Final Sustainability Benefits Methodology Report

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Purpose: The information and analysis contained in this report is intended for use when conducting an economic analysis for FEMA's grant programs. Any application outside of this intended purpose is not endorsed by FEMA.

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SECTION 1: BACKGROUND

The Benefit-Cost Analysis (BCA) Tool was developed by FEMA in the 1990s to determine the cost-effectiveness of proposed mitigation projects for their mitigation grant programs (FEMA, 2009). Since 2008, the tool has been updated based on stakeholder and user input and experience. The continuous improvement reflects new knowledge and a growing base of experience. Version 4 is the current version of the BCA Tool. This document details the additional benefits slated for Version 5.

The Tool provides guidelines, methodologies, and software modules for a range of major natural hazards, including:

- Flood (Riverine, Coastal Zone A, Coastal Zone V)
- Hurricane Wind
- Damage-Frequency Assessment
- Tornado Safe Room
- Earthquake
- Wildfire.

There are three sub-fields of sustainability benefits: economic, environmental, and social. Each of these areas is analyzed in this report.

A glossary, references, and a list of acronyms are included at the end of the report.

SECTION 2: PURPOSE

This document describes the process used to identify the methodology for including new sustainability benefits in the BCA Tool. Economic, environmental, and social sustainability benefits were analyzed separately with individual analysis reports, but have been compiled into this document. Even if a new benefit is applicable, it cannot be included in the BCA Tool if there is no data or sound methodology for determining an economic value. For this reason, this report details how (data sources and general methodology) each new benefit will be calculated in Version 5 of the BCA Tool. This report also explains why any of the initial potential sustainability benefits were not able to be incorporated into the tool at this time.

SECTION 3: DEFINITION OF SUSTAINABILITY BENEFITS

At its core, “sustainability” means that decisions made by the present generation will not reduce the options of future generations, but will pass on a natural, economic, and social environment that will provide a high quality of life[1]. Currently, there is no way to directly measure the sustainability benefits in economic values that a hazard mitigation project might provide. This is because sustainability can only be measured through environmental, social, and economic indicators that are applicable to mitigation projects and feasible for use in the BCA Tool.

To assess which sustainability indicators are applicable to hazard mitigation projects, a global list of indicators was developed. Indicators with no connection to hazard mitigation projects were removed. The following global list was compiled from the California Environmental Quality Act

[1] This was the definition established by the World Commission on Environment and Development (the Brundtland Commission) in 1987. It is generally regarded as the universal definition for sustainability.

questionnaire[2], Ventura County Sustainability Report[3], and the State of Maryland Genuine Progress Indicator[4].

Global List of Sustainability Indicators

1. Social Indicators

1.1. Health:
- Cost of physical injuries sustained during event
- Cost of psychological issues
- Cost of lost productive hours due to the above mentioned health issues
- Cost of lost leisure time (including time spent by volunteers)
- Cost of restoration of basic amenities like potable water, sanitation, gas and electricity.

1.2. Education:
- Cost of lost school hours
- Lost income for teachers and other school employees.

1.3. Safety:
- Cost of increased crime rate in communities
- Cost of increased domestic violence.

1.4. Social Services:
- Cost of increased social services
- Cost of increased long-term homelessness
- Cost of lost function of fire station and hospital.

2. Environmental indicators

2.1. Environmental quality:
- Cost of surface water pollution due to disaster
- Cost of potable water pollution
- Cost of increased air pollution
- Cost of increased noise pollution
- Cost of contaminated soil
- Cost of ocean contamination.

2.2. Natural habitat

2.3. Atmospheric change or Atmosphere:
- Cost of increased GHG (green house gases) and ozone depletion in the atmosphere.

2.4. Waste and Recycling:
- Cost of increased solid waste removal.

3. Economic Indicators

3.1. Housing:
- Cost of rebuilding home

[2] For more information, please visit: www.dot.ca.gov/ser/downloads/ceqa/CEQAchecklist.doc
[3] For more information, please visit: http://www.farmbureauvc.com/pdf_forms/StateoftheRegion.pdf
[4] For more information, please visit: http://www.green.maryland.gov/mdgpi

- Loss of rental income
- Cost of lost personal goods.

3.2. Transportation:
- Increased cost of commuting
- Cost of lost services of highways and streets
- Cost of increased automobile crashes
- Cost of lost or damaged public transportation and transportation systems
- Cost of transporting material to affected area.

3.3. Economy or Income:
- Loss of business
- Cost of lost productive hours
- Cost of lost revenue generating material
- Cost of unemployment.

3.4 Sustainable Construction:
- LEED Certified Building or similar construction standard
- Local Building code effectiveness.

The following sections provide the methodologies for the new sustainability benefits being added into the BCA Tool. They are divided into environmental, social, and economic indicators.

SECTION 4: ENVIRONMENTAL SUSTAINABILITY BENEFITS METHODOLOGIES

The feasible environmental benefits can be divided into two general classes:

1. Land use change; and
2. Non-land use change.

Land use change benefits occur when a hazard mitigation project changes the land use to one that provides more "ecosystem services" (Daily, 1997, Costanza, 1997) than the previous land use. Therefore, this term will be used synonymously with the land use change environmental benefits in this report. Simply put, ecosystem services combine economics and the environment. An example of a land use change from a hazard mitigation project would be a floodplain acquisition project that converts an urban/suburban developed land use to green open space, and as result improves water quality, infiltration, and habitat. Additionally, instead of actively maintaining an acquired parcel, subapplicants have the option to let the floodprone property revert back to native floodplain use, which could include additional environmental benefits attributed to wetland or riparian land use types.

Environmental benefits can also accrue to hazard mitigation projects outside of any land use change. For example, a mitigation project might prevent the need for solid waste debris to be taken to a landfill.

This section provides a more detailed discussion of how each feasible new environmental benefit will be incorporated into each BCA Tool module, as shown in Table 1.

Land Use Change Environmental Benefits

Appendix A shows the spreadsheet containing the research values that have been completed to date, which includes a total economic value per acre for each land use. Appendix B provides the justification documentation for each value shown in Appendix A.

Table 1: Additional Environmental Benefits per BCA Tool Module

BCA Module	Land Use	Air Quality	Debris Removal
Full Data Flood	Y	N	Y
Damage Frequency Assessment	Y	Y	Y
Hurricane Wind	N	N	N
Tornado/Hurricane Safe Room	N	N	N
Wildfire	N	N	N
Earthquake Structural	N	N	Y
Earthquake Nonstructural	N	N	Y

Appendix A also demonstrates that state-specific ecosystem services values are possible, as demonstrated by the "Hurricane Storm Hazard Risk Reduction" values in the Wetlands land use type. As provided from the source research, these values will be possible for projects within 100 kilometers of the coast. This means that a separate layer of benefits will be needed that will apply this hurricane wetlands value to acquisition projects within this 100 kilometer coastal buffer area.

In the BCA Tool, a new "Environmental Benefits" page will be added for acquisition/demolition, acquisition/relocation, and minor localized flood reduction projects. These project types are available for the Flood and Damage-Frequency Assessment (DFA) module. Because all ecosystem services are valued on a per-acre basis, users will be required to answer a new question of the size of the parcel being mitigated. Many urban parcels are a fraction of an acre while more rural properties or special-use land uses like mobile home parks might constitute several acres. Ecosystem services values for detention basins will be calculated on the total acreage of the permanent pool created. If there is no permanent pool created by the project, no environmental benefits would accrue to the land use change.

Depending on the project type, the user will be asked the following questions:

- Acquisition/demolition and acquisition/relocation projects:
  - ➢ What will the acquired land be used for after the project is finished?
    The user will then be asked to check one box for:
    - ❒ Green Open Space
    - ❒ Riparian Area
    - ❒ Wetland
    - ❒ Agriculture.

Depending on the selected answer above, the total acres of the project will be multiplied by the green open space, wetland, or agriculture total ecosystem services value given in Appendix A.

- Minor localized flood reduction projects:
  - ➢ How large is the pool of the detention basin (in acres)?

The answer to the acreage question will be multiplied by the Wetlands total ecosystem service value per acre, as provided in Appendix A.

Non-land Use Change Environmental Benefits

The values and methodologies for each non-land use environmental benefit are provided in this section, along with the procedure for how the values will be added in the BCA Tool.

Air Quality

A hazard mitigation project that prevents additional travel detour time can claim an additional benefit of reduced greenhouse gases. Since the BCA for roads can only be performed in the DFA module, air quality costs avoided will be added as a standard default to the cost per mile for road detours.

The standard value is two cents per mile and was determined according to methodology:

$$EG_C = [(Cg * Gg) + (Cd * Gd)]/M * SCC$$

Where EG_C = Environmental Cost of Carbon per mile

Cg = Weight carbon per volume for gasoline (grams/gal)
Gg = Volume of gasoline consumed (gal)
Cd = Weight carbon per gallon for diesel (grams/gal)
Gd = Volume of diesel consumed (gal)
M = Distance driven (mile)
SCC = Social cost or carbon per unit weight ($/metric ton)

According to 2009 data from the Federal Highway Administration, Office of Highway Policy Information[5], the total number of miles driven in 2009 was 2.9966 trillion, which is broken out into 133.366 billion gallons of gasoline and 35.3303 billion gallons of diesel. This means the total fuel purchased 168.6963 billion gallons. Dividing this value into the 2.9966 trillion miles driven yields an actual driven miles per gallon driven value of 17.76.

The amount of carbon in gallon is 8,887 grams for gasoline and 10,180 grams for diesel[6]. Because many more gasoline-powered miles were driven, a weighted by the number of miles driven is necessary.

The formula would look like this: [(# gasoline gallons * 8,887) + (# diesel gallons * 10,180)]/total fuel gallons = 9,160 grams per gallon. The social cost of carbon value is expressed in cost per metric ton: 9,160 grams = 0.00916 metric tons. The value 0.00916 metric tons per gallon divided by 17.76 mpg = 0.000916 metric tons per mile, and is the quantity of carbon released into the air per mile of travel.

The social cost of carbon (SCC) is the marginal cost of emitting extra carbon as carbon dioxide. There are wide ranges in SCC values because this is a relatively new economic concept and because there are uncertainties in the models that compute carbon's impact on the global environment (IPCC, 2007). Under the Obama administration, an Interagency Working Group on Social Cost of Carbon (IWG) was formed in 2009 to estimate SCC values for regulatory analyses. Their research provided a range of values to choose from: $5, $21, $35 and $65 and they ultimately selected a central value of $21 at a 3% discount rate (IWG, 2010).

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[5] http://www.fhwa.dot.gov/policyinformation/statistics/2009/vm1.cfm
[6] http://www.epa.gov/otaq/climate/documents/420f11041.pdf

This value has been questioned as being too low, ranging from the choice of the models used and the lack of clarity on certain decisions made during the value selection process to an incorrect choice of discount rate (Ackerman, 2010). Ackerman's article provided additional completed independent research to determine the Social Cost of Carbon value, taking into consideration essential factors he and his coauthors saw as missing in original research done by the IWG. According to their research, the Social Cost of Carbon value can range from $28 to $893. Additionally, research conducted by the government of the United Kingdom in 2009 generated a different set of values ranging from $41 to $124 per ton of carbon dioxide with a central value of $83.15. The U.K. analysis used very different assumptions, including a lower discount rate (Greenspan, et. al., 2011).

Because the IWG values are already in use by some federal agencies, it is prudent to continue using them. However, because the SCC is a global issue and not limited to the U.S., it is also advisable to consider the methodologies used by other countries. A compromise value would meld the IWG value at a lower discount rate of 2.5% instead of 3%. This means that the SCC value for use in the BCA Tool will be $36 for 2012, which is derived from the 2010 2.5% discount rate value of $35.

Multiplying .000516 by $36 provides the environmental cost of carbon in dollars per gallon. The value is $0.02 per mile. This value will be added to the cost per mile for detour time in the DFA module.

Debris Removal Costs

Regardless of the hazard type or BCA module, the cost of solid waste removal depends on two variables: debris quantity and the cost of haulage.

Cost of Haulage

The cost of waste haulage is determined by two factors: distance of haulage and the landfill costs. The distance variable will be different for each location, so that cannot be considered for a default value. However, it should be noted that a reduced or eliminated need for debris haulage does provide benefits for reduced emissions and fuel usage for large trucks. These environmental benefits could not be assessed for this report due to the known distance variable.

Landfill costs are determined by "tipping fees" (also called "gate fees") charged by landfill operators for the unloading of waste at their facility. Tipping fees are typically charged in dollars per ton, which means that any quantity of debris used in the BCA Tool must be converted to a value in tons. Because tipping fees help pay for the waste facility's eventual closing, more populated areas like New England have higher fees due to limited future availability of new landfill space.

The National Solid Wastes Management Association commissioned a report to study the tipping fee rates for 800 privately owned or operated municipal solid waste landfills and 120 incinerators around the country (Repa, 2005). The NSWMA report examined the history of annual tipping fees for seven regions (including a national average) from 1985 to 2004.

The study shows that tipping fees rose every year from 1985 to 1995, but have remained roughly unchanged to slightly higher from 1995 to 2004. To test the validity of the values in current dollars, random locations were selected around the country and an internet search completed for tipping fees in county landfills. The result showed that the published rates in the 2004 study are still very close to actual rates; therefore, no inflation value is needed.

For all modules, the tipping fees for each State are default values taken from the NSWMA publication (Repa, 2005), as shown in Table 2.

Table 2: Tipping Fees by Region

Region	Cost per ton	States
Northeast	$70.53	CT, ME, MA, NH, NY, RI, VT
Mid-Atlantic	$46.29	DE, MD, NJ, PA, VA, WV
South	$30.97	AL, FL, GA, KY, MS, NC, SC, TN
Midwest	$34.96	IL, IN, IA, MI, MN, MO, OH, WI
South Central	$24.06	AZ, AR, LA, NM, OK, TX
West Central	$24.13	CO, KS, MT, NE, ND, SD, UT, WY
West	$37.74	AK, CA, HI, ID, NV, OR, WA
National Average	**$34.29**	

Debris Quantity

While the cost of haulage will change depending on the State, the debris quantity values change depending on the BCA module, as detailed in the following sections.

<u>Flood</u>

For the Flood module, the quantity of debris will be determined by the information in FEMA Publication 329 (FEMA, 2010a). The quantity of personal property brought to the curb by the property owner for disposal is shown in Table 3. The conversion to tons from cubic yards comes from FEMA 329, which recommends four cubic yards per ton for mixed debris.

Table 3: Quantity of Debris in Cubic Yards and Tons (Residences only)

Type of Residence	Debris (cubic yards)	Debris (tons)
Residences Without Basement	27.5	6.875
Residences With Basement	47.5	11.875
Destroyed Mobile Home (Single-wide)	290	72.5
Destroyed Mobile Home (Double-wide)	415	103.75

The BCA Tool will be able to pull the user-input value for “with/without basement” to determine the correct basement figure above. To calculate the cost for debris removal, the BCA Tool will multiply the relevant tonnage value in Table 3 by the tipping fee for the relevant state from Table 2. For mobile homes, the standard value will be for a single-wide mobile home with a user override option to increase the value to double-wide with documentation.

The computed debris removal cost will be added as a new category in the depth damage functions for any flood depth that has a computed value for building and contents damage.

