplus which we do not measure. We choose not to measure the consumer surplus in this case for two reasons:

[46] These data were taken from http://www.treasurydirect.gov/RI/OFNtebnd.

[47] It is not exactly clear who first coined this phrase, but the concept and its importance are discussed in virtually every principles of economics textbook published in the last century. We discuss this topic in more detail below.

[48] Estimating consumer surplus requires knowledge or estimation of the consumer's entire demand curve, not just the point of purchase. In that sense, it is somewhat like contingent valuation, but yet very different as there are empirical methods for estimating the actual demand curve that vary considerably from the techniques of contingent valuation.

first, measuring consumer surplus is a difficult, expensive and time-consuming chore; and second, our approach is conservative and avoids controversy. This means that our estimates of benefits associated with restoration are very conservative, perhaps by a factor of two or three times.

One of the ways we have chosen to be transparent and conservative is to offer sensitivity analysis. For instance, we project that most benefits will persist for 50 years, and therefore, we compute the present discounted value of restoration gains out to the year 2060. However, we also present estimates over just 30 and 40 years as well. As another example, in the case of fisheries restoration, the science, as we have come to understand it, does not offer us a precise estimate as to when fish populations will return to their natural levels. To cope with this uncertainty, we computed gains in fishing from restoration under different scenarios, immediate restoration, 20 year lagged restoration, and 30 years for the fisheries to fully restore. Details of this method are discussed below.

Our approach is designed to let readers and critics see our methods and assumptions. This allows readers to make alternative assumptions about facts yet revealed in order to make their own conclusions. We chose this conservative approach because the future is uncertain, and a modicum of restraint seems appropriate given the risk and uncertainty about such a large project as CERP. Furthermore, we are striving to be reasonably non-controversial. In the end,we believe that our methods are based on the best, sound science. If anything, we expect that our critics might assert that our estimates of benefits of Everglades restoration are too small and not reflective of the actual gains that might accrue. We are comfortable with this position.

What Others Have to Say About Everglades and Everglades Restoration

There are more than a few commenters on the current state of the Everglades and the proposed restoration of this giant environmental asset. Our task is *not* to assess the value of the Everglades and its ecosystem, nor to comment on the advisability or scientific wisdom of undertaking restoration or its many parts. Instead we have the task of estimating, conservatively, the economic change that would take place if the proposed CERP is actually implemented in total. Our work should not be interpreted as an assessment of any particular part of CERP restoration or the advisability or economic consequences of any part. We have *not* undertaken this marginal approach. Instead, owing to time constraints and our directed assignment, we have attempted to estimate the impact of undertaking the entire complement of CERP projects taken as a whole.

Caveat emptor, and readers are ill-advised to take our work as speaking on the value or subjectivity of any particular aspect of CERP.

The National Park Service has this to say about the current state of the Everglades ecosystem:

> The same rains that fall on South Florida today once ran off the backs of our wood stork's forebears, but the similarity ends there. Now, extensive canal and levee systems shut off the life-giving bounty of the rain before it can reach the national park, which makes up only one-fifth of the historic Everglades. At times the water control structures at the park boundary are closed, and no water nourishes the wood stork's habitat. Or, alternately, water control structures are opened and unnaturally pent-up, human-managed flood waters inundate Everglades creatures' nests or eggs and disperse seasonal concentrations of the wading birds' prey. Added to these problems is the presence of pollutants from agricultural run-off. High levels of mercury are identified in all levels of the food chain.
>
> Many animals are specifically adapted to the alternating wet and dry seasons. When human manipulation of the water supplies are ill-timed with natural patterns, disasters can results. Alligators build their nests at the high-water level. If more water is released into the park, their nests are flooded and destroyed. Endangered snail kite birds feed on the aquatic apple snail. Low-water conditions, human caused or natural, reduce snail and snailkite populations. In the early 1960s only 20 to 25 snail kites remained in North America because of prolonged drought. Snails lay eggs above the water in the wet season. If managers release more water, snails fail to reproduce.
>
> Given present trends, the endangered wood storks may no longer nest in South Florida by the year 2000. The wood stork has declined from 6,000 nesting birds to just 500 since the 1960s. Their feeding behavior explains their predicament. Wood storks feed not by sight, but by touch -"tacto-location"- in shallow and often muddy water full of plants. Fish can't be seen in those conditions. Walking slowly forward the stork sweeps its submerged bill from side to side. Touching prey, mostly small fish, the bill snaps shut with a 25-second millisecond reflex action, the fastest known for vertebrates. Only seasonally drying wetlands (mostly in drying ponds) concentrate enough fish to provide the 440 pounds a pair of these

big birds requires in a breeding season. When natural wetlands cycles are upset by human water management, wood storks fail to nest successfully. The wood stork - which stands more than three feet tall, and has a 5-foot wing span, and weighs 4 to 7 pounds - was placed on the endangered species list in 1984.

Native trees, such as mangroves and cypress, are being replaced by exotic (introduced) species from other countries. Florida largemouth bass share their nesting beds with tilapia and oscars, fish imported from Africa and South America. As the Everglades yield to human introduced plants and fish, native species diminish.[49]

The Comprehensive Everglades Restoration Plan lists lofty goals as benefits. With the implementation of the plan, improvements will be made by:

* Restoring natural flows of water, water quality and hydroperiods;
* Improving the health of more than 2.4 million acres of the South Florida ecosystem, including the Everglades and Biscayne National Park;
* Improving hydrologic conditions will result in Lake Okeechobee once again, becoming a healthy lake;
* Improving native flora and fauna, including threatened and endangered species;
* Ensuring a reliable, adequate supply of fresh water for use by all – the environment, urban and agriculture;
* Maintaining flood protection set in place by the C&SF project; and
* Creating wide-ranging economic benefits, not only for Florida, but the entire nation.[50]

Richard Weisskoff has written extensively about Everglades restoration. In “The Economics of Everglades Restoration,” Weisskoff argues that the economy of Florida and the Everglades ecosystem are inseparable and that efforts to plan and implement a restoration of the Everglades ecosystem without incorporating likely economic effects are profoundly flawed. This premise is a response to the Everglades restoration planning Weisskoff observed in the late 1990s, which failed to consider the economic activity occurring within the region. To support the argument in favor of including economic factors in the restoration planning process, Weisskoff provides forecasts of the Florida economy with and without Everglades restoration using a Regional Economic Model (REMI) that he has adjusted to incorporate environmental factors specific to

[49] http://www.everglades.national-park.com/info.htm.
[50] http://www.evergladesplan.org/about/rest_plan_pt_08.aspx.

the Florida economy. These economic forecasts provide evidence of 1) the demands placed on the Everglades ecosystem in the areas of fresh water supply, urban land and agriculture and 2) the interdependence between South Florida's economic activity and the health of the Everglades ecosystem.

The forecasts produced in Weisskoff's book are pre-recession, and, although the author provides a range of economic growth scenarios, they are likely overestimates of actual economic activity in the region. Despite what might be errors in these forecasts, the scale of growth that will occur in the vicinity of the Everglades over the next 30 years is undeniable. Weisskoff argues that economic growth will be spurred by any restoration efforts and that the enhanced growth will lead to further degradation of the Everglades ecosystem. This assumed tradeoff between economic growth and environmental restoration is implicit in his work, and little attention is paid to the possibility both could occur in tandem.

Weisskoff's analysis does provide some estimates of ecosystem services, but they are produced using a variation of the approach described by Costanza (*Nature*, 1997). This approach is distinct from the macroeconomic forecasting methods used throughout the book. To estimate the ecosystem values for the Everglades, Weisskoff applies average ecosystem service values per land and sea acre for the areas included within the Everglades ecosystem. He uses two GIS land surveys of the Everglades to arrive at the land areas that are mapped to each ecosystem service. He finds that the economic contribution of ecosystem services provided by the land acres within the Everglades was $31.66 billion in 1995. This reduction of $2.42 billion from the 1988 value is due to changes in land usage. Both values are given in 1994 dollars. The value of ecosystem services provided by the water within the Everglades is added to the land totals to arrive at $58.7 billion in 1995. He notes that this estimate of the Everglades' ecosystem services is roughly equal to one-third of the South Florida economy. The Costanza methodology is described elsewhere in this literature review, but it is worth noting that it includes non-marketed economic values in the per-acre estimates, which is a substantial departure from the approach used in our analysis. Also, the Costanza estimates of per-acre ecosystem values are developed using global estimates of economic service values. Applying these global per acre ecosystem values to a single ecosystem such as the Everglades is fraught with issues of interpretation.

On Costs

As we mentioned earlier, we were not asked to estimate the costs of Everglades restoration or to analyze the estimates that others have derived. Our analysis is only about the benefits. However, for purposes of comparison, we use the cost estimates that others have derived, but with some adjustments. The details of that adjustment are reported in the appendix to this chapter. For our purposes, we take the cost of restoration as $11.5 billion in 2010 terms and use it only for comparison to the benefits we estimate (also in 2010 dollar terms).

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Appendix to Introduction

The following appendix describes our method of converting the original 1999 cost of Everglades restoration to 2010 terms, allowing for the so-called River of Grass option as opposed to the artificial pumping approach.

Since CERP was ratified 10 years ago, it has become obvious that certain aspects of it were either unreasonable or inappropriate. Accordingly, for this analysis the original CERP storage projects have been replaced with an alternative storage approach. This adjustment was made due to reasonable doubts that have been raised regarding the feasibility of the original storage options and their estimated costs. In addition, there exists a viable alternative storage method with sound cost estimates. CERP's original cost estimate included costs for the Lake Okeechobee ASR, In-ground reservoirs, and the EAA reservoir. In 1999 dollars, these three projects cost $2.6 billion, which represented 33.2 percent of the total $7.8 billion CERP cost. Since the original plan was completed, the feasibility and costs of these storage options have been reconsidered, and it is likely these costs were underestimated by a considerable amount. For our cost estimate, we have removed these costs from the CERP estimate and replaced the three storage projects with the River of Grass Reservoir storage option that has an estimated cost of $3.2 billion in 2010 dollars. The net effect of these changes is to adjust the total Everglades restoration costs to $11.5 billion in 2010 dollars.

Cost Estimates of Everglades Restoration					
	Construction	**Land**	**Total Initial**	**Annual O&M**	**Year of $**
3 projects that Bill pointed out within current CERP:					
Lake Okeechobee ASR	$1,108,797,000	$7,515,000	$1,116,312,000	$25,000,000	1999
In-Ground Reservoirs	$783,695,000	$255,277,000	$1,038,972,000	$3,205,753	1999
EAA Reservoir	$350,112,000	$86,536,000	$436,648,000	$14,458,409	1999
Total of these projects	$2,242,604,000	$349,328,000	$2,591,932,000	$42,664,162	1999
Total CERP	$5,598,113,000	$2,221,435,000	$7,819,548,000	$172,000,000	1999
			33.15%		
EF best guesses of true costs for these three projects; based upon realistic costs from ongoing projects and comparables; remove these from the original estimate					
Revised LO ASR	$1,800,000,000	$19,500,000	$1,819,500,000	$150,000,000	2010
Revised In-Ground	$1,680,000,000	$1,744,650,000	$3,424,650,000	$2,000,000	2010
Revised EAA Reservoir	$1,152,000,000	$224,000,000	$1,376,000,000	$2,066,667	2010
	$4,632,000,000	$1,988,150,000	$6,620,150,000	$154,066,667	2010
Add this back in:					
River of Grass Reservoir	$2,880,000,000	$350,000,000	$3,230,000,000	$6,400,000	2010
Fed - Corps gets money from two sources - land vs. operations					
State does not do it that way; they include operations costs to calculate rate of return & interest rates on bonds					

2005-07-01	124.678			1.12359976	8,786,042,244
2005-10-01	125.751			1.13326965	8,861,656,413
2006-01-01	126.382			1.13895623	8,906,122,900
2006-04-01	127.388			1.14802231	8,977,015,587
2006-07-01	128.312			1.15634941	9,042,129,746
2006-10-01	128.722			1.16004434	9,071,022,392
2007-01-01	129.994			1.17150762	9,160,660,064
2007-04-01	130.908			1.1797446	9,225,069,524
2007-07-01	131.355	1		1.18377297	9,256,569,555
2007-10-01	131.884	1.00402725		1.18854032	9,293,848,115
2008-01-01	132.066	1.00541281		1.19018051	9,306,673,631
2008-04-01	132.540	1.00902135		1.1944522	9,340,076,349
2008-07-01	133.954	1.01978608		1.20719519	9,439,720,743
2008-10-01	133.627	1.01729664		1.20424826	9,416,677,096
2009-01-01	134.317	1.02254958		1.21046655	9,465,301,305
2009-04-01	134.212	1.02175022		1.20952029	9,457,901,969
2009-07-01	134.260	1.02211564		1.20995287	9,461,284,523
2009-10-01	134.376	1.02299874		1.21099826	9,469,459,027
2010-01-01	134.584	1.02458224		1.21287276	9,484,116,760

12,100,000,000	12,397,445,092	
	0.331468264	
	8,288,085,490	
	3,230,000,000	
	11,518,085,490	2010 dollars

Chapter 1: Ground Water Purification and Aquifer Recharge

One of the prime benefits of restoring the Everglades will be that the ensuing increase in sheet flow will cause the groundwater extracted by communities, municipalities and individuals in the region to be less brackish than it is now or would be in the future absent restoration. As more water flows out of Lake Okeechobee into the restored Everglades region, groundwater will be recharged at higher rates with clean water mostly free of salt compounds. This higher grade water and increased flow will recharge the aquifers underneath South Florida, which will in turn reduce the amount of purification required for the current population and in the future as population and incomes grow.

Groundwater in the coastal counties of the South Florida Water Management District (SFWMD) is brackish, so it must be desalinated before most uses. The capital cost of desalination, given the state of the art of the reverse osmosis (RO) technology, is driven by the volume of fresh water that must be produced, which in turn is driven by population growth. The operating cost of desalination, on the other hand, is a direct function of the salinity of the water input. Saltier water must go through the RO membranes at a higher pressure, which requires more energy. Restoring sheet flow according to the Comprehensive Everglades Restoration Plan (CERP) can be expected to decrease groundwater salinity, because more fresh water allowed into the aquifer from above will displace seawater seeping into it from below. So, conservatively, we expect the restoration of the Everglades to result in at least the energy cost savings from having to desalinate less saline water. We ignore any potential capital cost savings from 1) the likely prospect that fewer desalination plants will be built in the first place, and 2) reduced labor and maintenance costs from using less saline input (assuming, that is, that RO membranes fail at higher rates when higher-pressure, more saline water is pushed through).

Using the assumptions detailed below, we estimate that restoration of the Everglades will result in energy cost savings amounting to between $13.5 and $29.6 billion over the next 50 years, combined across all parties, public and private, who are expected to desalinate water in the SFWMD.

We assume no change in reverse osmosis technology or in the cost of electricity, and we use a discount rate of 2.1 percent. Growing energy costs would increase these estimates. Improvements in desalination technology would decrease them. The higher figure assumes that all the water withdrawn must be desalinated. The lower figure assumes that only the water currently classified as saline must be desalinated. Current salinity readings indicate that all groundwater is brackish, not just that which is currently classified as saline. This makes the higher figure above plausible.

Finally, the energy costs are computed based on desalinating a combination of surface water and groundwater in proportions projected based on historic observations. Surface water salinity is much lower and growing more slowly. We treat it the same way as groundwater for simplicity: if it is saline, it will have to be desalinated. Its effect, however, on energy cost is far smaller than that of desalinating groundwater.[51]

Avoided Desalination Costs

General approach and data sources

Our model has four steps. First, we project population and income growth in the area of interest over the next 50 years, and use the projected values to model water withdrawals over the same period. Next, we use historical salinity readings to infer the change in salinity over the next 50 years without the Everglades being restored. Then, we infer the yearly desalination cost over the same period using regression analysis and engineering data published by the Texas Water Development Board (TWDB). Finally, we repeat the cost calculations assuming that if the Everglades were restored, water salinity would drop to its 1970 level and stay there even as the volume of water withdrawn grew as driven by population and income growth.

In other words, we assume that implementing CERP would result in a new steady state where the aquifer would be replenished with freshwater to a sufficient extent that it could sustain increased withdrawals with no increase in its salinity. The difference between the discounted streams of yearly desalination cost with and without Everglades restoration is our estimated economic benefit in the form of avoided desalination costs that can be credited to CERP.

[51] In our forecasting model, predicted groundwater salinity falls over time in some counties before it rises, and is predicted to dip below its 1970 baseline for the first few years after 2010. This can result in negative savings in the least-discounted years, with a disproportionate effect on the net present value of the savings combined over the next 50 years. This is the case of Miami-Dade County, where savings are negative and falling toward zero for the next 12 years before they move into positive territory. We could have zeroed out such negative savings under the theory that, while CERP might not make things better, it will not make them worse. We decided against it. This means that our benefits estimate, on this count, is probably biased downward too low.

We collected data on water use in SFWMD, by county and by year, from the U.S. Geological Survey (USGS). We collected salinity data from DBHYDRO, the official SFWMD data repository of water research results, and from the National Water Information System (NWIS) maintained by the USGS.

Technical details

Water use

The USGS collects county-level data on water withdrawals every five years. We are interested in data for the 16 counties in the SFWMD. The earliest available records are from the 1985 data set. The latest, from 2005. Table 1.1 reports the information over time.

Table 1.1: Total Water Withdrawals in the 16 SFWMD counties, Mgal/d

	1985	1990	1995	2000	2005
Groundwater, fresh	1,961.12	2,475.38	2,371.54	2,705.35	2,386.13
Groundwater, saline	0.00	0.00	4.63	0.00	3.26
Surface water, fresh	1,284.40	1,777.18	1,868.83	1,987.03	1,560.78
Surface water, saline	2,523.58	3,195.40	3,319.94	3,948.82	3,754.76
Total, fresh	3,245.52	4,252.56	4,240.37	4,692.38	3,946.91
Total, saline	2,523.58	3,195.40	3,324.57	3,948.82	3,758.02

Source: USGS Water use survey (http://water.usgs.gov/watuse/).

Using these data and yearly population and income figures by county over the same time span, we extrapolated water use into the future 50 years using a fixed-effects panel regression model where water withdrawals were modeled as a function of population and per-capita income. This model assumes that the effect of population or income on water use is the same across all counties of interest, and the differences come from their relative sizes – more populous counties draw more water, but at the same per-person rate as less populous ones. This may sound simplistic, but absent controls for other reasons why different counties might have different water needs (lawns in Palm Beach, industry in Miami) the model gives a fair representation of the average water needs. We used this specification for modeling separately four sub-totals of water withdrawals: saline and fresh groundwater, and saline and fresh surface water. Parameter estimates are in the appendix to this chapter.

Salinity

The SFWMD maintains DBHYDRO, an online database of water quality measurements taken over time by various parties. One of these measurements is salinity, defined as Chloride in milligrams per liter (same as parts per million). Each measurement comes with the location of the station and the date it was taken, so it is straightforward to combine them into yearly averages per county.

The USGS maintains the National Water Information System (NWIS), a similar online database with its own Chloride records, with the same unit of measurement, also with locations and time stamps.

Both DBHYDRO and NWIS record salinity separately by ground and surface water. In the case of groundwater, we are interested in measurements taken in wells no deeper than 500 feet. Below this depth, the water is saline. Southern Florida's fresh groundwater comes from surficial aquifers, with water withdrawn from depths well above 500 feet.

Table 1.1 shows that most groundwater withdrawn inside the SFWMD is classified as fresh. The two non-zero measurements for saline groundwater come almost entirely from one county – Miami-Dade. However, salinity measurements tell a different story: groundwater in the 16 counties has been growing increasingly brackish over time, even after discarding any samples taken from depths either unknown or greater than 500 feet (Figure 1.1). It is reasonable, then, to assume that desalination will be needed for all groundwater withdrawn in the SFWMD in the future, whether by private or public water supply systems. Restoring the Everglades will help decrease the expected cost of desalination to the extent that it will succeed in reversing the trend of increasing groundwater salinity.

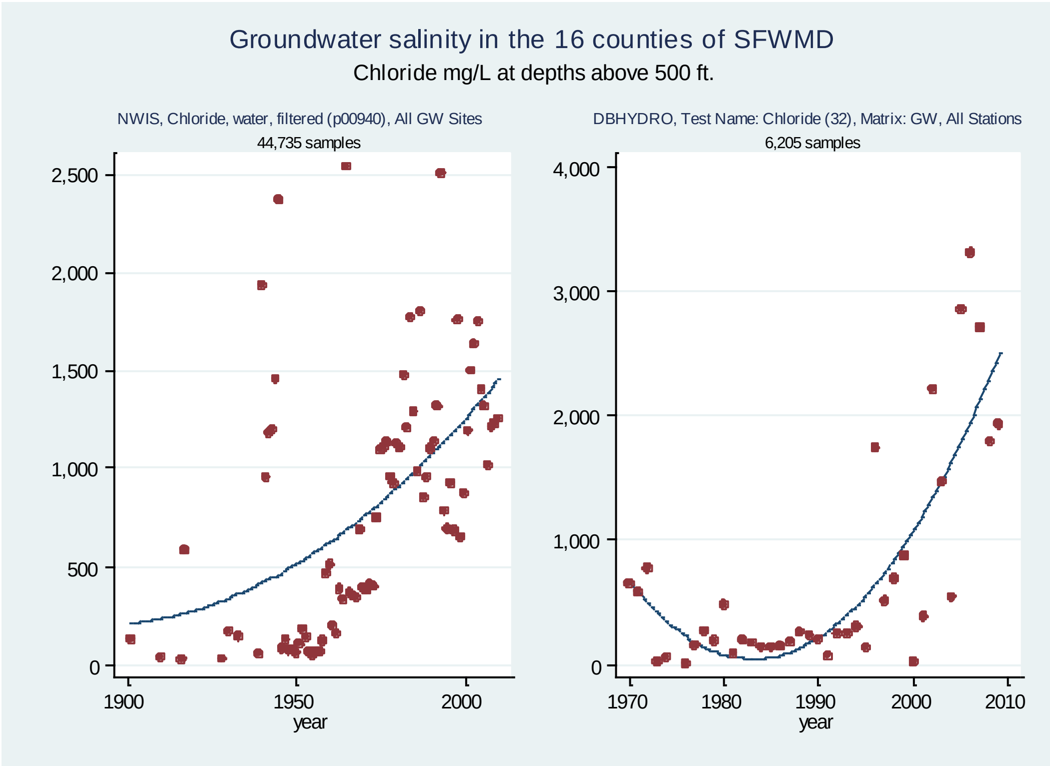


Figure 1.1: Evidence of growing salinity in Southern Florida's groundwater

Even as the DBHYDRO and the NWIS data differ about the extent of the growth in salinity, they agree that the trend is positive and accelerating. The estimated cost savings from avoided desalination depend on which of the two sets of salinity data we use to extrapolate salinity with and without CERP into the future. Though the NWIS data record a far larger number of samples, these cover only 7 of the 16 counties of interest as shown in Table 1.2 below. We had to choose between using data from fewer samples covering all counties or from more samples covering some of the counties. We chose DBHYDRO because we believe that complete coverage is more valuable than higher-density sampling of only part of the area of interest. As Figure 1.1 suggests, had we chosen NWIS our cost-saving estimates would have been lower, because projected salinity would have been lower based on the data summarized in the graph on the left.

Table 1.2: Coverage of Chloride samples

	DBHYDRO	NWIS
Broward	278	15,004
Charlotte	38	
Collier	533	4,644
Glades	92	
Hendry	193	639
Highlands	164	
Lee	276	4,694
Martin	242	
Miami-Dade	1,007	15,525
Monroe	3	148
Okeechobee	931	
Orange	33	
Osceola	432	
Palm Beach	1,264	4,081
Polk	263	
St. Lucie	456	
Total	**6,205**	**44,735**

The exercise assumes that CERP would result in groundwater salinity falling back to its 1970 level. Without CERP, salinity would continue to grow along its current path as shown in the right half of Figure 1.1. Surface water would be minimally affected: for the sake of simplicity, we treat it the same way as groundwater, but its salinity is low and growing very slowly.

The cost of desalination

Desalination requires a capital investment – building the plants – and an ongoing operating cost in the form of energy used, maintenance, and labor. Our understanding of the desalination problem comes from a study done for TWDB by LBG-Guyton Associates, available in PDF and referenced in the Chapter 1 References below. A brief summary follows:

The relation between the total cost of desalination and the salinity of the water input is a matter of very loose approximation because of technological progress, changes in the relative prices of the various inputs (both in the production of fresh water and the disposal of concentrates and brine), and local characteristics.

We do know that more saline input must be pushed through RO membranes at a higher pressure. Though the baseline of this relationship is dropping as RO technology improves, it remains true that the higher the pressure, the higher the energy expended, and there are no economies of scale in this process. This is the cost of interest to us, because everything else is subject to either scale effects or factors depending on local characteristics. For example, larger plants, as well as plants designed to operate at a higher baseline pressure, have some efficiencies built-in. The cost of disposing of the brine via deep-well injection depends on the local geographic options for doing so. The same goes for the cost of disposing of the concentrate (sludge that's saturated with impurities other than salt). We did not undertake to estimate any cost savings that might result from having to dispose of less salt, a scenario that would be the result of restoration.

The TWDB study documents two values of pressure required in pounds per square inch (psi) at given levels of groundwater input salinity in milligrams per liter (mg/L): it takes 200 psi to treat 3,000 mg/L water, and it takes about 1,000 psi to treat 30,000 mg/L sea water. Absent better data, we can only say that, as salinity grows by a factor of 10, the pressure required grows by a factor of 5. Filling in a few intermediate values, we estimated, via linear regression, the following functional relation between pressure y and salinity x:

(1) $y(PSI) = 78.18 + .029*x(mg/L)$.

Next, we estimated a similar relation between energy, in MWh/year, and pressure. The same study documents that a 10MGD (million gallons/day) plant takes 10,600 MWh/yr to operate at 300psi, 17,700 MWh/yr to operate at 500 psi, and 24,700 MWh/yr to operate at 700 psi. Our estimated functional relation between energy z and pressure y is:

(2) $z(MWh/yr) = 41.67 + 35.25*y(PSI)$.

Combining (1) and (2) yields the following relation between energy z and salinity x:

(3) $z(MWh/yr) = 2{,}797.5 + 1.014*x(mg/L)$.

We used equation (3) as our model of the annual cost of energy as a function of water input salinity assuming an energy price of $.08 per kW/h, based on the average electricity price in Florida for industrial use ($.0767 in 2007).[52]

[52] http://www.ppinys.org/reports/jtf/electricprices.htm.

Next, we projected this annual desalination cost for each SFWMD county, given its projected water withdrawals (ground and surface) and their respective salinity levels given their current path (groundwater salinity expected to rise at a growing rate as shown in Figure 1.1; surface water salinity, not shown, expected to remain unchanged for the most part). Then we repeated the calculations with salinity levels held at their 1970 level.

Results

Our avoided desalination cost estimate is the difference between projected desalination costs given the current path of rising salinity versus holding it constant at its 1970 level, which is our expected environmental effect of CERP. Net present values of the yearly savings between 2010 and 2060 are shown in Table 1.3 below. We assume a 2.1 percent discount rate, quadratic growth patterns in population and income, as well as in salinity (without CERP). We use DBHYDRO salinity readings. We perform this calculation under two assumptions regarding water withdrawn in the SFWMD over the next 50 years, by public and private parties: first, we assume that all water will have to be desalinated; second, we assume that only the water classified as saline will have to be desalinated. Though the latter sounds obvious and results, as expected, in a lower estimate, the former is not implausible. Current readings show that all groundwater in SFWMD tested at depths above 500 feet is saline to some extent, and it is growing more saline on average. If not all of it is treated now, it likely will need to be in the future.

Table 1.3: Projected avoided desalination costs* under CERP, by county

	(1)	(2)
Broward	4,874,613,988	3,336,185,306
Charlotte	1,845,151,810	110,230,864
Collier	3,199,893,209	1,264,661,598
Glades	1,219,888,896	0
Hendry	737,265,172	0
Highlands	451,662,287	0
Lee	2,028,597,261	1,125,228,393
Martin	1,058,726,538	0
Miami-Dade	2,076,442,179	1,469,949,796
Monroe	889,385,452	0
Okeechobee	473,328,531	0
Orange	2,065,805,877	1,358,980,032
Osceola	1,028,574,150	403,534,040
Palm Beach	5,279,093,539	3,440,020,286
Polk	1,192,452,967	625,697,186
St. Lucie	1,194,564,609	395,420,582
Total	**29,615,446,465**	**13,529,908,083**

(1) Assuming that all groundwater withdrawn must be desalinated
(2) Assuming that only saline groundwater must be desalinated
***** Energy costs only

These avoided desalination costs are energy-cost savings alone. Water desalination using reverse osmosis requires pretreatment to prevent membrane fouling, disposal of the byproduct brine and concentrates and non-trivial capital investments. We ignored maintenance and disposal costs because they are too dependent on local conditions to be believably projected from the TWDB study. And we assumed that capital costs would be unchanged with or without CERP, as new desalination capacity would be built according to freshwater needs, not to the salinity of the input. This makes our estimates above conservative.

