Collier County

Memorandum

To: Conservation Collier Land Acquisition Advisory Committee (CCLAAC)

From: Alexandra Sulecki, Principal Environmental Specialist

Date: July 8, 2014

Subject: Estimate of the Ecosystem Services of Existing Conservation Collier Lands in Collier County Florida

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The subject of a Conservation Land Valuation Study was presented to the CCLAAC at its November 18, 2013 meeting, and was subsequently recommended to be pursued. This study was initiated in response to comments made by Commissioner Donna Fiala at the November 5, 2013 Board of County Commissioner's Workshop discussing Conservation Collier's financial future. In discussions about sale or swap of Conservation Collier properties, Comm. Fiala noted that "it may be prudent where possible, to incorporate economic public benefits in areas of water quality preservation, improved wildlife habitats, etc. into the analysis."

As a result of the Commissioner's interest and the CCLAAC's positive recommendation, the attached report titled "Estimate of the Ecosystem Services of Existing Conservation Collier Lands in Collier County Florida" was contracted with the Southwest Florida Regional Planning Council, Jim Beever, Principal Planner IV. Mr. Beever and his associate Tim Walker, GIS Analyst, have prepared similar reports for the Pine Island Sound area and for Conservation 20/20 lands in Lee County. Mr. Beever and Mr. Walker are leading research scientists in this field in southwest Florida. They have developed and utilize a method of estimating ecosystem services called ECOSERVE, which uses GIS spacial analysis and documented ancillary use values gleaned from state and regional economic data.

Mr. Beever will be at the July 21st CCLAAC meeting to present the attached study.

Estimate of the Ecosystem Services of Existing Conservation Collier Lands in Collier County Florida

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Introduction and Background

The natural world, its biodiversity and its constituent ecosystems are critically important to human well-being and economic prosperity. They are consistently undervalued in conventional economic analyses and decision-making. Ecosystems and the services they deliver underpin our very existence. Humans depend on these ecosystem services to produce food, regulate water supplies and climate, and breakdown waste products. Humans also value ecosystem services in less obvious ways: contact with nature gives pleasure, provides recreation and is known to have positive impacts on long-term health and happiness (Watson and Albon 2011).

Human societies get many benefits from the natural environment. Especially in Southwest Florida, we are aware of how important eco-tourism, sport and commercial fishing, and natural products such as locally produced fruits, vegetables, and honey are to our regional economy. The natural environment also provides, for free, services that we would otherwise have to pay for, in both capital outlay, and operation and maintenance costs.

Ecosystem Services are the multitude of resources and processes that are supplied by natural ecosystems. "Ecosystems Services" refers to a wide range of natural processes that help sustain and fulfill human life, such as:

- Purification of air and water
- Detoxification and decomposition of wastes
- Pollination of crops and natural vegetation
- Cycling and movement of nutrients
- Protection of coastal shores from erosion by waves
- Moderation of weather extremes and their impacts
- Provision of aesthetic beauty and intellectual stimulation that lift the human spirit

The United Nations 2004 Millennium Ecosystem Assessment grouped ecosystem services into four broad categories:

- Provisioning, such as the production of food and water
- Regulating, such as the control of climate and disease
- Supporting (Habitat), such as nutrient cycles and crop pollination
- Cultural (Socio-economic), such as spiritual and recreational benefits

Ecosystem services values can be used by decision-makers when establishing and maintaining conservation lands, siting infrastructure, making land use decisions, putting numbers to the impacts associated with decisions, and adding data when critical trade-offs are being discussed. These values can also be useful in justifying grant funding and in leveraging restoration dollars.

Location

Collier County is a county in Florida located in the south of southwest Florida. The county has a total area of 2,305 square miles (5,970 km^2), of which 2,025 square miles (5,246 km^2) (or 88%) is land and 280 square miles (724 km^2) (or 12%) is water. This makes Collier County the second largest county in the state of Florida (Palm Beach County being the largest). The incorporated cities in the county are Naples (the county seat), Marco Island (located on the largest of the Ten-Thousand Islands), and Everglades City at the mouth of the Barron River, on Chocoloskee Bay. In 2010 the population of the county was 321,520. Most of the southeastern portion of the county lies within the Big Cypress National Preserve. The northernmost portion of Everglades National Park extends into the southern coastal part of the county.

As of February 2014, Conservation Collier lands made up approximately 0.02% of Collier County's land, with 19 properties totaling 4,060 acres (Figure 1).

Some Ecosystem Services Involving Florida

Tourism Industry

The travel and tourism industry is one of the United States' largest industries, generating $739 billion in travel expenditures this past year and $116 billion travel-generated tax revenue. Travel and tourism also is one of America's largest employers, with 7.7 million direct travel-generated jobs. Tourism is one of the largest economic industries in Florida, with approximately 82.4 million travelers visiting the Sunshine State in 2007. During their time here, visitors generated more than $65 billion in taxable sales. That amount of spending generated $3.9 billion in tax-related revenue to the state of Florida, which is spent on public necessities such as schools, transportation, museums and enhancing Florida's offerings to entice even more visitors. Nearly 1 million Floridians are employed by the tourism industry, creating a combined annual payroll of $15.4 billion.

Preliminary estimates released by VISIT FLORIDA – the state's official tourism marketing corporation – indicate that 94.7 million visitors came to Florida in 2013, an increase of 3.5 percent over 2012. This represents a record year for visitation to Florida, exceeding the previous high of 91.5 million in 2012. The number of direct travel-related jobs in 2013 was also a record high, with 1,088,200 Floridians employed in the tourism industry – up 2.9 percent from 2012. Tourism-related employment has lead the state in growth for 41 straight months.

Ecotourism

Webster's Dictionary indicates that the first known use of the term eco-tourism dates to 1982. Webster's defines it as "The practice of touring natural habitats in a manner meant to minimize ecological impact." Nationally, ecotourism encompasses a wide range of outdoor recreation activities with far reaching economic benefits (Florida Department of Economic Development 2014). Outdoor recreation contributes $730 billion annually to the nation's economy and supports nearly 6.5 million jobs across the United States (Outdoor Industry Foundation 2006). In Florida, "ecotourism" includes a diverse mix of activities, including cycling, camping, fishing, hunting, paddling, hiking, birding, visiting scenic byways, and other wildlife viewing.

Wildlife

The diversity of the State's wildlife attracts tourists and creates jobs. Wildlife attracted 9.2 million visitors in 2010 and produced a $552.8 million economic benefit in 2009 (National Park Service 2000). Visitors to the Everglades contributed $132 million to the local economy in 1998, and helped to create over 5,000 new jobs (American Hiking Society 2013). While this park specific study is now 14 years old and is dated, it still demonstrates the magnitude of the positive economic impact produced by just a single national park. The FWC indicates the total spent on wildlife viewing in Florida in 2006 was $1.23 billion, with a total economic effect of $5.2 billion. In another study the USFWS indicates $2,991,597,000 spent on wildlife viewing in Florida in 2006. Wildlife viewing created over 51,000 jobs in Florida in 2008 (Florida Fish and Wildlife Conservation Commission 2008). According to the State's Comprehensive Outdoor Recreation Plan (SCORP), 49 percent of Floridians (9.3 million) and 47 percent of visitors (39 million) participated in wildlife viewing activities during 2011. Next to going to the beach, wildlife viewing is their favorite leisure time activity. (Responsive Management 2011).

Fishing

Given Florida's lengthy coastline, plentiful freshwater lakes, and national parks, fishing is an obvious strength in the state's ecotourism tool box. Statewide, Florida ranks number one in the nation in the number of resident anglers (3,091,952) and non-resident anglers (1,197,279) (ASA 2013) and in total expenditures by resident (nearly $5 billion) and non-resident anglers (nearly $9 billion). This activity creates over 80,000 jobs. It generates over $2.5 billion in salary and wages, over $650 million in federal tax revenues and over $500 million in state and local government tax revenues. The associated impacts of the boating industry contribute an additional $18 billion, creating over 220,000 jobs (Florida Fish and Wildlife Conservation Commission 2014). In the Everglades region alone, the total economic impact from fishing enthusiasts is $1.2 billion (The Everglades Foundation 2009). Florida has the highest number of International Game Fish Association records, accounting for 14.4% records worldwide.