Damage Frequency Assessment (<u>DFA)</u>

The user has two choices when adding debris removal costs in the DFA module:

1. Provide documented actual expenses for debris removal and associate those costs with an historic flood event in the BCA Tool
2. For residential flood mitigation projects, calculate the debris removal cost for an historic flood event by multiplying the relevant state tipping fee and tonnage of debris in Tables 2 and 3. Then the user would associate this cost with the historic flood event in the BCA Tool.

Earthquake - Structural

The quantity of debris will be calculated by the BCA Tool as a default value according to the relevant "Model Building Type" value in Appendix C. The calculation steps are as follows:

1. The debris quantity value is taken from Appendix C.
2. Multiply the Step 1 value by the default haulage cost value for the relevant State in Table 2.
3. Because the values in Appendix C are in tons per 1,000 square feet, the tool must then divide the square foot user-input value for the structure by 1,000 and multiply this value by the value from Step 2.

Structural earthquake debris removal costs will be added as a new environmental loss avoided with no additional user entry required.

Earthquake – Nonstructural

The cost to remove nonstructural debris will be calculated according to the same general methodology as the "Earthquake – Structural". However, there is no Model Building Type data entry field in the seismic nonstructural module of the BCA Tool that would connect the structure to the debris quantity values provided in Appendix C.

The nonstructural earthquake debris quantity will be determined by dividing the "Fall or Failure Impact Area (sf)" user-input value by 1000 because the quantity of nonstructural debris provided in Appendix C is given in tons per 1000 sf. The debris quantity in tons will be determined by multiplying the area value by 4.65, which is the average value of 5.3 tons per 1000 sf for "Brick, Wood and Other" and 4.0 tons per 1000 sf for "Reinforced Concrete and Steel" construction types. This debris quantity will then be multiplied by the tipping fee for the relevant state, per Table 2.

In Appendix C, there are some model building types such as unreinforced masonry that have debris quantity values significantly higher than 4.65 tons per 1000 sf. For this reason, an override box will be available for the user to input a value according to Appendix C, with documentation.

This debris removal cost calculation is available for the earthquake nonstructural mitigation project options which have an area value associated with them. This means this methodology is feasible for the following general project types in the BCA Tool using the input value listed for each:

- Ceiling – suspended or dropped: Number of square feet of ceiling
- Electrical cabinets: Area affected by falling cabinets (sf)
- Fire sprinkler systems: Portion of building containing sprinklers only (square feet)
- Generators: Fall or failure impact area (sf)
- Generic contents and equipment: Fall or failure impact area (sf)
- Racks and shelves: Fall or failure impact area (sf).

The following mitigation project options function based on an economic cost per unit or linear foot instead of area, and is therefore not feasible for this methodology:

- Elevators
- HVAC fans
- HVAC ductwork
- Parapet walls and chimneys.

For mitigation projects that will benefit these four project types, instead of the methodology outlined above, a square footage input will be added that will be completed by the user. The debris removal cost calculation will then follow the same process outlined above by dividing the user-input value by 1000 and multiplying the result by tipping fee for the relevant State provided in Table 2.

SECTION 5: EXCLUDED ENVIRONMENTAL SUSTAINABILITY BENEFITS

Table 4 provides a list and brief explanation for why some of the identified potential environmental benefits from the global list of sustainability indicators could not added to the BCA Tool at this time.

Table 4: Excluded Environmental Sustainability Benefits

Potential Benefit	Reason for Exclusion
Cost of Surface Water Pollution	There is a FEMA standard value for the loss of function for wastewater services; however, there is an additional environmental cost when a wastewater treatment facility (WWTF) is forced to bypass raw sewage into the receiving stream. Several methodological approaches were assessed for determining an economic value for sewage bypasses. The costs and discharges were found to be too highly-variable for a standard value. Instead, since mitigation projects to protect WWTFs will most likely be completed in the DFA module, subapplicants can use actual, documented costs for sewage bypasses from past flood events.
Cost of Potable Water Pollution	There is a FEMA standard value for the loss of function of a potable water source; however, there is currently no method to value the environmental impact on contamination to a drinking water source. Like Surface Water Pollution above, the loss of service for potable water is already a valid economic benefit for a hazard mitigation project. In the current DFA module, subapplicants can currently attribute additional expenses incurred for returning potable water to pre-disaster usability as long as the project will prevent the documented costs from similar flood events.
Cost of Increased Noise Pollution	It is possible to assign an economic value to noise pollution; however, there is no direct connection between noise pollution and hazard mitigation projects.
Cost of Contaminated Soil	FEMA mitigation funding is contingent upon the project area being free of contamination. This means that basic eligibility requirements prevent mitigation funding from being used on a project with contaminated soil. Furthermore, any project that would have a significant impact on large areas of soil would most likely be found ineligible for FEMA mitigation funding on the grounds that it is a duplication of programs with other federal agencies.

Cost of Ocean Contamination	There are too many factors that could impact a mitigation project's effectiveness at improving ocean water quality. Even in situations where it might be applicable to a mitigation project, there will likely be spurious variables that make it difficult or impossible to judge whether water quality has improved specifically due to the completed project.

SECTION 6: SOCIAL SUSTAINABILITY BENEFITS METHODOLOGIES

The only social sustainability benefit that was found feasible from the Global List of Sustainability Indicators (Section 5) was Mental Stress and Anxiety. This new benefit is applicable for only the Flood, DFA, and Hurricane Wind BCA modules because the Wildfire, Tornado, and Earthquake modules already use a mental stress avoidance value in their value of a statistical life calculation.

Mental Stress and Anxiety

While there is a clear and definite connection between mental stress impacts and disasters, calculating an economic value for mental stress avoided because of a hazard mitigation project is more complex. There is extensive research on disaster-induced mental health problems – both for direct and indirect victims of disasters and to first responders – but few studies have sought to determine an economic cost. Complicating matters further is the fact that mental health issues can be classified as "major" and "mild or moderate", both of which can be tied to a natural hazard event as triggering the onset and have different effects on people.

Calculating an economic value for the impact of the onset of a mental illness caused by a natural hazard event requires a further subdivision into two separate costs: the cost of treatment and the cost of lost productivity.

Cost of Treatment

The cost of treatment value is further divided into two variables: prevalence and course.

Prevalence means the percentage of people we can reasonably expect to suffer from severe and mild/moderate mental health problems following a disaster. Assessing disaster-induced mental health prevalence is complex because it is more difficult to ascertain the affected population from a strong tornado impacting a metropolitan area, for example, than it is for a vehicle crash.

The American Red Cross (ARC) estimates that 30-40 percent of the impacted population will need some sort of mental health-related assistance (Welker, 2011), but this value is not divided into severe and non-severe mental illness categories. According to Galea's meta-analysis (2005), PTSD prevalence research has shown a range of 1 to 11 percent in excess of the prevalence rate expected of the general population. This value is corroborated by the research of Schoenbaum, et al (2009), which found that prevalence of major mental health issues following Hurricane Katrina and Hurricane Rita was 6% and mild/moderate mental health issues was 26%. Combined, the total morbidity rate of 32% fits with the ARC estimate of 30-40%.

Course refers to the rate of reduction of mental illness symptoms over time. Some individuals are able to seek professional help with their mental health issues, while for others the impact of the trigger event naturally fades away with time. Due to the debilitating nature of severe mental illness, the course for major mental health problems tends to be impacted less by treatment and intervention, and is slower to decline than mild or moderate disorders. Mild and moderate mental illnesses tend to have higher post-disaster prevalence rates and a course that declines more quickly from treatment or natural healing.

Schoenbaum (2009) provides the expected recovery rates for a population of severe mental health problems and mild/moderate mental health problems following a disaster. Because the research for this article seeks to assess the impact on post-disaster mental health prevalence if an "ideal" mental health program were implemented, the current expectations or "status quo" data for recovery rates should be considered. A limitation of the research is that this study ends after 25-30 months from the disaster event while mental health effects, especially for severe mental illnesses, can linger longer than 30 months and possibly an entire lifetime. However, these prevalence and course rates should be considered representative for all disasters, regardless of size (Schoenbaum, 2012) and are given in Table 5.

Table 5: Mental Health Prevalence Percentages for Severe and Mild/Moderate Illnesses with Effect of Course

Time after Disaster	Severe	Mild/Moderate
7-12 months	6%	26%
13-18 months	7%	19%
19-24 months	7%	14%
25-30 months	6%	9%

The best source found for the cost of mental health treatment expenses following a disaster is from Schoenbaum (2009). However, because the treatment costs included in the article are for an 'ideal' mental health program, the costs must be adjusted to reflect the fact that only a certain percentage of persons afflicted with a mental illness will seek treatment and a certain percentage of those seeking treatment will receive effective, or "minimally adequate" care. According to Wang, et al (2005), 58.9% of people with need will not seek treatment. Of the remaining 41.1% , 39% (or 16% of the total population) will receive inadequate care while 61% (25.1% of total) will receive minimally adequate care. However, the total treatment cost will be the calculated as the summation of the treatment cost for the percentage of population that received care – regardless of effectiveness. This means that the cost of treatment can be calculated as the cost, multiplied by the prevalence for each time period shown above in Table 5.

Appendix D shows the calculation for the mental stress and anxiety treatment costs at 7-12 months that assumes the 6% prevalence for severe mental health illness and 26% for mild/moderate illness taken from Table 5. The severe illness treatment cost totals $198.47 and the mild/moderate illness treatment cost totals $623.63 for a total treatment cost of $822.10 per person. Table 6 updates Table 5 with economic values first by assuming the longest duration for "Time after Disaster" variable (for example, instead of 7-12 months for the first time, 12 months is used) and by recalculating the spreadsheet in Appendix D with the associated prevalence rate for each time duration.

Table 6: Mental Health Costs for Severe and Mild/Moderate Illnesses with Effect of Prevalence and Course

Time after Disaster	Severe	Mild/Moderate	Total per Person
12 months	$198.47	$623.63	$822.10
18 months	$231.55	$407.76	$639.31
24 months	$231.55	$335.80	$567.35
30 months	$197.47	$215.87	$414.34
Total Treatment Costs			**$2,443.10**

Cost of Lost Productivity

In all researched sources, the cost of lost productivity greatly outweighs the cost of treatment. Therefore, a test of the methodology will be whether productivity losses are greater than the treatment cost. Several studies have been completed to analyze the impact of severe mental health illness on productivity. Although mild or moderate mental illness almost surely has an impact on productivity, no reliable sources could be found to document an economic value.

A study by Insel (2009) states that 7.6 days of healthy life are lost for each person in the population each year and that those who suffer from a serious mental illness were found to have lower individual earnings by $16,306 (2003 dollars) per year versus those without such a mental illness. Nationwide, according to Insel, this represents an annual reduction of $193.2 billion in reduced earnings associated with mental illness. Dividing $16,306 by 12 yields a monthly average productivity loss of $1,358.83 – or $1,681 per month in 2012 dollars.

Another study by Levinson, et al (2010) completed research for 19 countries to associate serious mental illness with earnings using the World Health Organization's World Mental Health Surveys. For the United States, the findings determined that individuals with mental health illness see a 25.5% reduction in earnings. Using the FEMA standard value for the Value of Lost Time of $30.07[7], multiplying $30.07 by .255 yields an hourly figure of $7.67 and multiplying this value by 6.9 hours per day[8] produces a daily value of $52.91, or $1,600 per month.

The Insel and Levinson sources were chosen because they both represent recent research and contain fewer research assumptions and calculations than other sources. Therefore, $1,600 per month will be used for the cost of lost productivity and will be subject to the same prevalence rates cited above for the treatment costs.

The Lost Productivity values in Table 7 are calculated as follows:

1. Productivity Loss is $1,600 per month, multiplied by the Time after Disaster value.

[7] The Value of Lost Time is provided by the Total Employer Costs for Employee Compensation (ECEC), a product of the National Compensation Survey of the U.S, Department of Labor, Bureau of Labor Statistics.
[8] The U.S. Department of Labor estimates that the Average Work Week for February 2012 is 34.5 hours – or 6.9 hours per day.

2. Prevalence Rate values come from the "Severe" values of Table 5.
3. Productivity Loss with Prevalence is the productivity loss multiplied by prevalence rate.
4. The total of all the Productivity Loss with Prevalence values is the proposed value for Lost Productivity.

Table 7: Productivity Loss due to Severe Mental Illness

Time after Disaster	Productivity Loss	Prevalence Rate	Productivity Loss per Worker
12 months	$19,200	6%	$1,152
18 months	$28,800	7%	$2,016
24 months	$38,400	7%	$2,688
30 months	$48,000	6%	$2,880
Total Productivity Loss			**$8,736**

In the BCA Tool, the Treatment Cost value will be multiplied by the user-input value for the number of people in the household. The Lost Productivity value will be multiplied by the number of wage earners in the residence. If there is only one person in the residence, the Tool will calculate the Lost Productivity value for one wage earner. For any value higher than one for the number of people in the residence, the value will be determined by multiplying the Productivity Loss by the average number of workers per household. According to the 2010 American Community Survey 1-Year Estimates, this is 1.18 workers[9]. Users should be given the opportunity to override this value if the number of workers in the residence is known to be two or more.

SECTION 7: EXCLUDED SOCIAL SUSTAINABILITY BENEFITS

Table 8 provides a list and brief explanation for why some of the identified potential social sustainability benefits from the global list of sustainability indicators could not added to the BCA Tool at this time.

Table 8: Excluded Social Sustainability Benefits

Potential Benefit	Reason for Exclusion
Physical Injuries	This is an eligible project benefit in the current BCA methodology if the mitigation project will reduce or eliminate these costs.
Lost Leisure Time	This is an eligible project benefit in the current BCA methodology as the "opportunity cost of lost time".
Restoration of Basic Amenities	This potential economic benefit includes service for potable water,

[9] Source: 2010 American Community Survey 1-Year Estimates
http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_10_1YR_S0501&prodType=table

	sanitation, gas, and electricity. The current BCA Tool allows for a loss of service for water, wastewater, and utilities, but does not provide default values for additional expenses to restore service like flushing contaminated pipes or to install and use of pumping equipment. As long as a mitigation project would prevent these and similar post-event service restoration activities, the costs would be applicable for use in the existing BCA Tool (with adequate documentation).
Lost School Hours	There is no available data that would provide a reliable and defensible method for estimating how to calculate the economic value of a school hour. Additionally, most communities are able to find alternative locations for temporary schoolrooms after a disaster event.
Lost Income for School Employees	This indicator is already considered in the BCA Tool for calculations that consider the annual budget in calculations of loss of function for schools.
Increased Crime in Communities	This is an eligible project benefit in the current BCA methodology if the mitigation project will reduce or eliminate these costs.
Increased Domestic Violence	A natural hazard event is stressful for all parties impacted. While it may be possible to measure the impact on mental health, assessing the impact specifically on levels of domestic violence adds unpredictable variables related to human behavior. No research could be found that provided an economic cost for increased domestic violence specifically after a natural hazard event. Because of these uncertainties, it is not possible to determine a standard economic value at this time.
Increased Social Services	It is likely that there is a measurable increase in the need for social services following a disaster. However, "social services" is a broad term related to education, food subsidies, health care, and subsidized housing to improve the life and living conditions of the children, disabled, elderly, and the poor. It is questionable whether some of these services could be impacted by a mitigation project. Additionally, some social services could duplicate existing benefits such as residential displacement costs. A narrower definition of social services would be needed for consideration as an applicable economic sustainability benefit.
Increased Long-Term Homelessness	No research could be found that relates natural hazard impacts to long-term homelessness. Short-term homelessness (or "displacement costs") is an included benefit in the existing BCA Tool.
Lost Function of Fire Station and Hospital	This is an eligible project benefit in the current BCA methodology if the mitigation project will reduce or eliminate these costs.