Chapter 1 References

Cost Analysis of Groundwater Desalination: http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWReports/Brackish%20GW%20Manual/35-Ch04.pdf

DBHYDRO data: http://www.sfwmd.gov/portal/page/portal/xweb%20environmental%20monitoring/dbhydro%20application

NWIS data: http://waterdata.usgs.gov/nwis

Appendix to Chapter 1

Part 1: Total water withdrawals model

	Withdrawals, Million gallons/day			
	Groundwater		Surface-Water	
	Saline	Fresh	Saline	Fresh
Population, April 1, thousands	0.001*	0.081	0.556***	0.086
	(2.02)	(1.87)	(4.76)	(1.21)
Per-capita income ($1,000)	-0.010	0.306	-1.951	0.431
	(-0.90)	(0.46)	(-1.09)	(0.40)
Constant	-0.329	105.201***	6.809	57.524*
	(-1.33)	(7.24)	(0.17)	(2.43)
R-squared	0.07	0.13	0.34	0.07
N	80	80	80	80

t-values in parentheses (* p<0.05, ** p<0.01, *** p<0.001)

Part 2: Details on U.S.G.S. data collection

We used the Google Chrome Sessions Manager to obtain water quality data from the U.S.G.S.

1. http://waterdata.usgs.gov/fl/nwis/nwis -- main portal to Florida data

2. http://nwis.waterdata.usgs.gov/tutorial/finding_qwdata.html -- tutorial on how to access historical data for any given watershed

3. http://nwis.waterdata.usgs.gov/fl/nwis/qwdata?search_criteria=county_cd&submitted_form=introduction -- GUI for downloading Florida data by county. This is where we selected out the 16 SFWMD counties.

4. http://nwis.waterdata.usgs.gov/nwis/pmcodes/pmcodes?pm_search=salinity&casrn_search=&radio_pm_search=srsname_search&srsname_search=potassium&format=html_table&show=parameter_cd&show=parameter_group_nm&show=parameter_nm&show=casrn&show=srsname -- water quality parameter code definitions

5. http://nwis.waterdata.usgs.gov/nwis/help/?read_file=site_tp&format=table -- USGS site type codes.

Part 3: Locations of and other information on existing SFWMD desalination plants

Desalination can be a confusing concept. The following information was obtained from the SFWMD and is reproduced here, *without alternation in its original form and format*, for information about current and future desalination in the region. (It is interesting to note that the last figure in this section (Named "Growth of Desalination in the SFWMD" and unnumbered) reveals a forecast of desalination which maps closely to our forecast of ground water salinity in Figure 1.1 which is some independent confirmation of our approach to groundwater.)

Desalination in South Florida – Frequently Asked Questions

What is desalination?
Desalination removes dissolved substances in groundwater, seawater and municipal wastewaters making water fit for human consumption, irrigation, industrial use and other purposes. In the past, distillation was the most widely used desalination process, but use of electrodialysis and particularly reverse osmosis, is increasing. Electrodialysis retains clean water and allows salts to pass. Reverse Osmosis (RO) purifies saltwater by forcing it through semi-permeable membranes, allowing water to pass, but retaining the impurities of heavy metals and compounds such as lead and nitrates called concentrate or reject that must be safely disposed. The filtered water is so pure that it must be post-treated and blended with other sources for potable supply.

What is the difference between brackish water and seawater?
The primary difference between these two sources of water is in the amount of dissolved salts. Seawater contains higher amounts of dissolved salts (from 15,000 milligrams per liter (mg/l) to over 35,000 mg/l of total dissolved solids). Brackish water has 1,00015,000 mg/l. The greater the salt content of the water, the higher the pressure or electric power needed to treat water using membranes, resulting in higher energy costs.

Why is desalination an important issue in Florida?
With more than 120 desalination plants in Florida, our state leads the nation in desalination. Texas has 38, California, 33. Florida leads because the water underneath, east and west of the peninsular is salty. The increasing demand for water, coupled with the state's vulnerability to drought events, compel water planners to consider all alternatives. The 2001 and 2007 droughts stressed surface water systems, but seawater sources are not affected by drought.

How does everyone benefit from seawater desalination?
Desalination benefits everyone in Florida through diversification of our choices. Treating seawater to serve coastal Florida reduces competition with the Everglades initiatives and relieves dependence on existing conventional surface water and groundwater supply sources. Using

seawater by coastal residents could increase availability of surface water for water users located away from the coast. Consequently, seawater desalination can indirectly benefit people who live farther away from the coast.

How does desalination affect the environment or climate change?
Environmental Protection Agencies have specific guidelines that must be followed by builders of desal facilities to avoid harmful effects to environments. Environmental impact studies are conducted to identify, investigate and issue recommendation regarding possible impacts of disposing waste on land, air and water. In the recently completed Tampa Bay seawater project, monitoring has shown no significant impacts on fauna and flora. Highly concentrated salts, the major by-products of desalination, can be safely disposed using best management practices. Desalination does not substantially affect climate change because its activities are insignificant compared to others. Advances in energy recovery devices and low-pressure RO systems are substantially reducing power demand and the carbon footprint.

How much does desalination cost?
Advancements in reverse osmosis technology have brought desalination costs closer to other alternatives. Ten years ago, desalinated water cost more than $9 per 1,000 gallons, but today, the range is $2 to $5 per 1,000 gallons. Israel's world-largest desal water costs are about $2 per 1,000 gallons and the recently completed 25 MGD Tampa Bay plant produces water at about $3 per 1,000 gallons. The cost depends on whether the source water is brackish groundwater or seawater. Brackish water desalination costs less than seawater desalination because it contains less dissolved salts. The total costs also depend on the amount of pre-treatment and post-treatment needed. Because of available grants, subsidies and innovative financing, the costs are not entirely passed to the end user.

Some pros and cons of water desalination
Pros:

- Provides a dependable, drought-proof source of water
- Provides an alternative that could allow other stressed water sources to recover.
- Prevents water "wars" and addresses the state legislation for source diversification
- Provides the way of the future either for potable or wastewater treatment due to advancing technologies and the associated reduction in costs
- Provides high quality water
- Saves construction of future dams and reservoirs.

Cons:

- Still more expensive than traditional sources due to high energy consumption
- Concentrate or waste brine from the desal process is an environmental concern
- Intakes and discharge points may present harm to marine life
- Permitting desal plants is still difficult

Does the District support or fund desalination projects?
The District's Regional Water Supply Plans have recognized desalination as an economically viable method and support it through the Alternative Water Supply Grant Program. Other state grant programs, federal appropriations and private/public partnering may be used to fund desalination projects.

How many brackish and seawater desalination plants are currently in operation in Florida?
Florida has more than 130 desalination plants. In the SFWMD, there are about 26 facilities using brackish water and reverse osmosis treatment with a total capacity of more thanover 140 MGD. In addition, there is over 120 MGD of RO capacity under construction within our District. Statewide, there are three seawater desalination facilities, the two oldest in Key West with a capacity of 3 MGD and the newest in Tampa producing 25 MGD.

Are there plans to build more desalination plants in Florida?
Every fiscal year, the District receives applications for new desalination facilities. Regarding seawater, the District completed a feasibility study in December 2006. The study identified three locations where seawater treatment facilities could be co-located with electric power plants to take advantage of abundant plant cooling water and existing intake and discharge facilities. Utilities are considering moving forward more thoughtfully and deliberately, in view of the experience gained from the new Tampa Bay seawater plant.

Contact Person: Ashie Akpoji **(561) 682-2571**, Water Supply Department, SFWMD

SFWMD RO Desalination Capacities

Plant	Planning Region	Yr.	Desal Cap.	System Cap.	Desal Percent	Plant completion sorted every two (2) years			
			MGD*	MGD	%	Facility	2008	2010	2012
Plantation Utilities	UEC	1990	0.4	0.4	100%	Plantation Utilities	0.4	0.4	0.4
St. Lucie West	UEC	2005	3.4	3.4	100%	St. Lucie West	3.4	3.4	3.4
Sailfish Point	UEC	1978	0.4	0.4	100%	Sailfish Point	0.4	0.4	0.4
Sailfish Point Golf Club	UEC	2007	0.4	0.4	100%	Sailfish Point Golf Club	0.4	0.4	0.4
Port St. Lucie			33.7	41.7	81%	**Port St. Lucie**			
Port St. Lucie-JEA	UEC	2005	22.5	22.5		*Port St. Lucie-JEA*	22.5	22.5	22.5
Port St. Lucie-Prineville	UEC	2003	11.2	19.2		*Port St. Lucie-Prineville*	11.2	11.2	11.2
Fort Pierce	UEC	2002	16.1	21.0	77%	Fort Pierce	16.1	16.1	16.1
South Martin Regional	UEC	2003	2.0	8.1	25%	South Martin Regional	2.0	2.0	2.0
Martin County Utilities			13.5	19.1	71%	**Martin County Utilities**			
Martin County North	UEC	1994	5.5	8.8		*Martin County North*	5.5	5.5	5.5
Martin Tropical Farms	UEC	1996	8.0	10.3		*Martin Tropical Farms*	8.0	8.0	8.0
Cape Coral			30.1	30.1	100%	**Cape Coral**			
Cape Coral - North	LWC	2009	12.0	12.0		*Cape Coral - North*		12.0	12.0
Cape Coral - SW	LWC	1976	18.1	18.1		*Cape Coral - SW*	18.1	18.1	18.1

Plant	Planning Region	Yr.	Desal Cap.	System Cap.	Desal Percent	Plant completion sorted every two (2) years				
Clewiston	LWC	2008	3.0	3.0	100%	Clewiston	3.0	3.0	3.0	
Fort Myers	LWC	2002	13.0	13.0	100%	Fort Myers	13.0	13.0	13.0	
Greater Pine Island	LWC	1999	3.8	3.8	100%	Greater Pine Island	3.8	3.8	3.8	
Island Water Association	LWC	1973	4.7	4.7	100%	Island Water Association	4.7	4.7	4.7	
Collier County			30.0	54.0	56%	**Collier County**				
Collier County North	LWC	1999	10.0	22.0		*Collier County North*	10.0	10.0	10.0	
Collier County South	LWC	2004	20.0	32.0		*Collier County South*	20.0	20.0	20.0	
Lee County Utilities			9.9	39.0	25%	**Lee County Utilities**				
Corkscrew	LWC	2008	1.0	15.0		*Corkscrew*	1.0	1.0	1.0	
North incl. Olga	LWC	2006	5.0	10.0		*North incl. Olga*	5.0	5.0	5.0	
Pinewoods	LWC	2008	2.9	5.0		*Pinewoods*	2.9	2.9	2.9	
Green Meadows	LWC	2008	1.0	9.0		*Green Meadows*	1.0	1.0	1.0	
Bonita Springs	LWC	2003	6.5	15.0	43%	Bonita Springs	6.5	6.5	6.5	
Marco Island	LWC	1992	6.0	12.7	47%	Marco Island	6.0	6.0	6.0	
Manalapan	LEC	2004	1.7	2.4	72%	Manalapan	1.7	1.7	1.7	
Tequesta	LEC	2008	2.4	5.1	47%	Tequesta	2.4	2.4	2.4	
Jupiter	LEC	1989	13.7	29.3	47%	Jupiter	13.7	13.7	13.7	
PBC - Lake Region WTP	LEC	2008	10.0	10.0	100%	PBC - Lake Region WTP	10.0	10.0	10.0	
North Miami	LEC	2012	6.0	14.0	43%	North Miami				***6.0***
Hialeah	LEC	2011	10.0	24.0	42%	Hialeah			10.0	
FKAA			9.0	24.0	38%	**FKAA**				

Plant	Planning Region	Yr.	Desal Cap.	System Cap.	Desal Percent	Plant completion sorted every two (2) years			
FKAA - Marathon	LEC	1980	2.0	2.0		*FKAA - Marathon*	1.0	1.0	2.0
FKAA - South Dade	LEC	2009	6.0	24.0		*FKAA - South Dade*		6.0	6.0
FKAA - Stock Island	LEC	1980	1.0	1.0		*FKAA - Stock Island*	2.0	2.0	1.0
North Miami Beach	LEC	2008	6.5	32.0	20%	North Miami Beach	6.5	6.5	6.5
Highland Beach	LEC	2004	3.0	3.0	100%	Highland Beach	3.0	3.0	3.0
Seacoast Utilities	LEC	2012	4.3	30.5	14%	Seacoast Utilities			4.3
Miramar	LEC	2009	2.0	14.8	14%	Miramar		2.0	2.0
Deerfield Beach	LEC	2010	3.0	23.0	13%	Deerfield Beach		3.0	3.0
Fort Lauderdale Dixie	LEC	2010	6.0	88.0	7%	Fort Lauderdale Dixie		6.0	6.0
Hollywood	LEC	1996	2.0	55.5	4%	Hollywood	2.0	2.0	2.0
MGD* = Million gallons per day							**207.1**	**236.1**	**250.4**
							2008	**2010**	**2012**

Updated October 8, 2009FKAA = Florida Keys Aqueduct Authority
LEC = Lower East Coast of the SFWMD
UEC = Upper East Coast of the SFWMD
LWC = Lower West Coast of the SFWMD

Source: South Florida Water Management District

South Florida Water Management District

Current and Projected Potable Water Desalination and System Capacity

District-Wide Desalination (Million Gallons per Day, MGD)			
	Desalination Capacity	Finished Water Use	Desalination (Percent of Finished Water Use)
2008*Actual	235	1,100	20
2025**Projected	540	1,500	35

*Includes plants started in 2008 that will be completed before 2012.
**Based on the 2006 / 2007 regional water supply plan updates.

Desalination is the treatment of brackish water that contains total dissolved solids (TDS) in excess of 1000 milligrams per liter. The treatment method used in desalination is reverse osmosis (RO). The Floridan and the Lower Hawthorn aquifers are common groundwater sources of high TDS. The use of seawater is limited.

Key Successes in Desalination

Kissimmee Basin *(Portions of Orange, Osceola, Polk, Highlands, Glades, and Okeechobee counties)*

- The Upper Floridan Aquifer contains fresh water and it is the main source of water in that basin; no brackish sources are currently used.

Lower West Coast (LWC) *(Lee, Collier, and portions of Hendry, Glades, and Charlotte counties)*

- Currently, the LWC has 95 MGD of desalinated water resources, which comprises 74% of its total finished water supply. This region is the District leader in brackish water desalination by volume.
- Seawater desalination is under consideration in Lee County.

Upper East Coast (UEC) *(Martin, St. Lucie, and portions of Okeechobee counties)*

- Currently, the UEC has 70 MGD of desalinated water resources, which could potentially supply 100% of its total finished water supply. Desalination is expected to continue to grow in this region.
- A seawater desalination plant co-located with a power plant is under investigation by St. Lucie County.

Lower East Coast (LEC) *(Palm Beach, Broward, Miami-Dade, Monroe, and portions of Hendry counties)*

- Currently, the LEC has 70 MGD of desalinated water resources, which comprises 8% of its total finished water supply. This region has the highest growth in desalination since 2003.
- Palm Beach County completed the Lake Regional 10 MGD desalination plant in March 2008.
- The LEC has two peaking seawater desalination facilities and it is considering future seawater plants.

Key Opportunities and Challenges to Increase Desalination

Desalination challenges affecting all regions

- Capital cost is high, RO treatment is energy intensive, and energy cost is increasing.
- Concentrate disposal is a limiting environmental issue.
- Permitting may restrict use of the Floridan Aquifer in order to avoid overuse and water quality issues.
- Resources can be an issue due to limited certified well drilling contractors, causing high bids.

Kissimmee Region

- Lower Floridan is brackish in some areas and concentrate disposal will be a challenge.

Lower West Coast

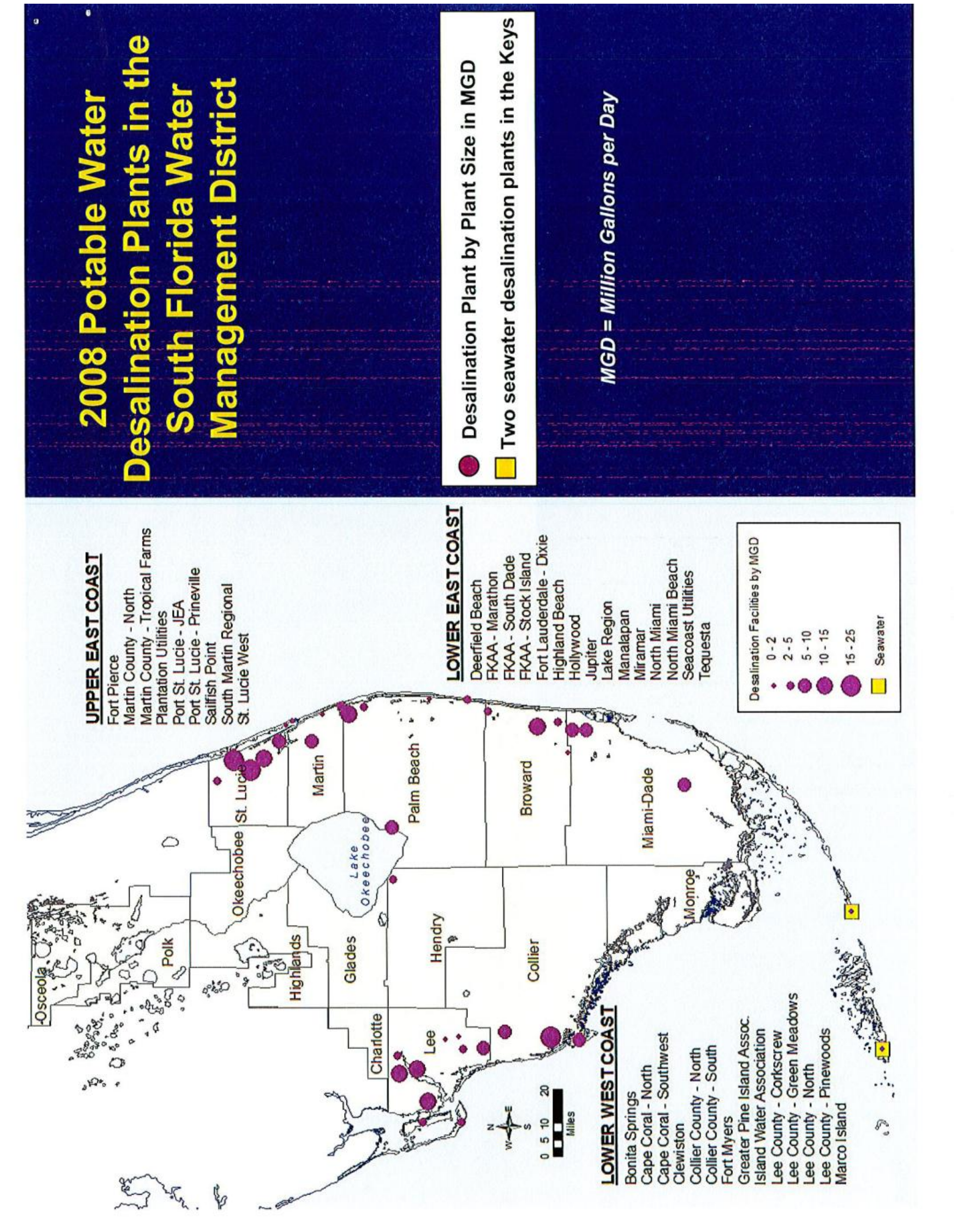
- Desire for increased use of traditional fresh groundwater sources.
- Brackish Floridan / Lower Hawthorn groundwater and seawater projected to meet future demands.

Upper East Coast

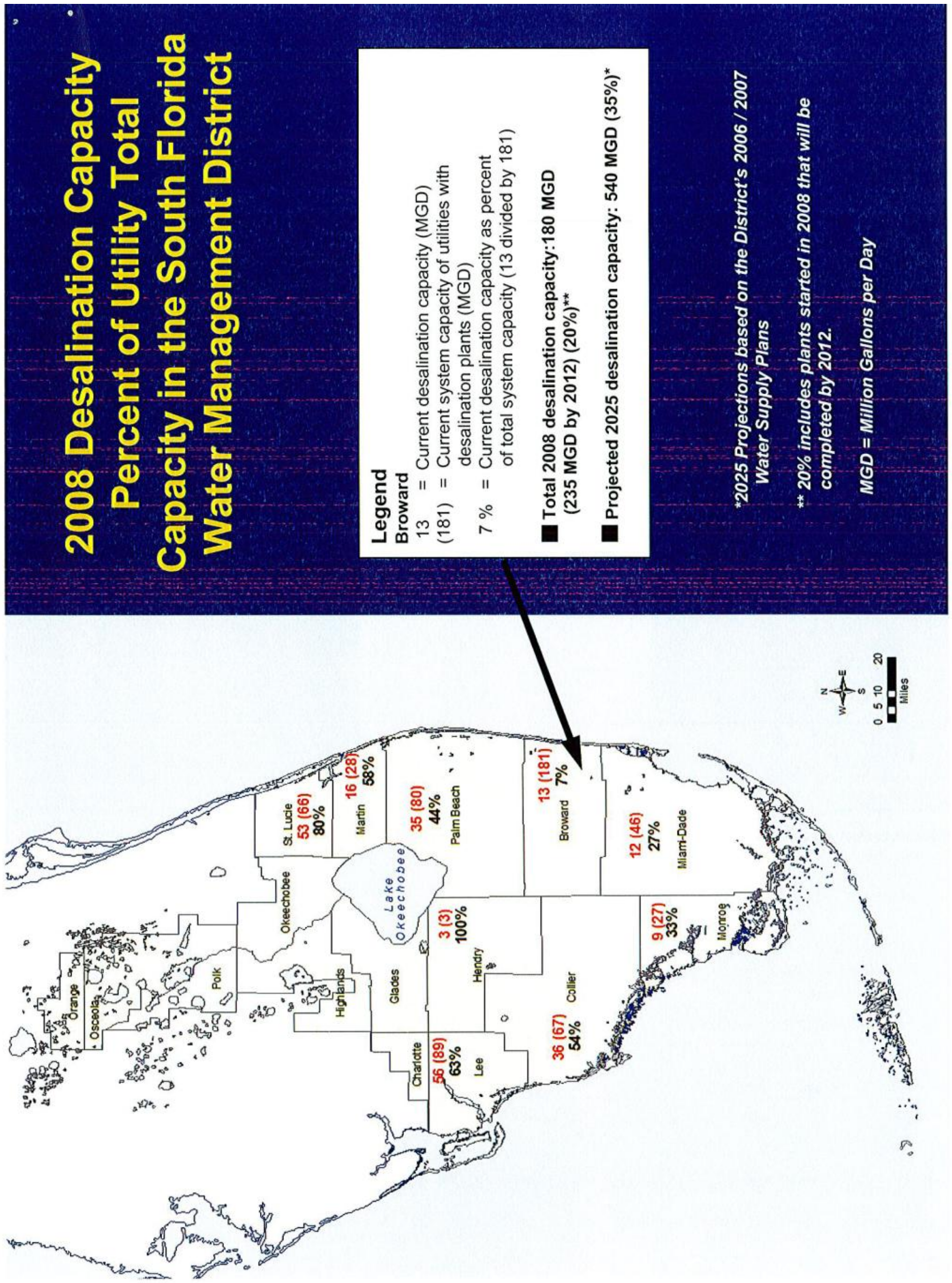
- Brackish groundwater desalination projected to meet future needs.

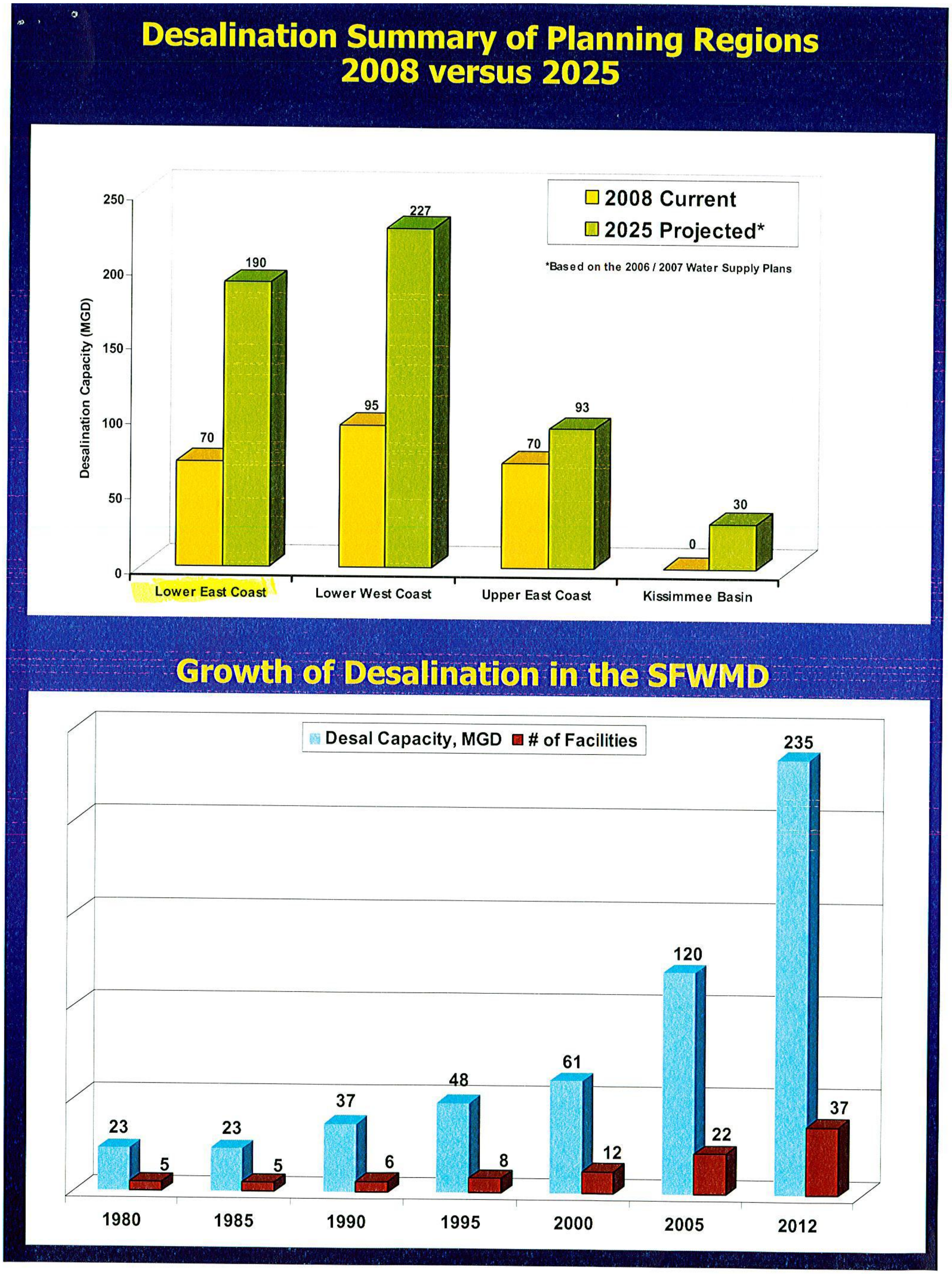
Lower East Coast

- Highest projected demand to be met by desalination.
- District's 2006 co-located seawater desalination study identified two desirable sites in Broward and Miami-Dade counties.