Hunting

Hunters created a total economic benefit of $714.6 million to the Florida economy in 2001, and supported 7,338 jobs (International Association of Fish and Wildlife Agencies 2002). Based on only retail sales, hunting within U.S. Forest Service lands added $180.6 million to Florida's economy in 2003, and supported 3,320 retail-related jobs (U.S. Forest Service, 2006). The USFWS (2007) indicates 239,000 sport hunters were active in Florida in 2006 with $365,366,000 in spending.

Some Prior Ecosystem Services Studies Involving Southwest Florida

Mangroves

In southwest Florida, 80% of commercial and recreational harvested marine species depend on mangrove estuaries for at least a portion of their lifecycles (Lewis et al. 1985). A 1986 Federal enforcement action in Lee County concerned a development known as "The Estuaries." The financial evaluation of damage, utilizing conservative estimators, found that a mature 6 meter (20 ft.) tall canopy of red mangrove forest contributed $2,040.54 per year in commercial fisheries landings in 1970 dollars. Adjusted for inflation, this translates into $12,252 per acre per year in 2012 dollars. If all of 86,793 acres of mangroves in the shoreline of Collier County were mature this sums to over $1 billion per year in 2013 dollars.

However smaller and shorter mangrove canopies, including trimmed canopies, contribute less to fishery values than taller, natural canopies because there is less net primary productivity available as export from shorter canopies (Beever 1999). The difference is non-linear. A 1.5 m (5 ft.) height contributes $143 per acre/year and a 10.7 m (35 ft.) tall canopy contributes $6,514 per acre/year, in 1975 dollars. Adjusted for inflation, this is $28,208 per acre/year in 2013 dollars. In order to apply this adjustment factor it is necessary to have an accurate map of the eight different types of mangrove forest and the variety of human altered mangrove shorelines to have accurate areas for calculation. Unfortunately this information does not currently exist, although studies have been proposed to obtain this information.

These mangrove ecosystem service values for commercial fisheries do not reflect recreational fisheries values, including the prey base, which range from 5.6 to 6.5 times the primary sales of commercial fisheries (Lewis *et al.* 1982). This would range from $68,608 to $79,635 per acre/yr in 2013. This would be an additional $5.9 billion to over $6.9 billion per year in 2013 dollars.

The total $6 billion to $8 billion per year fisheries value does not include ecosystem services provided by mangroves for erosion protection value, tourist income, recreational non-fishing boating, water quality enhancement, privacy screen value and habitat value of these mangroves to endangered and threatened species.

Total Ecosystem Services Values in Charlotte Harbor National Estuary Program (CHNEP)

In a presentation of some estimates of the economic values of ecosystem services provided by natural habitats found on conservation lands of southwest Florida at the Estero Bay Agency On Bay Management Cela Tega at Florida Gulf Coast University, Beever (2011) calculated the mangrove forest Total Economic Value for 63,831.96 total acres in the CHNEP as $49.2 billion in 2012 dollars; the seagrass bed Total Economic Value for 65,247.52 acres in CHNEP at $6.1 billion in 2012 dollars; and the salt marsh total economic value for 14,856.1 total combined acres in the CHNEP as $77.25 Million in CHNEP in 2012 dollars.

Jobs Created by Conservation Lands

Dr. Richard Weisskoff (2012) has calculated that 2.29 acres of conservation land, including Conservation 2020 lands generates one full-time job in the Lee County economy and the one time purchase price of Conservation 2020 lands in the Estero Bay Basin is one-third of a single year of tourist spending related to those lands, and subsequently conservation lands have been a good investment for Lee County. Extending Weisskoff's job estimate to all the Conservation 2020 lands generates a total of 10,905 full time jobs.

Methods

All the 57 existing habitat types found on Conservation Collier lands were identified by Collier County staff. The most recent available tabulation was utilized. The total area of Conservation Collier lands is 4,054.7 acres. The largest habitat type is Improved Pasture which constitutes 17.5% of all Conservation Collier lands. Pine Flatwoods are the most common type of native habitat constituting 8.3% of Conservation Collier Lands. Disturbed depression marsh is the most common freshwater wetland habitat (7.8%) and mangroves are the most common saltwater wetland habitat (7.6%). Improved Pasture, Pine Flatwoods, disturbed Depression Marsh, Mangrove Swamp, Upland Mixed Forest, Mixed Wetland Hardwoods, Wetland Scrub, and Cypress Swamp make up 64.4% of all the Conservation Collier lands.

The range and quantity of ecosystem services provided by existing habitats was estimated utilizing the methods developed by Beever and Walker (2013), including the estuarine and freshwater wetlands, and native and disturbed uplands of the Conservation Collier program. Dollar values for ecosystem services were obtained either directly or through calculation from Allsopp et al. 2008, Beever and Cairns 2002, Beever 2011, Beever et al. 2012, Casey and Kroeger 2008, Committee on Assessing and Valuing the Services of Aquatic and Related Terrestrial Ecosystems (CAVSARTE) 2004, Costanza et al. 1997, Costanza 2008, Costanza et al. 2008, Dale and Polasky 2007, Dlugolecki 2012, Engeman et al. 2008, Goulder and Kennedy 2007, Goulder and Kennedy 2011, Hazen and Sawyer 1998, Henderson and O'Neil 2003, Isaacs et al. 2009, Krieger 2001, Kroeger and Casey. 2007, Kroeger et al. 2008, Losey and Vaughan 2006, Lugo and Brinson 1979, McLeod and Salm 2006, Paling, et al. 2009, Pidwirny 2006, Quoc Tuan Vo et al. 2012, Metzger et al. 2006, Morales 1980, Sathirathai 2003, South Florida Water Management District 2007, Spaninks and van Beukering, 1997, Watson and Albon 2011, and Wells, et al. 2006. When a habitat was indicated as disturbed a 50% valuation of the full TEV for that habitat type was utilized based on consultation with Collier County staff concerning the extent of disturbance.

This produced a table using combined total estimated ecosystem services value for each habitat type. TEV for the total acreage of each habitat type were then calculated within the study area. Each dollar value for ecosystem service provided by a particular habitat was specified for its year of estimation. The dollar value of the ecosystem service estimate was then normalized using the inflation rate from the consumer price index (Bureau of Labor Statistics 2012) to a 2013 dollar value using the appropriate inflation multiplier. The resulting ecosystem service value per acre was then multiplied by the number of acres of that habitat type to obtain the total ecosystem services value for that habitat type on the Conservation Collier lands. All the habitat values were then summed to obtain a total ecosystem services value for the entire study area (Table 1).

Mangrove Total Ecosystem Services Values

The mangrove ecosystem has important direct and indirect economic, ecological and social values to man. Mangrove ecosystems have consistently been undervalued, usually because only their direct goods and services have been included in economic calculations (e.g. forestry resources), but this represents only a minor part of the total value of mangroves. Mangrove conversion built environments usually leads to short-term economic gain for some at the expense of greater, but longer-term, ecological benefits and off-site values. The non-market values, such as species biodiversity, and off-site functions such as nutrient export, are not easily quantified, but have been shown to be significant as recounted below. The total economic value of mangroves must be calculated in order to provide decision-makers with the real cost of converting mangroves to other apparently more profitable uses (Macintosh and Ashton 2002).

As the most common native saltwater habitat type of Conservation Collier property, Collier County asked for a detailed explanation of how the Total Ecosystem Services Value (TEV) is calculated for mangrove habitats. Similar method to determine TEV for all habitats were applied. The mangrove habitat TEV methodology is shown here in detail.

To determine the TEV, 32 ecosystem services were reviewed:

1. Production of Oxygen,
2. Other Gas Regulation,
3. Net Primary Productivity,
4. Carbon Sequestration
5. Local and Global Climate Regulation,
6. Disturbance Regulation,
7. Water Regulation,
8. Potable Water Supply,
9. Erosion Control and Sediment Retention,
10. Protection against Floods, Hurricanes and Tidal Waves,
11. Soil Formation,
12. Storage and recycling of complex organic matter and trace nutrients like metals,
13. Waste Treatment and Nutrient Removal,
14. Pollination Services,
15. Biological Control,
16. Habitat and Refugia,
17. Biological Maintenance of Resilience,
18. Biophysical support to other coastal ecosystems,
19. Commercial Fishery,
20. Recreational Fisheries,
21. Hunting,
22. Water Production,
23. Raw and Market Materials,
24. Genetic Resources,
25. Control of Disease,

26. Recreational and Tourism Benefits,
27. Cultural and Spiritual Benefits,
28. Privacy Screening,
29. Habitat for Indigenous Cultures,
30. Heritage Values,
31. Artistic Inspiration, and
32. Educational and Scientific Information.