SECTION 8: ECONOMIC SUSTAINABILITY BENEFITS METHODOLOGIES

To be useful in a benefit cost analysis, all of a project's losses avoided must be expressed in terms of dollar values; however, there is a difference between economic values and economic sustainability. All inputs in a BCA must have an economic value, but economic sustainability also measures whether inputs in an economy are sustainable. For example, an economy that depends on overuse of a limited resource is destined to fail when that resource is exhausted.

Because economic benefits are currently considered in the BCA Tool, they must be considered automatically applicable. However, there are new economic sustainability benefits to include.

Reconstruction and Repair Costs

Reconstruction and repair costs are included in the current BCA Tool as the "building replacement value," or BRV. However, an economic value that is not currently considered in the Tool is the increased cost to repair an historic structure. Historic structures are typically more highly-valued than an equivalent non-historic building because of a preference for preserving historical heritage, pride, and a community's sense of place. Historic structures are also more expensive to repair because all materials and repair techniques must also conform to the historic nature of the building. The subapplicant may or may not have factored in the increased costs to mitigate risk for historic structures. The current BCA methodology requires an average cost per square foot for equivalent construction. Therefore, if this cost per square foot value does not include consideration for the structure's historic nature, there are no economic benefits to offset the increased project costs.

Insurance industry research was completed to analyze the difference between historic and non-historic building replacement costs to see if a standard "historic multiplier" value could be applied. The research examined a "specific home analysis" for hypothetical structures constructed according to expected size, style, quality, construction, exterior, roof, and shape for homes built in 1920, 1880, and 1780. As shown in Appendix E, the analysis found a consistent historic multiplier value between 26 and 29% of the base value of the home. Because historic buildings can be lost due to fires, accidents, disasters, or other events, the current stock of historic buildings is likely to be valued more highly in the future than today. Therefore, a round number of 30% is proposed for the historic multiplier to be used in the BCA Tool and would apply to all project types in all BCA modules.

This new economic sustainability benefit will be added into the BCA Tool by tying the 30% historic property multiplier to the "Historic Structure" box in the "Add/Update Structure" menu. If the BCA Tool user checks this box, the "Value of Building (BRV)" value will automatically inflate by 30%. By checking this box, the user must be careful to verify that the "Value of Building (BRV)" does not already have the structure's historic nature considered or else it will double-count benefits.

Reduced Street Maintenance Costs

This proposed benefit is only applicable for flood acquisition or relocation projects that allow a community to remove or abandon certain lengths of road and associated infrastructure. Also, it would apply only to residential streets owned and maintained by the jurisdiction that is sponsoring the mitigation project.

No defensible standard value for the cost of street maintenance could be found. Instead, the appropriate method to calculate the cost per mile for street maintenance is to divide the street maintenance budget by the miles of street the community maintains to determine a cost per mile in that community for maintenance. Then this value would be multiplied by the length of road (in miles) that will be abandoned.

When determining the street maintenance budget values, acceptable budget line items include costs for maintenance materials for concrete and asphalt, sand and gravel, maintenance-related chemicals, crack sealing, seal coating, and related items. Street maintenance budget line items can also include equipment usage and contracted labor since many jurisdictions use contractors to complete at least a portion of their street maintenance. Budget line items should not include labor/personnel costs and related items because it is assumed that local street maintenance staff will remain employed, even with a reduced maintenance burden.

SECTION 9: EXCLUDED ECONOMIC SUSTAINABILITY BENEFITS

Table 9 provides a list and brief explanation for why some of the identified potential economic sustainability benefits from the global list of sustainability indicators could not added to the BCA Tool at this time.

Table 9: Excluded Economic Sustainability Benefits

Potential Benefit	Reason for Exclusion
Loss of Rental Income	This is an eligible project benefit in the current BCA methodology if the mitigation project will reduce or eliminate these costs.
Loss of Personal Goods	This indicator is currently used in the BCA Tool as the value of contents.
Increased Cost of Commuting	For mitigation projects that reduce or eliminate the need for traffic detours, this is currently an allowable benefit.
Lost Service of Highways and Streets	This is an eligible project benefit in the current BCA methodology if the mitigation project will reduce or eliminate the loss of function for the road.
Increased Automobile Crashes	There is a connection between vehicle crashes and natural disasters specifically for evacuations (hurricane and wildfire). Very few citations for evacuation-related deaths could be found. There is also a lack of connection between a mitigation project and the reduction of crashes since most eligible project types (FEMA, 2010) are for the protection of structures. Theoretically, the entire evacuation route away from the coastlines and wildfire areas could be viewed as major project and therefore ineligible for mitigation funding.
Lost or Damaged Transportation or Transportation Systems	Disaster-induced damage to public infrastructure is often addressed under FEMA's Public Assistance (PA) program. Mitigation can be completed within PA under certain conditions, but these projects are also eligible for hazard mitigation funding in non-disaster mitigation programs. The existing methodology in the BCA Tool is most often used to prevent road closures related to flood events, but this could be applied to other transportation systems for other hazards.
Material Transportation Costs to Affected Areas	Transportation costs will vary depending on the quantity and size of the material and distance of transportation. There are too many unpredictable variables for this to be considered an applicable or feasible project benefit
Loss of Business	The existing BCA methodology allows for loss of business benefits on a net revenue basis for non-residential displacement costs.
Loss of Productivity	Lost work hours would only be applicable for a mitigation project that prevents a long road detour, which is an eligible project benefit in the current BCA methodology.
Cost of Lost Revenue-Generating Material	Revenue generating material, such as food for a grocery store, is considered in the current BCA Tool as the value of contents in the non-residential displacement costs calculation.

Cost of Increased Unemployment	Business and employment are the central focus for important economic sustainability; however, OMB Circular A-94 prohibits this potential benefit with this language: *Employment or output multipliers that purport to measure the secondary effects of government expenditures on employment and output should not be included in measured social benefits or costs.*
Sustainable Construction	Current 'Green Construction' building codes do not provide additional hazard force resistance. This means that sustainable construction cannot currently be considered a direct project benefit. Like historic structures, there is an increased cost and societal preference for sustainable construction, but unlike historic structures, the insurance industry has not developed a way to determine a standard multiplier for an increased replacement cost. Sustainable construction should play a central role in any consideration of sustainability benefits. Perhaps a standard value will be possible in the future.
Local Building Code Effectiveness	Arguably the best mitigation is to make sure that structures are built according to codes that reduce risk exposure to wind, flood, wildfire, and earthquake hazards. However, the code itself does not reduce damages from natural hazards – that is a function of local building code enforcement. A community's Building Code Effectiveness Grading Scale (BCEGS®) rating is a defensible way to measure how well a structure will be built according to code in a community. There are several limitations that make it tenuous for including a community's BCEGS rating in the BCA Tool: 1. The BCEGS rating is copyrighted by the Insurance Services Office and is not publicly-available. Instead, the rating would have to be provided by the community with proper supporting documentation. 2. A BCEGS rating must be requested by the community and are therefore not all communities will have one. 3. Because the BCEGS rating is an index value from one to ten, there is a question about how to convert a rating into an economic value for use in the BCA Tool. This would require additional analysis and subject matter expert assistance.
Floodplain Management	For all flood mitigation projects, the subapplicant's Community Rating System (CRS) rating is an objective measure for a community's sustainability specifically related to its flood hazard. However, like the BCEGS® rating, a community's CRS rating is an index value from one to ten and would require additional analysis and subject matter expert input to translate into economic values.

Table 10 provides an overview of the new sustainability benefits will be incorporated into each BCA Tool module.

Table 10: New Sustainability Benefits Changes per BCA Tool Module

BCA Module	SOCIAL		ENVIRONMENTAL			ECONOMIC	
	Mental Stress & Anxiety	Lost Productivity	Land Use Change	Air Quality	Waste Removal	Reconstruction & Repair	Reduced Street Maintenance
Full Data Flood	X	X	X		X	X	
Damage Frequency Assessment	X		X	X	X	X	X
Hurricane Wind	X	X				X	
Tornado/Hurricane Safe Room							
Wildfire						X	
Earthquake Structural					X	X	
Earthquake Nonstructural					X	X	

SECTION 10: CONCLUSIONS AND RECOMMENDATIONS

Throughout the analysis for this report, several areas were noted that could represent additional research or study. As a relatively new general field of national importance, sustainability has experienced a rapid growth in research, development, and interest over the last two decades. Current gaps in understanding are likely to be filled with definitive answers in the future. There is also a higher likelihood that standards for sustainability will be developed in a way that can be measured easily. Until that day, here are some specific areas that could benefit from additional research or professional input that were mentioned in the report.

Additional Research

Some work that is in progress but not yet to the stage of being released or applied may be beneficial for measuring a community's resiliency to natural hazards. Additionally, a value for the Social Cost of Carbon is likely to be reviewed and implemented differently in the future. Also, as sustainable or green construction becomes more common in building preferences, it is more likely that the insurance sector will be able to calculate a building replacement cost multiplier for it and maybe the green construction building code will include building performance measures that will make structures more hazard-resistant. Additional values for the ecosystem services boxes in Appendix A could be researched to allow a more complete economic value for different land use types.

In this report, sustainability indicators that were applicable but not determined to be feasible could be studied further. This would include street abandonment and surface water contamination. Since jobs and economic development are so critical to a sustainable local economy, additional study could also determine if there is a way to calculate an economic value for unemployment avoided that would be acceptable within OMB guidelines.

Subject Matter Expert Input

There were also several areas of concentration identified in this report that were beyond the scope of including as a potential sustainability benefit because of their specificity. For example, green infrastructure is a burgeoning area of stormwater management research and development of its own that could be shown to provide additional environmental, economic, or social benefits outside of the traditional losses avoided. Subject matter experts would need to be convened to determine how to value green infrastructure benefits at a project level. There is also no easy way for BCEGS and CRS ratings to be transposed from ordinal rating numbers into justifiable and defensible economic values for use in the BCA Tool. A panel of building code and floodplain management experts would be needed. Additionally, a panel of mental health experts could define a different methodology to calculate an economic value for stress and anxiety and the associated loss of productivity. Finally, a methodology for developing debris removal costs could be developed for hurricane wind and wildfire mitigation projects and for non-residential buildings with the assistance of subject matter experts.

GLOSSARY

Acquisition/Demolition: A mitigation project in which an asset, usually a building, is purchased by the federal, state, or local government and, combined with structure demolition, eliminates future damage completely by removing the building from the flood hazard area.

Acquisition/Relocation: A project in which an asset, usually a building, is purchased by the federal, state, or local government and, combined with relocation, eliminates future damage completely by removing the building from the flood hazard area.

Benefit-Cost Analysis (BCA): An approach to making economic decisions which appraises the benefits and costs for a project, program, or policy proposal.

Benefit-Cost Analysis (BCA) Tool: The program created by FEMA that is used to demonstrate the cost-effectiveness of a hazard mitigation project, as required by regulations from the Office of Management and Budget (OMB).

Building replacement value (BRV): The cost to replace the part or entirety of a building that is damaged (without depreciation).

Debris removal cost: The cost of the clearance, pick up, hauling, processing, and disposal of all manner of debris generated by the declared event on public or private property. This cost includes woody debris, sand and gravel, components of buildings or other structures, and hazardous materials.

Defensible space: An area, either natural or manmade, where material capable of allowing a fire to spread unchecked has been treated, cleared, or modified to slow the rate and intensity of an advancing wildfire and to create an area for fire-suppression operations to occur.

Depth-damage function (DDF): The relationship of the amount of flooding inside a building to the amount of damage.

Elevation project: Flood mitigation project in which the first floor elevation of a building is raised above the level of the flood hazard.

Eligible Project Types: Projects which are eligible for FEMA mitigation funding. There are 14 generally-recognized eligible project types, some with additional sub-project types such as three different wildfire mitigation techniques within the larger wildfire mitigation project type. For more information, see Section D.1.1 of the FY10 Hazard Mitigation Assistance Program Guidance.

Emergency protective measures: Actions taken by a community to warn residents, reduce the disaster damage, ensure the continuation of essential public services, and protect lives and public health or safety. The measures include sheltering and subsistence, cleanup costs and emergency response efforts.

Emergency response services: Services provided by fire, police, emergency medical services (EMS), and the other public, nongovernmental, and private entities during and immediately following a disaster. The services include:

- Providing security in a disaster area, warning residents, and setting up barricades
- Boarding windows and doors and covering roofs
- Restoring accesses to roads and buildings
- Providing search and rescue
- Providing EMS.

Floodplain and wetland protection: A floodplain or wetland is an area of land whose soil is saturated with moisture either permanently or seasonally. Floodplain and wetland protection refers to projects that maintain or enhance the public benefit provided by wetlands through functions such as water quality improvement, flood control, and biodiversity.

Floodproofing: A flood mitigation technique applied physically sealing a building and preventing floodwater from entering.

Green Infrastructure: An adaptable term used to describe an array of products, technologies, and practices that use natural systems – or engineered systems that mimic natural processes – to enhance overall environmental quality and provide utility services. As a general principal, Green Infrastructure techniques use soils and vegetation to infiltrate, evapotranspirate, and/or recycle stormwater runoff.

Hazard Event: A natural hazard occurrence like a flood, earthquake, hurricane, tornado, wildfire, or ice storm.

Hazard Mitigation: Any sustained action taken to reduce or eliminate long-term risk to people and their property from hazards.

Hazardous fuels reduction: A type of "fuel modification" project whereby a natural or manmade change is made to the vegetative fuel characteristics that affect the fire behavior so that fires burning into them can be more readily controlled.

HAZUS®MH: A standardized methodology that contains models for estimating potential losses from earthquakes, floods, and hurricanes. HAZUS Multi-Hazard uses Geographic Information Systems (GIS) technology to estimate physical, economic, and social impacts of disasters.

Historic and cultural heritage preservation: Historic and cultural heritage is the legacy of physical artifacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations. Physical or "tangible cultural heritage" includes buildings and historic places, monuments, and artifacts that are considered worthy of preservation.

Ignition-resistant construction: A type of building material that resists ignition or sustained flaming combustion sufficiently so as to reduce losses from wildland-urban interface conflagrations under worst-case weather and fuel conditions with wildfire exposure of burning embers and small flames.

Loss avoidance study (LAS): The implementation of a methodology to assess the performance of hazard mitigation projects based on the analysis of actual post-construction hazard events.

Loss of function: The economic impacts to an individual or community that occur when a facility is damaged, and the normal function of the facility is disrupted because of the hazard event. Loss-of-function damage can vary widely depending on the type of facility damaged.

Mental stress and anxiety: Chronic and acute emotional or psychological problems (including stress, exhaustion, nightmares, depression, and despair) that can develop from disasters.

Minor localized flood reduction projects: These projects may include the installation or modification of culverts and floodgates, minor floodwall systems that generally protect an individual structure or facility, stormwater management activities such as creating retention and detention basins, and the upgrade of culverts to bridges.

National Flood Insurance Program (NFIP): Created by Congress in the Flood Insurance Act of 1968, the NFIP provides flood insurance for structures and contents in communities that adopt and enforce a floodplain management ordinance, and identifies areas of high and low flood hazard and establishes flood insurance rates for structures inside each flood hazard area.