2008 Potable Water Desalination Plants in the South Florida Water Management District
Desalination Plant by Plant Size in MGD
Two seawater desalination plants in the Keys
MGD = Million Gallons per Day
UPPER EAST COAST
Fort Pierce
Martin County - North
Martin County - Tropical Farms
Plantation Utilities
Port St. Lucie - JEA
Port St. Lucie - Prineville
Sailfish Point
South Martin Regional
St. Lucie West
LOWER EAST COAST
Deerfield Beach
FKAA - Marathon
FKAA - South Dade
FKAA - Stock Island
Fort Lauderdale - Dixie
Highland Beach
Hollywood
Jupiter
Lake Region
Manalapan
Miramar
North Miami
North Miami Beach
Seacoast Utilities
Tequesta
LOWER WEST COAST
Bonita Springs
Cape Coral - North
Cape Coral - Southwest
Clewiston
Collier County - North
Collier County - South
Fort Myers
Greater Pine Island Assoc.
Island Water Association
Lee County - Corkscrew
Lee County - Green Meadows
Lee County - North
Lee County - Pinewoods
Marco Island
Desalination Facilities by MGD
0 - 2
2 - 5
5 - 10
10 - 15
15 - 25
Seawater
Osceola
Polk
Okeechobee
St. Lucie
Martin
Highlands
Glades
Lake Okeechobee
Palm Beach
Charlotte
Lee
Hendry
Broward
Collier
Monroe
Miami-Dade
0 5 10 20
Miles


2008 Desalination Capacity
Percent of Utility Total
Capacity in the South Florida
Water Management District
Legend
Broward
13 = Current desalination capacity (MGD)
(181) = Current system capacity of utilities with desalination plants (MGD)
7 % = Current desalination capacity as percent of total system capacity (13 divided by 181)
Total 2008 desalination capacity:180 MGD (235 MGD by 2012) (20%)**
Projected 2025 desalination capacity: 540 MGD (35%)*
*2025 Projections based on the District's 2006 / 2007 Water Supply Plans
** 20% includes plants started in 2008 that will be completed by 2012.
MGD = Million Gallons per Day
Orange
Osceola
Polk
Okeechobee
Highlands
Glades
Charlotte
St. Lucie
53 (66)
80%
Martin
16 (28)
58%
Lake Okeechobee
35 (80)
44%
Palm Beach
3 (3)
100%
Hendry
56 (89)
63%
Lee
36 (67)
54%
Collier
13 (181)
7%
Broward
12 (46)
27%
Miami-Dade
9 (27)
33%
Monroe
0 5 10 20
Miles


Desalination Summary of Planning Regions
2008 versus 2025
2008 Current
2025 Projected*
*Based on the 2006 / 2007 Water Supply Plans
Desalination Capacity (MGD)
250
200
150
100
50
0
70
190
95
227
70
93
0
30
Lower East Coast
Lower West Coast
Upper East Coast
Kissimmee Basin
Growth of Desalination in the SFWMD
Desal Capacity, MGD
# of Facilities
23
5
23
5
37
6
48
8
61
12
120
22
235
37
1980
1985
1990
1995
2000
2005
2012

Chapter 2: Water Quality and Residential Real Estate Valuation

Impact of Improved Water Quality

We anticipate that a restored Everglades will improve the quality of water in the 16-county South Florida Water Management District.[53]

Water plays an important role in the determination of residential real estate values. Proximity, type (ocean, bay, lake, river, etc.), view, size and quality are among the water attributes that are valued by real estate buyers. For example, lakeside or seaside properties sell at a premium to properties located away from bodies of water. A home on a clear stream trades at a premium to a similar home on a polluted stream. Of course, water and its attributes are only a small part of the bundle of attributes that determine a property's value. House size, quality of finish, proximity to a city and a great many other factors also play important roles.

Economists have developed techniques to quantify the incremental value of environmental attributes.[54] One of the often-used and robust techniques employed is hedonic pricing.[55] This method estimates the price people are willing to pay for individual product characteristics, such as a swimming pool or air conditioning, and environmental goods, such as water quality, holding other attributes constant. Studies consistently show that the water-quality effect is positive; that is, property located on or around high quality water is more valuable, *other things the same,* than property located on or around lower quality water. The magnitude of this effect is generally in the 0.5 percent to 7.0 percent range.[56] That is, some level of water quality improvement can have up to a 7 percent impact on real estate values. The same techniques also find, for example,

[53] The CERP as currently planned leaves some question about the overall impact on water quality throughout the 16 county region. However, it is our determination, after consultation with Everglades Foundation scientists, that overall water quality will increase throughout all of the counties and probably by more than the estimate we provide below. With that said, an extremely conservative approach would be to carefully examine the proposed impacts of the CERP on each individual county exploring the expected changes in the relevant water quality parameters there. This individualized inquiry would be advised except for the lack of time and precise details about exactly how the CERP will improve water quality in each sub-region within South Florida.

[54] There is a giant literature on hedonic pricing as a generic method in economics. For the pure theory see Sherwin Rosen. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *Journal of Political Economy*. 82 (January/February1974): 34-55 or Jack E. Triplett. "The Economic Interpretation of Hedonic Methods." *Survey of Current Business,* 66 (January 1986): 36-40. For a recent paper involving environmental amenities, see Frank F. Limehouse, Peter C. Melvin, and Robert E. McCormick. "The Demand for Environmental Quality: An Application of Hedonic Pricing in Golf." *Journal of Sports Economics,* 11 (June 2010) : 261-286.

[55] See, for example, Tom Kauko, Roland Goetgeluk, Ad Straub, and Hugo Priemus. "Presence of water in residential environments – value for money?" OTB Research Institute for Housing, Urban and Mobility Studies, (2003).

[56] Kauko, et al. (2003).

positive effects on air quality and negative effects on proximity to toxic waste sites.[57] These results are both intuitively and scientifically robust.

For the purposes of this study, our role is to estimate the impact on residential real estate values that will derive from a restored Everglades due to improvements in water quality. The calculation is:

$$\Delta \textit{ Real Estate Value} = \textit{Total Real Estate Value} \text{ H } E_{wq} \text{ H } \Delta wq$$

where,

E_{wq} = home price elasticity of water quality

wq = measure of water quality.

In order to estimate this effect we need several inputs:

- The total value of real estate in the impacted area,
- The extent to which water quality will be improved based on a restored Everglades (Δwq), and
- The sensitivity of real estate values to changes in water quality (E_{wq}).

We cannot know any of these inputs with precision. However, there are proxies available and we have made assumptions as noted below.

Real Estate Change-in-Value Estimation Results

The aggregate owner-occupied residential real estate value in the 16-county SFWMD is approximately $976.217 billion.[58] Based on a survey of hedonic estimates of water-quality

[57] Boyle, M.A. and K.A. Kiel. "A Survey of House Price Hedonic Studies of the Impact of Environmental Externalities." *Journal of Real Estate Literature*, 9 (2001): 117-44.

[58] Florida County Perspectives 2009, University of Florida Bureau of Economic and Business Research.

effects, the elasticity of real estate values with respect to water quality is .07054.[59,60] Assuming that water quality, as measured by dissolved oxygen, can be returned to 1970 levels as a result of restoring the Everglades, there is a potential 23.454 percent improvement in water quality.[61]

Combining these estimates, we estimate the incremental value of a restored Everglades on real estate across all 16 counties as:

$976.217 Billion H.07054 X .234 = **$16.108 Billion.**

This change represents a 1.655 percent increase in the aggregate value of real estate, which is well within the range of typical studies on water-quality effects. However, we have also done what-if analysis, to examine the impacts based on different levels of water-quality improvements. The results of that analysis are reported in Table 2.1, which also lists the county-by-county best estimates of additional ecosystem services forthcoming from a restored Everglades. We also estimated the increased value of real estate by assuming that nitrogen levels would not achieve the high levels of 2004 and 2005 hurricane years. These estimates are also reported in Table 2.1. Additionally, we assumed that it would take 1, 2, 3, 4 and 5 years for water quality goals to attain. These alternative assumptions are designed to provide the reader and analyst with a measure of sensitivity. For instance, if it takes three years for the water quality impacts to render, then total effect on real estate is $15.1 billion instead of $16.1 for all 16 counties.

[59] Poor, P., J., K. L. Pessagno and R. W. Paul. "Exploring the Hedonic Value of Ambient Water Quality: A Local Waterhsed-Based Study." *Ecological Economics*, 60(4) (2007).

[60] A 100 percent improvement in water quality will produce a 7.054 percent increase in real estate values.

[61] Restoring the current water quality to the 1970 level means, increasing the average dissolved oxygen content from its 2009 level 4.2359 (unfiltered) milligrams per liter to its 1970-71 level of 5.2485. See the appendix to this chapter for more information on the time series of dissolved oxygen in the region. Dissolved oxygen is not the only measure of water quality. There is salinity, turbidity, nitrogen content, and others. However, these are typically, but not always, correlated. While other metrics can be used, we did in fact create an estimate using nitrogen levels and the results were robust, we assert that dissolved oxygen is the best, single metric.

Table 2.1: Value of Everglades Restoration on South Florida Real Estate via Improved Water Quality

Table 2.1 Value of Everglades Restoration on South Florida Real Estate via Improved Water Quality

Real Estate Value Improvement - Best Estimate

County	Incremental Real Estate Value
Broward	$ 3,032,000,000
Charlotte	$ 261,000,000
Collier	$ 974,000,000
Dade	$ 4,379,000,000
Glades	$ 7,000,000
Hendry	$ 21,000,000
Highlands	$ 96,000,000
Lee	$ 1,058,000,000
Martin	$ 333,000,000
Monroe	$ 307,000,000
Okeechobee	$ 21,000,000
Orange	$ 1,561,000,000
Osceola	$ 340,000,000
Palm Beach	$ 2,807,000,000
Polk	$ 557,000,000
St. Lucie	$ 353,000,000
Totals	$ 16,108,000,000

Years Until Water Quality Goals Met	Potential Increase in Real Estate Value at 2.1% Discount Rate
1	$ 15,777,000,000
2	$ 15,452,000,000
3	$ 15,134,000,000
4	$ 14,823,000,000
5	$ 14,518,000,000
Discount Rate	**2.10%**

Sensitivity Analysis

	Potential Real Estate Value Improvement Using Various % Change in Water Quality					
Basis	**1%**	**5%**	**23% - Best Estimate**	**25%**	**50%**	**100%**
Suspended Solids Model	$ 536,000,000	$ 5,357,000,000	$ 16,108,000,000	$ 13,392,000,000	$ 26,785,000,000	$ 53,570,000,000
Nitrogen Model	$ 689,000,000	$ 6,887,000,000		$ 17,216,000,000	$ 34,433,000,000	$ 68,865,000,000

mather:

Appendix to Chapter 2

Table 2.2 reports the average annual levels of two metrics of water quality in the South Florida region, milligrams of dissolved oxygen per liter (unfiltered) and the percentage of saturation of dissolved oxygen. These data were obtained from the U.S. Geological Survey. Our benchmark for assessing the impact of Everglades restoration on real estate is to assume that the milligrams of dissolved oxygen per liter will be returned to the average of the years 1970 and 1971. We compared this average, 5.2485 to the 2009 average level, 4.236. The 1970-71 level is 24 percent higher. Had we used the alternative measure of water quality, percentage of saturation of dissolved oxygen, the benchmark restoration would have been far more dramatic, a 75 percent increase in water quality (implying a much larger increase in real estate values, three times as large. Using our conservative principle, we used the smaller estimate.

Table 2.2
Dissolved Oxygen In South Florida Waters Overtime
Average Annual Means

Year	Dissolved oxygen, water, unfiltered, milligrams per liter	Number of Observations	Dissolved oxygen, water, unfiltered, percent of saturation	Number of Observations
1967	7.3106	85	8.9377	77
1968	6.4565	147	7.5547	148
1969	5.4644	436	6.9519	335
1970	5.0375	589	6.7288	358
1971	5.4596	1518	7.4381	698
1972	4.8122	1453	6.1584	676
1973	5.1197	1758	6.2592	174
1974	5.1655	1287	6.7667	339
1975	5.3458	2531	6.5041	386
1976	5.4192	2300	6.8203	507
1977	5.2386	2133	7.3425	313
1978	4.9491	1940	7.5598	500
1979	4.8722	904	5.9694	252
1980	4.9964	714	6.3149	242
1981	5.1637	658	7.3608	232
1982	5.7734	545	6.6579	254

1983	6.1857	481	7.1209	43
1984	5.8818	314	7.3077	13
1985	5.8915	271	6.8250	12
1986	5.2963	187	6.9316	19
1987	5.1434	198	6.2333	30
1988	5.9341	305	4.3400	10
1989	4.8433	217	3.4167	12
1990	5.2206	286	4.7500	8
1991	4.6030	166	4.4000	9
1992	4.9944	178	4.0800	5
1993	3.6132	152	4.1286	7
1994	4.1200	115	4.5143	7
1995	6.0110	82	5.1000	1
1996	4.6989	271	5.0906	32
1997	4.4092	759	5.1321	28
1998	3.8424	1004	4.5971	69
1999	4.5947	758	3.8577	26
2000	5.1187	610	4.2240	25
2001	4.2306	157	4.4622	45
2002	4.0013	149	4.1782	55
2003	4.7906	106	4.1545	44
2004	3.9030	912	4.9691	139
2005	4.5929	1247	5.3142	106
2006	4.4014	568	5.1630	73
2007	3.8034	561	5.5491	53
2008	3.6657	1149	6.1551	69
2009	4.2360	470	4.0500	80

Source: USGS (for details, see discussion in appendix to Chapter 1).

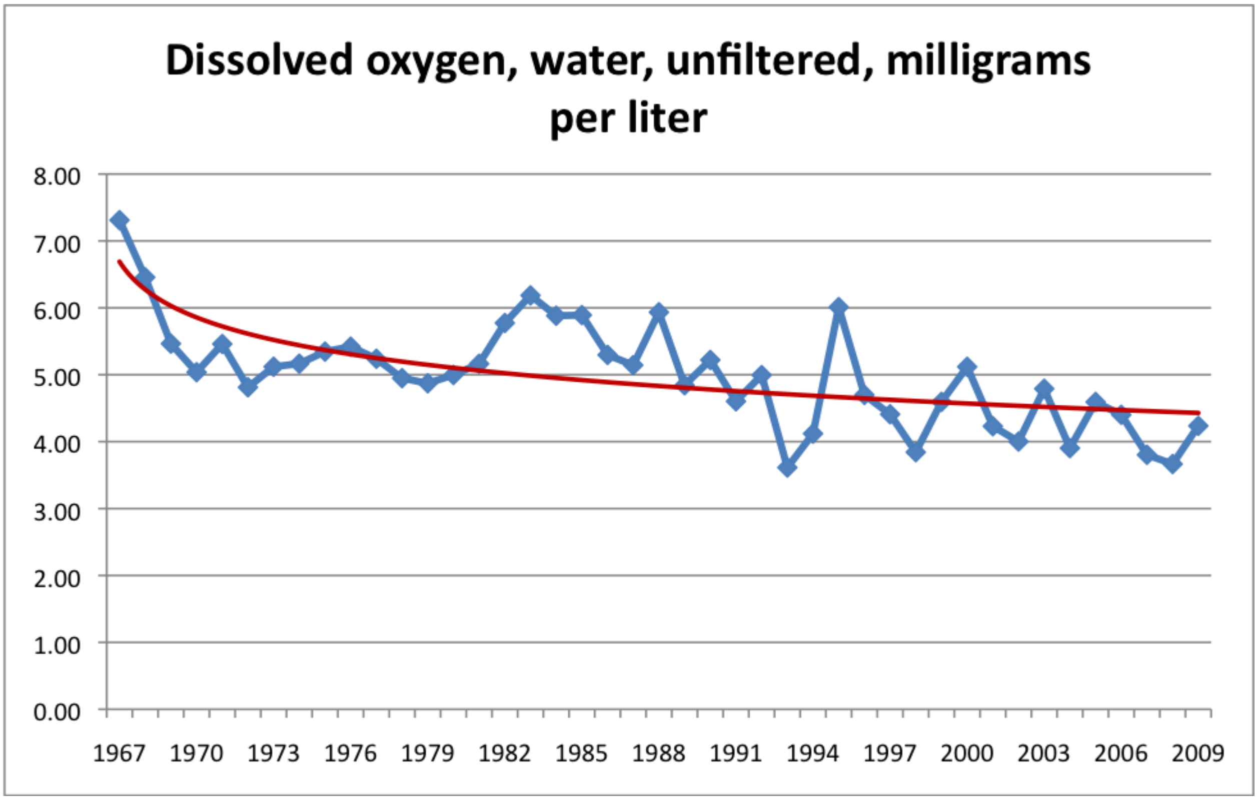


Figure 2.1 USGS Data on Dissolved Oxygen, annual averages, all stations, 16-County South Florida region

Figure 2.1 displays the decline in dissolved oxygen content over the past 40 years in South Florida. Our estimate of the impact of restoration on real estate values is based upon restoring dissolved oxygen to its 1970-71 levels.

Chapter 3: Recreation and Park Visitation Valuation

The Everglades is one of South Florida's main tourist and recreational attractions. The rivers, lakes, wetlands and waterbodies unique to the Everglades invite sightseeing, bird watching, manatee watching, sailing, camping, diving, snorkeling, boat tours, airboat tours, canoeing, kayaking, hunting, shelling, saltwater fishing and freshwater fishing. To the extent Everglades restoration will improve the quality of these activities, we expect the demand for these activities to increase and, consequently, the number of residents and non-residents visiting the Everglades to increase. This increase in recreational and park visitation activity translates to an economic value that we estimate in this section.

In economic studies similar to this one, sometimes, tourism is seen as a catch-all category. Here we have tried to use a more laser-like approach and break tourism down into smaller, more transparent, categories of recreation, park visitation, bird watching and wildlife habitat, hunting, and fishing. Thus, we have no overall category called "tourism" per se. However, our approach is deemed superior because it subsumes all the sub-categories and avoids the temptation or problem of doubling counting.

Methodology

To estimate the economic impact of Everglades restoration on recreational and park visitation expenditures, we employ the travel-cost method.[62] The basic premise of the travel-cost method is that expenses people incur while traveling to a recreation site or tourist destination represent the price of admission to that site. This outlay of expenditures reflects the traveler's willingness-to-pay, that is, the value that a recreationist or tourist places on accessing a particular site. By

[62] The travel-cost method is widely used throughout basic economics and natural resource economics to estimate the value that individuals place on events and locations that they visit. See Gardner Brown and Robert Mendelsohn. "The Hedonic Travel Cost Method." *Review of Economics and Statistics.* 66 (3) (August 1984): 427-33; K. G. Willis and G. D. Garrod. "An Individual Travel-cost Method of Evaluating Forest Recreation," *Journal of Agricultural Economics*, 42 (1) (January 1991): 33-42; Eric Bertonazzi, Michael Maloney and Robert McCormick. "Some Evidence on the Alchian and Allen Theorem: The Third Law of Demand?" *Economic Inquiry*, XXXI(3) (July 1993): 383-93; and for a detailed discussion see http://www.ecosystemvaluation.org/travel_costs.htm which was developed and written by Dennis M. King, Ph.D, Univ. of Maryland, and Marisa J. Mazzotta, Ph.D. and was funded by U.S. Department of Agriculture Natural Resources Conservation Service and National Oceanographic and Atmospheric Administration.

aggregating the travel expenditures of all visitors to an unrestored Everglades, then projecting a marginal increase in those expenditures attributable to Everglades restoration, we estimated the recreational and park visitation component of CERP's economic impact.

Our approach has five stages. First, we collected historical data on park visitation in South Florida.[63] Because many recreationists and tourists who travel to the Everglades visit the area's national parks, preserves, state parks and sanctuaries, we assume changes in park visitation reflect changes in overall tourist and recreational demands. Our team contacted Matt Johnson, a Supervisory Ranger for the National Park Services at Biscayne National Park, about park visitation data. He was very helpful in supplying data on annual park visitations for all of the parks in Florida: Everglades National Park, Biscayne National Park, Big Cypress National Park, and the Dry Tortugas. This data was available online in an interactive format breaking down the annual visitors into recreational activities, and it also dated back to the first year each park was opened. Our team also contacted Eve Irwin, the Coordinator of Research Program Services for the Bureau of Economic and Business Research at the University of Florida, regarding their Florida Annual Abstract, which provides data on State Park annual visitation at the county level. She was extremely helpful in providing all of the yearly data that they had available for county-level State Park visitation. We took the average increase in park visitations from year to year to determine the baseline.

Our team also contacted Corkscrew Swamp Sanctuary and Loxahatchee National Wildlife Refuge regarding annual park visitation, as these were larger parks in other counties within

[63] For the Everglades National Park, Big Cypress National Park, Biscayne National Park, The Dry Tortugas, Loxahatchee National Wildlife Reserve and Corkscrew Swamp Sanctuary, we obtained data specific to the total number of annual visits by their recreational activity. For the state parks, we obtained county-specific visitor data. While it might appear that turnstile data do not account for entries by boat, our investigation suggests otherwise. Matt Johnson, who is a supervisory park ranger at Biscayne NP, explained that because these four parks are part of the national park system they actually keep very good track on the numbers, not just of those entering through gates but for those entering by boat as well. Specificallyfor each national park: The Dry Tortugas accounts for every visitor because you can only access it by boat. Big Cypress National Preserve allows "chartered" boat companies in the area to do guided tours within the park and then those numbers are supposed to be reported annually to the park because there is an agreement. The monthly breakdown of visitors includes boat launches (see excel file bigcyp02.10YTD) and these numbers make up the annual report numbers that we used. Biscayne National Park – this number could be biased downward because there are more ways to participate in recreational activities within the park, but again the outside companies that offer tours have charters with the park. There are snorkeling companies and chartered boating companies, and the use of these services is already included in the data. Everglades National Park – again these numbers could be biased downward, but there are 5 entry points into the park that keep up with the visitors. If there are visitors accessing through other channels, we have now way to know how many there are or in which spending category (resident, non-resident, overnight, day trip) they fall. Data on all park visitation are online at http://www.nature.nps.gov/stats/state.cfm?st=fl.

South Florida that kept track of visitation annually. Sirena Rinker at Loxahatchee NWR compiled annual data by recreational activity dating back to the early 1970s. Her work was essential to our research. We were able to use these data for Palm Beach County in our estimation. Our main contact at Corkscrew Swamp Sanctuary, Ed Carlson, provided data for annual visitation to the park dating to when the Sanctuary opened in the late 1950s. Carlson and his team at the Swamp were very helpful in answering questions and providing data on historical park visitation.

Second, we used data from National Park Service visitor surveys to determine the ratio of resident to non-resident visitors for each park. We spoke with Matt Johnson of the National Park Service (NPS) who directed us to the NPS's Project Surveys conducted by the University of Idaho. The data that was collected within these studies on the ratio of resident to non-resident respondent visitors for each park was used as a random stratified sample to calculate the ratio of the total visitors annually. Since there are two national parks in Monroe County, Everglades National Park and The Dry Tortugas, the average of the respondents for each survey was taken to determine the ratio. These ratios of residents to non-residents were then applied to the counties without visitation data that were similar. Counties that were smaller had a ratio of 66 percent resident to 34 percent non-resident visitors, while larger counties had a ratio of 48 percent to 52 percent. Because there was a large portion of respondents that were Floridians visiting from another county partaking in these recreational activates, they were counted as resident visitors because of the high likelihood they were on a day-trip and returned home as shown by their estimated time of visiting the park. Non-resident visitors were shown to have a longer average stay time and stayed close to the area.

Third, we estimated county-specific, per-person, per-day travel expenditure figures for both residents and non-residents who visit the Everglades ecosystem parks, preserves and sanctuaries.[64] See Table 3.1. Our team contacted Kathy Torian, the Corporate Communications Manager for VISIT FLORIDA, Florida's official visitor's information company located in Tallahassee, Florida, because they have a research department that keeps track of tourism quarterly and annually for the State of Florida. VISIT FLORIDA produces an Annual Visitor's

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[64] There were 10 counties with specific data on the average daily expenditure for non-resident tourists. For counties that did not have a non-resident, per day expenditure, we used an average daily expenditure of $106, calculated by the Fish and Wildlife Conservation Commission for wildlife-viewing in Florida. To estimate resident travel expenditures, we used the National Park Service visitor survey data to calculate an average per day resident expenditure for counties that overlap with a national park: Collier, Monroe and Miami-Dade. For counties that did not have specific data on the per day expenditure for residents, we used the same FWC wildlife-viewing report which estimated an average daily expenditure of $152 for residents.

Study each year which tracks the total visitation within the entire state. The data they have for 2008 on resident and non-resident visitation in Florida were used to double check our ratios used from the NPS Surveys. However, we could not use state-wide data for our purposes. As a result of this, we looked up every Convention Bureaus or Tourist Development Councils for each of the 16 counties in South Florida, and contacted someone within each, requesting any data on the annual visitation to the county they might have and the average per-day travel expenditure. The following is a list of all the counties and everyone we contacted there concerning county level visitation annually. Some had information, others did not. Most information was available online. Some data were for multiple counties, and some counties did not have any data on the county level. The data on tourism were compiled by tourist marketing agencies in Miami-Dade, Broward, Palm Beach, Monroe, Collier, Lee, Osceola and Orange counties. The data from the tourist marketing agencies were obtained from the websites reported in Table 3.1.

Table 3.1 County-Specific Tourism Websites

County	Tourism Agency	Website
Miami-Dade	Greater Miami CVB	http://www.miamiandbeaches.com
Broward	Greater Ft. Lauderdale CVB	http://www.sunny.org/
Palm Beach	Palm Beach County TDC	http://www.pbcgov.com/touristdevelopment/
Collier	Naples, Marco Island Everglades CVB	http://www.paradisecoast.com/
Lee	Lee County CVB	http://www.leecvb.com
Monroe	Monroe County TDC	http://www.monroecounty-fl.gov/Pages/MonroeCoFL_TDC/index
Orange	Orlando/Orange County CVB	http://www.orlandoinfo.com/
Osceola	Kissimmee CVB	http://www.floridakiss.com/

Correspondence for the data on visitors annually and expenditures were obtained via email for the counties as listed below in Table 3.2. Some counties do not track these data. For counties with no available data, a county with data of similar size was used as a proxy for the average daily expenditure.

Table 3.2 County-Specific Information Sources

Palm Beach	Chesney, Jackie JCHESNEY@palmbeachfl.com	http://www.pbcgov.com/touristdevelopment/statistics.htm
St. Lucie	Lombard, Charlotte LombardC@stlucieco.org	http://www.youredc.com/html/visitors.asp http://www.visitstluciefla.com/media_center.html
Charlotte	Huber, Jennifer Jennifer.Huber@charlottefl.com	http://www.floridaedo.com/
Broward	Flippen, Justin jflippen@broward.org	http://www.sunny.org/partners/market-research/
Collier	Modys, Jonell JonellModys@colliergov.net	http://www.paradisecoast.com/media_center/research.php
Miami-Dade	Anderson, William Director, Panning & Research Telephone: 305.539.3065 Research@GMCVB.com	http://www.miamiandbeaches.com/members/webreports.aspx
Martin	Palozer, Mary (772) 288-5445	
Hendry	Beer, Kellie Hendry County Economic Development Council info@hendryedc.com	http://www.hendryedc.com/
Polk	Skinner, Brandy brandy@cfdc.org	http://www.cfdc.org/contact http://www.visitcentralflorida.org/contact/

There were 10 counties with specific data on the average daily expenditure for non-resident tourists. For counties that did not have a non-resident, per day expenditure, we used an average daily expenditure of $106, calculated by the Fish and Wildlife Conservation Commission for wildlife-viewing in Florida. This report was used in lieu of a report conducted by Robert

Kerlinger at Corkscrew Swamp Sanctuary in the early 1990s, which calculated the economic impact of birding ecotourism on the Corkscrew Swamp Sanctuary, because Kerlinger's report could not be obtained from either Corkscrew Swamp or Kerlinger himself. To estimate resident travel expenditures, we used the National Park Service visitor survey data to calculate an average per day resident expenditure for counties that overlap with a national park: Collier, Monroe and Miami-Dade. For counties that did not have specific data on the per day expenditure for residents, we used the same FWC wildlife-viewing report, which estimated an average daily expenditure of $152 for residents.

Table 3.3. Expenditure Estimates

County	Non-Resident	Resident	Average
Broward	$295.76	$152.00	$223.88
Charlotte	$295.45	$152.00	$223.73
Collier	$245.67	$140.00	$192.84
Lee	$120.08	$152.00	$136.04
Martin	$106.00	$152.00	$129.00
Miami-Dade	$242.76	$104.00	$173.38
Monroe	$360.00	$113.00	$236.50
Okeechobee	$106.00	$152.00	$129.00
Orange	$190.25	$152.00	$171.13
Palm Beach	$196.11	$152.00	$174.06
Polk	$106.00	$152.00	$129.00
St. Lucie	$143.00	$152.00	$147.50

In our fourth stage of analysis, we established a baseline of recreational and park visitation expenditures by multiplying the county-specific resident and non-resident expenditures by the number of resident and non-resident park visitors.