The photosynthetic process in mangroves produces 4 different categories of ecosystem services that can be segregated so as to avoid overlap in estimation and services counting including the 1) production of oxygen, 2) other gas regulation, 3) carbon sequestration, and 4) net primary productivity export to other estuarine and marine habitats. This study utilizes methods that avoid any double counting.

<u>Production of Oxygen</u>
Lugo et al. (1975) reports a mangrove net photosynthesis of 1.38 grams of oxygen per square meter per day with one of the highest efficiencies of photosynthesis recorded in nature. Six (6) molecules of oxygen are produced for each molecule consumed in plant respiration. Most vascular plants have a smaller P/R ratio in the range of 1 or less producing only one net molecule of oxygen (Van Oijen et al. 2010). For comparison southern slash pine produces 0.14 grams of oxygen per square meter per day (Teskey et al. 1994) a nine-fold reduction difference. There are 4,047 square meters in an acre. So each day an acre of mangrove produces 5.585 kilograms of oxygen. This is 2,038,473.9 kilograms of oxygen per acre/year. Current cost for a gram of pure elemental oxygen produced by humans is $2.50. So mangroves produce oxygen valued at $5,096,184,750.00 per acre/year into the air column. Assuming the majority of this oxygen is regionally miscible to the global oxygen budget then discounting the level of oxygen available at the local Collier County level as 0.0001 of the produced oxygen and not every acre of mangrove is functioning at peak photosynthetic rate, then the valuation for this model would be $254,809.24 per acre/year.

<u>Other Gas Regulation</u>
Other gas regulation includes the removal of carbon dioxide and other gases harmful to animal and plant life. Zeman and Lackner (2004) outlined a specific method of air capture using Carbon dioxide scrubber#Sodium hydroxide. Carbon Engineering, a Calgary, Alberta firm founded in 2009 and partially funded by Bill Gates, is developing a process to capture carbon dioxide in a solution of sodium hydroxide with a pilot plant planned for 2014 with hopes to capture CO_2 at a cost of $100 a ton (Eisenberg 2013). A crucial issue for carbon dioxide recovery (CDR) methods is their cost, which differs substantially among the different technologies, some which are not developed enough to perform cost assessments of. The American Physical Society (2011) estimates the costs for direct air capture to be $600/tonnes with optimistic assumptions. Eong (1993) shows carbon dioxide uptake at 1.5 tons per hectare per year. One metric tonnes is 1.1 ton and one hectare is 2.47 acres. So the costs would range from $100 to $545.50 per ton per hectare or $40.49 to $220.85 per ton/ acre. Multiply by the mangrove carbon dioxide uptake this would be a gas regulation value of $60.74 to $331.28 per acre. Using the average for this calculation this would be $196.01 per acre in 2013 dollars. Costanza et al. (1997) reports a gas regulation

value of $265 per hectare which is $107.29 per acre in 1997 dollars, and accounting for inflation that would be $155.73 per acre /year.

Net Primary Productivity

The net primary productivity (NPP) exported from natural red mangrove fringe, in the form of mangrove detritus that can be utilized in the marine food web by detritivores that are the prey base fo other predators, that becoem the prey of large fish speceis, that utlitmately feed top predators including eagles, dolphins, sharks, and man has been measured at 9.9 metric tons per ha/year by Pool et al. (1975). Teas (1979) derived 10.6 metric tons per ha/year for mature red mangroves and 1.3 metric tons per ha/year for shrubby 5 linear foot tall red mangrove fringes. The lowest reported NPP export for a mature red mangrove canopy was 7.3 metric tons per ha/year. It can be observed therefore, that a short canopy provides only 12% to 19% of the detrital export of a mature untrimmed red mangrove fringe. Utilizing the low value of 7.3 metric tons per ha/year then this is 2.96 metric tons per acre/year. In another method of calculation Pidwirny (2006) reports a net primary productivity for mangroves of 9,000 kilocalories/meter $^{-2}$ /year. One kilocalorie is equivalent to 0.001163 kilowatt hour (kWh). The Florida average cost was 11.7 cents per Kilowatt Hour in 2011. 1 acre is 4,047 m2. Nine thousand kcal is 10.47 kWh. So 1 acre of mangrove estuary produces $4,9587.54 in NPP in 2011. Calculating inflation this becomes $5,134.25 per acre/ year in 2013 dollars.

Carbon Sequestration

High soil carbon sequestration with low trace gas emissions from mangroves make a robust case for mangrove carbon credit projects. Coastal mangroves and salt marsh store up to 50 times more carbon in their soils by area than tropical forests, and ten more than temperate forests (Pidgeon 2009). Mangroves are highly efficient carbon sinks, holding large quantities of carbon in standing biomass and in sediments. They have among the highest measured levels of carbon sequestration per acre of any system measured to date. Fixation of 1 ton of Carbon is worth from $15 to $40 per ton today depending upon the market. It was worth $7 per ton in 2008 in the United States and from $10 to $25 in 2011 in the world markets including California. Peak mangrove carbon fixation is 16 tons per acre/year (Hicks and Burns 1975) in brackish water conditions. This would yield a carbon market value of $414.26 per acre/year.

Local and Global Climate Regulation

Costanza et al. (1997) defines local and global climate regulation as the regulating of local and global temperatures, precipitation, and other biologically mediated climatic processes. This can include shading, cloud formation from DMA, prevention of temperature inversions, disruption of heat island effects, changes in fog formation, changes in humidity. Mangroves are a tropical wetland forest Mangroves are considered to be a type of flooded tropical forest. Keirger (2001) reports the value of $90.20 per acre per year for tropical forest, which mangrove is. Taking inflation into account this is $118.72 per acre per year in 2013 dollars.

Disturbance Regulation

Disturbance regulation is the capacitance, dampening, and maintained integrity of the ecosystem response to environmental fluctuations mainly controlled by vegetation structure. Costanza et al. (1997) reports a value of $1,839.00 per hectare/year for mangroves. This is $744.53 per acre of mangrove in 1997 dollars. This inflates to $1,080.64 per acre/year in 2013 dollars.

Water Regulation

Water regulation is the regulation of hydrologic flows providing water for agriculture, industry, processes or transportation. Waters in mangrove forests in southwest Florida do not supply agricultural or industrial processes , but they are used in fishery transportation. Keirger (2001) reports value of $30.00 for tropical forest. Taking inflation into account this is $39.48 per acre/year in 2013 dollars.

Erosion Control and Sediment Retention

This function is the retention of soil within the ecosystem by erosion, tidal impacts, and other removal processes. this is principally performed by the many micro-roots of the mangroves holding onto very fine silts and muds that would otherwise go into suspension creating enormous turbidity damaging tot water quality and sensitive adjacent ecosystems like sea grass beds, soft corals, and fish nurseries. Mangroves are considered to be a type of flooded tropical forest. Keirger (2001) reports the value of $99.10 for tropical forest. This inflates to $111.34 per acre/year in 2013 dollars.

Protection against Floods, Hurricanes and Tidal Waves

Coastal wetlands reduce the damaging effects of hurricanes on coastal communities. Coastal wetlands in the US were estimated to currently provide $23.2 billion per year in storm protection services. Coastal wetlands function as valuable, self-maintaining "horizontal levees" for storm protection, and also provide a host of other ecosystem services that vertical levees do not. Their restoration and preservation is an extremely cost-effective strategy for society (Costanza et al. 2008). A regression model used 34 major US hurricanes since 1980. The natural log of damage per unit gross domestic product in the hurricane swath was the dependent variable and the natural logs of wind speed and wetland area in the swath was the independent variables. The model was highly significant and explained 60% of the variation in relative damages. A loss of 1 hectare of wetland in the model corresponded to an average $33,000 increase in storm damage from specific storms. Using this relationship, and taking into account the annual probability of hits by hurricanes of varying intensities, Costanza et al (2008) mapped the annual value of coastal wetlands by 1km x 1km pixel and by state. The annual value ranged from $250 to $51,000 ha/year, with a mean of $8,240 ha/year (median ¼ $3,230 ha/year) which was significantly more than previous estimates. This calculates to $3,336.03 in 2008 dollars which inflates to $3,609.57 per acre/year in 2013 dollars.