Natural and beneficial floodplain functions: Floodplain or wetland area that maintains or enhances environmental functions such as water quality improvement, flood control, and biodiversity.

Nontraditional fire suppression: Includes extinguishing fires, removing fuel sources, and evacuating people and property. However, nontraditional fire-suppression costs are incurred for additional damage caused by (1) fire following earthquake (i.e., structural or nonstructural earthquake damage causing a fire to a building) and (2) reduced fire suppression capability (i.e., a utility supplying water for fire suppression is out of service).

Other applicable benefits: Benefits that would accrue post disaster are not associated with emergency management costs and are not traditionally considered within the BCA tool.

Post-traumatic stress disorder (PTSD): A severe anxiety disorder that can develop after exposure to any event resulting in psychological trauma.

Recreational opportunities: Mitigation of some hazards may result in the protection of recreational sites or addition of open space for recreational uses.

Reduced insurance claim fees: Mitigation of hazards may reduce the need for flood insurance. A reduction in the need for flood insurance policies will result in a reduction in the claims made to the NFIP.

Reduced Project Worksheets costs: The mitigation of hazards will reduce the number of Project Worksheets that FEMA prepares for the Public Assistance Program following an event that the President declared a disaster.

Safe room: A safe room that meets the FEMA 361 and/or FEMA 320 criteria provides near-absolute protection for occupants during an extreme wind event.

Social Cost of Carbon (SCC): The marginal cost of emitting extra carbon (as carbon dioxide).

Transaction costs: Cost incurred in making an economic exchange. With regards to flood insurance, transaction costs include all of the material and labor costs associated with preparing an insurance claim or project worksheet.

Transfer payment: One-way payment of money for which no money, good, or service is received in exchange. Governments use such payments as means of income redistribution by giving out money under social welfare programs such as social security, old age or disability pensions, student grants, and unemployment compensation.

Volunteers and nongovernmental organizations (NGOs): Volunteers and NGOs perform many critical tasks in disaster response efforts. Well-known NGOs who provide services to disaster victims are the American Red Cross and the Salvation Army. Volunteers provide the majority of labor used by NGOs when offering disaster assistance. Often, these organizations shelter and/or feed these volunteers during their service.

Wildland: An area where development is essentially nonexistent, except for roads, railroads, power lines, or similar facilities.

Wildland-urban interface area: The geographical area where structures and other human development meet or intermingle with wildland or vegetative fuels.

ACRONYMS

BCA
Benefit-Cost Analysis

BRV
Building Replacement Value

DDF
Depth Damage Function

FEMA
Federal Emergency Management Agency

GSA
General Services Administration

LAS
Loss Avoidance Study

ICC
Increased Cost of Compliance

NFIP
National Flood Insurance Program

NGO
Nongovernmental Organization

PA
Public Assistance

PW
Project Worksheet

SCC
Social Cost of Carbon

USDA
U.S. Department of Agriculture

REFERENCES

Ackerman, Frank and Stanton, Elizabeth A. 2010. The Social Cost of Carbon: A Report for the Economics for Equity and the Environment Network. http://www.e3network.org/papers/SocialCostOfCarbon_SEI_20100401.pdf

Costanza, Robert, Ralph d'Arge, Rudolf De Groot, Stephen Farber, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Naeem, Robert V O'Neill, Jose Paruelo, Robert G Raskin, Paul Sutton, and Marjan Van Den Belt. 1997. "The Value of the World's Ecosystem Services and Natural Capital," Nature, Vol. 387, Issue: 6630: 253-260

Daily, Gretchen C., Nature's Services, Societal Dependence on Natural Ecosystems, Island Press, 1997.

Federal Emergency Management Agency (FEMA), 2008. NFIP Adjuster Fee Schedule. Available at: http://www.fema.gov/business/nfip/claimsadj.shtm Accessed Jan. 10, 2012.

-------- 2009. Final BCA Reference Guide. Available at: http://www.fema.gov/library/viewRecord.do?id=4830

-------- 2009a. Nontraditional Benefits: Methodology for Loss Avoidance Studies.

-------- 2009b. Multihazard Loss Estimation Methodology *Earthquake Model* HAZUS®*MH* MR4 Technical Manual. http://www.fema.gov/library/viewRecord.do?id=3731

-------- 2010. FY 2011 Hazard Mitigation Assistance (HMA) Unified Guidance. Available at: http://www.fema.gov/library/viewRecord.do?id=4225

-------- 2010a. Debris Estimating Field Guide (FEMA Publication 329). http://www.fema.gov/pdf/government/grant/pa/fema_329_debris_estimating.pdf

-------- 2011. *Additional Potential Benefits Analysis Final Report* Contract: HSFEHQ-10-D-0806, Task Order: HSFEHQ-10-J-1402

-------- 2011a. *Loss Avoidance Study: Riverine Flood Methodology Report, Version 2*.

-------- 2011b. National Flood Insurance Program Flood Insurance Manual. October 2011.

-------- 2011c. Correspondence with FEMA. November 2011.

Galea, Sandro; Nandi, Arijit Nandi; and Vlahov, David. 2005. *The Epidemiology of Post-Traumatic Stress Disorder after Disasters*. Epidemiologic Reviews, (July 2005) 27 (1): 78-91. http://epirev.oxfordjournals.org/content/27/1/78.full.pdf+html

Greenspan B, R. and Callan, D. 2011. *More than Meets the Eye: The social cost of carbon in U.S. climate policy, in plain English.* Washington, DC: Environmental Law Institute and World Resources Institute.

Insel, Thomas R., MD; Schoenbaum, Michael, PhD; Wang, Phillip S., MD, DrPH. 2009. Components of the Economic Burden of Serious Mental Illness in the U.S. *US Neurology Review - Touch Briefings*, v. 6, Issue 1.

IPCC (Intergovernmental Panel on Climate Change). 2007. IPCC Fourth Assessment Report: Climate Change 2007. http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch20s20-es.html

IWG (Interagency Working Group on Social Cost of Carbon). 2010. Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866.

Levinson, et al. 2010. Associations of Serious Mental Illness with Earnings: Results from the WHO World Mental Health Surveys. British Journal of Psychiatry. August; 197(2): 114–121.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2913273
See Table 4: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2913273/table/tbl4

Repa, Edward W, PhD. 2005. NSWMA's 2005 Tip Fee Survey. http://environmentalistseveryday.com/docs/Tipping-Fee-Bulletin-2005.pdf

Schoenbaum, Michael; Butler, Brittany; Kataoka, Sheryl; Norquist, Grayson; Springgate, Benjamin; Sullivan, Greer; Duan, Naihua; Kessler, Ronald; Wells, Kenneth. 2009. Promoting Mental Health Recovery After Hurricanes Katrina and Rita: What Can Be Done at What Cost. *Archives of General Psychiatry*, Vol. 66, #8, August 2009.

Schoenbaum, Michael. 2012. Personal interviews. Multiple dates.

Wang, Philip S., MD, DrPH; Lane, Michael, MS; Olfson, Mark, MD, MPH; Pincus, Harold A., MD; Wells, Kenneth B., MD, MPH; Kessler, Ronald C., PhD. 2005. Twelve-Month Use of Mental Health Services in the United States: Results from the National Comorbidity Survey Replication. *Archives of General Psychiatry*, v. 62, June.

Welker, Catherine. American Red Cross Liaison Officer to FEMA Headquarters Disaster Services. Personal correspondence, December 6, 2011.

APPENDIX A: ECOSYSTEM SERVICE VALUES FOR DIFFERENT LAND USES

Color Key	Significance
Green	Value Available in database or can be obtained
Orange	Value exists and can be calculated. Valuation study may exist
Gray	Land Cover does not provide this service
Yellow	Value exists, but no methodology exists for calculation. No study exists.

*= See additional tabs for state-specific values

Ecosystem Services	Wetlands	Green Open Space	Crops	Pasture	Forest	Riparian	Rural Housing
Provisioning Services (Goods)							
Food	$1,338.96					$609.44	
Fiber/Raw Materials	$560.72						
Fuel							
Water Supply	$218.57						
Regulating Services							
Hurricane Storm Hazard Risk Reduction	$3,982.70*						
Earthquake Risk Reduction							
Waste Reduction and Filtration/Water Quality	$731.21					$4,251.89	
Climate Regulation	$214.48	$13.19	$51.48		$395.23	$204.21	
Water Retention/Flood Hazard Risk Reduction	$5,335.30	$293.02				$4,007.01	
Fire Hazard Risk Reduction							
Air Quality		$204.47			$225.65	$215.06	

Ecosystem Services	Wetlands	Green Open Space	Crops	Pasture	Forest	Riparian	Rural Housing
Supporting Services							
Nutrient Cycling	$527.65						
Habitat	$164.07		$900.85			$835.41	
Biological Control			$14.29			$163.68	
Primary Productivity							
Erosion Control		$64.88	$127.14		$62.22	$11,447.30	
Soil Formation			$109.47				
Pollination		$290.08					
Cultural Services							
Recreation/Tourism	$483.57	$5,365.26				$15,178.07	
Scientific value							
Educational value							
Aesthetic values	$1,720.99	$1,622.37	$51.87			$580.87	
Spiritual/cultural							
Biodiversity	$113.12						
TOTAL Ecosystem Service Value	**$15,391.34***	**$7,853.27**	**$1,255.10**	**$0.00**	**$683.10**	**$37,492.94**	**$0.00**

(2011 USD per acre per year)

* Assumes the national value and no State-specific value is used for Hurricane Storm Hazard Risk Reduction

Ecosystem Services	Urban/ Suburban	Dunes and Beaches	Rivers and Lakes	Shrub	Estuary and Marine	Industrial Development
Provisioning Services (Goods)						
Food						
Fiber/Raw Materials						
Fuel						
Water Supply						
Regulating Services						
Hurricane Storm Hazard Risk Reduction						
Earthquake Risk Reduction						
Waste Reduction and Filtration/Water Quality						
Climate Regulation						
Water Retention/Flood Hazard Risk Reduction						
Fire Hazard Risk Reduction						
Air Quality						
Supporting Services						
Nutrient Cycling						
Habitat						
Biological Control						
Primary Productivity						
Erosion Control						
Soil Formation						
Pollination						

Ecosystem Services	Urban/ Suburban	Dunes and Beaches	Rivers and Lakes	Shrub	Estuary and Marine	Industrial Development
Cultural Services						
Recreation/Tourism						
Scientific value						
Educational value						
Aesthetic values						
Spiritual/cultural						
Biodiversity						
TOTAL Ecosystem Service Value (2011 USD per acre per year)						

Coastal Wetland Values by State

Ecosystem Services	National Average (nonzero)	AL	CT	DE	FL	GA	LA	ME	MA	MS
Regulating Services										
Storm Hazard Risk Reduction - Hurricane	$3,982.70	$3,854.27	$13,783.51	$123.70	$3,810.31	$481.74	$845.67	$372.40	$6,303.51	$1,120.00

	NH	NJ	NY	NC	PA	RI	SC	TX	VA
Storm Hazard Risk Reduction - Hurricane	$701.76	$523.95	$24,713.89	$4,603.42	$914.14	$3,500.63	$2,231.83	$5,979.37	$1,560.78

APPENDIX B: ECOSYSTEM SERVICE VALUE DOCUMENTATION

Values Summary

A summary of the researched values is provided in Table B1.

Table B1: Values Summary

Land Cover	Ecosystem Service	Ecosystem Service Value (2011 USD $/acre/year)
Wetlands	1) Hurricane Protection	$3,982.70 per acre per year (average – see state specific)
	2) Flood Hazard Reduction	$5,335.30 per acre per year
	3) Habitat Refugium	$164.07 per acre per year
	4) Food Provisioning	$1,338.96 per acre per year
	5) Water Supply	$218.57 per acre per year
	6) Water Filtration	$731.21 per acre per year
	7) Climate Regulation	$214.48 per acre per year
	8) Nutrient Cycling	$527.65 per acre per year
	9) Raw Materials	$560.72 per acre per year
	10) Recreation/Tourism	$483.57 per acre per year
	11) Aesthetic Value	$1,720.99 per acre per year
	12) Biodiversity	$113.12 per acre per year
Urban and Rural Green Open Space	13) Storm Water Retention	$293.02 per acre per year
	14) Air Quality	$204.47 per acre per year
	15) Aesthetic Value	$1,622.37 per acre per year
	16) Climate Regulation	$13.19 per acre per year
	17) Erosion Control	$64.88 per acre per year
	18) Pollination	$290.08 per acre per year
	19) Recreation/Tourism	$5,365.26 per acre per year
Riparian Area	20) Aesthetic value	$580.87 per acre per year
	21) Food Provisioning	$609.44 per acre per year
	22) Water Filtration	$4,251.89 per acre per year
	23) Climate Regulation	$204.21 per acre per year
	24) Flood Hazard Reduction	$4,007.01 per acre per year
	25) Air Quality	$215.06 per acre per year
	26) Habitat Refugium	$835.41 per acre per year
	27) Biological Control	$163.68 per acre per year
	28) Erosion Control	$11,447.30 per acre per year
	29) Recreation/Tourism	$15,178.07 per acre per year

Forests	30) Erosion Control	$62.22 per acre per year
	31) Climate Regulation	$395.23 per acre per year
	32) Air Quality	$225.65 per acre per year
Agricultural Lands	33) Pollination	$900.85 per acre per year
	34) Soil Erosion	$127.14 per acre per year
	35) Biological Control	$14.29 per acre per year
	36) Carbon Storage	$51.48 per acre per year
	37) Soil Formation	$109.47 per acre per year
	38) Aesthetic Value	$51.87 per acre per year

Data Sources

Peer-reviewed academic journal articles, agency analysis, and private studies examining the economic value provided by lands within and outside the floodplain have been gathered together into a database. These studies, conducted in the U.S., provide a robust basis for generating economic values useful to FEMA and other agencies for benefit-cost analysis. The research for this report identified over 200 studies with economic values for particular ecosystem services across land cover categories. The selected values and studies were reviewed by a Subject Matter Expert Panel as a key quality control measure.

Conversion Methodology

These studies provide a U.S. dollar value in a given year for a particular beneficial function (flood protection) across a period of time (generally one year). These values must be updated to account for inflation. All study values to 2011 USD value using the U.S. Bureau of Labor Statistics Inflation Calculator.[10]

Additionally, ecosystem service values are presented as a monetary value on a spatial and temporal scale. For example, the value of forested land for erosion control is measured as dollars per acre, per year, for a specified geographic range.

Values and Qualifications

There are 38 values for selected land cover/ecosystem service combinations with these fields:

Land cover type;
Ecosystem service;
Monetary value per acre per year (in 2011 U.S. dollars);
Bibliographic reference;
Valuation methodology;
Geographic area;
Study methodology;
Qualification of the study;
Future Analysis.

[10] Bureau of Labor Statistics, Inflation Calculator, http://www.bls.gov/data/inflation_calculator.htm.