Finally, in our fifth stage, we estimated the marginal increase in recreational and tourism expenditures under a 2 percent increase in park visitation projected out 50 years. See Table 3.4.[65] Preliminary regressions of water quality and tourist expenditures confirm this to be a likely

[65] The counties not listed here have tourism related benefits in other categories, hunting, fishing, wildlife viewing, but they do not have any official parks and hence there is no increment to park visitation. See Table 4.1 below for instance.

scenario.[66]

Table 3.4 Recreational and Park Visitation Expenditures 2 Percent Increase over 50 years

County	NPV Incremental Increase
Broward	$103,206,003
Charlotte	$58,458,420
Collier	$178,150,740
Lee	$122,795,151
Martin	$13,306,731
Miami-Dade	$201,075,047
Monroe	$518,206,430
Okeechobee	$987,239
Orange	$25,849,076
Palm Beach	$49,055,665
Polk	$5,519,029
St. Lucie	$34,978,795
Total	**$1,311,588,326**

[66] Early in our analysis, we investigated a link between species biodiversity, specifically wading bird populations, and visitation to parks. Carlson and Jason Lauritsen provided extensive data on Wood Stork nesting populations. We were given data on the number of mating couples each year, the date of nesting initiation, and the number of young fledged. We were also able to obtain water level data within the Sanctuary as well as the dissolved O_2 levels, phosphorous counts and nitrate levels within the swamp from the SWFMD interactive database. Matthew Harwell, a Senior Ecologist at Loxahatchee NWR, was very helping in establishing an understanding of the ecological impact. He sent extensive water data for the park to our team as well as further studies on the ecology of the Everglades. Due to the breadth and scope of this assignment, we did not use this approach to determine the impact restoring the Everglades pursuant to CERP would have on park visitation. However, we did find some initial evidence showing a link between red tide data that were collected and the total number of visitors per year to Corkscrew Swamp based on Wood Stork nesting habits and the water quality. Further investigation is required and extensive data collection is needed to explore this link further. Though we exhausted every contact at our disposal, we were not able to assemble this data set.

Results and Sensitivity Analysis

Our best estimate of the change in tourism valuation is based on an assumption of a 2 percent increase over 50 years. This amounts to an increase in economic well-being of $1.146 billion in net present value terms.

The following scenario analysis explains how the net present value of park visitation and recreational expenditures vary (a) under different percentage increases in park visitation and (b) projected to different time horizons. See Table 3.5.

Table 3.5 Sensitivity Analysis

	Percent Changes in Park Visitation		
Time Horizon	**1%**	**2%**	**4%**
30 years	**$470,784,000**	**$941,567,000**	**$1,883,134,000**
40 years	**$572,867,000**	**$1,145,734,000**	**$2,291,467,000**
50 years	**$655,794,000**	**$1,311,588,000**	**$2,623,177,000**

Chapter 4: Open-Space Valuation

If implemented in its entirety, the Comprehensive Everglades Restoration Plan will produce approximately 157,555 acres of preserved open space in South Florida. In the absence of the CERP, this land would likely be inaccessible to the public and or developed as Florida's population grows. But with restoration, this land will provide enhanced recreational opportunities and aesthetic benefits to the residents of South Florida. In this section, we quantify these values.

Primary Methodology

To estimate the value of open space preservation, we employed a multi-stage process. First, we used data from the Trust for Public Lands to estimate type-specific and county-specific willingness-to-pay (WTP) values per acre of preserved open space.[67] Our assumption is that open-space ballot initiatives reveal information on the open space values of Florida voters, namely, the per acre rate at which voters are willing to tax themselves in order to protect or enhance open space.

To collect information on voters' willingness to pay for open space, we communicated on 4/12/2010 and 4/30/2010 with Andrew DuMoulin, the National Programs Director of the Center for Conservation Finance Research for Trust for Public Lands. He assisted in creating the Land Almanac, which documents all land initiatives for a total of 10 states. Mr. DuMoulin explained and confirmed that the Land Almanac contains information on all voting initiatives specific to preserving land. Below is his description of the data from the Land Almanac:

> All of the COUNTY data in the Almanac has been derived from contacting every county in Florida that has passed a conservation finance ballot measure. All the dollars you see are those used for conservation purposes. In [TPL], the LandVote database which has the details on the ballot measures, you can see how much the bond, sales tax, prop tax, might generate, and how much of that would be dedicated to new land conservation. So in short LandVote will show you what was generated on Election Day, and the Almanac will show you what was spent.

[67] We gathered acreage and expenditure data by cross-referencing the Land Almanac and other conservation databases reported by the Trust for Public Land.

From the Land Almanac, we searched and extracted all data that pertained to Florida, which included initiatives at the federal, state, municipal and county level of government. We created individual datasets for every county in Florida that aggregated all county or municipal bond initiatives. We excluded Broward County from our value-per-acre county average because it was an extreme outlier. Specifically, Broward County's willingness to pay per open space acre was $352,686. This amount is more than 28 times the Florida average ($12,133), and more than 9 times the second highest value per acre (Palm Beach, $37,304). All of Broward County's land initiatives were managed by either Broward County Parks and Recreation or an unknown manager. Thus, the open space protected under these land initiatives was probably unlike the CERP land initiatives in scope and size.

We estimated type-specific WTP values because open space preservation projects of different scale and proximity produce different bundles of aesthetic and recreational benefits.[68] Specifically, we grouped the open space and conservation projects into three types: local open-space bond initiatives, state-wide conservation projects and federally funded wetland preservation projects.

We estimated county-specific WTP values because the marginal value of open-space preservation depends on numerous geographic and demographic variables such as population density and proximity to population centers. Everglades restoration under CERP will encompass restoration projects throughout South Florida, so using geographically specific values add precision to the open space valuation.

Averaging across all counties, we estimated WTP values per acre of open-space preservation of $12,133 for county projects, $4,505 for state projects and $740 for federally funded wetland projects. These figures comport with economic rationale; voters are willing to tax themselves at a higher rate for open space that they can enjoy more often and more easily, that is, local open space.

In the second stage of our analysis, we estimated county-specific open-space value ranges for each CERP project. We did this by multiplying the county, state and federal WTP values by the number of acres yet to be acquired under each specific CERP project. For instance, the "Lakes Park Restoration" project is in the "Lower West Coast" CERP region and has a remaining 40

[68] For instance, a municipal park in Broward County generates significantly different open space values than does a federally funded wetland restoration in Glades County.

acres yet to be restored. Because the "Lower West Coast" CERP region overlaps Hendry, Glades and Lee counties, we multiply an average of those three counties' local ($12,133),[69] state ($2,716) and federal ($740) WTP values by 40 to estimate a range of open-space values attributable to that particular CERP project. Our open-space value estimates for that project range from $485,331 (local WTP) at the upper bound to $29,600 (federal WTP), with our best estimate being $108,652 (state WTP).

In the final stage of our analysis, we aggregated the range of open-space values across the remaining acres of each CERP project. We report these aggregations for county, state and federal WTP values. These type-specific-value estimates define the range of possible open-space values from Everglades restoration. Because CERP most closely matches the kind of open-space preservation projects used to calculate the state-level WTP value, the state-level WTP estimate is our best estimate of the total open space value attributable to Everglades restoration under the CERP. That estimate is **$830,733,000** in net present value terms.

Table 4.1 Open Space Valuation Increase from Everglades Restoration

CERP Region	Counties	Open Space Value Increase
Everglades Agricultural Area	Palm Beach and Hendry	$31,187,000
Everglades, Florida Bay, and Keys	Broward and Miami	$318,739,000
Lake Okeechobee Watershed	Okeechobee, Glades and Highlands	$30,509,000
Lower West Coast	Hendry, Glades and Lee	$41,611,000
Miami Dade County	Miami-Dade	$115,507,000
North Palm Beach County	Palm Beach	$5,752,000
Upper East Coast	Martin and St. Lucie	$215,220,000
Water Preserve Area	Palm Beach, Broward and Miami	$72,208,000
	Total	**$830,733,000**

If we had used the county-level averages, within their county lines, the value of CERP restoration would have an aggregate value of $2,763,345,000. If we had used the federal-level averages for the specific counties with CERP projects, the open-space values of restoration would have an aggregate value of $116,593,000. We believe that CERP restoration, as planned, mostly closely reflects state-level valuations for the relevant open space and accordingly that is

[69] Because we did not have data for local open space bond initiatives in these counties, we used the state-wide average of $12,133.

our best estimate.

Though the benefits of open-space preservation accrue most directly to residents who live in close proximity to the conservation area, people who are not part of the local electorate and have no intention of visiting the Everglades may also be willing to pay for Everglades restoration. Though we did not include these so-called existence values in our open-space valuation, we can estimate them using a benefit-transfer method from the existing literature. However, because these values are based on stated preference (surveys) rather than revealed preference (ballot initiative voting) and because these values would not impact the South Florida economy, but rather the larger world economy, we have left them out. This makes our estimate of open space conservative.

Table 4.2 summarizes these calculations, our assumptions and our sensitivity analysis.

Table 4.2 Changes in Value of S. Florida Open Space Associated with Everglades Restoration

Lagged Response	
Years Until Increase Begins	**Present Value of Delayed Increase**
1	**$813,646,000**
2	**$796,911,000**
3	**$780,520,000**
4	**$764,467,000**
5	**$748,743,000**

Possible Range of Values		
Various WTP/Acre of Open Space		
Local	**State**	Federal
$2,763,345,000	**$830,733,000**	$116,593,000

Alternative Methodologies

If we had decided to use contingent valuation studies, we would have focused on studies that measured the value of an area similar in size and type to the Everglades. Two studies we found that measured the open space of large, vast areas were studies on the Adirondacks in New York and the Amazon in Brazil. Both studies surveyed individuals who were not in close proximity to the large areas. The study of the Adirondacks surveyed individuals who didn't necessarily live close to the Adirondack Park, but still had a willingness to pay $48 to $107 per year, per household for ecological improvements to the park. The study of the Amazon surveyed individuals from the UK and Italy and concluded that individuals who may never visit the Amazon had a willingness to pay £29.83 per year per household for 5 percent protection of the Amazon.

We also looked at the Florida Natural Area Inventory (FNAI) as a possible resource to track the value of conserved land. We spoke to Sally Jue there who explained that her reports included all land that had natural vegetation where the managing agency had a commitment to manage and upkeep the natural state; so this includes recreational parks if they have natural vegetation and maintain the natural resources. However, the natural areas that the FNAI reports on did not publish the respective costs to conserve those acres. Thus, it was difficult to assign a per acre value for the natural areas they track.

We also tried other measures to estimate the open-space value, which included measuring Florida Forever projects. Much of Florida's conserved land is purchased through Florida Forever (formally P2000). Florida Forever does publish the number of acres and the respective costs of purchasing those acres. So a value per acre is available. We spoke to Greg Brock at the Department of Environmental Protection on May 5, 2010, who explained that:

> Because the state's Florida Forever program funds numerous state, regional and local land acquisition programs, it is very confusing. The Florida communities Trust (FCT), which receives 22 percent of the Florida Forever funds, provides grants of matching funds to some local governments and 100 percent grants to other qualifying small local governments. The state agencies and water management districts also cooperate with local governments to acquire property on their overlapping lists, although many of these partnerships may not be as formalized as those under FCT. Thus, a local government may be representing any of these Florida Forever sources for matching funds or grants. Some local governments have specific program requirements or give great emphasis to matching local funds with state funds. The state program was authorized by a constitutional referendum in 1998 that allowed bonds to be sold for acquiring conservation lands but did not specify a specific amount. However, since then the state has appropriated more than $3 billion, mostly in bonds, to finance conservation land purchases of over 650,000 acres.

We also spoke to Theresa Johnson from the Department of Environmental Protection on May 6, 2010, who further explained that Florida Forever receives some funding from bonds that are bought by individuals. This funding does not accrue by vote of the general electorate and thus doesn't exactly convey the general public's willingness to pay.

Information Sources

The Nature Conservancy:

Our team contacted Thomas Jordan, director of The Nature Conservancy's (TNC) S. Florida office; Mary Anne Graves & Victoria Tschinkel in TNC's Tallahassee office; Bob Burns at the Orlando office; Dan Speilman at the Disney Wilderness Reserve office; Allison Higgins at the Florida Keys office; Jenny Conners, a senior federal policy representative; and Laura Geselbatch, a senior marine scientist.

The Conservation Fund:

Our team contacted the national, southeast, Gainesville, Tallahassee and West Palm offices.

Trust for Public Land:

Our team called the national office, and we were directed to the Florida office. Our contact in the South Florida office, Bob McClemins, pointed us to some existing literature.

Our team spoke with and had email correspondence with Kevin Mooney, the Florida Projects manager in the Tallahassee office. He was helpful in clarifying the LandVote data.[70] He explained that the ballot measures were prior to the land acquisition, so the voter didn't know the exact acreage they were voting on. Thus we couldn't use this data for an acreage value. He suggested we speak to his director, Will Abbarger, and the county Forever program contact, Doug Weaver.

Our team obtained the empirical data for open-space value in Florida from the Trust for Public Land's website. Our team used the LandVote database on their website, which reports voting measures on land conservation. Our team called the contact on the LandVote website who directed us to Andrew duMoulin. Mr. duMoulin is the National Programs Director for the Center of Conservation Finance Research. He was extremely helpful, and pointed us to the Land Almanac. He explained the data behind the Land Almanac database on his website.

American Land Conservancy:

Our team called the national office and spoke to Tim Richardson. He didn't have any specific data to offer, but he did refer us to a number of individuals listed below.

[70] See http://www.tpl.org/tier3_cd.cfm?content_item_id=12010&folder_id=2386 for details.

Florida Natural Areas Inventory (FNAI):
Our team spoke to Sally Jue, a conservation lands biologist. She was very helpful and supplied empirical data regarding the acreage of natural areas that are conserved throughout Florida. She said this included all land that had natural vegetation where the managing agency had a commitment to manage and upkeep the natural state, so this includes recreational parks if they have natural vegetation and maintain the natural resources. Ms. Jue noted that South Florida is more lenient on the classifications. This was a backup plan for determining the acreage value of conserved land in Florida. We obtained conserved acreage state wide and county wide.

Florida Forever (DEP):
Our team spoke to Theresa Johnson, who is involved with state lands acquisition. She explained how Florida Forever benefits from state bonds. She said that the legislature sets a budget that is approved by the governor and his cabinet. Then individuals buy Florida Forever specific bonds. We obtained Florida Forever (formally P2000) data on acreage and purchase amounts for public land. However, we felt this didn't accurately capture the general public's willingness to pay as well as would an initiative to pass a bond measure. Our team also spoke to Ray Petty, Florida Forever's bond specialist, who explained that the SFWMD sells their own bonds, and that the Everglades has one bond per year worth $40 million.

Our team spoke to Sheryl Jones, who supplied us with empirical Florida Forever data that contained both the approved commitments and the anticipated acquisitions for all agencies that receive Florida Forever funding. We considered this as a possible method to determining acreage value. However, we decided that the Land Almanac data captured a more accurate figure for estimating the open-space value of the Everglades. This Florida Forever data could not be broken down into county-level data. It also included greenways, trails, agriculture and water open spaces. This data also included land that was acquired by imminent domain, which definitely does show an individual's willingness to pay.

Via email correspondence, Greg Brock, director of Florida Forever, explained the Florida Forever bonds in the Land Almanac:

> Because the state's Florida Forever program funds numerous state, regional and local land-acquisition programs it is very confusing. The Florida communities Trust (FCT), which receives 22 percent of the Florida forever funds, provides grants of matching funds to some local governments and 100 percent grants to other qualifying small local governments. The state agencies and water

> management districts also cooperate with local governments to acquire property on their overlapping lists, although many of these partnerships may not be as formalized as those under FCT. Thus, a local government may be representing any of these Florida Forever sources for matching funds or grants. Some local governments have specific program requirements or give great emphasis to matching local funds with state funds. The state program was authorized by a constitutional referendum in 1998 that allowed bonds to be sold for acquiring conservation lands, but did not specify a specific amount. However, since then, the state has appropriated more than $3 billion, mostly in bonds, to finance conservation land purchases of more than 650,000 acres.

Our team was referred to Amy Graham in the DEP and John Atlan who is in the office of the secretary and part of the "Save our Everglades" campaign. Our team spoke to John Outland, from the DEP Office of Ecosystem Projects, who put us in touch with Jim Muller. Jim Muller sent us multiple pieces of literature and links.

Land Trust Alliance:
Our team contacted the national office in Washington, D.C.

Local Florida Land Trust Alliances:
Our team also tried calling all the local land trusts in Florida in efforts to gather more information on county specific open-space value. Our team called the Calusa Land Trust in Lee County and spoke to Bill Spikowski, who directed us to The Nature Conservancy. He directed us to some existing literature on land conservation. We also called the Conservation Foundation located in Sarasota County. Our team called the Indian River Land Trust and spoke with Dana who directed us to the director, Ralph Monticello. Mr. Monticello gave us contact information.

Our team contacted Manatee Audubon, Tall Timbers in Leon County, Green Horizon in Polk County, the Alachua Conservation Trust, Bay County Conservancy, Tampa Bay Conservancy, Putnam Land Conservancy, North Florida Land Trust located in Duval County, Treasured Lands located in Martin County, Lemon Bay Conservancy located in Sarasota County, Davie Land Trust located in Broward County and Conserve Florida located in Alachua County.

Individuals:
We were referred to a number of individuals from previous contacts at The Nature Conservancy, Trust for Public Land, American Land Conservancy and/or Land Trust Alliance:

Our team spoke to Mark Duda from responsive management. He offered some recreational studies and surveys on his website. However, that open space was not comparable to the open space in the Everglades. Our team spoke with Brad Gentner from Gentner Consulting group, who specializes in natural resource economics consulting. He pointed us to the Environmental Valuation Reference Inventory (EVRI) database, which contains contingent valuation studies for all environmental topics. We searched open space and other large open spaces, i.e. Adirondacks, and found some possible studies. However, our team decided not to use contingent valuation studies. Our team spoke with Rob Southwick from Southwick and Associates. Our team spoke to Evan Miller from Florida Acquisition & Appraisal. He explained to us different types of bonds used for land conservation. He then suggested we call Florida Forever. He also gave us a specific Hillsboro bond to look at as an example.

South Florida Water Management District (SFWMD):
Our team spoke with Anita from the SFWMD Palm Beach service center, and she said the entire 16-county area was serviced by the SFWMD, whose website says the area is a total of 17,930 square miles (11,475,200 acres) (over 7 million people) and includes 700,000 acres of Everglades Agricultural Area. The following map shows the boundaries of SFWMD by county: https://my.sfwmd.gov/portal/page/portal/pg_grp_sfwmd_aboutsfwmd/pg_sfwmd_aboutsfwmd_overviewmaps.

Our team also spoke to Clarence Tear, director of the Big Cypress SFWMD Office, who told us future water data is on the SFWMD website, under water supply plans. There are four areas: Upper East Coast, Lower East Coast, Lower West Coast and Kissimmee Basin. Each has its own water plan (and model) that projects water usage for the next 20 years. These are updated every five years (last one on web, 2005). Then, based on these reports, each county updates its utility plan.

County Level Desalination Efforts:
To learn about county-level desalination efforts, our team called the SFWMD regional service centers. Our team spoke to Jennifer Drozd in the permit office, and she said there weren't permits regarding desalination. Our team also spoke to Donna Ricabus, Sr. Scientist. We also contacted Mark Elsner in the water supply department. He pointed out the desalination section on their website: http://www.sfwmd.gov/portal/page/portal/xweb%20-%20release%203%20water%20supply/desalination. He also showed us the current and projected desalination efforts by region: http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/desal_comb_2008.pdf'. He pointed out the Water supply library, which has different water supply plans by region

and lays out project summaries by region: http://www.sfwmd.gov/portal/pls/portal/portal_apps.repository_lib_pkg.repository_browse?p_keywords=uecwatersupplyplandocs&p_thumbnails=no. For example, see the Upper East Coast Water Supply plan: http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/uec-plan_final.pd. The Water supply development plan, which has utility and project summaries in specific counties in Part III (starting on page 29). Mr. Elsner said that he would compile county-level data that would show data on each county's facilities, water capacity and desalination capacity as of 2012. Mark followed up in an email on 7/26/2010 with county-level desalination efforts.

Water Utilities:

Our team spoke to Lisa Bockarton, from the SEFLUC, in an effort to obtain water prices. She referred us to individual utilities departments to get the different prices of water by county. Our team spoke to Andy Potts from Collier County, and he faxed us over some rate tables from 2002 – 2008. This was our most successful contact at the county utility level.

Chapter 5: Commercial and Recreational Fishing Valuation

Literature Review and Background

Effect of Everglades Degradation on Fish Population

A number of studies and articles point to 1987 as the year when degradation of fish habitat and population began. The following statement from Broward and Robblee (1999) implies that the majority of occurrences that negatively impacted fish population, such as die-off of seagrasses, hypersaline conditions and algal blooms, all began after 1986:[71]

> The decline roughly coincided with the die-off of seagrasses in western Florida Bay beginning in fall 1987, drought-related hypersaline conditions between 1989 and 1991 and extensive algal blooms that persisted into the 1990s (p. S20).

In addition, a 2002 article in U.S. Water News Online reported the following:

> Although increasingly salty, Florida Bay still drew anglers from around the world who were attracted by its fabulous fishing and its crystal waters. Then, in the summer of 1987, about 100,000 acres of seagrass died off. Algae blooms and sponge die-offs followed, spoiling the water's clarity. The population of fish, shrimp, sponges and other creatures declined.[72]

These observations imply that 1986 may be an acceptable base year to use as an estimator of fishing value prior to the majority of degradation in Florida Bay. It is assumed that the timing of degradation in Florida Bay provides an appropriate estimate for the timing of fish habitat and population degradation throughout the rest of the 16 Everglades ecosystem counties.

Impact on Fish Population

From Browder and Robblee (1999), it is hypothesized that CERP will have the following consequences on fish population:

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[71] Browder, Joan A. and Robblee, Michael B. "Pink shrimp as an indicator for restoration of everglades ecosystems." *Ecological Indicators*, 9 (6, Supplement 1), (November 2009): S17-S28.

[72] http://www.uswaternews.com/archives/arcquality/2sciwar9.html.

> *Hypothesis 1:* CERP will expand the gradient of salinities from near fresh to polyhaline to cover a larger nearshore zone and will reduce salinity fluctuation to a range and frequency characteristic of natural estuarine conditions, increasing the area of optimum salinity conditions for many species and, as a result, expanding local distribution, increasing abundance, and allowing a richer species assemblage.
>
> *Hypothesis 2:* CERP will reduce the intensity, duration, and area of coverage of hypersaline conditions, thereby increasing the area of optimum salinity conditions for nearshore fish and invertebrates.
>
> *Hypothesis 3:* CERP will increase the area covered by patchy or heterogeneous seagrass habitat, thereby increasing the area of optimum habitat for seagrass-associated fish and invertebrate species.
>
> *Hypothesis 4:* CERP will increase the length of shoreline receiving direct freshwater inflow and establish more persistent salinity gradients, thereby increasing the area of optimum habitat for fish species spending all or a part of their life cycle along the shoreline.
>
> *Hypothesis 5:* CERP will increase the area of overlap of favorable salinities with favorable bottom habitats and shoreline features, thereby increasing the distribution and abundance of a richer assemblage of species characteristic of estuaries.[73]

The Comprehensive Everglades Restoration Plan states that “not enough is known about the linkages between fishing and hydrological changes, which would be brought about by plan implementation, nor is enough known about the timing of the linkages between these changes, the resulting ecological changes, and ultimately the changes in the value of fishing, to estimate the economic effects on fishing in this study.” CERP therefore does not currently provide an estimate by which to measure the effect of fish population due to restoration.

However, the 2009 paper “Pink shrimp as an indicator for restoration of Everglades ecosystems”

[73] Browder and Robblee (2009).

by Browder and Robblee suggests a means by which to measure the success of the CERP in terms of marine life post-restoration and suggests they adjust restoration according to this measure. The authors state that an appropriate target for CERP to adopt is the maintenance, at a minimum, of an annual mean density of pink shrimp at the 75th quartile of the long-term record. Pink shrimp thrive at particular levels of salinity, and actions could be taken to keep average salinity within the optimal range. Their description is as follows:

> Annual assessment will consist of determining whether mean shrimp density exceeds a threshold based on the available pre-CERP data. Because shrimp density is expected to vary from year to year as a result of natural patterns of variability in salinity and other influencing factors, annual mean density (fall and spring separately) will also be viewed as a three-year running average when sufficient data become available. Annual mean density targets for each season are to meet or exceed the 75th quartile from the long-term record for each assessment area.[74]

We assumed that if the CERP adopts this measure, the catch of pink shrimp would also be 75 percent of the long-term record. It is also assumed that all fish populations would respond similarly. Under these assumptions, the year with the largest amount of commercial catch (in pounds) would serve as the base by which to calculate the 75th percentile target catch.

Impact on Commercial Fishing

Methodological Approach

Data on commercial catch per species for each county in Florida were obtained for the years 1986 through 2008.[75] Earlier data are considered unreliable (according to the Florida Fish and Wildlife Research Institute), and 2009 data are currently incomplete. Nine of the 16 Everglades counties affected by CERP have local commercial fishing industries. These counties are Broward, Charlotte, Collier, Miami-Dade, Lee, Martin, Monroe, Palm Beach and St. Lucie.

In order to determine the total commercial catch in Everglades ecosystem counties in a given year, total commercial catch (in pounds) for all species caught in each of the nine counties in that year were added together. Figure 5.1 illustrates the general decrease in total catch over the 23

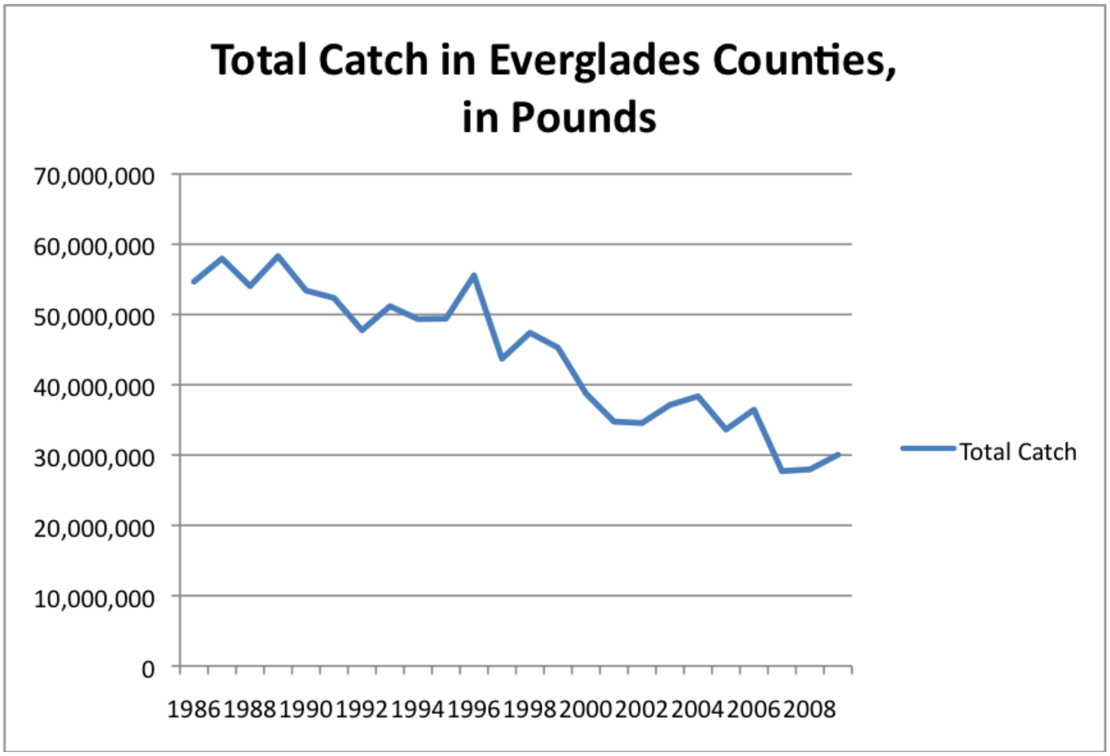
[74] Browder and Robblee (2009).

[75] Commercial catch data obtained from Steve Brown at the Florida Fish and Wildlife Research Institute; this data can also be viewed at http://research.myfwc.com/features/view_article.asp?id=19224.

years examined.