Soil Formation

Mangrove soils develop through a combination of two processes: mineral sediment deposition and organic matter accumulation but the relative contribution of these processes varies with geomorphology and other factors. Elevation change rates (mm yr^{-1}) from soil formation in mangroves measured with Surface Elevation Tables varied widely: Florida Fringe Mangrove (+0.6), Florida Basin Mangrove (+2.1), Belize Fringe Mangrove (+4.1), and Florida Restored Mangrove (+9.9). Root mass accumulation varied across sites (82 to 739 g m^{-2} yr^{-1}) and was positively correlated with elevation change. Surface growth of turf-forming algae, microbial mats, or accumulation of leaf litter and detritus also made significant contributions to vertical accretion. Surface accretion of mineral material accounted for only 0.2 to 3.3% of total vertical change. Those sites with high root contributions and/or rapid growth of living mats exhibited an elevation surplus (+2 to +8 mm yr^{-1}), whereas those with low root inputs and low (or non-living) mat accumulation showed an elevation deficit (−1 to −5.7 mm yr^{-1}). This study indicates that biotic processes of root production and benthic mat formation are important controls on accretion and elevation change in mangrove ecosystems (McKee 2011) common to the Caribbean Region. To date, at least 14 studies (Webb *et al*., 2013) have included rates of accretion and elevation change in mangrove ecosystems using the SET-MH approach, and eight studies have provided sufficient information to describe trends by hydro-geomorphology. The duration of these elevation studies ranged from 1.0 to 6.6 years. Among these, rates of elevation change ranged from vertical accretion ranged from 0.7 to 20.8 mm yr^{-1} with basin and riverine forest having the greatest accretion rates. One millimeter is 0.039 inches so this is 0.027 to 0.818 inches per year. This works out to 0.00023 cubic yards per square meter. Average prices for topsoil in Florida range from $12.00 to $18.00 per cubic yard. So the value of the mangrove soil accumulation is $0.003 to $0.004. There are 4,046.856 meters in an acres. Therefore the annual soil formation value per acre for mangroves would be $12.14 to $16.19 for an average of $14.17 per acre of mangrove/year in 2013 dollars

Storage and recycling of complex organic matter and trace nutrients like metals

This function includes the capture and storage of complex organic molecules including polycyclic hydrocarbons, heavy metals like iron, mercury, lead, copper, nickel, zinc, chromium, and lead, immobilization of sulphur. The fine textured mangrove sediments are highly efficient and effective sinks for heavy metals. Metal concentrations in mangrove tissues, particularly in young leaves, correlate with concentrations in the sediments. Bioaccumulation of metals occurs in mangroves but differs between species and mangrove tissue types. Lead is selectively concentrated in bark and wood of mangroves whereas zinc and copper reach their highest concentrations in young leaves (Saenger and McConchie 2004). Storage and recycling of complex organic matter and trace nutrients like metals by mangroves is reported by Costanza et al. (1997) at $373.10 per hectare/year or $151.05 per acre/year. This inflates to $219.24 per acre of mangrove/year in 2013 dollars.

Waste Treatment and Nutrient Removal

This function includes nitrogen fixation, nitrogen removal and phosphorus removal from the water column and sediments with incorporation in the mangrove as biomass and metabolites. other Waste treatment and nutrient removal by mangroves is reported by Costanza et al. (1997) at $6,696.00 per hectare per year or $2,710.93 per acre per year. This inflates to $3,934.77 per acre of mangrove/year in 2013 dollars.

Pollination Services

Pollination services from insects and other mangrove species provide vital reproductive assistance to the mangroves and adjacent upland and wetland habitats. It is estimated that in North America around 30% of the food humans consume is produced from bee pollinated plant life. About 150 agricultural plants in the United States are pollinated by bees and other pollinators and the annual value of just honey bee pollination to U.S. agriculture is estimated at over $16 billion (Delaplane and Mayer 2000, National Agricultural Statistics Service 2007). All pollinators, such as bees, wasps and flies, contributed approximately $29 billion to farm income in the United States in 2010 (Calderone 2012). Mangroves support 38 species of insect pollinators (Hermansen et al. 2014). The total area of the 50 United States is 3.79 million square miles or 2,425,600,000 acres. Calculating the pollination value as an average it would be $11.96 per acre/year.

Biological Control

Biological control is the control of pests and undesirable plant species through natural predators and herbivores. Losey and Vaughan (2006) estimate that the $7.32 billion lost annually to native insect pests is 35% of what would be lost if natural biological controls were not functioning. If no natural biological controls were functioning to control native insect pests, they estimate that the pests would cause $20.92 billion in damage in the United States each year. By subtraction, the value of pest control by our native ecosystems is approximately $13.60 billion. The total area of the United State's 48 contiguous states is 3,119,884.69 square miles or 1,996,726,201.6 acres. Calculating the biological control value as an average it would be $6.81 per acre/year.

Habitat and Refugia

Natural mangrove forests provide critical habitat for at least 217 fish species, at least 250 species of arboreal arthropods, 19 species of mammals, at least 182 species of birds, 24 species of reptiles, and at least 300 species of aquatic invertebrates which can attain a total biomass in excess of 100 dry grams of carbon/m2 (Odum et al. 1982). Aquatic invertebrates include barnacles, sponges, polychaete worms, gastropods, bivalves, isopods, amphipods, mysids, crabs, carideon shrimp, penaeid shrimp, copeopods, ostracods, coelenterates, nematodes, bryozoans and tunicates. At least 74 species of marine algae are epiphytic on mangroves (Rehm 1974) which have an additional NPP rate of 1.1 gC/m2/day (Lugo et al. 1975). There are at least 30 species of vascular wetland plants which can associate with mangroves. At least nine endangered species and four threatened species utilize natural mangrove habitats. This includes Florida panther (*Puma concolor coryi*), West Indian manatee (*Trichechus manatus latirostris*), wood stork (*Mycteria americana*), American crocodile (*Crocodylus acutus*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Kemp's ridley sea turtle (*Lepidochelys kempii*), hawksbill sea turtle (*Eretmochelys imbricata)*, small-toothed sawfish (*Pristis pectinata)*, roseate tern (*Sterna dougallii*), piping plover (*Charadrius melodus*), snowy plover (*Charadrius alexandrinus*), and Atlantic loggerhead turtle (*Caretta caretta*).

Our understanding of the value of endangered species to humans has increased together with the recognition that human activities cause extinction. In general, benefits of species can be classified as ecological, economic, and social. Different combinations of benefits occur for any particular species, and some species are obviously more "valuable" than others (Mazzotti 2002). One method of assessing economic value of rare, threatened and endangered species to citizens of the USA has been measured using the contingent valuation method (CVM) (Loomis and White 1996). Economists have developed a hypothetical market method, called the Contingent Valuation Method (CVM) that uses a survey to measure household willingness-to-pay (WTP). A CVM survey involves developing a hypothetical market or referendum which an individual uses to reveal or state his or her WTP for protection of a specific species in a particular location. The structure of the hypothetical market involves three elements:

1. description of the species and habitat proposed for preservation--this includes location of habitats and specific changes in population as well as the consequences of paying or not paying;

2. the form and frequency of the payment--for T&E species, common forms include higher income taxes, increases in utility bill and payments into a dedicated trust fund; and
3. how they are asked their WTP. For example, as an open-ended question (e.g., what is the most you would pay?), circling a dollar amount from a list of alternative figures on a payment card or simply responding 'yes' or 'no' to a single dollar amount (which varies across respondents).This latter question format is called 'dichotomous choice' or 'referendum' due to its similarity to voting on a bond issue (Loomis and White 1996).

CVM has been upheld by the US District Court of Appeals (Department of Interior, 1989) and has been approved for use by federal agencies performing benefit-cost analysis (US Water Resources Council, 1983) along with valuing natural resource damages.

Currently there are no existing CVM WTP for Collier County. Elsewhere in the United States annual willingness to pay (WTP) range from a low of $6 per household for small fish to a high of $95 per household for the charismatic birds of prey. The Safe Minimum Standard approach is an alternative for endangered species preservation decisions. The values reported in scientific literature are most useful to assess whether the costs are likely to be disproportionate to the benefits. To date, for even the most expensive endangered species preservation effort (e.g., the northern spotted owl) the costs per household fall well below the benefits per household.