Ecosystem Service Value Qualifications - Wetlands

Value 1: Coastal Wetland Provisioning of Hurricane Protection Value

1. **Land Cover:** Wetlands (Fresh Marsh, Intermediate Marsh, Brackish Marsh, Saline, Shrub Wetland)
2. **Ecosystem Service:** Disturbance Regulation – Hurricane Buffering (State Specific)
3. **FEMA Value (Geographic Region):** $3,982.70 per acre per year regional average (state-specific averages per Table B2)

Table B2: State-Specific Economic Values for Value 1

State	Value (2011 USD per acre per year)
Alabama	$3,854.27
Connecticut	$13,783.51
Delaware	$123.70
Florida	$3,810.31
Georgia	$481.74
Louisiana	$845.67
Maine	$372.40
Maryland	$246.81
Massachusetts	$6,303.51
Mississippi	$1,120.00
New Hampshire	$701.76
New Jersey	$523.95
New York	$24,713.89
North Carolina	$4,603.42
Rhode Island	$3,500.63
South Carolina	$2,231.83
Texas	$5,979.37
Virginia	$1,560.78
Mean	**$3,982.70**
Median	**$1,560.78**
Standard Deviation	**$6,005.20**

4. **Reference:** Costanza, R., O. Perez-Maqueo, M.L. Martinez, P. Sutton, S.J. Anderson, and K. Mulder (2008). "The value of coastal wetlands for hurricane protection." Ambio 37(4): 241-248.

5. **Valuation Method:** Avoided Cost
6. **Geographic Area of Study:** Wetland within 100 kilometers of the coastline. Alabama, Connecticut, Delaware, Florida, Georgia, Louisiana, Maine, Maryland, Massachusetts, Mississippi, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Texas, Virginia.
7. **Methodology Description:** "The authors estimated the value of coastal wetlands for hurricane protection in the US using two basic steps. In step 1 they used a multiple regression analysis using data on 34 hurricanes that have hit the US since 1980 with relative damages as the dependent variable and wind speed and wetland area as the independent variables. In step 2 they used a version of the relationship derived in step 1, combined with data on annual hurricane frequency to derive estimates of the annual value of wetlands for storm protection. This analysis allowed the authors to estimate how this value varies with location, area of remaining wetlands, proximity to built infrastructure, and storm probability. Additionally, the authors analyzed gross domestic product spatially through using satellite imagery techniques. The authors completed step 1 of the analysis by deriving from the regression equation the total expected damages and avoided damages per hectare of wetlands from storms of a given wind speed, GDP in swath, and wetland area in swath."[11]
8. **Calculation:** See the article for the specific state-by-state calculations.
9. **Qualification:** This study was chosen because it was recently conducted, it provides a wealth of values, and exercises sound methodology. This study includes Hurricane Katrina (not Hurricane Rita) while all peer reviewed wetland hurricane protection value studies to this date do not include Hurricanes Katrina and Rita. This is the best value available at this time. The value provided in this study presents the ecosystem service value as a regional average. Peer-reviewed studies provide ecosystem service values in a variety of ways. Some examples include averages, ranges, medians, and site-specific values. This study offers both a regional average and state specific ecosystem service value. Louisiana State University collected spatially specific physical data of hurricane buffering value by measuring the debris line left by the storm surge of Hurricane Rita across the Louisiana coastline. The data provides very specific information on the value of barrier islands, salt marsh and other wetland features for reducing storm surge. It will be used to calculate better estimates of avoided cost hurricane storm protection value provided by wetlands. However, it will be some time before this analysis appears in the literature.
10. **Future Analysis:** Several significant hurricanes have occurred since this study and the values would likely be significantly higher with a follow-up analysis. In addition, aspects such as shipping disruption on the Mississippi River if a hurricane caused the river to shift out of the current coarse have been identified as clear risks, with tremendous potential costs, but were not included in this analysis. The separation of wind and storm surge damages into two separate values would improve the usefulness

[11] Costanza, R., O. Perez-Maqueo, M.L. Martinez, P. Sutton, S.J. Anderson, and K. Mulder (2008). The value of coastal wetlands for hurricane protection. Ambio 37(4): 241-248.

of this value to FEMA.

Value 2: Flood Protection and Risk Mitigation from Wetlands

1. **Land Cover:** Wetlands
2. **Ecosystem Service:** Disturbance Regulation – Flood Protection
3. **FEMA Value (Geographic Region):** $5,335.30 per acre per year (National)
4. **Reference 1:** Leschine, T.M., Wellman, K.F., Green, T.H. 1997. The Economic Value of Wetlands: Wetlands Role in Flood Protection in Western Washington. Washington State Department of Ecology.

   Reference 2: Allen, J., Cunningham, M., Greenwood, A., Rosenthal, L., 1992. The value of California wetlands: an analysis of their economic benefits. Campaign to Save California Wetlands. Oakland, California.
5. **Valuation Method:** Cost Avoidance and Contingent Valuation
6. **Geographic Area of Studies:** Western Washington, North Central (all states that are not along hurricane belts).
7. **Methodology Description:** Cost avoidance was used to assign a dollar amount per wetland for flood control based upon the amount of flood damage avoided when the wetland is left intact. A cost benefit analysis was implemented in both studies to show how existing wetlands in a flood plain provide greater net flood control benefits than dam or reservoir systems.
8. **Calculation: (all values in 2011 USD)**

   Leschine et al: $6,445.45 per acre per year
   Allen et al: $4,225.14 per acre per year
   Average**: $5,335.30 per acre per year** (National application)
9. **Qualification:** Although these studies are not published in a peer-reviewed journal, both were developed to address the benefits of wetland preservation in flood-prone areas. The study by Leschine et al. was developed for the Washington State Department of Ecology to address flooding problems in developing cities of Washington State. Wetlands in the state have become highly fragmented, leading to the degradation of floodwater flow and storage systems.[12] Allen et al. address flooding concerns in California where agricultural and industrial development destroyed 90% of native wetlands.[13]

Value 3: Habitat Value in Wetlands

1. **Land Cover:** Wetland (Fresh Marsh, Intermediate Marsh, Brackish Marsh, Saline, Shrub Wetland)

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[12] Leschine, T.M., Wellman, K.F., Green, T.H. 1997. The Economic Value of Wetlands: WetlandsTole in flood Protection in Western Washington. Department of Ecology.
[13] Allen, J., Cunningham, M., Greenwood, A., Rosenthal, L., 1992. The value of California wetlands: an analysis of their economic benefits. Campaign to Save California Wetlands, Oakland, California.

2. **Ecosystem Service:** Habitat
3. **FEMA Value (Geographic Region):** $164.07 per acre per year (National)
4. **Reference:** Woodward, R., and Wui, Y., 2001. "The economic value of wetland services: a meta-analysis." Ecological Economics 37, 257-270.
5. **Valuation Method:** Meta-analysis
6. **Geographic Area of Study:** All Wetland Areas
7. **Methodology Description:** "Data from 39 wetland valuation studies were identified that had sufficient commonalties to allow inter-study comparisons. The authors used two techniques to learn about the valuation function, both of which can be broadly described as meta-analysis since many studies are used to identify general relationships. The first method employed utilizes bivariate graphical and standard techniques. This gives them both an indication of the extent to which particular characteristics, such as habitat, influence wetland values while also portraying the full distribution of the data. The second technique is more standard, using a multivariate regression of wetland values on the characteristics of both the wetlands and the studies. Together, these two techniques provide a richer basis from which the authors can draw lessons on the factors determining wetland value."[14] The studies do not provide primary research, but bring together the research and economic valuation from 39 studies.
8. **Qualification:** This study was included as a habitat value for wetlands because it highlights some the issues associated with Benefit Transfer methodology (called the "Value Transfer Methodology" by the authors). This study provides a rich diversity of calculations for environmental benefits of wetland habitat values; the meta-analysis provides a robust basis for a national value. The authors acknowledge that the Value Transfer Method has problems in measuring error margins and scale of applicability. However, they discuss wetland services that are most valuable, and the potential biases of the valuation methods.[15] Additionally, they conclude that values should be derived as close as possible to the geographic sites for a new study area. This fits well with the appraisal methods that FEMA applies for houses and businesses in the current BCA Tool. For this reason, it provides a defensible "low estimate" for the wetland/habitat ecosystem service value combination for use at a national scale. The authors recognize that these are conservative estimates and acknowledge that values can range widely. Low-end values ensure that existing habitat values are counted, while recognizing the wide range of differences. This national value could be replaced with more appropriate and better regional or local valuation information for habitat where it exists.
9. **Future Analysis:** In many areas wetlands have specific and high habitat values for harboring endangered species. This value could be improved by allowing for an additional value based on specific habitat attributes of the wetland area.

[14] Woodward, R., and Wui, Y., 2001." The economic value of wetland services: a meta-analysis." Ecological Economics 37, 257-270.
[15] Ibid 269.

Value 4: Food Provision from Wetlands

1. **Land Cover:** Wetlands
2. **Ecosystem Service:** Food Provision (Commercial Fishing)
3. **FEMA Value (Geographic Region):** $1,338.96 (National)
4. **Valuation Method:** Meta-Analysis
5. **Geographic Area of Study:** US National Average
6. **Reference:** Woodward, R., and Wui, Y., 2001. "The economic value of wetland services: a meta-analysis." Ecological Economics 37, 257-270.
7. **Methodology Description:** "Data from 39 wetland valuation studies were identified that had sufficient commonalties to allow inter-study comparisons. The authors used two techniques to learn about the valuation function, both of which can be broadly described as meta-analysis since many studies are used to identify general relationships. The first method employed utilizes bivariate graphical and standard techniques. This gives them both an indication of the extent to which particular characteristics, such as habitat, influence wetland values while also portraying the full distribution of the data. The second technique is more standard, using a multivariate regression of wetland values on the characteristics of both the wetlands and the studies. Together, these two techniques provide a richer basis from which the authors can draw lessons on the factors determining wetland value."[16] The studies do not provide primary research, but bring together the research and economic valuation from 39 studies.
8. **Qualification:** Woodward and Wui's meta-analysis includes a collection of studies that value commercial fishing benefits provided by wetlands. This study was included as food provisioning value for wetlands because it highlights some the issues associated with Benefit Transfer methodology. This study provides a rich diversity of calculations for environmental benefits provided by wetlands as commercial fishing values. Using studies of wide national geographic distribution, multiple methodologies, this meta-analysis provides the most robust basis for a national value for food provisioning of wetlands. The authors acknowledge that the Benefit Transfer Method has problems in measuring error margins and scale of applicability. This is because each individual study has a different shape of error, and in bringing them together in the meta-study there is no methodology for estimating the shape, margin, and magnitude of error. However, they discuss wetland services that are most valuable, and the potential biases of the valuation methods are most often in omitting value rather than overestimating value.[17] Additionally, they conclude that values should be derived as close as possible to the geographic sites for a new study area. This fits well with the appraisal methods that FEMA applies to houses and businesses in the current BCA Tool. For this reason, it provides a defensible "low estimate" for the wetland/fish ecosystem service value for use at a national scale. The authors recognize that these are conservative estimates and

[16] Woodward, R., and Wui, Y., 2001." The economic value of wetland services: a meta-analysis." Ecological Economics 37, 257-270.
[17] Ibid 269.

acknowledge that values can range widely. Low-end values ensure that existing habitat values are counted, while recognizing the wide range of differences.

9. **Future Analysis:** Commercial fishing benefits do not exist in all wetlands. In addition, some wetlands are far more productive than others both locally and at a regional scale. Replacing the national value with more appropriate regional, state or local values would strengthen the application of fisheries values. In addition, this only includes fisheries values. There are many other food values, such as harvestable plants and animals, as well as fur production, which are not included in the current value.

Value 5: Water Supply from Wetlands

1. **Land Cover:** Wetlands
2. **Ecosystem Service:** Water Supply
3. **FEMA Value (Geographic Region):** $218.57 (National)
4. **Valuation Method:** Meta-Analysis
5. **Geographic Area of Study**: US National Average
6. **Reference:** Woodward, R., and Wui, Y., 2001. "The economic value of wetland services: a meta-analysis." Ecological Economics 37, 257-270.
7. **Methodology Description:** As stated above, data from 39 wetland valuation studies were identified with sufficient commonalties to allow inter-study comparisons. The two techniques provide a richer basis from which the authors can draw lessons about the factors determining wetland value. The first method employed utilizes bivariate graphical and standard techniques. This gives them both an indication of the extent to which particular characteristics, such as habitat, influence wetland values while also portraying the full distribution of the data. The second technique is more standard, using a multivariate regression of wetland values on the characteristics of both the wetlands and the studies. In the case of water supply, the estimate was based on six national studies and encompassed an area of nearly 150,000 acres within the US.
8. **Qualification:** Woodward and Wui conclude that values should be derived as close as possible to the geographic sites for a new study area. However, this meta-study provides the best available global value for the US. This fits well with the appraisal methods that FEMA applies in the current BCA Tool. The authors recognize that these are conservative estimates and acknowledge that values can range widely. Low-end values ensure that at least a value greater than zero is given to the value of water supply provided by wetlands. As in the fisheries case, because this is a meta-analysis, the full shape of the error cannot be estimated.
9. **Future Analysis:** These national values could be replaced with more appropriate and better regional or local valuation information for habitat where it exists. There are a number of water supply systems in the US that are heavily dependent upon wetlands for filtration and water supply from the Mississippi Basin and Delta, to forest sourced watersheds in the Northwest US where wetlands provide important supply functions. Critical also are water supply systems within floodplains that utilize wetlands where the built capital may be subject to disasters such as floods or fire. A next step could be

examining these regional, local and floodplain related aspects of wetlands and water supply.

Value 6: Water Filtration in Wetlands

1. **Land Cover:** Wetlands
2. **Ecosystem Service:** Water Filtration (Waste Filtration)
3. **FEMA Value (Geographic Region):** $731.21 (National)
4. **Valuation Method:** Meta-analysis and Replacement Cost
5. **Geographic Area of Study**: US National Average and Ontario, Canada
6. **Reference 1:** Woodward, R., and Wui, Y., 2001. "The economic value of wetland services: a meta-analysis." Ecological Economics 37, 257-270.

   Reference 2: Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services. David Suzuki Foundation, Vancouver, Canada. Available at: http://www.davidsuzuki.org/publications/downloads/2008/DSF-Greenbelt-web.pdf
7. **Methodology Description:** Woodward and Wui used data from 15 national water quality wetland valuation studies with sufficient commonalties were examined allowing inter-study comparisons. The authors used two techniques to learn about the value function provided by wetlands for water filtration. The first method employed utilizes bivariate graphical and standard techniques. This gives them both an indication of the extent to which particular characteristics, such as habitat, influence wetland values while also portraying the full distribution of the data. The second technique is more standard, using a multivariate regression of wetland values on the characteristics of both the wetlands and the studies. This meta-analysis utilized many studies to identify general relationships. Together, these two techniques provide a richer basis from which the authors can draw lessons on the factors determining wetland value. Wilson estimated the value of water filtration using the potential increase in water treatment costs in the absence of the services provided by wetlands in Ontario, Canada. In this case study, it was demonstrated how wetlands act as a waste treatment system for human and agricultural waste. By estimating the nitrogen and phosphorus loss from farms, Wilson took the average costs of nutrient abatement and calculated an annual cost.
8. **Calculation: (All Values in 2011 USD)**
   - Wilson: $1,275.58
$200.39
   - Woodward and Wui: $717.67

   [717.67 + 200.39 + 1,275.58]/3 = $731.21 per acre per year
9. **Qualification:** Wilson's study was not included in Woodward and Wui's meta-analysis. It was included here because it represented a newer, more robust analysis of water filtration benefits from wetlands. Wilson clearly demonstrates the methods used to accurately calculate the avoided cost of treating polluted water sources. When taking an average of the values provided in Wilson's publication, the final value is nearly

equal to that derived in Woodward and Wui's estimation and falls within their range. Woodward and Wui's study provides diverse calculations for environmental benefits of wetland water filtration values across a larger geography. The meta-analysis provides an important basis for a national value. The authors acknowledge that the Value Transfer Method has problems in measuring error margins and scale of applicability. However, they discuss wetland services that are most valuable, and the potential biases of the valuation methods.