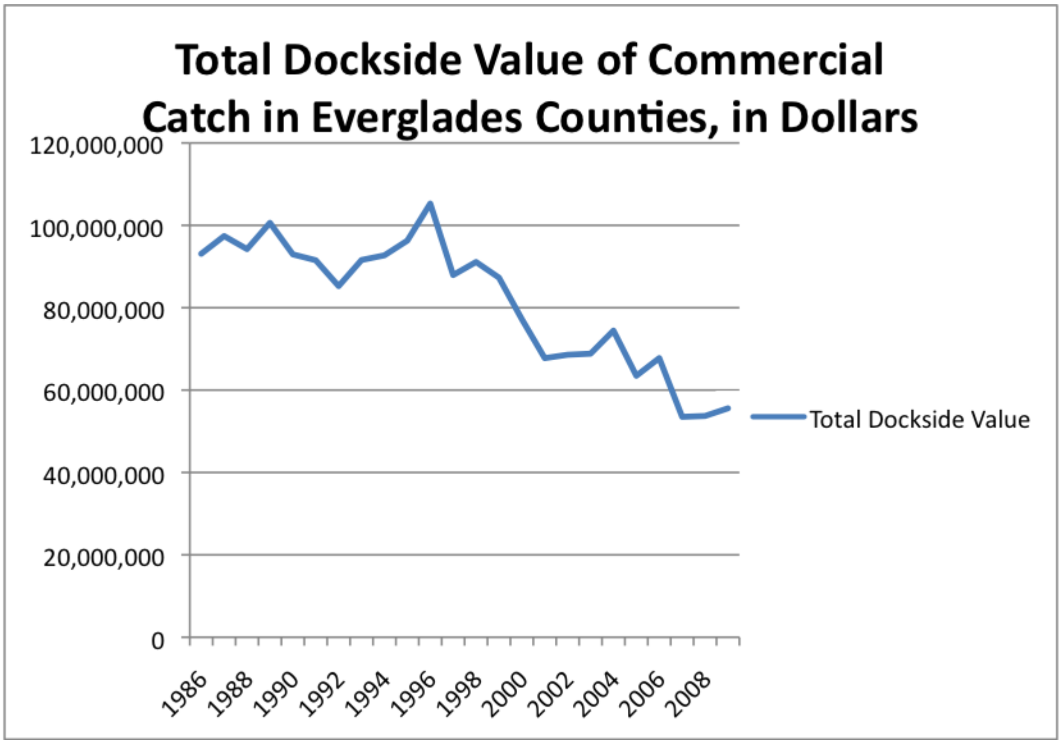
In order to determine the direct value of commercial catch in the Everglades for a given year, commercial catch in each county (in pounds) was summed for each species; these values were then multiplied by the 2009 average dockside values for the species to obtain total dockside values for catch of each species in all Everglades counties.[76] These total dockside values for all species were then summed to obtain the total dockside value of commercial catch in all Everglades counties. Figure 5.2 shows the values for each of the 23 years examined.

Figure 5.1: Total Commercial Catch in Everglades Counties (pounds)



[76] Available on the Florida Fish and Wildlife Conservation Commission's website http://research.myfwc.com/features/view_article.asp?id=19224 under commercial landings, statewide.

Figure 5.2: Total Dockside Value of Commercial Catch in Everglades Counties (dollars)



As an initial estimate of the change in the direct value of commercial fishing due to Everglades degradation, total dockside value of commercial catch in 2008 was compared with total dockside value in 1986 in Table 5.1. It is assumed that commercial fishing regulations are enacted such that commercial fishing catch as a percent of fish stock remains constant over time, and thus, as fish stock increases with restoration, regulations will change to allow total commercial catch to increase linearly.

Table 5.1: Historical Change in Commercial Catch and Dockside Value, 1986 to 2008

	1986	2008	Change in Value	Percent Change
Total Catch	54,675,865	27,962,536	-26,713,329	- 48.9%
Total Dockside Value	$93,096,606	$53,717,243	-$39,379,363	- 42.3%

Dockside value decreased $53,717,243 or 42.3 percent, from 1986 to 2008. However, there was a net ban that went into effect in Florida in 1995: "The net ban which was passed by plebiscite in 1994 and became effective in July of 1995 has reduced the number of commercial fishermen by several thousand."[77] In order to eliminate the possibility of this net ban as the cause of this large decrease in catch and dockside value, we also calculate the change in dockside value between 1996 and 2008 in Table 2. The effects in Everglades counties appear to be about the same when comparing 1986 to 2008 as they are when comparing 1996 to 2008. Table 5.2 shows that dockside value decreased by $51,560,745, or 49 percent, from 1996 to 2008.

Table 5.2: Historical Change in Commercial Catch and Dockside Value, 1996 to 2008

	1996	2008	Change in Value	Percent Change
Total Catch	55,561,538	27,962,536	-27,599,002	- 48.7%
Total Dockside Value	$105,277,988	$53,717,243	-$51,560,745	- 49.0%

Based on the recommended CERP measure discussed in Browder and Robblee's 2009 pink shrimp study, we assume that total commercial catch post-CERP will be at least 75 percent of the highest commercial catch on record. The year with the highest commercial catch in Everglades counties is 1989. The estimates for expected post-CERP value (75 percent of 1989) and total future dockside value are shown in Table 3. Future dockside value was calculated by adding up catch in all Everglades counties for each species, multiplying this by .75, then multiplying these estimated numbers for future catch by the per-pound 2009 price for each species. These values were summed to obtain the expected future dockside value given in Table 5.3. The difference in total dockside value post-CERP using 1989 values and this means of estimation is $23,271,221, or a 43.3 percent increase in 2009 dollars from current 2008 value.

[77] http://www.southeasternfish.org/Documents/EcoValueAquatic.pdf.

Table 5.3: Estimated Change in Commercial Catch and Dockside Value Post-CERP (based on 1989 catch)

	1989	Post-CERP estimate (89)	2008	Change in Value	Percent Change
Total Catch	58,302,223	43,726,667	27,962,536	15,764,131	+ 56.4%
Total Dockside Value	N/A	$76,988,464	$53,717,243	***$23,271,221***	**+ *43.3%***

If we look at the years post-1995 in order to take the net ban into account, the largest commercial catch landed in Everglades counties was in 1996. The estimation technique used in Table 5.4 is the same as that described using the 1989 catch for Table 5.3. The difference in total dockside value is $25, 241, 248, or a 47 percent increase, using 1996 values and this means of estimation.

Table 5.4: Estimated Change in Commercial Catch and Dockside Value Post-CERP (based on 1989 catch)

	1996	Post-CERP estimate (96)	2008	Change in Value	Percent Change
Total Catch	55,561,538	41,671,154	27,962,536	13,708,618	+ 49.0%
Total Dockside Value	N/A	$78,958,491	$53,717,243	***$25,241,248***	**+ *47.0%***

The estimated change in commercial dockside value per year in Everglades counties (direct value) due to completed CERP restoration, based upon the target measures laid out by Browder and Robblee, is estimated as an increase in value between $23,271,221 and $25,241,248. CERP is estimated to take 20 to 30 years to reach its complete restoration goals. We assume that CERP will cause a linear increase in the dockside value of commercial fish over this period, and then remain at a constant dockside value in perpetuity once the restoration point is reached. A 20-year restoration period was used for our calculations in Table 5.5, and a 30-year restoration period was used for calculations in Table 5.6. Both estimations used a 2.1 percent discount rate.

Using the 20-year restoration period (Table 5.5), we estimate that CERP will increase total Everglades commercial dockside value by $1,262,062.40 each year for 20 years (using the 1996-based estimate of a 49 percent increase in catch). This is followed by a constant expected restored dockside value of $25,241,1250 above non-restoration expected value (if conditions remain as-is in perpetuity) in perpetuity beginning in year 21. The present value for each year's increase in value was calculated and discounted back to the present based on a 2.1 percent discount rate in Table 5.5. The sum of these numbers provides an estimated increase in the present value of commercial fishing in the Everglades due to CERP of $1,052,463,057.

Using the 30-year restoration period (Table 5.6), we estimate that CERP will increase total Everglades commercial dockside value by $841,375 each year for 30 years (using the 1996-based estimate of a 49 percent increase in catch). The present value for each year's increase in value was calculated and discounted back to the present based on a 2.1 percent discount rate in Table 5.6. The sum of these numbers provides an estimated increase in the present value of commercial fishing due to CERP of $24,603,244 over these 30 years.

Table 5.5: Estimated Increase in Dockside Value of Commercial Fishing due to CERP Using 20-Year Restoration Period.

Year	Increase in value/yr (as compared to non-restoration value)	PV20
1	$ 1,262,062	$ 1,237,316
2	$ 2,524,125	$ 2,426,110
3	$ 3,786,187	$ 3,567,809
4	$ 5,048,250	$ 4,663,802
5	$ 6,310,312	$ 5,715,444
6	$ 7,572,374	$ 6,724,052
7	$ 8,834,437	$ 7,690,909
8	$ 10,096,499	$ 8,617,265
9	$ 11,358,562	$ 9,504,336
10	$ 12,620,624	$ 10,353,307
11	$ 13,882,686	$ 11,165,332
12	$ 15,144,749	$ 11,941,531
13	$ 16,406,811	$ 12,682,999
14	$ 17,668,874	$ 13,390,798
15	$ 18,930,936	$ 14,065,964
16	$ 20,192,998	$ 14,709,505
17	$ 21,455,061	$ 15,322,401
18	$ 22,717,123	$ 15,905,607
19	$ 23,979,186	$ 16,460,051
20	$ 25,241,248	$ 16,986,636
SUM of 20 year PVs		$ 203,131,174
PV of Perpetuity (beginning in yr 21)		$ 849,331,883
Total Increase in Value		**$ 1,052,463,057**

Table 5.6: Estimated Increase in Dockside Value of Commercial Fishing due to CERP Using 30-Year Restoration

Year	Increase in value/yr (as compared to non-restoration value)		PV30	
1	$	841,375	$	824,877
2	$	1,682,750	$	1,617,407
3	$	2,524,125	$	2,378,539
4	$	3,365,500	$	3,109,202
5	$	4,206,875	$	3,810,296
6	$	5,048,250	$	4,482,702
7	$	5,889,625	$	5,127,273
8	$	6,731,000	$	5,744,844
9	$	7,572,375	$	6,336,225
10	$	8,413,750	$	6,902,206
11	$	9,255,125	$	7,443,555
12	$	10,096,500	$	7,961,021
13	$	10,937,875	$	8,455,333
14	$	11,779,250	$	8,927,199
15	$	12,620,625	$	9,377,310
16	$	13,462,000	$	9,806,338
17	$	14,303,375	$	10,214,935
18	$	15,144,750	$	10,603,739
19	$	15,986,125	$	10,973,368
20	$	16,827,500	$	11,324,425
21	$	17,668,875	$	11,657,496
22	$	18,510,250	$	11,973,152
23	$	19,351,625	$	12,271,948
24	$	20,193,000	$	12,554,422
25	$	21,034,375	$	12,821,101
26	$	21,875,750	$	13,072,495
27	$	22,717,125	$	13,309,101
28	$	23,558,500	$	13,531,403
29	$	24,399,875	$	13,739,870
30	$	25,241,250	$	13,934,959
SUM of 30 year PVs	$	264,286,741	$	264,286,741
PV of Perpetuity (beginning in yr 31)			$	696,747,966
Total Increase in Value			**$**	**961,034,707**

Period.

Our best estimate is that commercial fishing catch will increase, in present value terms, by a total of $524 million (assuming a 20-year time to full recovery for the fishery).[78] Table 5.7 captures these calculations in summary form.[79]

Table 5.7 Estimates of Commercial Fish Catch Increase From Everglades Restoration

			Time for Fishery to Recover After Everglades Restoration	
Discount Rate	2.1%			
		Immediately	**20 Years**	30 Years
	NPV Increase	716,129,276	**$524,131,653**	$41,139,562

Impact on Recreational Fishing

The estimates for commercial fishing suggest that there is potential for a 49 percent to 56 percent increase in commercial fishing catch post-CERP (see table 5.3 and 5.4, percent change in commercial catch). It is assumed that this estimated percent increase in commercial catch can also be applied to recreational fishing in the Everglades.

According to Fedler (2009), largemouth bass is the most common fish targeted in the Everglades region, but we note that it is not the most valuable.[80] Saltwater fish such as bone and tarpon have much higher valuation in the eyes of fishermen,[81] and these species will be impacted in Florida Bay in a positive way by the return of sheet flow. However, as is revealed below, we use a conservative approach using time series data from the fresh water species where the impacts of restoration are more certain in our eyes. In addition, CERP's Lake Okeechobee Performance

[78] As a check on our estimates, we also estimated the change in fishery catch using data from the net ban that went into effect in Florida in 1995. This method suggests that Everglades restoration will increase catch by about 57 percent. To be conservative in our forecasts, we use the earlier, lower estimate already discussed.

[79] Keep in mind that we are only forecasting a return to 49 percent of the baseline catch. Therefore, our estimates are only 49 percent of the values in Tables 5.5 and 5.6. Again, this emphasizes our conservative approach to benefits calculations.

[80] A survey of Everglades anglers by Fedler provided this information; 40 percent of saltwater angler days are spent targeting largemouth bass.

[81] See Fedler and Hayes, "Economic Impact of Recreational Fishing for Bonefish, Permit and Tarpon in Belize for 2007," online at http://www.turneffeatoll.org/fota-action-plan/economic-study where the value of these species are estimated in nearby Belize.

Measure Documentation Sheet (2007)[82] states that desired post-restoration conditions include: "Improved density, age structure, and condition of black crappie, largemouth bass and brim in the littoral and near-shore regions of the lake. Increased diversity and extent of forage fish. Fish are expected to respond directly to changes in habitat structure, caused by more favorable water levels, and changes in resource availability, which will be determined in part by external nutrient inputs. Setting quantitative targets for the fish populations requires further research and data collection." Thus, we choose to use increase in recreational catch of largemouth bass to estimate the increase in consumer surplus for recreational anglers due to CERP restoration.

We again assume that quantitative targets are set at 75 percent of total fish population, as suggested by Broward and Robblee and used to estimate the changes in commercial fishing catch in the previous section. Thus, we estimate that there is potential for a 49 percent increase in recreational fishing catch.

On average, recreational anglers catch 59 bass each year in Southeast Florida, with an estimated marginal value per fish of $4.32.[83] The FWC 2006 survey of Fishing, Hunting and Wildlife estimates that each angler in Florida spends 17 days fishing (this is an average of residents and non-residents); therefore we estimate that on average, anglers currently catch 3.47 bass per day.

Using the potential 49 percent increase in catch due to the CERP estimated for commercial fishing, this provides a potential estimated increase in catch per angler, per day of 1.7 bass. The total number of fishing licenses sold[84] in 2008 in the 16 Everglades counties was found by Stronge (2010) to be 362,300.[85] However, the FWC states, "It is important to note that only about half of Florida anglers actually have to purchase a license due to various exemptions, so these numbers do not reflect participation."[86] Therefore, we multiply resident angler licenses in Everglades counties by 1.5 in order to estimate the number of resident anglers in these counties. The number of combination licenses sold was given only in total number rather than by resident status; as residents purchased 54 percent of freshwater licenses and 67 percent of saltwater licenses, we estimate that about 60 percent of combination licenses will have been purchased by residents, and we multiply this number by 1.5 in order to estimate the number of resident fresh

[82] http://www.evergladesplan.org/pm/recover/recover_docs/et/lo_pm_fish.pdf.

[83] http://myfwc.com/CONSERVATION/FishingBassConservationCenter_Value.htm.

[84] This includes both residents and nonresidents for freshwater licenses, saltwater licenses, and combination licenses.

[85] Stronge, W.B. *The Economics of the Everglades Watershed and Estuaries: Phase 2 - 2010 Update of Data Analysis.* Prepared for the Everglades Foundation (March 2010).

[86] http://myfwc.com/CONSERVATION/Conservation_ValueofConservation_EconFreshwaterImpact.htm.

and saltwater combination anglers.

We then sum these estimates to obtain the estimated number of anglers who have purchased licenses in Everglades counties or fish in Everglades counties, but are exempt from the need to purchase a license. We assume this is an appropriate (though on the low-end) estimate for the number of anglers fishing in Everglades counties in a given year. Given the FWC estimates the average number of days spent fishing per angler at 17.2, the estimate of 467,855 anglers in the Everglades leads to an estimated 8,047,113 angler-days fishing in the Everglades. Table 5.8 reports these details.

Table 5.8: Estimated Number of Recreational Fishermen in Everglades Counties

Estimated # Recreational Saltwater Anglers (x1.5)	173,278.50
Estimated # Recreational Freshwater Anglers (x1.5)	100,005.00
Nonresident Saltwater Licenses	99,913.00
Resident Freshwater Licenses	31,995.00
Estimated # Resident Combo Anglers (x.6x1.5)	43,382.70
Estimated # Nonresident Combo Licenses (x.4)	19,281.20
Sum of Non-residential Licenses and Resident Angler Estimates	467,855.40
EST DAYS (Sum licenses x 17)	8,047,112.88

This estimated number of angler days is multiplied by the estimated increase in Everglades recreational bass catch post-CERP (1.7) to get an estimated increase of 13,841,034 fish caught each year. The estimated increase in value due to restoration (based on a marginal value per bass of $4.32) is then $59,793,267.54 for each year after restoration is complete. A 20-year restoration period was used for our calculations in Table 5.8. A 30-year restoration period was used for calculations in Table 5. 9. A 2.1 percent discount rate was used for both estimations.

Using the 20-year restoration period (Table 5.8), we estimate that CERP will increase total angler surplus in the Everglades by $2,989,663 each year for 20 years. This is followed by a constant expected restored dockside value of $59,793,268 above non-restoration expected value (if conditions remain as-is in perpetuity) in perpetuity beginning in year 21. The present value for each year's increase in value was calculated and discounted back to the present based on a 2.1 percent discount rate in Table 5.9. The sum of these numbers provides an estimated increase in the present value of recreational fishing in the Everglades due to CERP of $2,287,076,218.

Table 5.9: Estimated Increase in Value to Recreational Anglers due to CERP Using 20 Year Restoration Period.

Year	Bass value increase	Present Value
1	$ 2,989,663	$ 2,931,043
2	$ 5,979,327	$ 5,747,142
3	$ 2,989,664	$ 2,817,228
4	$ 11,958,654	$ 11,047,947
5	$ 2,989,665	$ 2,707,832
6	$ 17,937,980	$ 15,928,413
7	$ 2,989,666	$ 2,602,684
8	$ 23,917,307	$ 20,413,191
9	$ 2,989,667	$ 2,501,620
10	$ 29,896,634	$ 24,525,653
11	$ 2,989,668	$ 2,404,480
12	$ 35,875,961	$ 28,287,950
13	$ 2,989,669	$ 2,311,112
14	$ 41,855,287	$ 31,721,077
15	$ 2,989,670	$ 2,221,369
16	$ 47,834,614	$ 34,844,924
17	$ 2,989,671	$ 2,135,111
18	$ 53,813,941	$ 37,678,335
19	$ 2,989,672	$ 2,052,203
20	$ 59,793,268	$ 40,239,155
SUM of 20 year PVs		$ 275,118,470
PV of Perpetuity (beginning in yr 21)		$ 2,011,957,749
Total Increase in Value		$ 2,287,076,218

Using the 30-year restoration period (Table 5.10), we estimate that CERP will increase total Everglades commercial dockside value by $1,993,109 each year for 30 years. The present value for each year's increase in value was calculated and discounted back to the present based on a 2.1 percent discount rate in Table 5.10. The sum of these numbers provides an estimated increase in the present value of recreational fishing to anglers due to CERP of $24,603,244 over these 30 years.

Table 5.10: Estimated Increase in Value to Recreational Anglers due to CERP Using 30-Year Restoration Period.

Year	Bass value increase	Present Value
1	$ 1,993,109	$ 1,954,028
2	$ 3,986,218	$ 3,831,428
3	$ 5,979,327	$ 5,634,453
4	$ 7,972,436	$ 7,365,298
5	$ 9,965,545	$ 9,026,101
6	$ 11,958,654	$ 10,618,942
7	$ 13,951,762	$ 12,145,849
8	$ 15,944,871	$ 13,608,794
9	$ 17,937,980	$ 15,009,699
10	$ 19,931,089	$ 16,350,435
11	$ 21,924,198	$ 17,632,822
12	$ 23,917,307	$ 18,858,633
13	$ 25,910,416	$ 20,029,594
14	$ 27,903,525	$ 21,147,385
15	$ 29,896,634	$ 22,213,639
16	$ 31,889,743	$ 23,229,950
17	$ 33,882,852	$ 24,197,864
18	$ 35,875,961	$ 25,118,890
19	$ 37,869,069	$ 25,994,494
20	$ 39,862,178	$ 26,826,103
21	$ 41,855,287	$ 27,615,106
22	$ 43,848,396	$ 28,362,854
23	$ 45,841,505	$ 29,070,662
24	$ 47,834,614	$ 29,739,807
25	$ 49,827,723	$ 30,371,535
26	$ 51,820,832	$ 30,967,056
27	$ 53,813,941	$ 31,527,545
28	$ 55,807,050	$ 32,054,149
29	$ 57,800,159	$ 32,547,981
30	$ 59,793,268	$ 33,010,122
SUM of 30-year PVs		$ 626,061,222
PV of Perpetuity (beginning in yr 31)		$ 1,650,506,118
Total Increase in Value		$ 2,276,567,341

Table 5.11 shows the present value of recreational fishing value increases over a 50-year period using this estimate of a $90,464,861 increase in value each year after CERP is completed. This is calculated for both a 20- and 30-year restoration period (assuming catch increases linearly over those years), as well as for instant restoration.[87] Our best estimate is that Everglades restoration will increase the value of recreational fishing by a total of $2.04 billion in net present value terms.

Table 5.11 Estimates of Recreational Fish Catch Increase From Everglades Restoration

Discount Rate	Time for Fishery to Recover After Everglades Restoration		
2.1%	Immediately	**20 Years**	30 Years
NPV Increase	$2,783,890,688	**$2,037,516,539**	$1,714,891,823

[87]We also estimated the total number of anglers in Everglades counties using the ratio (number Everglades counties)/(number counties in Florida) and multiplied this by the estimated 2.8 million anglers fishing in Florida. We then used this ratio to estimate the number of anglers in the Everglades to recalculate the increase in bass caught and increase in value. The results are numbers that are similar and suggest that either assumption is appropriate.

Additional Commercial Fishing Figures

Figure 5.12: Total Finfish Caught Commercially in Everglades Counties (pounds)

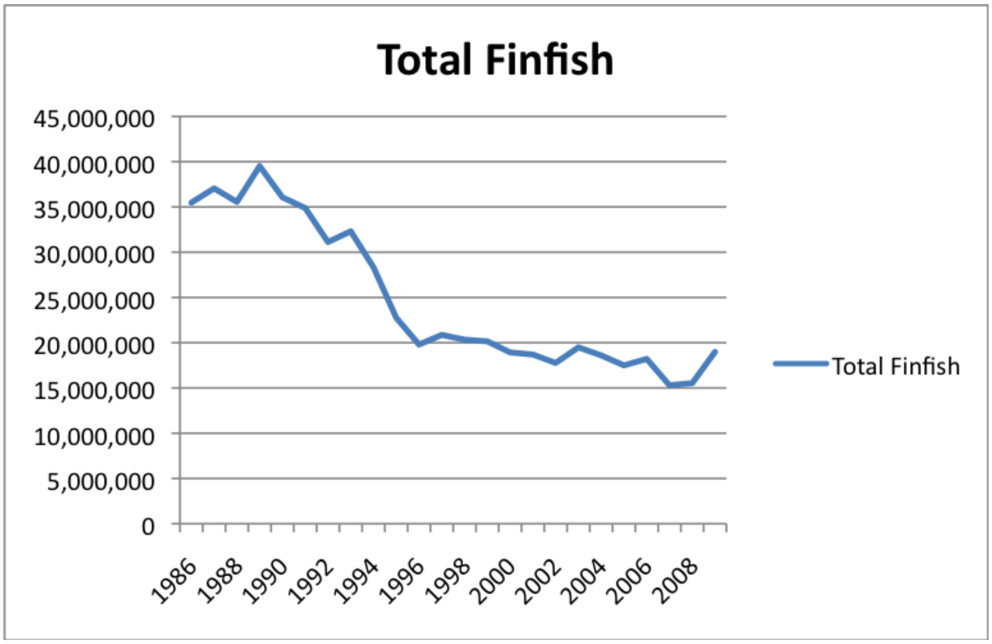
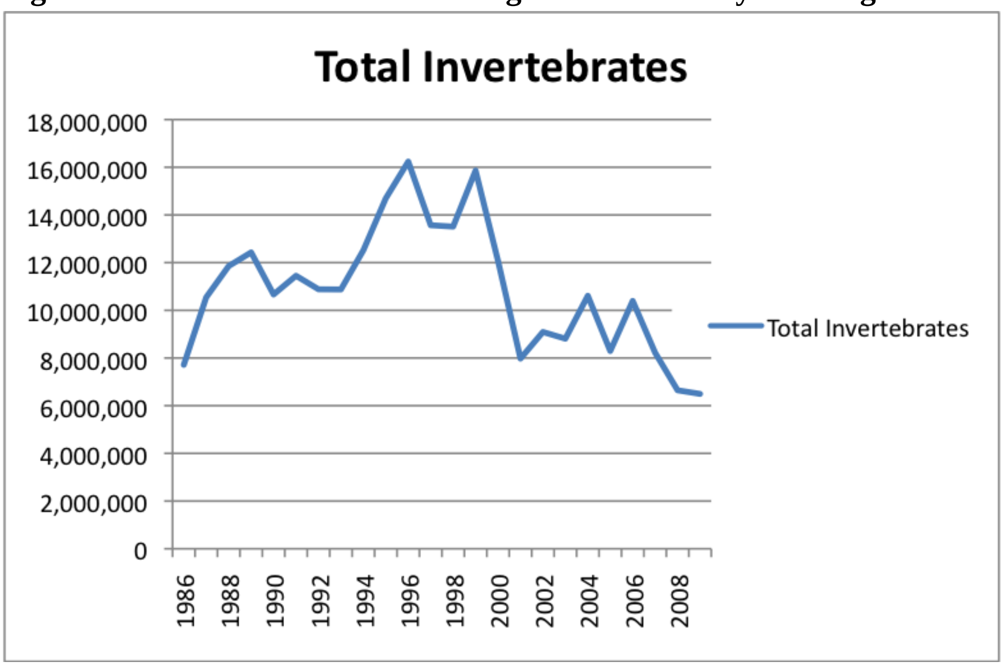


Figure 5.13: Total Invertebrates Caught Commercially in Everglades Counties (pounds)



Chapter 5 References

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Chapter 6: Wildlife Habitat and Hunting Valuation

While fishing is a major recreational activity in Florida, hunting and wildlife viewing are popular pastimes as well. In this section, we detail our estimates of the economic impacts on these pursuits as we model them subsequent to Everglades restoration.[88]

Impact on Hunting

There are two important hunting groups in the Everglades: deer and waterfowl (primarily ducks). Restoration stands to impact hunting, it turns out, both positively and negatively. Deer have moved into and flourished in the drained wetlands over the last half century, and ducks have been driven out. Restoration will reverse these recent trends.[89]

Methods and Literature

As an initial study into the valuation of non-market resources, we performed a literature review on environmental valuation, focusing on the economic impact of ecosystem services that cannot be directly valued on a market. Within this type of valuation, the methodology can be broken down into two major categories: contingent valuation (CV) and revealed preferences. The contingent valuation method of economic analysis can be defined as a means of valuing non-market resources by using surveys and questionnaires to estimate the population's "willingness to pay" for a service. One relevant example of this method in existing literature is found in a 1995 paper by Fried, Adams, Berren, and Bergland[90] in which the authors evaluate the value of increased quality of elk hunting in the Starkey Experimental Forest in Oregon. In this experiment, hunters in the area were given a "dichotomous choice" survey, offering an increased

[83] There is considerable evidence that deer populations might actually increase in certain areas after restoration, but as is revealed below, there is evidence from Holy Land Management Area that deer hunting does not necessarily follow the growth in species. We can note that deer populations have been increasing throughout the United States over the past 30 years, but deer hunting has been declining. The presence of more deer does not by itself lead to additional hunting.

[89] We fully expect that alligator hunting will increase after restoration, but we have not attempted to assay these benefits in any scientific way for three reasons: *i)* there is considerable uncertainty about the regulatory regime for alligator hunting owing to their potential endangered status and the methods required for hunting; *ii)* we assert that the economic benefits are small and compared to the overall effects we are measuring, they are second order or smaller impacts here; and *iii)* we have so far been unable to get any reliable indications on the value of alligator hunting, the total extent of it, or a reliable forecast of its impact post restoration. With all this said, out best estimate is that alligator habitat and populations will increase and that alligator hunting will also go up some.