Extending the reported values to the number of mangrove inhabiting listed species calculates a listed species diversity value of $1,235 per household in CVM 1996 dollars. There were 120,938 households in Collier County in 2012 (U.S. Census 2012). There are 86,793.28 acres of mangroves in Collier County (SFWMD 2008). This leads to a calculation of $1,720 per mangrove acre in 2012 dollars. Adjusting for the fact that for each of the listed species not all of their life history and life span is spent in mangrove habitat then this would be pro-ratable to $238.15 for the American crocodile and small-toothed sawfish which are mangrove resident plus $14.55 total for the other 11 species that use mangroves a small part of their life history, summing to $252.70 in 2012 dollars. This inflates to $256.40 per acre of mangrove per year in 2013 dollars. This is an underestimate because of relative uncertainties on the distribution of manatees in Collier County during much of the year.

In addition to the listed species values there is general habitat value of mangroves for other non-listed species. This general habitat value of mangroves is reported by Costanza et al. (1997) at $169.00 per hectare/year or $68.42 per acre/year. This inflates to $99.31 in 2013 dollars.
For this project the two values (listed species and general species habitat and refugia) are combined for $355.71 dollars per acre/year in 2013 dollars.

Biological Maintenance of Resilience

In ecology, resilience is the capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly. Such perturbations and disturbances can include stochastic events such as fires, flooding, windstorms, insect population explosions, and human activities such as deforestation and the introduction of exotic plant or animal species. Disturbances of sufficient magnitude or duration can profoundly affect an ecosystem and may force an ecosystem to reach a threshold beyond which a different regime of processes and structures predominates (Folke et.al 2004). Human activities that adversely affect ecosystem resilience such as reduction of biodiversity, exploitation of natural resources, pollution, land-use, and anthropogenic climate change are increasingly causing regime shifts in ecosystems, often to less desirable and degraded conditions (Peterson and Holling 1998). Interdisciplinary discourse on resilience now includes consideration of the interactions of humans and ecosystems via socio-ecological systems, and the need for shift from the maximum sustainable yield paradigm to environmental management which aims to build ecological resilience through resilience analysis, adaptive resource management, and adaptive governance (Walker et al.2004). Ecosystem resilience is often interpreted as insurance. By decreasing the probability of future drops in the provision of ecosystem services, resilience insures risk-averse ecosystem users like commercial and sports fishermen or ecotourism against potential losses. Using a general and stringent definition of "insurance" and a simple ecological-economic model, Baumgartener and Strunz (2014) derive the (marginal) economic insurance value of ecosystem resilience and how it depends on ecosystem properties, economic context, and the ecosystem users' risk preferences. They show that (i) the insurance value of resilience is negative for low levels of resilience and positive for high levels of resilience, (ii) it increases with the level of resilience, and (iii) it is one additive component of the (overall always positive) economic value of resilience.

One way to look at the value of the resilience of a mangrove ecosystem is to estimate the cost of replacement that would be charged for a mangrove restoration. The rates are set by the cost of doing the restoration if the system fails and must be restored. Reported costs of mangrove restoration range from $225 to $216,000 per hectare (Lewis 2001). Utilizing a reasonable average of $450.00 per hectare or $182.19 per acre and adjusted for inflation this would be this would be $239.79 per acre/year in 2013 dollars.

Biophysical Support to Other Coastal Ecosystems

Mangroves play an important role in the functioning of adjacent ecosystems, including terrestrial wetlands, peat swamps, saltmarshes, seagrass beds and coral reefs. There are harmful repercussions in these other ecosystems when common ecological processes are compromised through poor management decisions involving mangroves (Macintosh and Ashton 2002). One important ecological service of mangroves is the support to off-shore fisheries by serving as a breeding ground for early life stages. While these relationships have been well documented the level of analysis has been qualitative (Harborne et al. 2006, Nagelkerkan et. al. 2001) and the contributions of mangroves to the support of seagrasses, mangroves, and the pelagic food ecosystems has not been separated from the calculations of the ecosystem services values for those habitats (Conservation International 2008). For the purposes of calculation in this report the already listed values for net primary production, storage and recycling of complex organic matter and trace nutrients like metals, and disturbance regulation will be utilized.

Commercial Fishery

Commercial fishery landings in Collier County in 2012 listed in BEBR (2012) were tabulated. The wholesale and retail prices per pound were then obtained from current market sources in Florida using Collier sources first, then Southwest Florida sources second if Collier sources were not available and then South Florida sources if southwest Florida values were not available. This will underestimate some species that are shipped to other US and foreign markets that pay significantly more for foods like stone crab, red snapper, and pompano. The fishes that are not mangrove dependent for at least a portion of their lifecycles were excluded. An examination of 2012 commercial fisheries landings for Collier County demonstrates that 99.59% of the commercially harvest fish are mangrove dependent for at least a portion of their lifecycles. The total dollar value (in 2013 dollar) of the commercial fish landing that were mangrove dependent is $29,489,957.60. There are 86,793.28 acres of mangroves in Collier County (SFWMD 2008). This results in a commercial fishery TEV in 2012 dollars of $339.77 per acre/year which inflates to $344.75 per acre/year in 2013 dollars.

Recreational Fisheries Landings

For recreational fisheries, including the prey base, values range from 5.6 to 6.5 times the primary sales of commercial fisheries (Lewis et al. 1982). This is a recreational fishery landing TEV in 2013 dollars of $1,930.60 to $2,240.88 per acre/year. For this calculation the average of $2,085.74 per acre/year will be utilized.

Food and Goods Production From Hunting

In the late-1800s and early 1900s, hunting game which were dependent on mangroves was largely concentrated on the plume trade. Today hunting in mangroves is not a common activity as compared to upland and shallow freshwater wetland habitats in Florida but some does occur. Currently, this includes mangrove hog hunting (Spomer 2013). Duck hunting also occurs in mangroves including ruddy duck, wood duck, blue-winged teal and red heads. This mostly occurs from Tampa Bay northward.

Since the Conservation Collier mangrove lands are not utilized for hunting a hunting value was not generated for this study.

Water Production

Mangroves are facultative halophytes which means salt water is not a physical requirement for growth. Most can grow well in fresh water, but mangrove communities are not found in strictly freshwater environments in Collier County. In southwest Florida mangrove habitats are not a major source of aquifer recharge of potable surface waters. In contrast large areas of freshwater with mangroves can be found elsewhere in the world at large river deltas such as the Amazon, Niger, and Sundarbans. Mangrove forests in Collier County do not provide a freshwater supply that can be calculated for TEV. While there are seasonal areas of low salinity mangrove forests these areas are a moving ecotone that does not provide an appreciable watershed for potable water. A water production TEV for mangroves was not calculated for this study.

Raw and Market Materials

Among the raw materials that mangroves can provide are bark that is used as a source of tannins and dyes. Mangroves produce durable and water resistant wood used in houses, boats, pilings, fence posts and furniture in Asia, Africa Central and South America. Dense black mangrove and buttonwood wood is used in charcoal production. The fruits may be eaten. Leaves are used as source of tea, medicine, and livestock feed. The flowers are used in the honey industry. Leaves can also be dried and smoked as a substitute for tobacco.

Historically in southwest Florida buttonwood was the preferred wood for smoked mullet by commercial fishermen. During pioneer times, mangrove wood was used as a marine building material. Other than mangrove honey production most direct uses are destructive.

Tri et al (1998) calculated around 0.2 kg per ha/year of honey can be collected from mangroves. Assuming a market price of $4.50 per kg and 0.2 kg per ha/year, the value is around $0.90 per ha/year or $0.36 per acre/year that inflates to $0.52 per acre/year in 2013 dollars.