10. Future Analysis: As in the case of water supply, water filtration value varies greatly from region to region and can be utility specific. Future analysis could examine the specific geographies where wetlands water filtration provides greater or lesser value.

Value 7: Climate Regulation of Wetlands

1. **Land Cover:** Wetlands
2. **Ecosystem Service:** Climate Regulation
3. **FEMA Value (Geographic Region):** $214.48 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study**: Ontario, Canada and the Mississippi Alluvial Valley
6. **Reference 1:** Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services. David Suzuki Foundation, Vancouver, Canada. Available at: http://www.davidsuzuki.org/publications/downloads/2008/DSF-Greenbelt-web.pdf

   Reference 2: Jenkins, A.W., Murray, B.C., Kramer, R.A., Faulkner, S.P. 2010. Valuing Ecosystem Services from Wetlands Restoration in the Mississippi Alluvial Valley. Ecological Economics. 69. 1051-1061.
7. **Methodology Description:** Wilson valued the annual carbon uptake of five different wetland types using CITYgreen's carbon module quantification software tool. The CITYgreen software is a statistical tool for ecosystem service analysis and is available at the American Society of Landscape Architects website.[18] Carbon sequestration estimates are based on total tree canopy cover. Annual costs were estimated using the global average cost of carbon emissions. Similarly, Jenkins et al. use field data from the Community Energy Planning Toolkit (CEAP) software to estimate carbon sequestration based on total canopy tree cover.[19] The carbon benefits were estimated using carbon market cap-and-trade system, where carbon dollar figures were derived from the Chicago Climate Exchange and the European Union Emissions Trading Scheme. The Chicago Climate Exchange values are generally considered the low end of values as it is a voluntary market. Estimates of the full public cost of carbon emissions as from the Stern report are considered to be more complete estimates of the value of carbon

[18] Available at: http://www.asla.org/ContentDetail.aspx?id=14874
[19] Available at: http://www.aea.nt.ca/resources/resource_library

sequestration.[20]

8. **Calculation: (All Values in 2011 USD)**
    - Jenkins: $83.38
    - Wilson: Open Water Wetland: $5.54
        - Bog: $182.71
        - Swamp: $206.83
        - Marsh: $229.60
        - Fen: $578.82

    [83.38+206.83+578.82+229.60+5.54+182.71]/6 = $214.48 per acre per year

9. **Qualification:** Both studies represent carbon sequestration values in wetlands for the different biome climate zones in the U.S. Wilson's case study represents the northern forests found in both the U.S. and Canada. Jenkins et al. value wetlands off of the Gulf of Mexico. The combination of these values represents six different wetlands types, providing an average value that captures many of the wetland types in the U.S.

10. **Future Analysis:** Wetlands vary greatly in carbon sequestration value depending on the length of the growing season, anaerobic conditions, wetland type, and other aspects. Often the wetland type is known within a statewide GIS database in the US. A more detailed and accurate valuation based on the wetland type could be included in the FEMA BCA Tool.

Value 8: Nutrient Cycling from Wetlands

1. **Land Cover:** Wetlands
2. **Ecosystem Service:** Nutrient Cycling
3. **FEMA Value (Geographic Region):** $527.65 (National)
4. **Valuation Method:** Benefit Transfer and Avoided Cost
5. **Geographic Area of Study:** Mississippi Alluvial Valley
6. **Reference:** Jenkins, A.W., Murray, B.C., Kramer, R.A., Faulkner, S.P. 2010. Valuing Ecosystem Services from Wetlands Restoration in the Mississippi Alluvial Valley. Ecological Economics. 69. 1051-1061.
7. **Methodology Description:** Jenkins et al. base their estimation of the value of nutrient cycling on a nitrogen credit trading model used by Ribaudo et al. (2005).[21] This model was used to explore trading in the entire Mississippi Basin using the U.S. Agricultural Sector Mathematical Programming tool. Wetlands absorb and recycle damaging nutrients, primarily fertilizer runoff. Unchecked, these nutrients cause damage to water supply and/or fisheries. Fisheries are damaged because nitrogen and phosphorus promote algal blooms and hypoxia (oxygen depleted water). In the model, farmers were able to provide nitrogen reduction credits by introducing several farming techniques

[20] Stern, N. 2007. The Economics of Climate Change: The Stern Review. Cambridge University Press, Cambridge, UK.
[21] Ribaudo, M.O., Heimlich, R., Peters, M. 2005. Nitrogen sources and Gulf hypoxia: potential for environmental credit trading. Ecological Economics. 52 (2). 159-168.

that resulted in reduced nitrogen runoff levels. The exercise was able to show the cost of the alternative approaches to restoring wetland areas providing a value for wetland nutrient cycling/reduction.

8. **Calculation:** No additional calculation was made to the value.
9. **Qualification:** Denitrification provided by wetlands is valuable. However, no published study provided a monetary value for the denitrification provided by wetlands until recently. Jenkins et al. provide a peer-reviewed study that values this benefit in the Gulf region. Many studies attempt to value nitrogen removal from surface waters, however this study examines deintrification provided by wetlands. In addition, the denitrification respiratory process reduces oxidized forms nitrogen by returning N_2 to the atmosphere, rather than acting as a nitrogen bank. This is of higher value because the nitrogen cannot be re-released into water.
10. **Future Analysis:** This study is specific to the Gulf Region. Further primary studies could provide more detailed information on the value of wetlands for nutrient cycling for other regions of the nation.

Value 9: Raw Materials in Wetlands

1. **Land Cover:** Wetlands
2. **Ecosystem Service:** Raw Materials
3. **FEMA Value (Geographic Region):** $560.72 (National)
4. **Valuation Method:** Meta-Analysis
5. **Geographic Area of Study:** Global
6. **Reference:** Brander, L.M., Florax, R.J., Vermaat, J.E. 2006. The Empirics of Wetland Valuation: A Comprehensive Summary and a Meta-Analysis of the Literature. Environmental & Resource Economics. 33. 223-250.
7. **Methodology Description:** Brander et al. conducted a meta-analysis of 80 studies, including 215 total values. Given that 38 of these studies valued wetland raw materials specifically, the authors were able to separate fuel wood from raw materials, which are both used in the calculation below. Each value was conducted under multiple methodologies, including market price and consumer surplus models. Raw materials include tree materials (not used for fuel), non-edible berries, animal products, plant roots, and several other harvestable goods were included. The econometric model used in the derivation of the values included all potential influential variables simultaneously. Multicollinearity was tested and found to be insignificant in the model and hesteroskedasticity was treated. The value for both fuel wood and raw materials was found to be statistically significant at the five percent level.
8. **Calculation: (All Values in 2011 USD)**
   - Raw Materials: $450.99 per acre per year
   - Fuel Wood: $109.73
     $450.99+$109.73 = $560.72 per acre per year

9. **Qualification:** These valuation studies were selected from sampled a pool of 191 studies, based on a selection criteria for use of values in a statistical model. This analysis was conducted following the steps and methodologies of two other wetland meta-analyses including that written by Woodward and Wui (2001). The authors were able to address minor issues present in these previous meta-analyses. Brander et al. broadened their study to the global domain and collected wetland valuation articles release previous to 2005. Studies were collected from 25 countries, with half of the values come from North America. Because these studies were drawn from an international pool, they may reflect higher values for fuel wood from other countries and lower overall values for other raw materials such as timber or furs.
10. **Future Analysis:** This study could be conducted with U.S. based wetland valuation studies to provide a better value for national application. Some raw materials are regionally specific, thus a regional values would provide greater detail for the FEMA BCA Tool.

Value 10: Recreational Value of Wetlands

1. **Land Cover:** Wetland
2. **Ecosystem Service:** Recreational
3. **FEMA Value (Geographic Region):** $483.57 per acre per year (National)
4. **Reference:** Kozak, J., Lant, C., Shaikh, S., and Wang, G. (2011). The geography of ecosystem service value: The case of the Des Plaines and Cache River wetlands, Illinois. Applied Geography 31, 303-311.
5. **Valuation Method:** Contingent Valuation Method
6. **Geographic Area:** Rural Southern Illinois and Urban Northeastern Illinois
7. **Methodology Description:** This paper explores the geography of ecosystem service benefits using a comparative case study of the 2555 ha Cache River wetlands in rural southern Illinois and the 362 ha Des Plaines River wetlands in urban northeastern Illinois. Applying log-linear and exponential distance decay functions from source ecosystems to residents of zip code units yields annual economic values. This study provides wide ranges in estimated value highlighting the importance of spatial discounting in ecosystem service valuation and, and to a lesser extent, the importance of the spatial unit to which values are applied. The range extended from $483.57 per acre per year in rural Illinois to $95,565.47 per acre per year of wetland benefits in Metropolitan Chicago. Given that the purpose of this value provided to FEMA is intended for the acquisition of mostly rural areas, the lower and more conservative value was used. In future analysis, a more specific consideration of urban areas may yield more accurate calculations.
8. **Calculation:** There is no additional calculation. The value is drawn from the paper.
9. **Qualification:** This study is one of very few studies providing a value for ecosystem services under a spatial discounting methodology. The requirements for this type of study rely on geographic and statistical data, suggesting a high level of methodological integrity. The author is also able to address many similar studies that fail to account for

bias in data associated with spatial half-lives of recreational benefits, which has not been addressed in an environmental analysis of recreational benefits. Published in 2011, the study represents the most recent document on the valuation of recreational benefits from forested wetlands in the U.S.

Value 11: Aesthetic Value of Wetlands

1. **Land Cover:** Wetlands
2. **Ecosystem Service:** Aesthetic Value
3. **FEMA Value (Geographic Region):** $1,720.99 (National)
4. **Valuation Method:** Hedonic Pricing
5. **Geographic Area of Study**: Ramsey County, Minnesota and Portland, Oregon
6. **Reference:** Doss. C. R., Taff, S.J. 1996. The Influence of Wetland Type and Wetland Proximity on Residential Property Values. Journal of Agricultural and Resource Economics. 21(1). 120-129.
7. **Methodology Description:** The study used a hedonic pricing model to estimate the increased value to homes within close proximity to a natural amenity, which in this case are wetlands. Many studies have shown that closer proximity to a wetland increases the value to residential and commercial properties. Doss and Taff present a more detailed case by studying the increase in home value within proximity to four different wetland types including scrub, open water, forested, and emergent wetlands. Only three of these were used in this analysis, given that the value for forested wetlands was not statistically significant in the hedonic model. The value of forested wetlands was estimated at approximately $1,946.54 per acre per year, which would not have changed the average value below substantially. The omission also results in a more conservative single value for wetlands.
8. **Calculation: (All Values in 2011 USD)**
    - Scrub Wetlands: $1,046.63
    - Open Water Wetlands: $539.34
    - Emergent Wetlands: $3,577.01

    [1,046.63+539.34+3,577.01]/3 = $1,720.99 per acre per year
9. **Qualification:** Hedonic analyses are one of the most accurate and widely used methodologies for estimating aesthetic value.[22] The detailed analysis Doss and Taff provide allows for the value to be easily applied nationally. Though housing prices as a whole may rise or fall, wetlands yet contribute value to these housing values. Emergent, open water and scrub wetlands include a large percentage of the wetlands that exist in the U.S. The inclusion of these wetlands types, which provide varying levels of aesthetic value, represent a well-rounded single value for national application.

[22] Doss. C. R., Taff, S.J. 1996. The Influence of Wetland Type and Wetland Proximity on Residential Property Values. Journal of Agricultural and Resource Economics. 21(1). 120-129.

10. **Future Analysis Needed:** There are many other wetland types identified, and a more regional or localized values could be provided to displace the single national value where better information exists.

Value 12: Biodiversity in Wetlands

1. **Land Cover:** Wetlands
2. **Ecosystem Service:** Biodiversity
3. **FEMA Value (Geographic Region):** $113.12 (National)
4. **Valuation Method:** Meta-analysis
5. **Geographic Area of Study:** World
6. **Reference:** Schuyt, K., Brander, L. 2004. Living Waters: The Economic Values of the Worlds Wetlands. World Wildlife Fund. Switzerland.
   Available at: assets.panda.org/downloads/wetlandsbrochurefinal.pdf
7. **Methodology Description:** This meta-analysis includes 89 studies that use several methodologies for valuing the protection of biodiversity including avoided cost, production costs, hedonic analysis and contingent valuation. The median economic values were estimated by wetland type. The authors explained that, due to outlier values that exist in some of the studies, an average value would have rendered a less accurate value. It was shown how, for some ecosystem services like food source provisioning, values were much higher in some regions where communities may rely more heavily upon the service. However, the protection of biodiversity, which often represents endangered species, is a global problem. Therefore, the transferability of the value of biodiversity protection is justifiable. Additionally, wetland types across the meta-analysis were split into five categories to differentiate values in different wetlands types across the world.
8. **Calculation:** No additional calculation was made.
9. **Qualification:** The 89 studies used in this meta-analysis represent the highest number of studies used to derive a single numerical value for wetland ecosystem services. The study reflected upon previous attempts[23] to value ecosystem services benefits and outlined the methodological issues that were addressed in their own estimations. Of the 89 total studies, 49 were from the U.S. across 18 different states, which represent over 1,500 (75+ million acres) wetlands sites. Several attributes of the wetlands were taken in consideration including the wetland area, latitude, capital income of area, population density of area, and several more.
10. **Future Analysis Needed:** Biodiversity is localized. Thus, regional or more local analysis would provide better values.

[23] Costanza, R., dArge, R., deGroot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., Oneill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., vandenBelt. M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253-260.

Ecosystem Service Value Qualifications – Green Open Space

Value 13: Stormwater Retention Regulation in Green Open Space

1. **Land Cover:** Green Open Space
2. **Ecosystem Service:** Water Retention (Flood Prevention)
3. **FEMA Value (Geographic Region):** $293.02 per acre per year (National)
4. **Reference 1:** Trust for Public Land. 2011. The Economic Benefits of Seattle's Park and Recreation System. Available at: http://cloud.tpl.org/pubs/ccpe-seattle-park-benefits-report.pdf

   Reference 2: Trust for Public Land. 2010. The Economic Benefits and Fiscal Impact of Parks and Open Space in Nassau and Suffolk Counties, New York. Available at: http://cloud.tpl.org/pubs/ccpe--nassau-county-park-benefits.pdf
5. **Valuation Method:** Avoided Cost
6. **Geographic Area of Studies:** Seattle and two counties in New York State
7. **Methodology Description:** To determine the water retention value of each city's urban green open space, the authors compared the perviousness of the system with the perviousness of the more built-up surrounding city as a whole. They also analyzed the perviousness within the same region where there was no green open space. Next, they included rainfall data for each region. This allowed for the comparison of rainwater runoff in areas with green open space against those without. Finally, the authors used this data in the Peak Flow Calculator developed by the Western Research Station of the U.S. Forest Service to estimate the value of retained stormwater runoff due to vegetation. Inputs to the model include geographic location, climate region, surface permeability index and green open space size. This tool calculated the number of cubic feet of water removed per year, per acre by green space. This was compared to the cost of stormwater conveyance in each study area to find the value of stormwater conveyance average cost for the entire region. Three separate regions were combined to provide values from three separate regions in both studies to calculate an average that would be applicable nationally.
8. **Calculation: (All values in 2011 USD)**

   Trust for Public Land (2010): $162.97 per acre per year

   Trust for Public Land (2011): $423.07 per acre per year

   Average: $293.02 per acre per year
9. **Qualification:** This study was chosen because it was recently conducted, uses a respected metric for measuring stormwater conveyance, and exercises sound methodology. Although this study is not published in any major journal, the methodology is replicable and has been adopted in many studies. Parks and urban green open spaces are abundant across the nation. Some green space land covers, such as ball parks and partially forested areas are very similar. Other natural areas may vary greatly from desert habitat to old growth forests.