[90] Fried, B., R. Adams, R. Berrens, O. Bergland. "Willingness to pay for a change in elk hunting quality." *Wildlife Society Bulletin* 23(4), (1995): 680-686.

quality of hunting along with an increased fee to hunt the area. This survey had a "take it or leave it" format, with different prices assigned at random to survey participants. Based on the aggregate of their choices, it is possible to estimate the demand curve for increased hunting quality. However, this method is difficult to implement accurately, because it requires boots on the ground conducting surveys, and it requires a significant number of surveys to be conducted if it is to be accurate. Another example of contingent valuation estimation for non-market assets occurs in a 2000 paper by John Loomis[91] In this paper, Loomis evaluates different methods of "nonmarket valuation concepts and techniques" and presents a detailed case study in using dichotomous-choice contingent valuation to estimate a community's willingness-to-pay for a restoration project that would upgrade ecosystem services. He analyzes a 72-kilometer section of the South Platte River in Colorado and attempts to estimate the non-use value the community puts on the river and associated riparian zone.

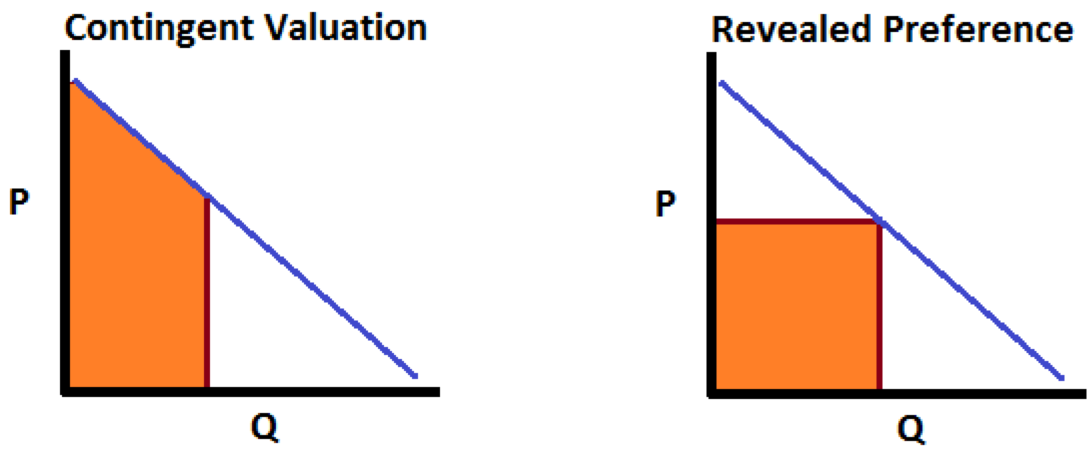
The alternative to the contingent valuation method is the revealed preference method. Instead of focusing on what affected people would be *willing* to pay, revealed preference analyses determine what those same people have actually spent in the past due to changes in similar circumstances. This method is more effective at determining the current value of non-market services, as it is unlikely to overestimate or encourage exaggeration on the part of the CV survey takers. Among other options, revealed preference estimations can use travel cost, historical fee payments or license purchases or visitation statistics to measure willingness to pay. The U.S. Fish and Wildlife Service released a report entitled "National Survey of Fishing, Hunting, and Wildlife-Associated Recreation," in which they estimate the economic impact of various wildlife-associated recreational activities using the travel-cost method.

After reviewing the various methods of estimating the valuation of non-market resources, we chose to focus -- in this section of our model -- exclusively on revealed preference estimations for a number of reasons. First, revealed preference is a more objective, scientific method of determining current values of an ecosystem service. When implementing CV surveys, survey takers may be inclined to overstate their actual willingness to pay, as they will not actually be required to pay any money. Revealed preference estimations use the money that people have actually spent, guaranteeing that this method is not overestimating the value of the assets in the area. Essentially, contingent valuation estimations attempt to capture the entire consumer surplus (or what consumers would be *willing to pay* in addition to what they are actually paying) for a service, while revealed preference merely captures the money consumers spent on the service.

[91] Loomis, John. "Can Environmental Valuation Techniques Aid Ecological Economics and Wildlife Conservation?" *Wildlife Society Bulletin.* 28(1). (2000): 52 – 60.

This difference ensures that revealed preference is a more conservative, baseline estimate of any service's value. While contingent valuation might provide a more accurate estimate under some conditions, it also greatly increases the risk of overestimating the value of an asset.

Shown below is an illustration of the area under a demand curve that contingent valuation estimations attempt to capture compared to the area that revealed preference estimations attempt to capture. This further illustrates the conservative nature of the model we have created.



In this figure, the downward sloping (blue) line represents a demand curve for a service. As the price (P = price of service) increases, the number of people demanding the service (Q = quantity of service demanded) decreases. Because the actual expenditures in our revealed preference models only captures this smaller area, we can ensure that there is a very low probability of overestimation in our base-line estimates. On the other hand, contingent valuation attempts to capture the total consumer surplus, so any overstatement by the survey takers directly translates to an overestimation on the part of the model.

Using data presented in the Florida Fish and Wildlife Conservation Commission's 2003 Report entitled "The Economics of Selected Florida Wildlife Management Areas" for 17 selected statewide Wildlife Management Areas, we computed an estimated ratio of the economic value of hunting in the WMAs located within the Everglades to the economic value of hunting in WMAs statewide. From the lower-bound estimates for each WMA's value, we calculated the ratio of hunting expenditures in the Everglades to the entire state. This estimation suggested that approximately 46 percent of total expenditures on hunting and fishing in Florida occurred in the Everglades watershed. We then multiplied this ratio by the U.S. Fish and Wildlife Service's estimate of the total economic value of hunting in Florida, $377,394,000 annually. This method leads to a baseline estimate of $175,000,000 per year that hunting in the Everglades area contributes to the Florida economy.

Fluctuations in water levels are responsible for current high mortality rates among deer in South Florida. CERP estimates that, with the restoration of the Everglades, white tail deer populations will be reduced to pre-drainage numbers, but that deer mortality due to drowning and starvation will decrease. CERP estimates suggest that deer hunting in Big Cypress National Preserve should not be impacted in either direction, but that deer hunting in Everglades WMA will be adversely affected. For purposes of this model, we assumed no net change in deer hunting in Big Cypress and a decrease of 75 percent in Everglades and Rotenberger WMAs. The decrease is due to lower deer populations and increased difficulty in accessing huntable areas. We further assumed that Holey Land would undergo half the total effect of Everglades or Rotenberger, because it is already partially rehydrated. It has already seen a notable transition from deer hunting to waterfowl hunting as a result of higher water levels.

The Everglades occupy the western portion of the Atlantic Flyway as it passes through Florida. Increasing year-round water levels in Everglades and Rotenberger WMAs would provide more ideal habitat for waterfowl. It would also induce a shift in hunting patterns in these areas from primarily deer hunting to primarily duck hunting, as seen in Holey Land WMA after its restoration. At present, waterfowl hunting in the Everglades does not provide a significant portion of total hunting expenditures, but we expect that, after restoration, duck hunting will increase significantly in quality, and thus it will become an attraction and increase its significance greatly.

We used the rehydration of Holey Land WMA as a measure of the consequences of restoration on hunting in the Everglades. This rehydration, which began in 1991, drastically changed hunting patterns within the Holey Land WMA, and we expect a similar shift in the Everglades. We used days of hunting to estimate percent changes.

Table 6.1 Estimates of Change in Hunting

	Waterfowl Hunting (days)	Deer Hunting(days)	Total Hunting (days)
Prior To Restoration	Negligible	972	972
Post Restoration	266	156	422

The calculations in Table 6.1 suggest a notable decline in total hunting in the area due to restoration, but we expect the quality of duck hunting in the various areas to be super additive, because the benchmark reference case does not properly mimic the substitution that will take place in the Everglades. In the Holey Land WMA, hunters simply moved their deer hunting to adjacent properties. In the case of Everglades restoration, there are no nearby areas for deer hunters to go, so we expect many of them to turn to duck hunting, hence the super additive effect.

We note that restoration, while leading to flooding of existing deer habitat, may not have a dramatic impact on deer population as the wetlands have hammocks and dry spots for deer to reside. However, the Holey Land experiment is the best estimate of the impact of restoration on *hunting*, and while it stands to be conservative in the sense that the impact on deer populations is not likely to be as severe as a decline of 75 percent, we think the experiment in place is the best available science, and hence it is our approach. We concede that deer hunting may *not* fall as dramatically as the Holey Land restoration suggests, but our judgment is to be conservative for all the reasons issued earlier.

Figure 6.1 reveals the potential for deer population increases as estimated by Jane Comiskey.[92] Accordingly, there is good reason to believe that deer populations will not be negatively impacted, overall, by restoration, and might even improve. If this turns to be true, and contrary to the Holy Land restoration, then our estimates of benefits are biased downward, and restoration is more valuable than we conclude there.

[92] See Appendix D (Attachment C) of the 1999 Restudy report. The text on D-C-88 suggests that, overall, deer herd will be reduced (based on this breeding potential index) only slightly with CERP (Aternative D) compared to without CERP (2050 Base.

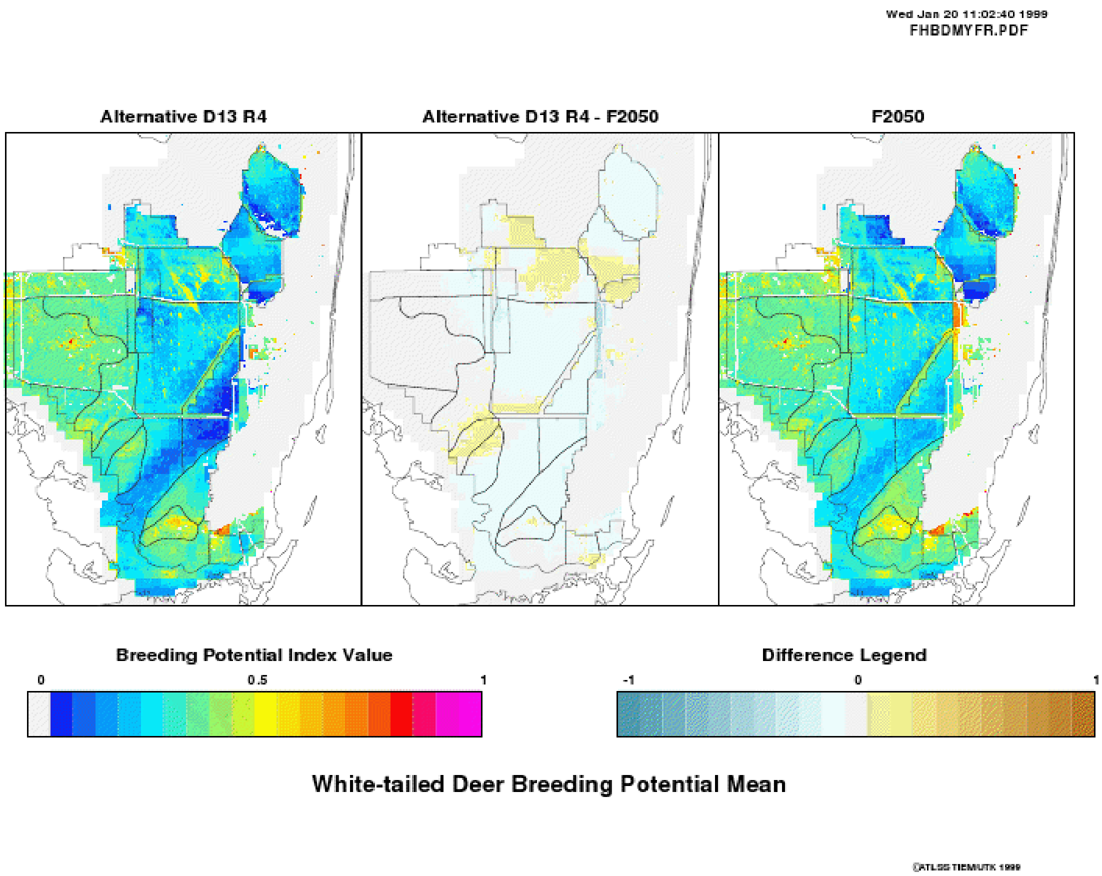


Figure 6.1 Potential for Deer Populations Post Restoration

All said, our best estimate is that, as hunters shift from deer to ducks, there will be a 75 percent decrease in deer hunting and a concomitant increase in duck hunting. As a sensitivity test, we estimated the change in hunting assuming duck hunting increases proportional to 100 percent, 200 percent, 250 percent, 300 percent and 500 percent of the relative changes seen in the Holey Land WMA benchmark case. Using relative hunting days in all areas, and allowing for no change in Big Cypress[93] and half the change in Holey Land WMA as is expected in Everglades WMA, our best estimate is that there will be an annual reduction in hunting of $16.6 million (-9.5 percent) per year. We estimate a range from, in the best case, a $50.5 million increase to, in the worst case, a decrease of $38.9 million. The actual change that occurs here will depend on

[93] According to CERP, Big Cypress National Preserve will not be significantly impacted by restoration.

the proportion of deer hunters who cease hunting altogether or move to a different area to deer hunters who begin taking advantage of the improved duck hunting in the area instead.

While the marginal impact of Everglades restoration on hunting expenditures might be negative, the expected change in wildlife viewing expenditures is almost surely positive and far larger than the potentially negative impact on hunting expenditures. The expansion of habitat produces additional services, primarily through viewing of birds and other wildlife. We have already computed the additional value of viewing by tourists, and, to avoid double counting, in this section we only estimate the habitat impact on resident viewings in and around their homes, that is, local bird and wildlife watching. The increased demand from restoration will also be reflected in increased expenditures on bird watching equipment such as feeders, food and binoculars.

Impact on Habitat and Wildlife Viewing

The U.S. Fish and Wildlife Service estimates that the state of Florida has more than $3 billion in annual expenditure by wildlife watchers.[94] Of the 1.5 million people who engage in away-from-home wildlife watching each year, more than 1.1 million engage in waterfowl watching and 1.29 million watch other non-game water birds. In comparison, only 421,000 engage in viewing of large land mammals.[95] Using data for 17 statewide Wildlife Management Areas, for purposes of scaling the state total to the region, we used as a proxy the ratio of the economic value of hunting in the WMAs located within Everglades to the statewide value. We then multiplied this number by the U.S. Fish and Wildlife Service's estimate of the total economic value of wildlife watching in Florida, which was $3.08 billion annually. This leads to an estimated value of $1.43 billion per year that non-consumptive wildlife recreation in the Everglades contributes to the Florida economy.

The primary source of wildlife watching value in Florida comes from bird-watching, primarily of wetlands species, either waterfowl or wading birds.[96] CERP estimates significant habitat improvement for water-reliant bird populations, specifically waterfowl and wading birds. Due to the Everglades' position along the Atlantic Flyway, a large portion of migrating waterfowl pass through the area on their way from Canada to the Caribbean. Increasing year-round water levels in Everglades and Rotenberger WMAs along with Everglades National Park will provide more ideal habitat for waterfowl and non-game wetlands birds. It will also induce a shift in wildlife

[94] Table 31; page 39; FWS – FHWAR. We excluded for our calculations the "special equipment expenditure" category because we are attempting to measure the habitat-only demand and not travel- or tourism-related demand.

[95] Table 26; page 35; FWS – FHWAR.

[96] Table 26; page 35; FWS – FHWAR.

watching demand in these areas due to increased quality relative to other areas.[97]

CERP estimates improved habitat for the following endangered species:

- West Indian Manatee
- American Crocodile
- Snail Kite
- Wood Stork
- Cape Sable seaside sparrow

Table 6.2 reports wildlife participation rates in the Everglades region.

Table 6.2		
Wildlife Watching Participation Figures		
Wildlife Type	Participants**	% Participants
Waterfowl	1166	74.7%
Wading Birds	1290	82.7%
Birds of Prey	858	55.0%
Total birds	1418	90.9%
Marine Mammals	685	43.9%
Other Wildlife*	985	63.1%
TOTAL	1560	100.0%

* "Other Wildlife" includes reptiles and insects
** Numbers in thousands

On page ii of the CERP's Draft Fish and Wildlife Coordination Report, it is estimated that the wading bird population has declined by 90 percent from its natural level. In spite of these drastically reduced numbers, Florida remains the number one tourist destination in the United States for wildlife watching. The state currently draws 746,000 visitors a year to participate in wildlife watching. Restoration should return wetland-dependent bird populations to some larger percent of their historical population. Ecologists use wading-bird population as an indicator of environmental health because these birds are a fragile part of the ecosystem. Due to this frailty, their success indicates a successful ecosystem. For this reason, and because of the high percentage of wildlife viewing aimed at wading birds, the economic impact of improved habitat

[97] CERP Sections 8.7 and 8.8.

on demand for wildlife watching can be conservatively estimated by measuring the effect of increasing bird populations on wildlife-watching expenditures.

Over the last several years, the number of wading birds residing within the Everglades has grown rapidly. The population increase is believed to be a result of several years of high rainfall, and it corresponds to a dramatic increase in the economic impact of wildlife watching in Florida. Since 2001, the total expenditure for non-consumptive, wildlife-associated recreation in the state of Florida has approximately doubled. The 1990s were a low-population period for wading birds, and their recent recovery is correlated with the large increase in wildlife-watching activity in the state. The change in bird numbers along with the change in bird-watching values indicates a relatively high elasticity of demand based on the quality of bird watching and changing preferences. The implication of this is that Everglades restoration will lead to important and significant increases in wildlife populations, viewing and enjoyment. As habitat and bird populations increase, the economic impact of wildlife watching should improve at an even more rapid rate than it has recently.

To calculate these values, we estimated the baseline value of habitat and non-consumptive wildlife appreciation in the Everglades. We used wading-bird populations as our indicator metric for habitat value in the Everglades. The University of Florida estimates that, just prior to drainage, there was a stable population of approximately 70,000 mating pairs of wading birds living in the Everglades. This is our reference benchmark for restoration. Using 2005 bird populations, our conservative best estimate is that restoration will return these numbers to 75 percent of the 70,000 mating pairs reference benchmark. We then estimated the marginal impact of changes in species populations on demand for viewing by extrapolating the changes seen between 2000 and 2005 to the increased, restored numbers estimated in the table below. Our best estimate, or 75 percent of historical populations restored, provides an annual improvement in habitat value of approximately $424 million.

Table 6.3 Estimated Nesting Pairs	1999 - 2001	2004- 2006	75% Restoration	100% Restoration
Great Egret	5996	8296	-	-
Snowy Egret	4270	6410	-	-
White Ibis	16555	24926	-	-
Wood Stork	1538	800	-	-
Total	28359	40432	52500	70000
Birdwatching Value:	$734,174,000	$1,435,977,000	$1,900,427,000	$2,573,934,000
	Value of Restoration:		$464,450,000	$1,137,957,000

Changes in total number of wading birds inhabiting the Everglades

Δ (2000 - 2005)	Δ(2005 - 75% Restored)	Δ(2005 - 100% Restored)
12073	12068	29568

Though we have estimated a portion of these values in our recreation and park visitation model, which measures park visitation changes, wildlife viewing generates additional values not captured by our park visitation model. These values should be considered when evaluating Everglades restoration, particularly to local residents who derive pleasure from the increased number of animals residing around their homes. To fully capture the value of the impact of restoration on wildlife habitat and hunting, we summed the values from habitat and hunting calculations. Our best estimate is that Everglades restoration will increase wildlife habitat and hunting services by $407.4 million annually.

As a final word about habitat and hunting, it is important to note that the impact on hunting will only be negative if significant numbers of deer hunters do not transition to duck hunting as duck populations expand. The experience with Holey Land restoration suggests that it is complicated to forecast the impacts on hunting associated with expansive additional CERP restoration. On the one hand, it appears that additional duck populations attract people to duck hunting, and this is reasonable from the point of view of economic theory. It may also be true that existing duck hunters will chose to hunt locally more often and forego trips to distant duck hunting areas such as Louisiana, but we cannot estimate these shifts with any precision. In order to be conservative, we have assumed a very low elasticity of substitution between deer and duck hunting and a low elasticity of new duck hunters. Accordingly our negative estimate on hunting is probably biased, and the likely outcome is not so dire. Additional information on hunter switching could refine this estimate.

Chapter 7: Other Everglades Valuations, Miscellany

There are four broad areas of ecosystem services that, at present, we have not conclusively valued that might be forthcoming or enhanced as a result of Everglades restoration: the potential for carbon sequestration, potential fire damage reduction, the potential for enhanced water purification, and the option value of unknown compounds and life forms living in the Everglades. While these values stand to be real and to change in important ways as the Everglades is restored, we are not prepared at this point in time to offer estimates of the pro forma financial calculations for two reasons. First, the science of these services is somewhat unsettled and unclear, compared to the other services, and second, the markets for these services are immature and undeveloped. Hence, while there is rampant speculation about how these services might be highly valued and special, we are not presently prepared to put hard numbers to these theories, as good as they might turn out to be.

We can note that if the world moves to a market for carbon sequestration, and such markets are developing, the amount of carbon sinking in the Everglades could be important. Our best estimate at this time is that the amount of carbon is small, but we have low confidence in that assessment. There is evidence that higher temperatures will lead to higher sea levels. As this happens, sheet flow, aquifer recharge, and peat accumulation take on increasing importance. Accordingly, restoration of the Everglades could be a formidable force for adjustment to climate change. However, given the uncertainty of these events, and the lack of any existing markets with which we might measure these changes, we take the conservative, not sanguine, approach of not including any value to restoration on this count. This is doubtless conservative. For, even if climate change does not occur, there is evidence of its possibility. Hence, restoration creates an option value mitigating against climate change. Our position is that we are simple incapable of putting a dollar figure on this option value. So basically, while we acknowledge the potential for important values of carbon sequestration services and changes that might flow from restoration, in order to maintain our conservative stance, we will not add any hard numbers. As time proceeds, we will revisit our position on this topic.

Another topic for further study is the potential for Everglades restoration to improve South Florida's water quality in ways not captured by our real estate and recreation value estimates. Because wetland ecosystems are known for effectively filtering nutrients, we suspect a restored Everglades would produce significant cost savings in water treatment and the secondary impacts of poor water quality. In particular, we have researched the potential for CERP to reduce water quality treatment costs, beach closures and health impacts in South Florida. However, we have chosen to omit that research and the corresponding valuations from this report because there exists significant disagreement in the scientific community over the connection between nutrient reductions and such water contamination cost drivers as harmful algal blooms, beach clean-ups, and shellfish poisoning. Like carbon sequestration, this topic should receive additional attention as this research continues and progresses. We discuss this topic in more detail below.

A third topic we might investigate further is the potential value of unknown compounds and life forms in a restored Everglades. These are commonly called "biodiversity values," and we have found evidence of nascent markets in biodiversity. Michele Zebich-Knos reports on a contract between Merck Pharmaceuticals and INBio, a Costa Rican NGO for biodiversity development.[98] The amounts of money at play in this market are not fully public. We are confident that there are others, and this appears to be a fertile area for further analysis. At present, however, given the high levels of uncertainty, we are not prepared to put hard and fast estimates to these option values. Given the scientific and policy uncertainty over these topics, our omission makes our valuation estimates more robust. However, future work should probably pay close attention to developments here.

The Potential Benefit of Cleaner Water from Restoration

Nutrient Loading

Background

Environmental degradation of the Everglades has caused several problems in the water flow in South Florida. Due to the lack of natural flows southward (from the Kissimmee down to Lake Okeechobee and out to Key Biscayne) and the redirecting of these flows east and west (via the St. Lucie and Caloosahatchee estuaries), the natural, slow filtration and storage capabilities of the Everglades ecosystem no longer function as they had in the past.

Damming and flow redirection were beneficial for the agricultural industry, but they depleted the natural environment. The "River of Grass" has dried up in many areas and has been reduced

[98] "Preserving Biodiversity in Costa Rica: The Case of the Merck-INBio Agreement." *The J. of Environment and Development*, 6(2), (1997).

drastically in size. Redirecting the water flow east/west had several negative impacts on the environment. Lake Okeechobee receives excess flows from the Kissimmee area, which bring nutrients and pollutants through the lake. During dry seasons, the lake stores this runoff instead of letting it filter naturally, thereby taking in deposits of these nutrients.

Fresh water that slowly flowed south now flows east/west, and at times there are sudden overflows due to storms and flood control measures. This impacts not only the Everglades, but also the estuarine areas where the St. Lucie and the Caloosahatchee flow into the Atlantic and the Gulf of Mexico. This excess water not only distorts the natural estuarine water with freshwater, but also brings runoff from the agricultural areas (phosphorous, nitrogen, potassium and other pollutants) into the estuarine ecosystem. Environmental conditions in the estuaries deteriorate due to the excess freshwater and nutrient-saturated water. This also has a negative impact on the local wildlife.

Theory and Methods

One option under the Comprehensive Everglades Restoration Plan is to restore the River of Grass flowing from Lake Okeechobee to South Florida. This restoration model is designed to restore the water filtration function of the wetland habitat prior to its engineered conversion to dry-land agriculture. In particular, restoring the River of Grass will enhance the absorption and filtration of excess nutrients and pollution coming from agriculture, stormwater, and waste.

In addition to enhancing water filtration, this approach would reduce stresses on stormwater treatment facilities because the restored habitat would store and filter the excess runoff. Treatment facilities would not be overrun with flows (either from dam discharges, storms or flood control maneuvers). Fewer overflows at treatment facilities would reduce unnatural saturation of the estuaries, and natural abatement would reduce the stresses on treatment facilities. The treatment facilities would be less stressed because less nutrients and pollution would need to be treated and filtered. If the water was less saturated with nutrients and pollutants, the facilities would have to spend less effort to treat the water because the water would flow south and any nutrients or pollutants would be absorbed into the ecosystem through the slow-moving River of Grass.

Additionally, reduced overflows of the treatment facilities would reduce the impact of agricultural runoff in the two estuaries. With the regulations on the agricultural industry, less pollution emanating from farms as well as the restored absorption capabilities of the Everglades, the environmental conditions in South Florida would improve, and these improved conditions would have a measurable economic impact.

The economic impacts of our theorized effects could have been measured by estimating the expected reduction in pollution/nutrient runoff and tying that to an ecosystem service. For example, a certain reduction in the amount of phosphorous per gallon flowing into the Caloosahatchee estuary would improve the overall health of the estuary, which in turn might have multiple effects on local economic conditions. Among the possible effects are: improved property values (discussed by Michael, et al., (1996) and Krysel, et al., (2003)), a boost in tourism and tourism services (hotels, water sports, beach activities), reduced cleanup costs on beaches, more fishing revenues, fewer expenditures on treating food poisoning from healthier shellfish/fish, reduced cost to treat stormwater, nutrient-saturated water and excess runoff as well as reduced need for treatment facilities and other indirect economic effects due to improved water quality as discussed in Abbott, et al., (2009); Steidinger, et al., (1999); Parsons, et al., (2008); Hoagland, et al., (2002); and Morgan, et al., (2009) as well as numerous other reports.

Results and Discussion

After speaking with several water quality experts in South Florida, we realized that the hydrological connections between Everglades restoration, water quality treatment, beach closures, and human health impacts were present but too uncertain, in our minds, to quantify and value. Though most of the experts agreed that restoration would reduce nutrient loading of the Caloosahatchee and St. Lucie estuaries – and that nutrient loading reductions would reduce treatment, beach closure, and human health costs – none were willing to speculate on the magnitude of those cost reductions.

Helpful information in reaching this conclusion came from Tracy Piccone at South Florida Water Management District, Sandra Whitehead at the Florida Department of Health, and Eric Bush with the United States Army Corps of Engineers. In particular, Tracey Piccone and Eric Bush suggested that restoration of the natural habitat and flow would not necessarily reduce the need for stormwater treatment and might, in fact, increase it. This suggestion is premised on the belief that the flows redirected from Lake Okeechobee southward will have phosphorus concentrations high enough to damage a restored Everglades ecosystem.