Genetic Resources

Genetic resources are the genetic material of plants, animals and micro-organisms of value as a resource for future social, economic, environmental purposes. Genetic resources of mangroves is typically assessed as a potential rather than a present economic value based on replacement cost and/or dollars saved. The genetic diversity in mangroves is almost unknown. The movement of mangrove plant genetic material for reforestation purposes, or other uses, must be controlled and recorded more carefully than at present. Genetic material should come from local sources wherever possible, using good quality mangrove forest stands as the source of the material. The knowledge on mangrove genetic resources is very sparse in the literature. There is limited information from DNA sequences, allozymes and growth adaptability experiments. It is highly important to know more information about this to make proper gene resource management especially for mangrove tree species (Mcintosh and Ashton 2002). Mangroves are biochemically unique, producing a wide array of novel natural products some of which are used in traditional medicine (Bandaranyake 1998) and others have potential commercial applications (Kathiresan 2000). Since the mangrove forests currently in the Conservation Collier program are not being surveyed or harvested for genetic resources, a general value is used from Krieger (2001) for southeastern wetlands forest of $16.60 per hectare. This is $6.72 per acre/year in 2001 dollars which inflates to $8.97 per acre/year in 2013 dollars.

Control of Disease

Mangrove swamps are often thought of as a source of disease. This is because of the possibility for mosquitoes and sand flies to breed in areas of mangroves that become stagnant, through human and natural activities, without access for larval eating fish. Malaria is transmitted among humans by female mosquitoes of the genus *Anopheles. Culex nigripalpus* is the greatest culprit of mosquito-transferred diseases in Florida. This breed of mosquito can carry St Louis encephalitis, West Nile encephalitis, and Dog Heartworm Disease. *Aedes aegypti* is the primary transmitter of yellow fever. Native to Africa, Yellow fever sometimes emerging in Florida in the summer months. Florida *Aedes, Anopheles and Culex* species do not breed or occur in naturally in salt water mangroves.

The mosquitoes in Florida mangroves where flow has been restricted (often by humans) and mosquito predators are unable to find the larvae are *the s*alt marsh mosquito that do not carry vectors harmful to man but they are a transmitter of dog heartworm disease if they have contact with infected dogs (which did not occur in natural conditions). The salt marsh mosquitoes *Ochlerotatus taeniorrhynchus* and *Ochlerotatus sollicitans* will not lay their eggs upon standing water and do not occur in tidally influenced mangroves.

The consumption of mosquito larvae by mangrove sourced fishes like *Gambusia* and other aquatic predators forms a vital component of modern mosquito control through source reduction. For mosquitoes successful biological control is associated with generalist predators that can kill a large portion of the target population, often causing local extinction, and that can persist in the absence of the target organism. While these mangrove aquatic predators provide valuable services in terms of pest control, no monetary valuation of these services in research or trade literature of mosquito control scientists were found.

Many species in the mangrove forest have medicinal value and it has been proved that these plants are antiviral and antibacterial in nature. Plant species including black mangrove have chemical properties that can kill *Anopheles, Culex* and *Aedes*, which cause diseases such as malaria, filariasis and dengue fever (Revathi et al. 2013). Mangrove plants are also a source of medicines. For instance, the ashes from burnt *Ceriops australis* and *Camptostemon schultzii* wood is used to heal sores and infections, while the bark of *Avicennia marina* is used to treat stingray stings in Australia (Duke 2013). While these resources are being developed and utilized in India and Indonesia that is not the case in Collier County.

In the absence of documentable values of the biological control service provided by mangrove fishes and other predators of insect vectors, both larval and adult, a TEV for this service has not been added. This could be a valuable area for future research.

Recreational and Tourism Benefits

Tourism is vital for Naples, Marco Island and the Everglades. As the leading employer and the primary economic engine for the region, the tourism industry is responsible for 26,200 jobs in Collier County. This is 1 out of every 7 employed people. Over 1.3 million visitors in 2003 spent over $593 million dollars, resulting in a total economic impact of over $885 million. In 2013 the total economic effect of Collier County tourism reached more than $1.4 billion. Residents benefited from the tourism industry through enhanced amenities in the community and through tax savings. An estimated tax savings of $518 per resident is enjoyed thanks to the expenditures of visitors. Visitors leave over $8.6 million in tourist development taxes in Collier County and they provide $60 million in sales tax revenue (Klages 2012 and Tourist Development Council of Collier County 2013). On Collier County's tourism home pages, www.ParadiseCoast.com or www.classicflorida.com, tourism in Collier County is promoted as the "Paradise Coast" featuring ecotourism, boating and fishing, parks and preserves, nature and wildlife. The two most important natural resources, in terms of their ability to draw people to Southwest Florida, are the beaches and the area's wildlife. Together, they create powerful incentives for people to visit the area. Beaches are the number-one attraction in attendance and financial value.

Utilizing a calculation approach based on Collier county information, Collier County has a total area of 2,304.93 square miles which is equivalent to 1,475,155 acres. Some 876,510 of these acres (59%) are conservation lands with ecotourism uses. According to the Fish and Wildlife Conservation Commission (FWC), 67 % of the mangrove habitats in Collier County were in conservation status in 1994 (the last time such a measure was taken). Using an assumption of equal distribution of use by ecotourism this generates a 39.5% share of the total county recreational value. So mangrove recreational value excluding extraction of goods like fish landing would be $553,000,000 total in 2013 and $6,371.46 per acre/year.

Cultural and Spiritual Benefits

Celebrations throughout the world including traditional spiritual festivals like the Hindu Rash Mela and offering to mangrove goddesses, gods, and forest spirits around the equator to the subtropics in both northern and southern hemispheres (Uddin et. al. 2013). Mangroves are at the center of cultural and spiritual perception of Collier County as the "Paradise Coast." Real estate offerings in print and video media portray the mangrove boating, canoeing, kayaking, and fishing experiences as part and parcel of the quality of life. Mangroves and spirituality in yoga meditation in Collier County/Naples are associated with high-rise residential sales. Advertisements on billboards, print, and television proclaim the mangrove estuary as the "million-dollar view." Real estate advertisements extol "panoramic gulf, bay & sunset views with bay, gulf frontage, and mangrove waterfront from this gorgeous 17th floor residence in luxurious Pelican Bay." (The Naples Area Board of Realtors website 2014.) The sense of wilderness imparted by the mangrove coast provides both the real and perceptual "Outward Bound" experience. The Conservancy of Southwest Florida hosts a "Magic Under the Mangroves" fundraising events. This study captures most of the cultural and spiritual benefits of mangroves within the tourism valuation previously calculated. Since there is no partitioning accounting variable on the real estate value of mangrove views relative to Conservation Collier properties a ecosystem services value was not calculated for that component.

Privacy Screening

Mangroves can provide a privacy screening that allows residences to be on public waterways and canals without having a direct view of the residences from passing vessels, anchored vessels, or residences across the same waterway or canal. Mangrove privacy screening can also reduce noise (sound barrier), protect against harsh winds (windbreak), and capture floating and windborne debris. Depending on an individual the value of privacy can be lower or very high. Some demand an unimpeded view of open water and their docks and want their residence to be admired by even tour boats. Other including celebrities prefer not to have an open view to photographers and the general public of their swimming pools and homes.

Utilizing values from landscape architect and local real estate sources vegetation privacy screens add $1,500 to $5,000 in 2013 to a standard residential lot with 150 foot water frontage. The value range relates to the real estate location of the upland residence. For the Conservation Collier calculation the value of $3,250 per 150 feet of shoreline in front of residential uses could be utilized principally for the Gordon River Greenway where 8 residential properties are provided privacy screening. This is a value of $26,000 for that specific project area.

Habitat for Indigenous Cultures

The Calusa occupied southwest Florida mangrove region from 500 to 1750 AD. Spanish accounts suggest that the Calusa tribe were the dominant tribe of south Florida and operated a complex chiefdom that was comprised of a number of village communities all organized within a chiefly hierarchy. By the time the English gained control of Florida in 1763, the Tequesta and Calusa tribes had been destroyed by incoming European diseases. According to early settlers, some of the remaining native people retreated deeper into the Everglades, while others migrated to Cuba to begin new settlements there in the late 1700s. (Everglades National Park and Mound Key Archaeological State Park 2014 websites)

Conservation Collier mangroves are not resided upon or utilized by any native indigenous human population today. Therefore no habitat for indigenous cultures ecosystem services value was calculated for this study.

Heritage Values

Currently, Everglades National Park is the only Ramsar World Heritage Site in the United States with mangroves. The park is the largest designated subtropical wilderness reserve in North America. Featuring a variety of wetlands and forests, it has become a sanctuary for a large number of birds, reptiles, and threatened or protected species. The property was placed on the List of World Heritage in Danger in 2010 due to degradation of the property resulting in a loss of marine habitat and decline in marine species. The property was previously listed as in danger from 1993–2007 due to sustained hurricane damage and deterioration of water flow and quality due to agricultural and urban development.