10. **Future Analysis:** Increasingly green open space is being seen as a provisioning area for storm water retention and conveyance as well as floodwater storage and conveyance. This is an area of fast-moving research and there will be much more local, regional and national data and analysis soon available that could be useful for FEMA.

Value 14: Air Purification in Green Open Space

1. **Land Cover:** Rural and Urban Green Open Space
2. **Ecosystem Service:** Air Purification (Gas Regulation)
3. **FEMA Value (Geographic Region):** $204.47 per acre per year (National)
4. **Valuation Method:** Avoided Cost
5. **Geographical Area of Studies:** Southern Ontario (1), Urban Sacramento (2), and Urban Seattle (3)
6. **Reference 1:** Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services. David Suzuki Foundation. Vancouver, Canada. http://www.davidsuzuki.org/publications/downloads/2008/DSF-Greenbelt-web.pdf
Reference 2: McPherson, E.G., Scott, K.I., Simpson, J.R. 1998. Estimating Cost Effectiveness of Residential Yard Trees for Improving Air Quality in Sacramento, California, Using Existing Models. Atmospheric Environment. 32. 1. 75-84.

   Reference 3: Trust for Public Land. 2011. The Economic Benefits of Seattle's Park and Recreation System. Available at: http://cloud.tpl.org/pubs/ccpe-seattle-park-benefits-report.pdf
7. **Methodology Description:** All three studies utilize a market-priced avoidance cost methodology to measure the cost of losing air purification benefits from green open space areas. The removal of gaseous and large particulate pollution like carbon dioxide, nitrogen dioxide, sulfur dioxide, ozone, and particulates is measured in tons per year. Measurably reducing the concentration of these pollutants provides assessable health benefits. Avoided costs were calculated for pollution removal in each study region. The studies selected include both rural and urban areas. These estimates are underestimates of the true value of urban green space air purification value because they do not include recent health data on micro-particulates. It is now recognized that micro-particulates are more damaging to human health than previously thought. This value may be added in the future.
8. **Calculation: (all values in 2011 USD)**

   Wilson: $159.49 per acre per year
   McPherson et al: $30.84 per acre per year
   Trust for Public Land: $423.07 per acre per year
   Average: $204.47 per acre per year
9. **Qualification:** All three studies represent different geographical areas, diverse tree species and variety in population densities. These studies sufficiently represent a broad range of values applicable to other areas in the U.S. Both studies from McPherson et al. and Wilson have been cited in several reports. The most recent study conducted by the Trust of Public Land utilizes the iTree model developed by the U.S. Forest Service,

which provides replicable and more defensible figures.[24] As in many studies examining the economic benefits of natural systems, there is a notable increase in value in more recent studies. This is largely due to improvements in economic methodology and data quality. In the future, the 1998 value may be dropped; however, it was well developed and represented a significant area of the US, and thus was included it.

10. **Future Analysis:** Air purification benefits are much more valuable in more populated areas. The limited green space absorbs air pollution, especially within cities that have heavier industrial activities. Under future analysis, rural and urban green space should be analyzed separately in order to attribute the higher value to the urban cases.

Value 15: Aesthetic Value of Green Open Space

1. **Land Cover:** Rural and Urban Green Open Space
2. **Ecosystem Service:** Aesthetic Value
3. **FEMA Value (Geographic Region):** $1,622.37 per acre per year (National)
4. **Reference 1:** Qiu, Z., Prato, T., Boehm, G. 2006. Economic Valuation of Riparian Buffer and Open Space in a Suburban Watershed. Journal of the American Resources Association. 42. 6, 1583–1596.

   Reference 2: Bolitzer, B., Netusil, N.R. 2000. The Impact of Open Spaces on Property Values in Portland, Oregon. Journal of Environmental Management. 59.
5. **Valuation Method:** Hedonic Pricing
6. **Geographic Area of Studies:** Rural and Urban Missouri (North of St. Louis) and Urban Portland, Oregon
7. **Methodology Description:** Qiu et al. adopted both hedonic pricing and contingent valuation methods in separate econometric models measuring increased value to residential properties within proximity of green open space. This value was taken from homes near a 36 mile creek that bordered several green areas. Similarly, Bolitzer and Netusil use hedonic pricing econometric techniques to view the price of homes near green open spaces while also reflecting housing structure, environment and neighborhood attributes. Both hedonic techniques were a time-series analysis which eliminated time specific influences.
8. **Calculation: (All values in 2011 USD)**
   Qiu et al: $1,143.53 per acre per year
   Bolitzer and Netusil: $2,101.20 per acre per year
   Average: $1,622.37 per acre per year
9. **Qualification:** Property values increase with the creation of a nearby natural area. This value is difficult to measure without the use of hedonic pricing methods. The authors address problems inherent in historical uses of the model and adopt parametric and non-parametric models to avoid these errors. The studies are conducted in different

[24] Trust for Public Land. 2011. The Economic Benefits of Seattle's Park and Recreation System. Available at: http://cloud.tpl.org/pubs/ccpe-seattle-park-benefits-report.pdf

geographical areas of the U.S. with different population densities. This helps reflect different values across the country. The aesthetic value of green space provides benefit to both landowners and non-land owners who experience the green open space. Hedonic value provides only for aesthetic value that measurably increases property values, thus underestimating the total value.

10. **Future Research:** The aesthetic value of green spaces in urbanized areas is known to provide substantial added value to residential and commercial properties.[25] In contrast, rural areas attribute little value to the landscape and place higher value on other characteristics of lands like agricultural productivity potential. Under future analysis, rural and urban green space should be analyzed separately in order to attribute the higher value to the urban cases.

Value 16: Climate Regulation from Green Open Space

1. **Land Cover:** Green Open Space
2. **Ecosystem Service:** Climate Regulation
3. **FEMA Value (Geographic Region):** $13.19 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study:** Global Estimates and Ontario, Canada
6. **Reference 1:** Harris, D., Crabtree, B., Newell-Price, P. 2006. Economic Valuation of Soil Functions Phase 1: Literature Review and Method Development. Prepared for Department of Environment, Food and Rural Affairs. UK. Available at: http://www.cjcconsulting.co.uk/pdfs/FINALEcon%20Valuation%20of%20Soil%20Functions%20Rept%20Phase%20I_0806.pdf

   Reference 2: Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services. David Suzuki Foundation, Vancouver, Canada. Available at: http://www.davidsuzuki.org/publications/downloads/2008/DSF-Greenbelt-web.pdf
7. **Methodology Description:** Both publications use models that estimate the costs of carbon emissions and hence the global potential benefits of reduced emissions. The benefits can be inferred from the damage cost of carbon related to atmospheric changes that result in damages from sea level rise, floods and storm events, impacts on agricultural production and effects on health and disease. Harris et al. estimated carbon uptake estimations on non-agricultural grasslands and open space previously used for agricultural purposes. Given the limited carbon storage capacity of grass types and the similar characteristics between the open green space land types studied by Harris et al., both values are globally transferable. Wilson estimated carbon uptake using the CITYgreen software. CITYgreen is a statistical tool for ecosystem service analysis used to estimate carbon storage and uptake in different land types. It is at the American

[25] Qiu, Z., Prato, T., Boehm, G. 2006. Economic Valuation of Riparian Buffer and Open Space in a Suburban Watershed. Journal of the American Resources Association. 42. 6, 1583–1596

Society of Landscape Architects website[26]. In the calculation below, the global and North American estimates were averaged.

8. **Calculation: (All Values in 2011 USD)**
   - Wilson: $26.11
   - Harris et al: $7.94
     $5.53

   [26.11+7.94+5.53]/3 = $13.19 per acre per year

9. **Qualification:** The value estimated above represents common variations in green open space land types in the U.S. The most common green space land covers include grasslands, untilled open space, and green open space previously used for agricultural services. The selection of land types used in this valuation aligns with the land types that are acquired by FEMA for mitigation purposes. The carbon sequestration value above also reflects the lower carbon uptake capability of grasslands, suggesting that the value is an underestimate for green open space areas that have trees or shrubs.

10. **Future Analysis Needed:** Among the plethora of studies concerning carbon sequestration, there is a lack of specificity land types specificity, so that grasslands, green open space and several agricultural land covers are all included here. In future analysis, the division of these land types would render more accurate values. With the 2012 adoption of the Carbon Initiative in California, and implementation of a trading scheme, carbon values for all eligible land classes will be significantly increased within California and the within other regions (Washington and Oregon) with the capacity under the California law to participate in the trading system.

Value 17: Erosion Control in Green Open Space

1. **Land Cover:** Green Open Space
2. **Ecosystem Service:** Soil Erosion Control
3. **FEMA Value (Geographic Region):** $64.88 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study:** U.S. National Estimates
6. **Reference:** Pimentel, D., Harvey, C., Resosudarmo, P., Sinclair, K., Kurz, D., McNair, M., Crist, S., Shpritz, L., Fitton, L., Saffouri, R., Blair, R. 1995. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. Science 267, 1117-1123.
7. **Methodology Description:** Pimentel et al. considered multiple factors that influence soil erosion rates in the U.S. and globally, including slope of land, soil composition, extent of vegetative cover and its influences. The authors used data from a 20 year period to confirm that water and nutrient loss are heavily influenced by conversions of grassland and open space to cropland, also by animal grazing and general human activities. After detailing all of the energy, on-site and off-site costs, the study

[26] Available at: http://www.asla.org/ContentDetail.aspx?id=14874

concludes that erosion costs are above the global average in the U.S.

8. **Qualification:** This study conducted a heavy analysis on the effects of soil erosion of several lands types, including grasslands, pastures and agricultural lands. Large amounts of data were collected to include all influences of soil erosion. Pimentel et al. provided national cost averages of soil erosion that are cited in several reports.[27]
9. **Future Analysis:** This is a particularly important value but does not include erosion zones related to flooding and open space. An additional value examining flood events and erosion zone protection would complement this value and provide a good mitigation value where landslides and mass wasting occur with flood events.

Value 18: Pollination from Green Open Space

1. **Land Cover:** Green Open Space
2. **Ecosystem Service:** Pollination
3. **FEMA Value (Geographic Region):** $290.08 (National)
4. **Valuation Method:** Market Price
5. **Geographic Area of Study:** National Average
6. **Reference:** Pimentel D., Wilson, C., McCullum, C., Huang, R., Dwen, P., Flack, J., Tran, Q., Saltman, T., Cliff, B. 1997. Economic and Environmental Benefits of Biodiversity. BioScience. 47. 11. 747-757.
7. **Methodology Description:** The benefit of pollination from grasslands and prairies is essential to sustaining many cropland yields. Approximately one-third of the world's food production relies either on direct or indirect insect pollination, much of this from wild pollinators.[28] The conversion of grasslands and prairies to agriculture is a hindrance to pollination levels locally as wild pollinators are lost. Pollinators thrive on the wild flowers provided by these natural areas. Pimentel et al. based their estimation of the value of pollination on national agriculture production estimates. Data was collected from across the nation to provide estimates of these ecosystem services. Pimentel et al. showed how the 4,000 species of bees and other insects in the U.S. produced approximately $40 billion per year in pollination benefits when considering the values of insects pollinated legumes fed to cattle. The authors used this figure to conservatively estimate the national value of insect pollination alone. Data from approximately 990 million acres of agricultural land was taken to derive the value of pollination from open green space sources outside of these agricultural areas.
8. **Qualification:** Pimentel et al. also discussed the pollination benefits from wind and self-pollinating plants that was not included in their analysis. The authors placed emphasis on the importance of diverse plant species that exist in undeveloped

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[27] Example of citation: Sala, O.E., Paruelo, J. 1997. Ecosystem Services in Grasslands. In: Natures Services: Societal Dependence on Natural Ecosystems. Edited by Daily, G.C., Island Press. Washington, D.C.

[28] Pimentel D., Wilson, C., McCullum, C., Huang, R., Dwen, P., Flack, J., Tran, Q., Saltman, T., Cliff, B. 1997. Economic and Environmental Benefits of Biodiversity. BioScience. 47. 11. 747-757.

grasslands. Large costs are associated with the implementation of artificial pollinators, especially as degraded habitats from development and pesticide use adversely affect pollinator populations.[29] This publication serves as a broad ecosystem service valuation of the pollination benefits of biodiversity. The authors' study was published in BioScience, a prestigious natural sciences journal.

9. **Future Analysis Needed:** Given the agricultural dependency on nearby grasslands and prairies, the estimated value for pollination likely applies to those open green space areas near croplands as well. This value is likely smaller for those green space areas that are not near croplands, though urban gardens benefit. Under future analysis, two separate values for open green space values could be provided, those in close proximity to croplands and those outside natural pollinator range.

Value 19: Recreation in Green Open Space

1. **Land Cover:** Green Open Space
2. **Ecosystem Service:** Recreation
3. **FEMA Value (Geographic Region):** $5,365.26 (National)
4. **Valuation Method:** Contingent Valuation (Willingness to Pay) and Hedonic Pricing
5. **Geographic Area of Study:** Kentucky Farmland (average of all counties) and Boulder, Colorado
6. **Reference 1:** Ready, R.C., Berger, M.C. 1997. Measuring Amenity Benefits from Farmland: Hedonic Pricing vs. Contingent Valuation. Growth and Change. 28. 438-458.

   Reference 2: Breffle, W.S., Morey, E.R., Lodder, T.S. 1997. Using Contingent Valuation to Estimate a Neighborhood's Willingness to Pay to Preserve Undeveloped Rural Land. University of Colorado.
7. **Methodology Description:** Two standard hedonic models were used by Ready and Berger in a semi-log functional form to estimate an amenity value for rural horse pasture in open space. Both equations provided a good statistical fit, where the total price of a horse farm amenity, or rural open space, was also statistically significant. The authors compared these results to those from a contingent valuation survey. The survey asked local residents for their willingness to pay (WTP) to preserve the open horse fields from alternative agricultural development for continued recreational use. The survey itself was developed on the decisions of a focus group. Breffle et al. developed a contingent valuation survey based on the WTP for the preservation of an undeveloped land in urban Boulder, Colorado. This abandoned land was found to be home to native wildlife and also provided benefits to walkers, wildlife watchers, birders, and others who passed through the area. Data collected from the personal surveys were used in an analysis that included a distance decay-function of the WTP within one mile of the undeveloped area.

[29] Ibid.