Conversations with the SFWMD and local water management districts confirmed disagreement over the effect of Everglades restoration on nutrient loading in South Florida. Specifically, SFWMD staff and treatment facility administrators do not expect restoration of the Everglades ecosystem would provide South Florida with a *natural* water treatment facility. Their belief was that the redirected stormwater, runoff, and flows resulting from CERP implementation would require additional facilities to be constructed. It was suggested that the newly redirected water (south flowing) would need to be filtered down to acceptable levels because the local Native American population required a maximum of 10 ppb of phosphorous for all flows. Thus, according to SFWMD staff, *additional* water treatment capacity will be required following restoration; not less. The additional capacity will most likely take the form of stormwater treatment areas ("STAs"), which are artificial wetlands constructed to absorb nutrient loads.[99]

According to Tracey Piccone, in order to achieve high standards for water quality (low parts per billion), existing treatment facilities would need to work harder to remove each incremental part per billion. Thus, with more stringent regulation expected, the cost per pound of phosphorous reduction may increase in coming years. This approach to pollution reduction seems to ignore our theory that there are cost savings from the Everglades naturally abating nutrients/pollution. In addition to conceptual disagreements over the potential water quality improvements flowing from Everglades restoration, the South Florida Water Management District took exception to our proposed method of measuring water quality improvements in terms of parts per billion (ppb). Specifically, the SFWMD only considers whether a water body meets the Total Maximum Daily Load (TMDL) promulgated by the Environmental Protection Agency. Theirs is a binary world of either compliance or non-compliance; thus, marginal improvements in water quality which do not cross the TMDL threshold are irrelevant to the SFWMD. While these TMDL's serve as measures of clean water, they do not clearly measure the impact from individual projects on water quality. In other words, we needed to measure incremental changes in nutrients due to specific projects outlined in CERP. SFWMD and the EPA could only provide the required nutrient levels regardless of any projects or cleanup efforts.

Another problem with TMDL's mentioned by Rae Ann Wessel is that the process to issue a TMDL to a specific body of water is not a quick process and many areas in the Everglades ecosystem still do not have TMDL classifications. TMDL's do not measure the impact of restoration efforts outlined in CERP.

The final problem with measuring a direct economic impact from water quality improvements is

[99] It should also be noted that CERP clearly outlines construction projects where STAs (including filtration, treatment and storage facilities) are an important part in restoring the natural habitat. Thus, while there doesn't appear to be any cost savings in STAs, the cost of CERP already includes these new construction projects.

that a causal relation between pollutants, nutrients (for example ppb of Phosphorous) and environmental conditions is not yet established in the scientific community. Biologists and scientists admit that there may be some relation between nutrients and algal blooms/fish kills, but that relation is unknown.

It appears that no relevant expert will venture an opinion at this point on the true source of increased or decreased algal blooms. If there were only one factor that affected HAB's, the relation might be measurable. However, in the Gulf of Mexico, there are numerous known and unknown sources of nutrients (manmade or natural) that may cause a sudden growth in an algal bloom. The source of these events cannot be attributed solely to nutrient runoff from Florida farms or stormwater runoff from the two estuaries.

After numerous conversations with experts in South Florida from a variety of organizations, we still do not know the impact Everglades restoration will have on nutrient loading in South Florida. The relation between different ecosystems within the Everglades, the sum of their roles in the larger Everglades Ecosystem, and the roles of the Everglades in the larger South Florida/Gulf of Mexico/Atlantic Ocean ecosystem are not understood with sufficient certainty for our team to attempt an economic valuation. These relations or "linkages" are still not understood completely and in some cases are still debated among biologists and scientists.

Harmful Algal Blooms, Beach Closures, and Public Health Impacts

Background

Existing literature on algal blooms by Abbott, et al., (2009) and Steidinger, et al., (1999) provide some background on the subject. Algae forms naturally in the Gulf of Mexico and has been recorded in Florida since the 1800's. The algal bloom is swept by ocean currents and occasionally makes landfall on beaches. Algal blooms deplete oxygen, thereby inducing fish kills or poisoning fish and shellfish. Harmful algal blooms routinely cause beach closures and warnings in South Florida. It is generally believed that the recent increases in polluted water flowing into the estuarine areas (as well as into Lake Okeechobee and other bodies of water) contribute to the blooms of harmful algae.

As noted by Abbott, et al., (2009); Steidinger, et al., (1999); Parsons, et al., (2008); Hoagland, et al., (2002); and Morgan, et al., (2009), beach warnings and closures attributable to harmful algal blooms have a negative economic impact on Florida's economy, both in terms of reduced tourist expenditures and increased beach clean-up costs. Morgan et, al., (2006, 2007) report losses of

$6.5 million due to beach red tides between 1995-2000 in Okaloosa County, as well as losses in Pinellas, Sarasota, Lee, and Collier counties and cities of Longboat Key and Naples of $654,890 between 2004-2007. In addition, harmful algal blooms can impact humans who catch and eat polluted fish. Hoagland, et al., (2002) estimates costs per shellfish poisoning to be between $1,100-1,400 per case and $700-1,000 for ciguatera fish poisoning. Fish kills and beach closures have significant, negative impacts on the South Florida economy. This section explains our attempt to quantify those impacts.

Scientific Uncertainty

Much like the impact of Everglades restoration on water quality, the relationship between restoration and harmful algal blooms is disputed in the scientific community. According to Rae Ann Wessel, Sanibel Captiva Conservation Foundation, nutrient-saturated water from agricultural runoff does not necessarily cause the development of algal blooms (red tide, bluegreen algae, microalgae and others) but may have some impact on the intensity of algal blooms presently occurring.

On the other hand, Stevenson, et al., (2007) note the following relations between nutrient loading and algal growth:

1. Reductions in algal growth rates from maximum rates to 33 or 66 percent lower rates with nutrient load reductions should have great benefits for controlling macroalgal accumulation.

2. Reductions in TN and TP concentrations to less than 0.591 or 0.026 mg/L, respectively, should reduce the extent of cover of spring bottoms by Vaucheria spp. in Florida springs; however, greater reductions in TN and TP will likely be necessary to substantially reduce Vaucheria cover.

3. Reductions in TN and TP concentrations to less than 0.250 or 0.033 mg/L respectively should reduce the extent of cover of spring bottoms by Lyngbya wollei in Florida springs; however, greater reductions in TN and TP will likely be necessary to substantially reduce Lyngbya wollei cover.

4. In many springs, nitrogen reductions may be the only practical restoration strategy because natural phosphorus concentrations may be higher than the concentrations that constrain algal growth.

Supporting the assertion that nutrient loading increases algal blooms, Patricia M. Gilbert and

Daniel E. Terlizzi (1999) also note, “In aquaculture ponds, dinoflagellate blooms were found on 10 of 14 occasions to co-occur with concentrations of urea in excess of 1.5 M nitrogen. When urea levels were <1.5 M nitrogen, on seven occasions, no evidence of dinoflagellate blooms was observed in these ponds.”

Although a clear and measurable relation is still uncertain between nutrient outflow/saturation and algal blooms (such as Red Tide), Hoagland, et al., (2002), Abbott, et al., (2009) and Steidinger, et al., (1999) suggest that effects of polluted waters on local fisheries is generally accepted. Fish and shellfish can become poisoned or die from excess pollution. Fish poisonings and kills can cause human health impacts if the poisoned fish or shellfish are consumed, and they can cause beach closures and warnings. The cost of beach closures has been estimated by Parsons, et al., (2008), ranging from $25,000-$852,000 depending on location, time of year and day of week, as well as by Hoagland, et al., (2002) to be about $170,000 per mile, per year of cleanup in Florida. While these estimates may be used to estimate costs per closure due to HAB events, estimating HAB events and their incremental change (as well as an economic value of that change) would require knowledge of the interaction between nutrient loading from the Everglades and red tide incidence and intensity.

If runoff saturated with nutrients exacerbates the intensity of South Florida algal blooms, then a reduction in nutrient concentrations following Everglades restoration would likely reduce algal bloom intensity and frequency. However, none of the experts with whom we spoke had attempted to quantify this potential impact. They were also unwilling to speculate on the magnitude of algal bloom reduction given the myriad variables – in addition to nutrient loading – which influence algae growth. A potential reduction in algal blooms would have significant economic impact. For example, Habas, et al., (1974, 1975) report a three- to five-month bloom caused $15-$20 million in losses.

Also unknown is the relation between harmful algal blooms intensity and fish kills. Algae deplete oxygen and grow from organic matter. Thus, nutrient runoff that increases organic matter would likely increase the intensity of the algal blooms and decrease oxygen concentrations, thereby killing fish and shellfish. Algae will also feed off the dead fish and continue to bloom, potentially creating a positive feedback loop as described by Abbott, et al., (2009) and Steidinger, et al., (1999).

Here again, the experts with whom we spoke agreed that reducing nutrient concentrations would reduce harmful algal blooms and, therefore, the occurrence and severity of fish kills, but they were unwilling to speculate on the likely magnitude of the fish kill reduction. Though the economic impact of discrete fish kills and harmful algal blooms has been measured in the past, as discussed by Abbott, et al., (2009); Steidinger, et al., (1999); Hoagland, et al., (2002); and Morgan, et al., (2009), modeling the impact of Everglades restoration on fish kills and algal blooms throughout the South Florida coastline has not yet been done.

In addition to environmental impacts, there are certain health effects that might be linked to reductions in nutrient pollution. The potential health impacts are discussed by Abbott, et al., (2009) and Steidinger, et al., (1999) and include, but are not limited to ingestion of tainted shellfish/fish and contact with polluted water. For example, Dwight, et al., (2005) estimate the economic impact of shellfish and fish poisoning at $33.35 per illness; Rabinovici, et al., (2004) employ a more expansive cost model and estimate the impact at $280 per illness; Hoagland, et al., (2002) also present a survey of cost estimates; and Sandra Whitehead at the Florida Department of Health confirms there is an economic cost of swimming in polluted waters, though she has not quantified that cost. A more technical discussion on algal blooms and health is presented by Fleming, et al.

Despite these cost estimates, predicting the marginal reduction in illness and illness costs attributable to Everglades restoration is fraught with scientific uncertainty. The precise reduction in pollution is unknown and none of the experts with whom we spoke has attempted to estimate the reduction in pollution, the resulting reduction in harmful algal blooms, or the reduction in human health impacts.

Beach Clean-Up Model

Despite these complexities, our team attempted to model avoided beach cleanup costs following Everglades restoration and, more specifically, various reductions in the nutrient concentrations of the Caloosahatchee and St. Lucie estuary discharges. Our literature review revealed that the most consistent metric for beach clean-up costs is "feet of beach cleaned per year" as indicated by Hoagland, et al., (2002). However, the best available data on harmful algal blooms in South Florida reported their impact in terms of beach closures and beach warnings (i.e., beach action days). As such, our team converted beach action days into linear feet of beach cleaned per year using county-specific data from the Florida Fish and Wildlife Conservation Commission (FWC) and the FWC's 1:4 ration of beach clean-up to beach closure/warning. We use the approach by Hoagland, et al., (2002) that assumes only about 1:4 of total beach miles is cleaned due to patchiness of red tide events. Next, we regressed estimated nutrient concentration reductions against beach action days and then we converted the marginal reduction in beach action days to the marginal reduction in linear feet beaches cleaned. The results of this modeling effort were not statistically significant, so we have excluded them from our final results table.

Public Health Model

We assembled data on shellfish poisoning as presented in Hoagland, et al., (2002), which reported all shellfish poisoning cases for several years in several states. We found total populations for those states and calculated the ratio of illness to population. We then applied this ratio to the counties in South Florida to find an estimated illness rate. We estimated an arbitrary reduction in pollution would decrease the number of these incidences and found the economic impact of these reductions. Our literature review shows studies of costs per poisoning, which we applied to our estimates.

The challenge of measuring health effects is that shellfish poisoning is largely underreported and when it is reported it may be misdiagnosed as poisoning from other sources. Deaths from shellfish poisoning are very few and so far unreported in Florida. Another challenge is, again, to measure what the relationship between poisoning incidence and pollution levels is. Not only is this difficult to measure, but the source of the poisoning and the pollution may not be clear. Following our conservative principle, this model was not used in the final report.

We did not attempt to measure sickness due to swimming in polluted bodies of water. Individual characteristics and time spent in the polluted body of water are variable. Assigning a dollar value of sickness as a result of pollution/nutrient levels proved impossible given our assessment of the current state of the science and the relevant available data.

Conclusions Regarding Water Quality Impacts

To summarize, we have so far been unable to find any record or study of the expected impacts of Everglades restoration on nutrient loading, harmful algal blooms, beach closures and clean-ups or human health impacts. We were also unable to find any scientist or study willing to predict those marginal impacts. Because the precise impact of Everglades restoration on nutrient loading is still unknown – and depends in large part on the choice and implementation of various restoration plans – our attempts to model the secondary and tertiary economic impacts failed to produce scientifically significant results.

Fire

There is speculation that the current Everglades is more fire prone because of reduced sheet flow:[100]

> The second change to the fire regime has been indirectly caused by human changes to the hydrologic regime. In some areas, water has been impounded, thus fire frequencies are decreased (Gunderson and Loftus 1993). But the larger management problem is where marshes have been drained either by stopping sheet flow or by increasing runoff in canal systems. Under these drainage scenarios, severe ground fires have become more common resulting in changes to plant communities (Gunderson and Loftus 1993, Robertson 1953, Snyder 1991). Wildfires under dry conditions in the 1990s have caused at least top-kill of all trees on many thousands of tree islands within the water conservation areas (Hoffman et al. 1994). Statements by several authors and policies by managing agencies dating as far back as the 1950s reflect concern over the perceived increase in frequency with which tree islands suffered severe fire due to changes in hydrology and fire ignition patterns (Robertson 1953, Taylor 1981). Marshes in urban interface areas often have shortened hydroperiods as waters are diverted for flood control. These same areas are often subject to increased fire ignition sources as accident or arson. Thus these areas often experience increased fire frequencies (Lockwood et al. 2003).[101]

The real issue is: How might one go about modeling the reduction of fire, and then, estimating the economic impact of fewer fires?[102] According to our principle of a conservative approach to estimating benefits, we have decided to not include any air quality or other impacts that a restored Everglades might have on fire duration, intensity, or frequency. With that said, we suspect that a restored Everglades might likely have fewer and less severe fires. And, we know that fire creates negative economic impacts. Fires in the Everglades, as they do elsewhere, cause air quality issues via smoke, plus they stand to destroy valuable property.[103]

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[100] For a clear and detailed discussion of fire in the Everglades, see http://www.forestencyclopedia.net/p/p270.

[101] http://www.forestencyclopedia.net/p/p270.

[102] See "Modeling the Effects of Hydrology on Fire, Vegetation Dynamics, and their Interaction in the Florida Everglades." USGS, (October 2004): http://pubs.usgs.gov/fs/2004/3110/ for a discussion of modeling fires in the Everglades.

[103] http://www.forestencyclopedia.net/p/p1769. see also http://www.env.gov.bc.ca/epd/bcairquality/topics/forest-fires-air-quality.html and http://www.nasa.gov/vision/earth/environment/central_am_fires.html.

Thus, reduced fires, if they were to be a result of Everglades restoration, would count as an additional benefit, but one we eschew economic evaluation of at this time.

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Chapter 8: Impact On Job Creation And Earnings

Restoration of the Everglades through the implementation of CERP will impact jobs in the State of Florida. Changes to the different ecosystem services in the Everglades will impact the number of jobs in a variety of industries and the economic activity that restoration will generate.

It is very important to understand that jobs are *not* an additional benefit above and beyond the present value calculations we have already presented. Instead, they are an alternative way of representing the overall change that is likely to be forthcoming from restoration. Economists often speak of a circular flow of economic activity where firms purchase inputs (land, labor, capital, and the like) from households in order to engage production. As compensation for the release of these inputs, households are paid income (sometimes broken into finer gradients called wages, interest, rents, and profit). Firms then sell the outputs made from the inputs to households in exchange for money. According to this logical truism, one may count the sales of the goods and services as one measure of the output of the firms, but one might also count the value of the inputs consumed. They have to be equal by the accounting identity. Jobs then are a loose or casual way of talking about the extent of economic activity. Most academic economists would prefer to discuss the sales of the output of the firms rather than the jobs used in production, but for some reason or another, policy makers, pundits, and politicians seem to prefer the jobs numbers approach. For sure, jobs are easier to calculate and perhaps easier for lay people to appreciate. Our point here is to respond to that latter audience, but it would be a *big* mistake for anyone to interpret our discussion here as additive. The jobs are *not* in addition to the calculated benefits. They are an alternative way of visualizing the impact of Everglades restoration. We urge the reader to be careful on this point.

While we do not expect an increase in water supply to have much, if any, direct and significant effect on new jobs, we do expect an improvement in water quality to directly affect jobs and earnings in commercial fishing, recreational fishing, and real estate (residential construction and real estate services). We also expect that habitat and open-space enhancements will have a direct impact on the number of tourists who visit Florida. An increase in tourism will positively affect jobs and earnings in hotels and lodging, eating and drinking establishments, transportation, retail trade, and entertainment. Conversely, we expect the repurposing of crop land (mostly sugar cane) for storm water storage and treatment facilities to have a direct and negative impact on the number of jobs and earnings in the agricultural sector. In sum, we predict Everglades restoration will have both positive and negative impacts on the number of jobs in the South Florida economy. We have designed our jobs model to account for both impact types and thus to report a net impact on jobs creation.

Our approach to estimating net job creation relies on an input/output model that uses data generated by the key components of this study (inputs) to estimate the number of incremental jobs and earnings as a result of CERP (outputs). We calculated outputs using jobs and earnings (or total economy) multipliers from different sources. Unless otherwise specified, we used total economic output multipliers to reflect the impact on the broader economy (direct, indirect, and induced jobs). In some cases, we used only direct multipliers to avoid overlap (double counting) among the different sectors.

As detailed below, our work shows that as a direct effect of Everglades restoration more than 442,000 new jobs over a 50-year period will be added to the State of Florida with the highest number coming in the residential construction and real estate services sector. Total contribution to the local economy will be in excess of $17 Billion. Repurposing of mostly sugar cane crop land for storm water storage and treatment facilities will result in the loss of 3,724 jobs and $471 Million in earnings.

Commercial Fishing

To determine the impact that an increase of commercial fishing due to a restored Everglades will have on jobs, we estimated the net present value (NPV) of the incremental dockside value ($ million) of saltwater and freshwater fish (including finfish, invertebrates, and shrimp) caught over a 50-year period and applied a commercial fishing jobs multiplier.

- Input: Net present value of the incremental dockside value of commercial fisheries (finfish, invertebrates and shrimp) caught in a restored Everglades.

- Multipliers: Fishing producer employment multiplier equal to 15,409 jobs/$ billion export value[104].

- Key Formulas:
  - Increase in employment (# jobs) = (NPV dockside value ($ million)/1000) * Producer employment multiplier (15,409 jobs/billion $ export value)
  - Increase in earnings & economic activity ($ million) = NPV dockside value ($ million) * economic output multiplier (1.710).

- Results:

Sector	Incremental Jobs (over 50 years)	Incremental Value ($ millions)
Commercial Fishing	6,798	$ 754

[104] 2008 ERS Trade Multipliers, Open Model (USDA Economic Research Service – Updated November 2009).

Recreational Fishing

To determine the impact of the increase of recreational fishing due to a restored Everglades on jobs, we estimated the incremental number of freshwater and saltwater anglers over a 40-year period and its inherent impact on "fishing-related expenditures." To the net present value of fishing related expenditures, we applied multipliers derived from Tony Fedler's[105] report to estimate impact on jobs and overall economy. Fedler's report focuses exclusively on Florida residents, but we have used its results to estimate ratios that could be used for a broader group of anglers.

- Input: Incremental saltwater and freshwater anglers and expenditures in the Everglades region. We used a modified (50 percent) tourist (visitor) yearly growth-rate to determine the increase in anglers to the region (using the 2 percent tourist growth scenario). The incremental number of anglers (over a growing base) due to a restored Everglades was multiplied by average yearly "fishing-only" expenditures (to avoid overlap with tourism—shopping) to calculate incremental expenditures. Fishing-only expenditures include:
    - Trip expenditure categories: guide fees; live and cut bait; ice; equipment rental; boat fuel; boat launch fees; boat mooring; maintenance and insurance.
    - Equipment expenditure categories: Rods and reels; lines and leaders; artificial flies; lures and baits; hooks, swivels and sinkers; tackle boxes; creels, stringers and nets; minnow traps, seines and containers; electronic devices; scales knives and miscellaneous equipment; boats, maintenance and tow vehicles.

  Fishing-related expenditures (trip and equipment) account for 66.21 percent of total angler expenditures in the Everglades region as calculated from Fedler's study. This rationale was applied to yearly total expenditures over a 50-year period. Expenditures that were not included as fishing-related expenditures include: food, drink and refreshments; lodging; airline transportation; other public transportation; private vehicle transportation; public access fees; private access fees; and heating and cooking fuels.

[105] The Economic Impact of Recreational Fishing in the Everglades Region; Prepared by Tony Fedler Ph.D. for the Bonefish and Tarpon Trust; December 2009.

- Multipliers: Employment (jobs per $ million) and earnings (not total economy to avoid overlap with tourism) from Tony Fedler's report: "The Economic Impact of Recreational Fishing in the Everglades Region."

- Key Formulas:
    - Increase in fishing-related jobs (# jobs) = NPV Incremental Freshwater and Saltwater Angler expenditures in the Everglades Region ($ millions) * Employment multiplier (17.14 jobs per $ million) * 66.21%
    - Increase in earnings ($ million) = NPV Incremental Freshwater and Saltwater Angler expenditures in the Everglades Region ($ millions) * Earnings multiplier (0.524)
    - NPV Incremental Freshwater and Saltwater Angler Expenditures in the Everglades Regions ($ millions) = NPV ($\sum_1^{40}$) (#anglers 2% change scenario * fishing expenditures - #anglers no change scenario * fishing expenditures))
    - # anglers no change and 2% change scenarios = 50% growth rates of no change and 2% change scenarios in incremental tourism to the Everglades region

- Results:

Sector	Incremental Jobs (over 50 years)	Incremental Value ($ millions)
Recreational Fishing	36,868	$ 1,668

Residential Construction & Real Estate Services

Everglades restoration will have a direct impact on real estate activity – both construction and real estate services. As demand for real estate increases, so will direct and indirect jobs tied to the sector. Three types of impacts are estimated for non-residential construction and real estate related transactions: direct effects, indirect effects, and induced effects. Direct effects are the changes in the industries to which a final demand change was made. Indirect effects are the changes made in inter-industry purchases as they respond to the new demands of the directly affected industries. Induced effects typically reflect changes in spending from households as income increases or decreases due to the changes in production.

- Input: Incremental value (from the "Potential Value Increase based on 23 percent Improvement in Water Quality" scenario) and subsequent activity in residential construction and real estate services. Elasticity between "increase in real estate value" and "increase in construction activity" was set at 0.55.

- Multipliers: Residential construction and real estate multipliers (Direct + Indirect + Induced) were calculated from existing jobs and earnings data.[106]

Figure 8.1. Residential Construction & Real Estate Services Multiplier Calculations

		Earnings			Earnings Multiplier			
	New in 2005	Direct	Indirect	Induced	Direct	Indirect	Induced	Total
Residential construction ***	$36,940,456,476	$ 12,153,937,000	$ 5,827,958,000	$ 4,315,513,000	0.329	0.158	0.117	0.604
Demand for real estate transactions ***	$ 6,352,883,351	$ 46,062,000	$ 39,182,000	$ 23,749,000	0.007	0.006	0.004	0.017

		Jobs			Employment Multiplier (jobs per $ 1million)			
	New in 2005	Direct	Indirect	Induced	Direct	Indirect	Induced	Total
Residential construction ***	$36,940,456,476	336,216	189,744	165,529	9.102	5.136	4.481	18.719
Demand for real estate transactions ***	$ 6,352,883,351	45,725	20,423	11,138	7.198	3.215	1.753	12.165

*** Shimberg Center for Affordable Housing; THE IMPACT OF RESIDENTIAL REAL ESTATE ON THE FLORIDA ECONOMY; 2005 update (Using Roll Year 2004 Property Appraiser Data)

[106] Shimberg Center for Affordable Housing; THE IMPACT OF RESIDENTIAL REAL ESTATE ON THE FLORIDA ECONOMY; 2005 update (Using Roll Year 2004 Property Appraiser Data).

- Key Formulas:
  - Increase in residential construction and residential real estate employment (# jobs) = Potential Value Increase based on 23% Improvement in Water Quality ($ millions) * 0.6 * (Total construction employment multiplier + Total real estate services employment multiplier)
  - Increase in residential construction and residential real estate economic activity $ million) = Potential Value Increase based on 23% Improvement in Water Quality ($ millions) * 0.6 * (Total construction earnings multiplier + Total real estate services earnings multiplier)

- Results:

Sector	Incremental Jobs (over 40 years)	Incremental Value ($ millions)
Residential Construction & Real Estate Services	273,601	$ 7,319

Tourism

A restored Everglades will generate increased tourism activity in the region. Increased tourism will positively impact direct and indirect job creation. To determine the impact of tourism on jobs and earnings we looked at its impact on five directly and indirectly related sectors in all 16 counties.

- Input: Incremental visitors and expenditures in local tourism by specific NAIC[107] sector for all 16 counties:
    - Hotel and lodging (NAICS code 7211)
    - Eating and drinking establishments (NAICS codes 7221, 7222, 7224)
    - Transportation (NAICS codes 485113 , 485119 Other Urban Transit Systems; 485210, 485310 , 487110, 487210)
    - Retail trade (NAICS codes 45211, 4451, 4452, 4453, 4461, 4481, 4482, 4512)
    - Entertainment (NAICS code 71).

- Multipliers: We used total effects multipliers from the REMI II model[108]. We utilized Large Metro, Small Metro, and Rural multipliers depending on the specific county. Figure 8.2. portrays our county classification for the purpose of assigning multipliers.

Figure 8.2. County Classification for Tourism Specific Multipliers

County	Select County Type
Broward	Larger Metro
Charlotte	Rural
Collier	Smaler Metro
Glades	Rural
Hendry	Rural
Highlands	Rural
Lee	Smaler Metro
Martin	Rural
Miami-Dade	Larger Metro
Monroe	Smaler Metro
Okeechobee	Rural
Orange	Larger Metro
Osceola	Rural
Palm Beach	Smaler Metro
Polk	Rural
Saint Lucie	Rural

[107] QWI ONLINE LOCAL EMPLOYMENT DYNAMICS; US Census Bureau.
[108] MGM2 MODEL, the University of Michigan.

Figure 8.3. Tourism Multipliers

Sector	Total effects multipliers (Jobs/ MM sales) *				Total Effect
	Rural	Smaler Metro	Larger Metro	State	
Hotels And Lodging Places	35.24	33.04	30.26	27.41	1.52
Eating & Drinking	40.41	38.80	37.86	35.05	1.44
Amusement And Recreation	38.85	40.61	39.08	35.47	1.45
Local transportation	42.94	37.71	35.52	32.98	1.43
Apparel from purch mate	19.50	19.70	20.21	19.72	1.36
Sporting goods	12.50	18.48	17.70	17.11	1.42
Manufacturing	16.11	15.83	17.22	17.02	1.33
Retail Trade	44.67	37.00	34.42	31.54	1.38
Wholesale trade	18.84	18.93	18.08	16.40	1.38

Retail is average or sum of the 7 retail trade sectors

* Money Generation Model Version 2 (MGM2); University of Michigan

- Key Formulas:
  - Increase in employment (# jobs) = increase in lodging spend * Hotels and lodging multiplier + increase in eating & drinking spend * eating & drinking multiplier + increase in transportation spend * local transportation multiplier + increase in retail trade spend * retail trade multiplier + increase in entertainment spend * amusement and entertainment multiplier
  - Increase in income ($ millions) = increase in lodging spend * Hotels and lodging total effect multiplier + increase in eating & drinking spend * eating & drinking total effect multiplier + increase in transportation spend * local transportation total effect multiplier + increase in retail trade spend * retail trade total effect multiplier + increase in entertainment spend * amusement and entertainment total effect multiplier

- Results:

Sector	Incremental Jobs (over 50 years)	Incremental Value ($ millions)
Tourism (Lodging, Eating & Drinking, Transportation, Retail, Entertainment)	48,552	$ 1,905

Agriculture

In order to retain wet-season water flows in the northern watershed instead of diverting it to sea and the Everglades, the CERP contemplates the purchase of land in the Everglades Agricultural Area (EAA) to develop storm water storage and treatment facilities. These measures to improve water retention south of Lake Okeechobee will have a negative impact on agricultural activity in the region. Some of the counties impacted by potential loss of sugar cane land are in the process of evaluating ways to diversify their agriculturally dependent economies.[109]

To determine the economic impact of expanding water storage and treatment facilities in the EAA, we use a dynamic simulation model of crop production, soil loss, and water retention developed by Marcel Aillery, et al.,[110] which addresses the potential cost of forgone agricultural profit. The model estimates the NPV of lost crop production over a 15-year period under various land acquisition scenarios (for conversion into water storage and treatment areas. (Table 8.1. summarizes income loss under different land acquisition scenarios.)