Since none of the Conservation Collier mangrove areas are in a Ramsar World Heritage Site or contains a location of an archeological or historical resource on the National registry, no heritage TEV was calculated for this study.

Artistic Inspiration

In Florida nonprofit arts and culture are a significant industry generating $3.1billion in economic activity. This spending ($1.4 billion) by nonprofit arts and culture organizations and an additional $1.7 billion in event-related spending by their audiences supports 88,326 full-time equivalent jobs, generates $2.1 billion in household income to local residents, and delivers $446.5 million in local and state government revenue. In Florida, 84.4% of the 57.8 million nonprofit arts attendees were residents and; 15.6% were non-residents. Non-resident arts and culture event attendees spent an average of 137 percent more than resident attendees per person ($57.49 versus $24.25) (Americans for the Arts 2009).

It is difficult to develop a specific value for mangrove related art in Collier County since records on art expenditures available publicly are not detailed enough. There are no specific records of how much of each type of mangrove art inspired by Collier County mangroves is sold per unit time and how much mangrove inspired art is purchased and enjoyed by residents and visitors to Collier County.

Mangroves provide significant artistic inspiration to a number of art forms in public and commercial forums in Collier County, the State of Florida and to the world. Well know art works featuring mangroves include:

- paintings by Carol McArdle, Diane Pierce, Linda Soderquist, Danielle Perry, Mark Susin, Robert Bruce Ferguson, Megan Kissinger, Eve Wheeler, Roxanne Tobaison, Charles Yates and Xavier Cortada;
- photography by Clyde Butcher, Marvin Spates and Matt Tilghman;
- mangrove sculptures of Lee C. Jones, Jim Leak, Ryan Jenkins, Linda Ritchie, Larry Hoff, Eric Kraft, Candace Knap and Ed Koehler;
- poetry by Kenneth Slessor;
- music and songs by Dale Crider, Willie Nelson, Slim Dusty, Kenneth Slessor, BREEF9, Carly Bernstein, The Electric Mangroves, Scott McDonough, Julia Hubo, Beneath the Sea, Rosie Emery, Toyah and RZJ among others.

The sales price of mangrove art range from $28 to $220 for photographic art posters. Original oils and acrylic paintings range from $2,000 to $9,500. Metal sculptures range from $100 to $1,000 for smaller pieces and up to $10,000 for large life size metal sculpture.

In the absence of a reliable empirical method to place a value on artistic inspiration, a TEV has not been generated for this study.

Educational and Scientific Information
The mangroves of southwest Florida provide a valuable asset for both education of students and the public, and academic and commercial research. The benefits derived relate to expenditures within the local and national economy (i.e. economic impact) and from the additional knowledge and enjoyment gained. The economic impact can be determined by the amount of expenditure within the local economy because of educational trips and research studies. The wider benefits accruing from the enhanced education and research knowledge are far more difficult to estimate. An example of the economic impact of education is the fact that approximately 3,000 students visit Rookery Bay NERR on educational school visits each year. Part of this value and their expenditure can be attributed to the mangroves. Assuming direct expenditure and costs of $15.00 per student per visit, and 50% of the visit attributable to mangroves results in $22,500 per year for 110,000 acre. This would be $0.20 per acre of mangrove in 2013 dollars.

There may be expenditure of approximately $50,000 per year on salary, accommodation and food from an average PhD researcher focusing on mangrove research while visiting Collier County. In Collier County there have been at least 4 PhD and MS students focusing on mangrove research. This has resulted in expenditure of approximately $200,000 specifically relating to mangroves. This calculates to $2.30 per acre.

Summation
Summing the Ecosystem Services Values described above yields a TEV for Collier County Mangroves of $279,307.71 per acre/ year.

Results and Conclusion

Estimating ecosystem services values for the ecologically rich Conservation Collier lands is the third valuation, following a study of Pine Island Sound and its associated islands (Beever and Walker 2013) and of the Lee County Conservation 2020 lands (Beever 2013) using ECOSERVE in southwest Florida. Ecosystem services values can be used by decision makers when establishing and maintaining conservation lands, siting utilities, or making development decisions, putting numbers to the impacts associated with those decisions, and adding data when critical trade-offs are being discussed. These values will also be useful in justifying other grant funding and in leveraging future restoration dollars.

The output of this project is an assessment of the total ecosystem services provided by all habitat types on the Conservation Collier property, including the mangrove habitat which is detailed above. This assessment will be made available to local governments and the public to assist in planning for use in developing conservation plans.

This work is intended to identify the range and quantity of ecosystem services provided by all the land covers types on Conservation Collier lands including marine, estuarine and freshwater wetlands and native upland habitat, and disturbed habitats.

The current calculations the 2013 TEV of the Conservation Collier property is $144,988,312.22 per year (Table 1). Please note that this is only includes the Collier County owner lands in the Conservation Collier program, a small subset of the total of all the conservation lands in Collier County.

The majority (90.65 %) of the TEV for Conservation Collier property is found in the top twelve habitats including mangrove swamp (58.13%), pine flatwoods (7.32%) upland mixed forest (5.6%), mixed wetland hardwoods (3.1%), cypress (2.9%), wetland scrub (2.65%), depression marsh (2.06%), wetland forest mixed (1.99%), upland mixed forest disturbed (1.57%), depression marsh disturbed (1.57%), bottomland forest (1.44%), cypress- cabbage palm-pine (1.21%) and saltwater marsh (1.11%). These twelve habitats make up 64.62% of the physical area of the Conservation Collier property.

Given more time and resources this project could be improved by detailed mapping of the Conservation Collier lands including salt marsh type and mangrove forest type to better estimate the ecosystem services provided by each type and better represent the relative functions of each type in location and landscape. Alternate futures could be evaluated with regard to hydrologic changes, climate change perturbations, alternate land use plans, and regulatory environments.

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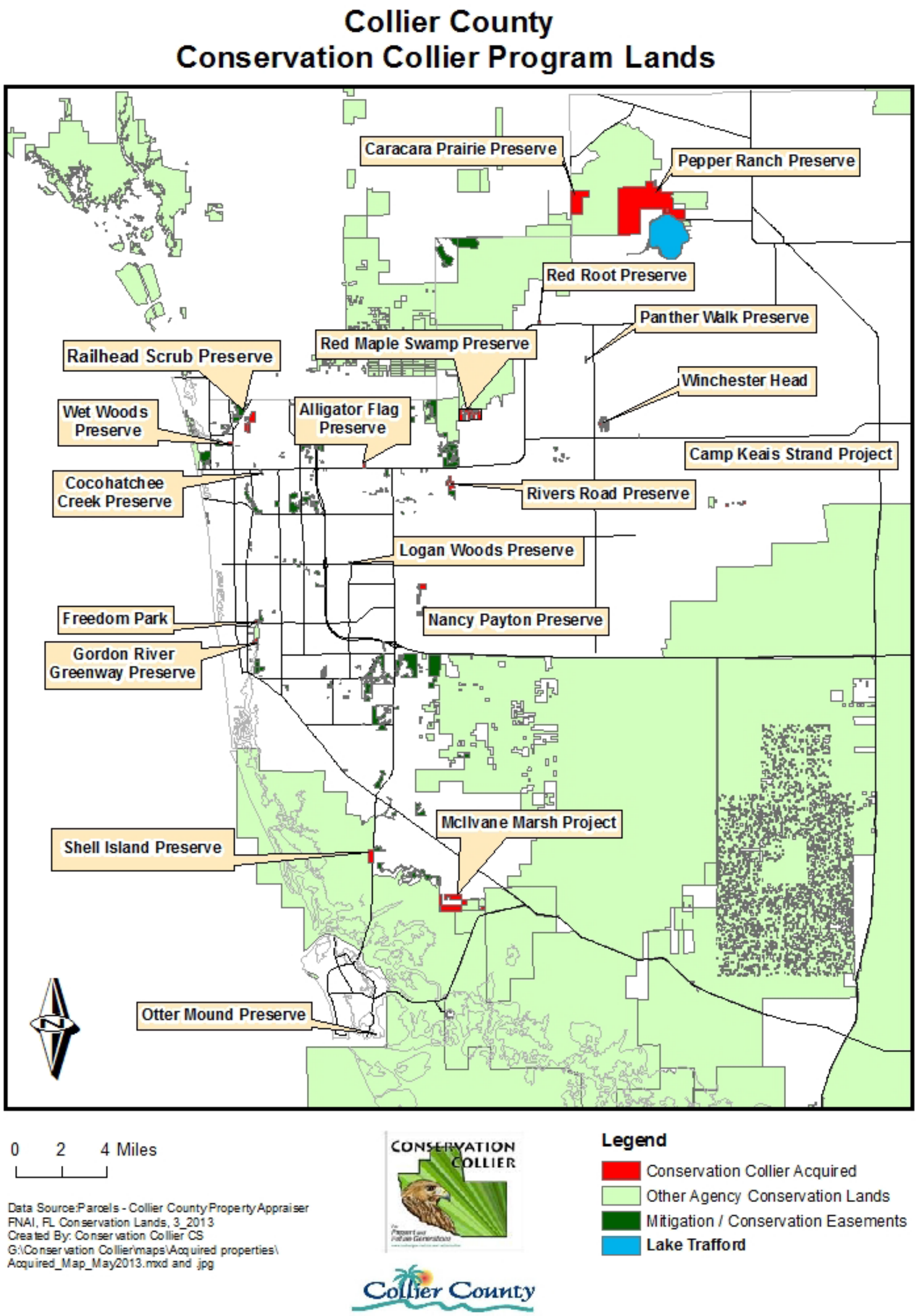