Figure 8.4. EAA Water Retention Scenarios – Agricultural Income Loss

[109] The Collins Center for Public Policy has information on this adjustment. See http://www.collinscenter.org/.

[110] Aillery, Marcel, Shoemaker, Robbin, and Caswel, Margriet. "AGRICULTURE AND ECOSYSTEM RESTORATION IN SOUTH FLORIDA: ASSESSING TRADE-OFFS FROM WATER-RETENTION DEVELOPMENT IN THE EVERGLADES AGRICULTURAL AREA."

Scenario	Land Acquisition Scenarios (Acres)	Total Acres	PV Income Loss ($ millions) -- 15 Years
1	STA (43,500)	43,500	$ 13.70
2	STA+RS(25,000)	68,500	$ 15.80
3	STA+RS(40,000)	83,500	$ 50.00
4	STA+RS(50,000)	93,500	$ 65.90
5	STA+RS(50,000)+FR(10,000)	103,500	$ 81.40
6	STA+RS(75,000)	118,500	$ 104.10
7	STA+RS(75,000)+FR(25,000)	143,500	$ 141.30
8	STA+RS(75,000)+FR(50,000)	168,500	$ 180.20
9	STA+RS(75,000)+FR(75,000)	193,500	$ 225.30

STA -- stormwater treatment area FR -- Floodwater retention area

RS -- Reservoir storage area

*Agriculture and Ecosystem Restoration in South Florida: Assessing Trade-Offs From Water-Retention Development In The Everglades Agricultural Area; Marcel Aillery, Robbin Shoemaker, and Margriet Caswell

- Input: It is estimated that under the CERP proposal, 60,000 acres of productive agricultural land will be repurposed for storm water storage and treatment facilities. To err on the conservative side, we used a scenario in which 83,500 acres of productive agricultural land would be repurposed (43,500 acres for storm water treatment area and 40,000 acres for reservoir storage area).

  The water-retention model estimates economic loss due to loss of sugar cane agricultural acreage. Sugar cane crops are estimated at 88% of total EEA crop production. Output results from our model are adjusted to account for all types of crops.

- Multipliers: We used the USDA Economic Research Service "Sugar Cane and Sugar Beets" producer employment multiplier[111] (22,173 jobs/billion $ export value). To determine the impact on earnings we projected five-year historic weighted average yearly wages for NAICS code 111[112] and multiplied by the number of incremental jobs. We utilized a multiplier of 5 for total economic impact.

- Key Formulas:
  - Decrease in employment (# jobs) = NPV of Sugar Cane Agricultural Activity Loss ($129 million over 50 years) in 83,500-acre scenario) * Producer

[111] 2008 ERS Trade Multipliers, Open Model (USDA Economic Research Service – Updated November 2009).

[112] QWI ONLINE LOCAL EMPLOYMENT DYNAMICS; US Census Bureau.

employment multiplier (22,173 jobs/billion $ export value) * 1.136 (adjust for total crops)

- Decrease in Earnings ($ million) = 5 * Decrease in employment (# jobs) * Weighted average of five-year historical yearly wages
- We converted Water Retention model 15-year NPV results to a 50-year baseline

- Results:

Sector	Incremental Jobs (over 50 years)	Incremental Value ($ millions)
Agriculture	(3,724)	$ (471)

Wildlife Habitat and Hunting

Variations in Wildlife Habitat and Hunting activity due to Everglades restoration will have a direct effect on jobs and economic activity. Since overall hunting activity will decrease, its impact on jobs will be negative. However, the net effect of Wildlife Habitat and Hunting on jobs is positive and very significant.

- Input: Incremental expenditure in direct goods and equipment for Wildlife Habitat and Hunting. This excludes transportation, lodging, food (except bird food and feeders), etc.

- Multipliers: We used total effects multipliers from the REMI II model[113]. We utilized the multipliers for sporting goods since we are mostly measuring the impact on direct equipment shopping. Multipliers were adjusted as needed.

- Key Formulas:
  - Increase in employment (# jobs) = NPV of Hunting Expenditures over 50 years * Sporting Goods Jobs Multiplier + NPV of Wildlife Habitat Expenditures over 50 years * Sporting Goods Jobs Multiplier (adjusted)
  - Increase in Economic Activity ($ millions) = NPV of Hunting Expenditures over 50 years * Sporting Goods Economic Activity Multiplier + NPV of Wildlife Habitat Expenditures over 50 years * Sporting Goods Economic Activity Multiplier (adjusted)

- Results:

Sector	Incremental Jobs	Incremental Value ($ millions)
Wildlife Habitat & Hunting	80,569	$ 6,664

[113]MGM2 MODEL, the University of Michigan.

Figure 8.5. Summary of Jobs Impact Drivers and Approach

Ecosystem Service	Industries	Value Drivers	Incremental Jobs Approach
Water Supply	Not relevant		
Water Quality	Commercial fishing	Lbs & value of fish caught (finfish, invertebrates & shrimp)	Apply fishing jobs multiplier (USDA Economic Research Service) to incremental dockside value projections. Use 2008 annual wage average to estimate yearly earnings increase (projecting at inflation rate). Calculate NPV of earnings at 2.1% discount rate
	Recreational fishing	Saltwater & freshwater angler expenditure in the region	Estimates year-over-year growth in number of anglers in the region and determines annual expenditure in “fishing related” goods and services (to avoid overlap with “Tourism”). Applies jobs and earnings multipliers from Fedler’s study
	Real estate	Residential construction & real estate services activity	Apply direct, indirect and induced jobs and earnings multiplier for residential construction and real estate services. Uses the "Potential Value Increase based on 23% Improvement in Water Quality" as an input. Elasticity between "increase in real estate value" and "increase in construction activity" is set at 0.55
Habitat & Open Space	Tourism	Hotel & lodging expenditure	Apply direct + indirect jobs multiplier to projected incremental spend per sector (i.e., lodging, eating & drinking, transportation, shopping, entertainment). Multiply jobs by average (2011) yearly wages to determine total earnings
		Eating & Drinking expenditure	
		Transportation expenditure	
		Shopping expenditure	
		Entertainment expenditure	
Other	Agriculture	Agricultural acreage repurposed for storm water storage & treatment	Use the Aillery, Shoemaker & Caswell water-retention model to estimate the NPV of lost sugar cane income (88% of crops in EAA) under proposed land acquisition program. Use USDA sugar cane multiplier to estimate the number of lost jobs. Use average 2008 annual wage as base to estimate lost job earnings. The model also uses an 1.136 multiplier to adjust for other kinds of crops (other than sugar cane) and possibility of purchasing further croplands for stormwater storage
	Hunting	Baseline jobs not available due to low number of current jobs with	

		unemployment

Figure 8.6. Summary of Jobs Impact Results

Sector	Incremental Jobs	Incremental Value ($ millions)
Commercial Fishing	6,798	$ 754
Recreational Fishing	36,868	$ 1,668
Residential Construction & Real Estate Services	273,601	$ 7,319
Tourism (Lodging, Eating & Drinking, Transportation, Retail, Entertainment)	48,552	$ 1,905
Agriculture	(3,724)	$ (471)
Wildlife Habitat & Hunting	80,569	$ 6,664
TOTAL	**442,664**	**$ 17,840**

Direct Jobs Created as a Result of Restoration Construction

In addition to the jobs created by the impacts restoration, there will be jobs created to do the actual work of restoration. The Corps of Engineers estimates that there will be approximately 22,000 jobs created in the construction projects detailed below in Table 8.7 as reported in Kopecky (2010). Table 8.7 is reproduced, unaltered, from that report.

Table 8.7. Direct Job Creation as a Result of Construction, COE Estimates[114]

Appropriation requests were run through IMPLAN (Minnesota IMPLAN Group) software. This is an input-output analysis that attempts to project employment, output and earnings for a given change or event in the economy's activity. This model is typically set up to run at regional levels, but contains a National function as well and this is what was analyzed. There are three types of effects

- **Direct effects** take place only for the industry immediately affected:

[114] See Kopecky (2010) which is reproduced here exactly.

- **Indirect effects** concern inter-industry affects
- **Induced effects** measure the effects of the changes in household income. These changes effect the related industries employment.

The category of construction used was Sector 36 (Construction of other new non-residential). This is the closest to our construction technique.

South Florida Water Management District
Job Creation in Everglades Restoration
AS RUN BY COE USING IMPLAN
February 1, 2009

Project	Appropriation Request	Direct	Indirect	Induced	Total
Herbert Hoover Dike Rehabilitation **(3)**	$77,000,000	645	382	510	**1538**
C-44 Reservoir and STA	$363,000,000	3042	1801	2406	**7249**
C-43 Reservoir **(1)**	$473,000,000	3963	2347	3135	**9446**
Kissimmee River **(3)**	$31,000,000	260	154	205	**619**
Picayune Strand /FAKA Union Pump Station Works and Road Removal	$57,000,000	478	283	378	**1138**
Picayune Strand /Merritt Canal Pump Station Works and Road Removal **(3)**	$52,000,000	436	258	345	**1038**
C-111 Spreader Canal	$35,000,000	293	174	232	**699**
C-51/STA1E	$8,000,000	67	40	53	**160**
L31 North Seepage Pilot Project **(3)**	$5,000,000	42	25	33	**100**
Seminole/Big Cypress **(3)**	$3,000,000	25	15	20	**60**
TOTALS(SFWMD PROVIDED)	**$1,150,000,000**	**9636**	**5707**	**7623**	**22966**

Chapter 9: Last Words

Diamonds and Water

Economic theory has an ageless conundrum called the diamond-water paradox. This conundrum ponders why diamonds, which are so unnecessary to life, are so valuable while water, so necessary, is so cheap. The paradox is resolved by noting that the prices of diamonds and water are *marginal* valuations to society of an additional unit of each, *not the total or average value*. The implication of this line of reasoning is profound. For instance, professional football players earn a much higher salary than do high school teachers, yet it is almost surely true that the value of high school teachers to the world exceeds the total value of football players. Marginal values do not reveal total values, as every economist is taught.

So it is with ecosystem services (or any other product for that matter). Accordingly, if we were to capture the *total* value of Everglades restoration, we would have to engage a more complicated and detailed process. Suffice to say here, our estimates are not total estimates.[115] They only capture a portion of the total value of restoration. There is considerable consumer surplus, to use economic jargon, that is not captured by our methodology. Thus, our approach understates the total value to society of spending resources to restore the Everglades. Indeed, based on other studies, our gut feeling is that the true total benefits are several times larger than our marginal valuation estimates.

Consider Figure 9.1. Our calculations that we report here effectively estimate the shaded area labeled E. There is potentially a much larger area, labeled CS, that represents economic well-being, or willingness to pay, which buyers or consumers of services obtain without paying for them. We call this consumer surplus. It is the unrequited or unpaid-for happiness that a consumer gets from a purchase, *above and beyond the purchase price.* We have not attempted to estimate this component of economic system services, but as the graph suggests, the area of CS can be substantially larger than the area of E, depending upon the price elasticity of demand for the particular service. As our work progresses, we will attempt to assay and estimate these valuations. They are important to any properly conceived analysis of economic well-being or welfare.

[115] For more discussion on this point, consult http://www.ecosystemvaluation.org/market_price.htm.

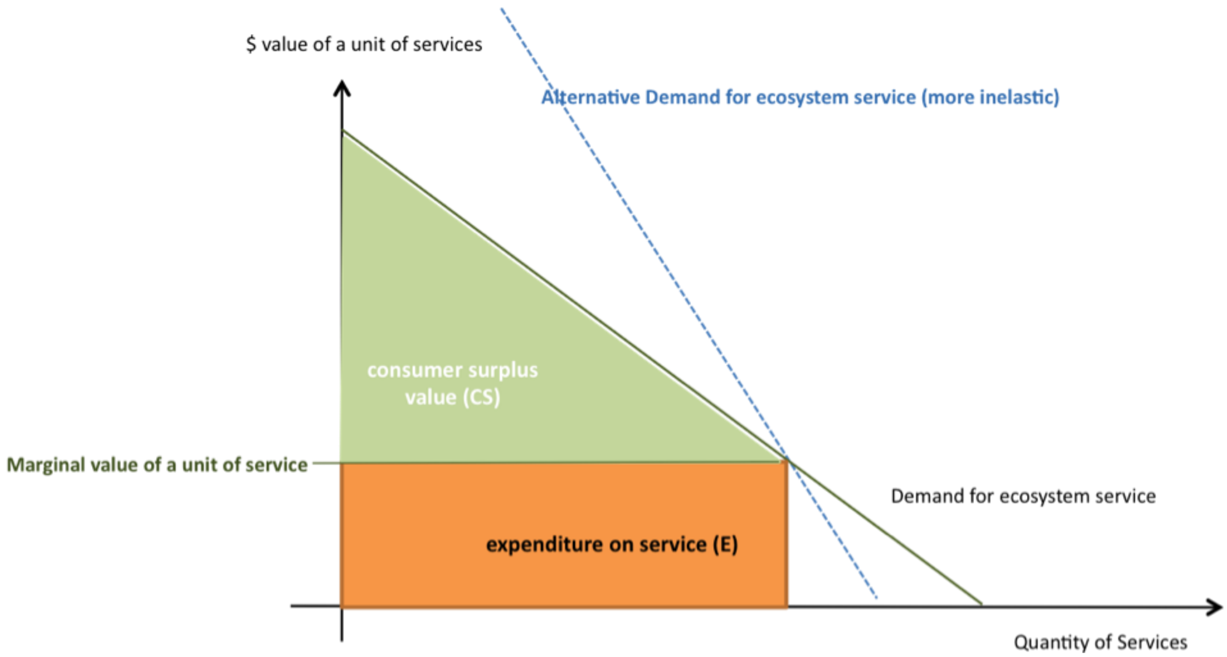

Figure 9.1 Consumer Surplus (triangles) and Expenditures (rectangles)

Regarding the effect of Everglades restoration on jobs, from the point of view of economic well-being or welfare, the important consideration is not total jobs, but incremental welfare above and beyond the opportunity cost of time or leisure. In a way similar to consumer surplus, most workers are paid wages higher than the underlying value of their time. This is called economic rent or producer. This is measured by the triangle above the supply curve of labor. Therefore, while many people view jobs as an economic good, the real increase in welfare comes not from employment, but from wages higher than the lost alternatives of leisure or home production. We have not estimated these additional benefits in our analysis, but suffice to say that, like the uncounted consumer surplus we mention, it stands to be important and non trivial. Our omission of this additional welfare makes our estimate of return on investment even more conservative.

Why don't we attempt to measure the total change in economic welfare, the area of E plus the area of CS? There are two good reasons here. First, the time and research costs are substantial. In order to properly estimate the total economic welfare, we would have to determine not only the prices at which consumers bought ecosystem services, but also their willingness to pay over a large range of quantities. In many if not most cases, there are no data available to perform this calculation. Where it has been done, the estimates suggest that the area of consumer surplus can be large compared to the area of expenditure. For instance, Bin et al. estimate that the consumer surplus of a day at the North Carolina beach is $11-80 for day visitors and $11-$41 for overnight visitors. Since there is no charge for visiting the beach, the ratio of consumer surplus to expenditure cannot be calculated.[116][117] Brynjolfsson, Hu and Smith say that:

> Our analysis indicates that the increased product variety of online bookstores enhanced consumer welfare by $731 million to $1.03 billion in the year 2000, which is between 7 and 10 times as large as the consumer welfare gain from increased competition and lower prices in this market. There may also be large welfare gains in other SKU-intensive consumer goods such as music, movies, consumer electronics, and computer software and hardware.[118]

What is our point here? It is actually quite simple. We have underestimated the consumer welfare increase associated with Everglades restoration. We are not sure by how much, but leaving aside all of our earlier conservative assumptions, not counting the consumer surplus associated with restoration stands to be substantial. So for those who might wonder about the underestimated costs of restoration in the CERP plan, or the ambiguity of some of the estimated benefits, rest assured that there are potentially large and significant benefits to consumers of restoration that are not being counted, and we have explained why.

Outrunning the Bear

At the outset of this evaluation, we promised to execute our assignment according to best practices and methods of economic science. We believe we have lived up to this promise, and we invite all readers to evaluate our success. It bears noting that one of the time-honored tenets of economic methodology, owed to Nobel Laureate Milton Friedman (and many others) is the concept that it takes a theory to beat a theory. In this spirit, while readers may criticize or

[116] Bin, Okmyung, Landry, Craig E., Ellis, Christopher L.,Vogelsong, Hans. "Some Consumer Surplus Estimates for North Carolina Beaches." *Marine Resource Economics*, Volume 20 (2005): 145–161.

[117] See also Bapna, Ravi, Janks, Wolfgang, Shmueli, Galit. "Consumer Surplus in Online Auctions." *Information Surplus in Online Auctions*, 19(4), (December 2008): 400-16.

[118] Brynjolfsson, Erik, Hu, Jeffrey, Smith, Michael. "Consumer Surplus in the Digital Economy: Estimating the Value of Increased Product Variety at Online Booksellers." paper 176, Center for eBusiness @MIT, (November 2003): 1.

disagree with our assumptions and techniques here, any such complaints will fall on deaf ears unless a superior alternative is proposed. Put bluntly, we will not accept criticism that simply says, "Your assumptions are wrong." Let the critic propose adequate or superior alternatives. What this means in practical terms is that our work need not be perfect in order to be useful and acceptable. It just needs to be better than the rest. This does *not* mean that we believe we have done our job as well as it can be done. Rather, it is meant to convey that our minds are open to suggestions of better ways to do this project but not to simple statements that our work is wrong or incorrect. The Olympic Gold Medalist need not set a world record to climb to the top of the podium at the medal ceremony. She only need outrun the woman in second place. Of course, we hope that each piece of our work "sets a world record," but we will sleep soundly if our work is better than any other work tendered or suggested.

Chapter 10: Acknowledgements

We are grateful to a large number of people for their help on this project. First of all, the team at the Everglades Foundation, including members of the Board, were especially valuable (natural) resources and always available to us with advice, helpful criticism, and comments. We are also grateful to them for affording us the opportunity to work on this project. We appreciate the time and energy that so many people at various agencies, local, state, and federal took to answer our questions, render helpful suggestions, and point us in the right direction, including the U.S. Army Corps of Engineers, Jacksonville Office; Everglades National Park; the South Florida Water Management District; Florida Forever; Florida Earth Foundation; National Wildlife Foundation; Ducks Unlimited and a host of others.

Additionally, we appreciate the remarks, comments, and suggestions received in a number of workshops on our work, including individuals at the Army Corps of Engineers, Institute for Water Resources, Washington, D.C.; the Property Environment Research Center in Bozeman, MT.; and particularly the comments of many at the Everglades Summit in Washington, D.C., May, 2010. Kathryn S. Watson provided insightful remarks and opinions that helped move this project successfully. Of course, we alone are responsible for all errors remaining in this work.

Chapter 11: Mather Economics Everglades Valuation Team Biographies

Bobby McCormick, Ph.D., Principal Investigator

Professor Bobby McCormick attended Clemson University with a two-year interruption for military service as 1LT in the U.S. Army, graduating with a B.A. in Economics in 1972 and M.A. in1974. Bobby earned the Ph.D. in Economics from Texas A&M University in 1978. He served as Assistant Professor of Business Administration at the Graduate School of Business at the U. of Rochester and, beginning in 1982, was Associate and then Professor of Economics at Clemson. In 2000 he was named BB&T Scholar and Director of the BB&T Center for Economic Education at Clemson.

Bobby has won several Clemson University teaching awards: The Prince Innovative Teacher of the Year (1998), the Alumni Professor of the Year (2000), the MBA Professor of the Year (several occasions), and the National Scholars Mentor Award (2004 and 2006).

In 2001, Bobby was the Julian Simon Research Fellow at the Property Environmental Research Center (PERC) in Bozeman, Montana. The following year, he was recognized as Senior Fellow at PERC, a position he still holds today. From 2002-2005, he was the Director of the Kinship Conservation Institute housed in Bozeman, MT. Starting in 2006 to the present, Bobby has been the Director of TEAM, a training program for environmental scientists and policy makers at PERC.

Bobby has served as an associate editor of the academic journals, *Journal of Corporate Finance* and the *Southern Economic Journal* and is a frequent reviewer of manuscripts for publication in a wide array of other academic journals. He consults on corporate financial affairs, litigation matters, and a wide range of economics-related matters. His scholarly research and extensive publications cover a broad spectrum of microeconomics, including the areas of antitrust, public choice, regulation, sports and economics, managerial and financial economics, environmental economics, and general microeconomic theory.

Robert Clement, MA

Robert Clement is a consultant to a variety of businesses. Robert provides consulting in the areas of business strategy, business operations, project management, and antitrust economics. In addition, Robert has lectured at the PERC Enviropreneur Institute, Clemson University, Consortium of Universities for International Studies in Asolo, Italy, and the University of Notre Dame.

Robert had a 15-year career at Accenture, one of the world's largest technology consulting companies, from which he retired as a Partner in 2004. Robert's work at Accenture included consulting with several of the world's largest telecommunications companies. Robert has also participated in a number of conferences on free market environmentalism at PERC and the Liberty Fund.

Robert serves on the boards of PERC and The Reserve at Lake Keowee Foundation. Robert holds a BS in Economics and MA in Economics, both from Clemson University.

Daniel Fischer, MBA
Daniel Fischer is an executive and entrepreneur with over 20 years of international experience in business strategy and strategic marketing in best-in-class companies and a variety of industries.

Daniel has been a management consultant with several top-tier consulting companies including A.T. Kearney, Arthur D. Little and Zyman Group where he led and performed in-depth business strategy, branding and marketing spend effectiveness work for best-in-class clients including: Vodafone, EDS, Bellsouth, Dell, Alcoa Chick-fil-A, Clorox, InterContinental Hotels, Merck, Safeco and Colgate Palmolive.

In addition to being a consultant, Daniel was a senior executive at TLC Vision – a company that owns and operates over 80 Lasik eye surgery centers in the US -- where he built and managed the Strategic Marketing & Analytics department.

Daniel also spent five years as an entrepreneur when he founded, managed and ran marketing and business development functions at Comerxia -- a company that provides US online retailers with a platform (i.e., technology, logistics and marketing) for international cross-border ecommerce. The company's largest single shareholder is UPS, and it was featured in TIME magazine as the leading solution for international ecommerce.

Daniel graduated from The Wharton School's Executive Education Program, holds an MBA from IESA and a BSEE from Simon Bolivar University and the University of Tel Aviv.

Matt Lindsay, Ph.D.
Matt Lindsay is the Managing Partner of Mather Economics LLC, an economics consultancy based in Atlanta, Georgia. He has worked as an applied economist for eighteen years specializing in pricing strategy, forecasting, market analysis, and financial modeling.

Prior to founding Mather Economics, Matt worked for Arthur Andersen Business Consulting and United Parcel Service. Matt received a Ph.D. in Economics from the University of Georgia, an MA in applied Economics from Clemson University, and a BBA in Economics from the University of Georgia. Matt speaks frequently on the topics of applied economics at conferences, and he has published white papers on applied economics with a focus on using this type of analytical framework to increase profits, lower costs, or grow revenues within multiple industry contexts. Matt's work has led to millions of dollars of increased profits for his clients.

Reed Watson, JD MA

Reed Watson is the Director of Applied Programs and a Research Fellow at the Property and Environment Research Center in Bozeman, Montana. Reed is primarily interested in entrepreneurial environmental stewardship and the ability of markets to improve environmental quality. He conducts research and coordinates workshops on water markets, payments for ecosystem services and environmental contracting. He also directs PERC's state-wide educational campaign on the link between private resource ownership and environmental stewardship.

In addition to his role at PERC, Reed advises state and local governments, non-profits, and private landowners on environmental resource contracting. This consulting practice specializes in asset specification and measurement, payment structures, and resource valuation.

Reed holds a J.D. and M.A. in Environmental Economics from Duke University and a B.S. in Economics from Clemson University.

Danielle Alderman

As an analyst at Mather Economics, Danielle is proficient in econometric modeling and STATA programming. Danielle earned her bachelor's degree from Mercer University in International Finance and Economics. She also attended Hong Kong Baptist University in Hong Kong, China, where she completed a Chinese Language and Business Cultural Studies program, and also studied in London, England where she completed an International Studies in Corporation and Business Environment program.

Kristina Catani

Kristina Catani was born and raised in Washington Township, New Jersey. She attended Clemson University in 2005 as a Clemson National Scholar and obtained her B.S. in Economics in 2009. At Clemson, she spent much of her time in Death Valley at Tiger football games and served five years in various roles on Clemson's student government. Her college summers were spent studying abroad in England, Iceland, Ireland, and the Czech Republic. Kristina also spent a summer as an intern at The Property and Environment Research Center in Bozeman, Montana, where she immediately fell in love with the mountains and the West. She is currently pursuing an M.A. in Economics from Clemson and working as a Teach for America corps member in Denver, Colorado.

Joanna Fister

Joanna joined Mather Economics in 2008. She graduated with a B.A. in Economics from the University of Georgia. While at Mather Economics, Joanna has created survival analysis that demonstrates a customer's profitability and helped to develop strategy to retain more customers for her clients. She has worked with over 50 newspaper clients in optimizing their renewal pricing strategy for new and existing customers. She has also helped to develop revenue models that project fiscal year revenue which clients use as a budgetary tool.

Prior to working at Mather Economics, Joanna worked at Culpepper and Associates as a Research Analyst for two years. While at Culpepper and Associates, Joanna assisted in processing worldwide salary surveys that provided market data on compensation and employee benefits. Additionally, Joanna has interned for Athens-Clarke county Human and Economic Development Department, where she assisted in creating a housing trust fund plan.

Gabi Huber, Ph.D.

Gabi received his BSc in Economics from the University of Cluj in Romania and the Ph.D. in Applied Economics from Clemson University, with concentrations in industrial organization and labor economics. He worked in, then managed the Economic Analysis Group at the UPS headquarters in Atlanta, where he modeled costs and outputs in the UPS network. Gabi specializes in applied microeconometrics using Stata.

Exley McCormick

Exley holds the B.S. in Biomaterials Engineering and B.A. in Economics from Clemson University. He has extensive laboratory work while in undergraduate school. He has worked as guide and ranch hand in South Africa and Montana. Exley is currently Research Assistant at the Property Environmental Research Center in Bozeman, MT. He is past state cross-country champion while in high school and an avid kayaker. He is a proficient computer programmer and analyst in economics and engineering data.

Arvid Tchivzhel
An Analyst with Mather Economics LLC, Arvid has developed numerous econometric and financial models that have been applied to a variety of industries. Major projects include: predicting ticket sales in state and international lotteries, optimizing newspaper pricing and circulation, analyzing revenue channels for international hotels, and valuing ecosystem services.

In addition to work with the Everglades Foundation, Arvid has conducted independent research within the field of environmental economics. An econometric approach successfully measured sensitivity of automobile sales to changes in fuel prices and informed a pragmatic discussion of viable future options in alternative energy. Also completed was a cost-benefit study of converting all university vehicles to alternative fuels, which was submitted for review to the Furman Sustainability Planning Council.

Prior to Mather Economics, Arvid worked with various companies in the financial services industry, including Waterfield Mortgage and Morgan Stanley. Arvid was born in Petrozavodsk, Russia, and immigrated to the United States with his family at a young age. He graduated from Furman University in Greenville, South Carolina, with degrees in Economics and Spanish.

Emily Wood, MA
Emily is a freelance copyeditor based in Clemson, South Carolina. She is certified in Proofreading Skills by the Business Writing Center and holds a B.A. and an M.A. in English Literature, both from Clemson University.

About Mather Economics
Mather Economics is an economics consultancy based in Atlanta, Georgia. Mather Economics was founded in 2002, and we work with our clients to improve their performance through applied economic analysis. We have worked extensively as economic consultants in multiple industries and to complete economic valuations of ecosystem services. In addition to our consulting engagements, we work with over 70 clients on a recurring basis to assist them with applied analytics and performance reporting. We have particular expertise at helping companies that have customers on a subscription or contractual relationship maximize profitability. In this work, our analytics focuses on balancing customer acquisition and retention with revenue so that each customer's lifetime value to the company is maximized. Mather Economics utilizes

econometric modeling and other quantitative modeling approaches to support our recommendations, and we use extensive tracking and reporting to monitor the performance of our programs. For further information, please contact us at information@mathereconomics.com or at (770) 993-4111.