Figure 1: Map of Conservation Collier Lands as of May 2013

Description of Habitat Type	Acres in Conservation Collier	Total Ecosystem Services Value per Acre in 2013 dollars	TEV Combined Value in 2013 dollars
Industrial	1.58	$0.00	$0.00
Oil field	5.64	$0.00	$0.00
Improved pasture	707.36	$1,387.62	$981,546.88
Improved pasture, hydric	47.69	$1,387.62	$66,175.60
Woodland Pasture	93.28	$1,957.39	$182,585.34
Other Open Lands (Rural)	2.13	$247.00	$526.11
Dry prairie	4.09	$1,957.39	$8,005.73
Dry prairie, disturbed	45.09	$978.70	$44,129.58
Shrub and Brushland	1.32	$1,934.39	$2,553.39
Palmetto Prairie	2.45	$1,934.39	$4,739.26
Pine Flatwoods	336.41	$32,340.94	$10,879,815.63
Mesic flatwoods, disturbed	75.65	$16,170.47	$1,223,296.06
Xeric Scrub Oak	48.51	$32,340.94	$1,568,859.00
Oak-Pine-Cabbage Palm	48.77	$28,672.91	$1,398,377.82
Tropical Hardwoods	2.42	$33,385.94	$80,793.97
Oak Hammock, disturbed	1.57	$16,170.47	$25,387.64
Cabbage Palm	13.81	$32,340.94	$446,628.38
Cabbage Palm Hammock, disturbed	8.12	$32,340.94	$262,608.43
Prairie Hammock	11.21	$32,340.94	$362,541.94
Upland mixed forest	271.74	$30,628.54	$8,322,999.46
Upland mixed forest, disturbed	161.76	$14,458.81	$2,338,857.11
Upland mixed forest, burned	34.65	$13,603.35	$471,356.08

Australian Pine	4.17	$392.31	$1,635.93
Other Surface Waters	1.01	$7,562.00	$7,637.62
Streams and Waterways	36.23	$8,498.00	$307,882.54
Lakes	2.09	$8,498.00	$17,760.82
Lake less than 10 acres	1.37	$7,562.00	$10,359.94
Bays and Estuaries	11	$35,528.25	$390,810.75
Mangrove Swamp	309.49	$279,307.71	$86,442,943.17
Bottomland forest	92.33	$23,218.39	$2,143,753.95
Bottomland forest, disturbed	6.27	$10,325.63	$64,741.70
Inland Ponds and Sloughs	3.06	$16,666.14	$50,998.39
Mixed Wetland Hardwoods	255.08	$18,084.14	$4,612,902.43
Mixed Wetland Hardwoods Disturbed	0.25	$9,042.07	$2,260.52
Cypress	172.45	$24,979.39	$4,307,695.81
Cypress, Cabbage Palm, Pine	90.39	$19,845.14	$1,793,802.20
Hydric Pine Flatwoods	52.46	$19,845.14	$1,041,076.04
Wetland Forested Mixed	149.29	$19,845.14	$2,962,680.95
Wetland Scrub	243.37	$16,200.54	$3,942,725.42
Wetland Scrub, disturbed	14.17	$8,100.27	$114,780.83
Depression marsh	154.02	$19,919.25	$3,067,962.89
Freshwater Marsh with shrubs, brush, and vines	2.12	$14,785.00	$31,344.20
Depression marsh, disturbed	315.51	$7,392.50	$2,332,407.68
Saltwater Marsh	68.49	$24,165.79	$1,655,114.96
Wet Prairie	62.67	$14,785.00	$926,575.95
Wet prairie, disturbed	7.99	$7,392.50	$59,066.08

Sand Other than Beaches	3.82	$72.42	$276.64
Disturbed Lands	0.07	$72.42	$5.07
Borrow Areas	1.5	$0.00	$0.00
Spoil Areas	13.13	$72.42	$950.87
Burned Areas	11.64	$0.00	$0.00
Transportation	1.49	$0.00	$0.00
Roads and Highways	14.76	$0.00	$0.00
Shell road, graded and drained	20.63	$1.00	$20.63
Primitive trail	4.9	$72.42	$354.86
Utilities	0.39	$0.00	$0.00
Electrical Power Transmission Lines	1.84	$0.00	$0.00
Addition of privacy screening function for mangroves.			$26,000.00
Total	4,054.70		$144,988,312.22

TABLE 1 TEV for the Conservation Collier Lands By Florida Land Use and Cover Classification System in 2013 Dollars

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Borrow Areas	1.5	$0.00	$0.00
Burned Areas	11.64	$0.00	$0.00
Transportation	1.49	$0.00	$0.00
Roads and Highways	14.76	$0.00	$0.00
Utilities	0.39	$0.00	$0.00
Electrical Power Transmission Lines	1.84	$0.00	$0.00

TABLE 2 TEV for the Study Area in 2013 Dollars Ordered by Total Amount (not including privacy screening value of mangroves)

Mangrove Ecosystem Service	TEV Value in 2013 dollars per acre per year
1. Production of Oxygen	$254,809.24
2. Other Gas Regulation	$155.73
3. Net Primary Productivity	$5,134.25
4. Carbon Sequestration	$414.26
5. Local and Global Climate Regulation	$118.72
6. Disturbance Regulation	$1,080.64
7. Water Regulation	$39.48
8. Potable Water Supply	$0.00
9. Erosion Control and Sediment Retention	$111.34
10. Protection against Floods, Hurricanes and Tidal Waves	$3,609.57
11. Soil Formation	$14.17
12. Storage and recycling of complex organic matter and trace nutrients like metals	$219.24
13. Waste Treatment and Nutrient Removal	$3,934.77
14. Pollination Services	$11.96
15. Biological Control	$6.81
16. Habitat and Refugia	$355.71
17. Biological Maintenance of Resilience	$239.79
18. Biophysical support to other coastal ecosystems	Already listed values for net primary production, storage and recycling of complex organic matter and trace nutrients like metals, and disturbance regulation
19. Commercial Fishery	$344.75
20. Recreational Fisheries	$2,085.74
21. Hunting	$0.00
22. Water Production	$0.00
23. Raw and Market Materials	$0.52
24. Genetic Resources	$8.97
25. Control of Disease	Not documentable
26. Recreational and Tourism Benefits	$6,371.46
27. Cultural and Spiritual Benefits	Captured in Recreation and Tourism
28. Privacy Screening	$26,000 for the Gordon

	River.
29. Habitat for Indigenous Cultures	**$0.00**
30. Heritage Values	**$0.00**
31. Artistic Inspiration	**In the absence of a reliable empirical method to place a value on artistic inspiration, a TEV has not been generated for this study.**
32. Educational and Scientific Information.	**$2.30**
Total TEV in 2013 dollars per acre per year	**$279,307.71**

TABLE 3 TEV for the Mangrove Habitat in 2013 Dollars per Acre per Year