8. **Calculation: (All Values in 2011 USD)**
   - Ready and Berger: $0.70
   - Breffle: $18,921.59

   [(.70) + (18,921.59)]/2 = $9,461.15
9. **Qualification:** Ready and Berger used both the hedonic pricing and contingent valuation methods that rendered nearly the same results for the benefits from rural open space. Similarly, Breffle et al. were able to compare their analysis to the financial pledges made from the same study population for the preservation of the same lot of land. The results were compared and found to be similar, given the circumstances of the pledge system.
10. **Future Analysis Needed:** The values above reflect studies from both rural and urban areas. The recreational value of green open space is highly responsive to location and population density. The studies included here span low and high values. Recreational values provided by open space included in this study including sports activities, hiking, biking, walking, birding and more. With relatively little additional research stronger values for the recreational value of open space can be calculated. In addition, open space becomes increasingly more valuable as scarcity rises. In a rural area, there is no shortage of green space, which reflects the low value. Under future analysis both of these lands types should be separated to capture the variation in value.

Ecosystem Service Value Qualifications – Riparian Area

Value 20: Aesthetic Value of Riparian Buffer

1. **Land Cover:** Riparian Area (Reconnected Forest Side-Channel)
2. **Ecosystem Service:** Aesthetic Value
3. **FEMA Value (Geographic Region):** $580.87 per acre per year (National)
4. **Reference 1**: Qiu, Z., Prato, T., Boehm, G. 2006. Economic Valuation of Riparian Buffer and Open Space in a Suburban Watershed. Journal of the American Resources Association. 42. 6, 1583–1596.
5. **Valuation Method:** Contingent Valuation, Hedonic Pricing, and Travel Cost Method
6. **Geographic Area of Studies:** Urban Missouri (North of St. Louis)
7. **Methodology Description:** Aesthetic value for riparian areas was measured with both contingent valuation and hedonic pricing methods. Qiu et al. adopted a hedonic pricing method to measure the increased value to residential properties within proximity of a riparian area. A contingent valuation survey was used to compare to the hedonic results in order to confirm the validity of the calculated values. The approach addressed bias inherent in the econometric models.
8. **Calculation: (All values in 2011 USD)**

   Qiu et al: $580.87 per acre per year no additional calculation
9. **Qualification:** Qiu et al. conducted both a hedonic and contingent valuations for aesthetic value. They showed that the hedonic valuation came well within the

contingent valuation range. The use of the willing-to-pay survey allowed for the comparison of aesthetic values from the econometric models. The survey was also created to provide study participants with sufficient information to accurately judge payments for aesthetic benefits.

10. **Future Analysis:** There are many aesthetic studies, and aesthetic value is highly site specific. This value would be stronger bringing in further studies from around the US and setting a methodology or model for estimating national and locally specific riparian aesthetic values.

Value 21: Food Provisioning from Riparian Areas

1. **Land Cover:** Riparian Areas
2. **Ecosystem Service:** Food Provision
3. **FEMA Value (Geographic Region):** $609.44 (National)
4. **Valuation Method:** Avoided Cost and Market Price
5. **Geographic Area of Study:** Wiltshire, England
6. **Reference:** Everard, M., Jevons, S. 2010. Ecosystem Services Assessment of Buffer Zone Installation on the Upper Bristol Avon, Wiltshire. Environment Agency. Bristol. Available at: http://publications.environment-agency.gov.uk/PDF/SCHO0210BRXW-E-E.pdf
7. **Methodology Description:** The cost avoidance value is based on the production savings to farmers and improved farm profitability. A riparian buffer limits nutrient runoff, this results in less fertilizer and manure usage (more nitrogen is retained on the fields) avoiding additional input costs. The riparian buffer also provides benefits to people who utilize the river downstream, like irrigation and public water supply that would otherwise be lost to contaminated water. Pimentel derived the figures from an average savings across 117 farms in the study area.
8. **Calculation:** No additional calculation was made for this value.
9. **Qualification:** Given that farming practices are very similar in the U.S. and U.K., the cost savings associated with farming in the U.K. can be used to compare to the potential savings in the U.S. This study is the only one found that values the water-based food provisioning services for agricultural areas. Despite the fact that this study resides in the UK, the methodology used allows for the transferability of this to the U.S. The riparian conditions and crops are similar to the US, as are farm costs and the value of farm products.
10. **Future Analysis Needed:** This food provisioning benefit is specific to farmlands with riparian areas. Most farmlands do have riparian areas. Under future analysis, an indicator of how much farmland contains or is adjacent to riparian areas would allow for a better calculation of the value.

Value 22: Water Filtration in Riparian Areas

1. **Land Cover:** Riparian Area
2. **Ecosystem Service:** Water Waste Reduction/Filtration (Water Quality)
3. **FEMA Value (Geographic Region):** $4,251.89 (National)
4. **Valuation Method:** Replacement Cost
5. **Geographic Area of Study**: Clark County, Ohio and Wiltshire, England
6. **Reference 1:** Everard, M., Jevons, S. 2010. Ecosystem Services Assessment of Buffer Zone Installation on the Upper Bristol Avon, Wiltshire. Environment Agency. Bristol. Available at: http://publications.environment-agency.gov.uk/PDF/SCHO0210BRXW-E-E.pdf

   Reference 2: Zhongwei, L. 2006. Water Quality Simulation and Economic Valuation of Riparian Land-use Changes. University of Cincinnati. 257. (book)
7. **Methodology Description:** Everard and Jevons analyzed the potential costs of contaminated water sources from agricultural sources such as dairy farming. The downstream beneficiaries face the costs of developing potable water supplies from contaminated wells. Zhongwei conducted an analysis on the purification potential of several types of riparian buffers of varying sizes. All buffer analyses investigated the filtration of nitrogen and phosphorus removal from agriculture sources upstream. Hydrological computer models such as BASINS and HSPF along with GIS geospatial maps were used in this analysis.
8. **Calculation: (All Values in 2011 USD)**
   - Everard and Jevons: $2,464.75
   - Zhongwei:
     - Forested Buffer: $276.97
     - Wetland Buffer: $6,525.01
     - Grassland Buffer: $11,315.12

   [(276.97+6,525.01+11,315.12)/3 + 2,464.75]/2 = $4,251.89 per acre per year
9. **Qualification:** The level of detail provided in Zhongwei's book (previously his PhD thesis) is the level of analysis one would hope to find for all environmental service valuations. The 257 page document analyzes three different types of riparian buffer: forest buffer, grassland filter strips and grassed swales (wetland based grasslands). Zhongwei went into further detail by studying the riparian benefits at different buffer widths (60m, 90m and 120m). As Zhongwei's research was focused on pollutants from applied fertilizers, Everard and Jevons' study was included to incorporate other elements of water pollution, particularly from dairy farming practices. Despite the fact that this study resides in the U.K., the methodology used allows for the transferability of this to the U.S. These values are averaged here to provide a national value because the vegetation type of riparian areas is not differentiated within the FEMA table.
10. **Future Analysis Needed:** The various species that act as riparian buffers along a creek or river often provide ecosystem services at similar levels, but in many cases provide very different levels of ecosystem service. Under future analysis, it would be worth

sub-categorizing the land type "riparian buffer" under different species categories. In addition, the Eugene Water and Electric Board (Eugene, Oregon) is setting up a payment system for farms that protect riparian areas and plant riparian buffers in native species. This provides a new income source to farms for the protection of riparian areas. This direct payment for water quality improvements provided by riparian areas will serve as an improved value. The scheme could begin as early as 2013.

Value 23: Climate Regulation from Riparian Areas

1. **Land Cover:** Riparian
2. **Ecosystem Service:** Climate Regulation
3. **FEMA Value (Geographic Region):** $204.21 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study:** New Jersey and Ontario, Canada
6. **Reference 1:** Mates, W.J., Reyes, J.L. 2006. The Economic Value of New Jersey State Parks and Forests. New Jersey Department of Environmental Protection. Available at: www.nj.gov/dep/dsr/economics/parks-report.pdf

   Reference 2: Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services. David Suzuki Foundation, Vancouver, Canada. Available at: http://www.davidsuzuki.org/publications/downloads/2008/DSF-Greenbelt-web.pdf

   Reference 3: Harris, D., Crabtree, B., Newell-Price, P. 2006. Economic Valuation of Soil Functions Phase 1: Literature Review and Method Development. Prepared for Department of Environment, Food and Rural Affairs. UK. Available at: http://www.cjcconsulting.co.uk/pdfs/FINALEcon%20Valuation%20of%20Soil%20Functions%20Rept%20Phase%20I_0806.pdf
7. **Methodology Description:** This ecosystem service value is based on an average between the carbon sequestration values of forests and open green space provided. These studies all utilized the cost avoidance and damage avoidance methodology. These damage estimates are based on one or more carbon market trading systems, which include the European Union Emissions Trading Scheme and the Chicago Climate Exchange. Harris et al. estimated carbon uptake estimations on non-agricultural grasslands and open space previously used for agricultural purposes. Both of which are based on globally transferable land types. Mates and Reyes showed how differences in the carbon storage capabilities among tree species change the ecosystem service value with different amounts of carbon storage. Wilson utilized the CITYgreen software, which provides different estimates of carbon storage based on tree species and age.
8. **Calculation: (All Values in 2011 USD)**
   - Mates and Reyes: $118.48 (Forest - uptake) + $316.15 (forest - sequestration)
   - Wilson: $14.52 (forest - uptake) + $341.31 (forest - sequestration)
     $26.11 (green open space – sequestration)
   - Harris et al: $7.94 (green open space - carbon sequestration)

$5.53 (green open space – carbon sequestration)

[($14.52 + 341.31) + (118.48 + $316.15)]/2 (forest)
+
[$26.11 +$7.94+5.53]/3 (grassland)
/2
= $204.21 per acre per year

9. **Qualification:** Riparian buffers are generally comprised of several different tree and plant species, from grasslands to old growth forests. Carbon sequestration storage values vary greatly between these species and their physical genres. Ecosystem service valuations on riparian buffer areas are often conducted with the purpose of analyzing specific services that are inherent to riparian systems, such as erosion control, water quality, or habitat services. Carbon sequestration certainly exists in riparian areas, but these benefits are better realized through the analysis of a particular tree species or vegetation type, like coniferous forests. The average taken for this value of carbon sequestration in riparian areas represents the average value between the different land types that present in riparian areas. The average figures that were provided above were used for the valuation of carbon sequestration from forests and open green space. This logic provides a best first estimate for use at a national scale.
10. **Future Analysis:** Under future analysis, riparian areas should be separated into multiple land types (forested riparian, wetland riparian, grassy riparian, rocky riparian). This will allow the benefits of riparian forests to be differentiated from riparian grasslands. This would provide far more specific values in each of these riparian land-class categories. A classification with respect to the flood plain and erosion zones would also be helpful to FEMA.

Value 24: Flood Protection and Risk Mitigation from Riparian Areas

1. **Land Cover:** Riparian
2. **Ecosystem Service:** Flood Control (Water Retention)
3. **FEMA Value (Geographic Region):** $4,007.01 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study:** Elkhorn Slough Salt Marsh Wetland in California
6. **Reference:** Rein, F. 1999. An Economic Analysis of Vegetative Buffer Strip Implementation. Case Study: Elkhorn Slough, Monterey Bay, California. Coastal Management. 27. 4. 377-390.
7. **Methodology Description:** Reins shows how riparian buffers along rivers can serve as temporary flood storage areas, thereby reducing flood damage. The Pajaro River, north of the Elkhorn Slough has a hydrological connection to the study region. This area witnessed extensive flooding damage in 1995 and 1998.[30] Economic data from these flood events allowed Rein to calculate the avoided cost of future floods given the

[30] Rein, F. 1999. An Economic Analysis of Vegetative Buffer Strip Implementation. Case Study: Elkhorn Slough, Monterey Bay, California. Coastal Management. 27. 4. 377-390.

installation of the riparian buffers.

8. **Calculation:** No additional calculation was made to establish this value.
9. **Qualification:** The availability of historic flood data near the study region (from the Governor's Office of Emergency Services) provided basic data for the study. This allowed Rein to appropriately estimate flood damage in an area that will see increased flooding. In light of increased threats of flooding nationally, these values represent a very conservative estimation of avoided cost. The 1995 and 1998 flood costs were based on damages to local infrastructure. Federal disaster funds requested only in 1995.
10. **Future Analysis:** Riparian areas are critical to flood protection and this value will vary considerably. Regional studies for the Northwest, Southwest, the Mississippi Basin (upper and lower, and/or east and west) as well as the North East, and South East would add a great deal of value for mitigation BCA calculations.

Value 25: Air Quality in Riparian Areas

1. **Land Cover:** Forests
2. **Ecosystem Service:** Carbon Sequestration
3. **FEMA Value (Geographic Region):** $215.06 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study:** New Jersey and Ontario, Canada
6. **Reference 1:** Mates, W.J., Reyes, J.L. 2006. The Economic Value of New Jersey State Parks and Forests. New Jersey Department of Environmental Protection. Available at: www.nj.gov/dep/dsr/economics/parks-report.pdf

   Reference 2: Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services. David Suzuki Foundation, Vancouver, Canada. Available at: http://www.davidsuzuki.org/publications/downloads/2008/DSF-Greenbelt-web.pdf
7. **Methodology Description:** Riparian areas with forests and green open space provide air quality value by reducing pollutants like carbon dioxide, nitrogen dioxide, sulfur dioxide, ozone, and particulates. This ecosystem service value is based on an average between the air quality values of both forests and green open space. All methodologies used in these sources utilized the avoidance cost of pollution-related illnesses (and the resulting health costs). Estimates of pollutants absorbed per unit were valued using the market prices of alternative methods of air purification. These benefits are usually much higher in urban areas. Specifying the different values between urban and rural forest and green open spaces would add greater detail to the economic value provided by riparian areas for air quality.
8. **Calculation: (All Values in 2011 USD)**
   - Mates and Reyes: $225.65 (forests)
   - Wilson: $159.49 (green open space)
   - McPherson et al: $30.84 (green open space)
   - Trust for Public Land: $423.07 (green open space)

($225.65 + ($159.49 + 30.84 + 423.07)/3)/2= $215.06 per acre per year

9. **Qualification:** Riparian buffers provide air quality benefits depending on the different plant species present, for example grasslands to old growth forests. Air purification values vary greatly between these species genres and in relation to population density and overall pollution levels. Ecosystem service valuations on riparian buffers are often conducted with the purpose of analyzing specific services that are inherent to riparian systems, such as erosion control, water quality, or habitat services. Air purification certainly exists in riparian areas, but these benefits are better realized through the analysis of a particular land cover type, such as forests or grasslands. To provide a national value, the average carbon sequestration value based on values provided in non-riparian areas that reflect the land cover types in riparian areas was calculated. Utilizing the two most diverse land cover types, forests and green open space a national value was calculated. Though this is a crude methodology, the value of riparian areas for air quality exists, providing a rough estimate for the value is superior to excluding a clearly present value.
10. **Future Analysis:** Riparian areas should be separated into multiple land types, such as riparian forests, riparian shrub and riparian open space. In addition, there could in the future be a differentiation between urban and rural so that a more finely graded scale of the value of air quality for riparian areas could be included in the BCA Tool. This will allow the benefits of riparian forests to be differentiated from riparian grasslands, for example providing better estimates.

Value 26: Habitat Services in Riparian Areas

1. **Land Cover:** Riparian Areas
2. **Ecosystem Service:** Habitat (Nursery)
3. **FEMA Value (Geographic Region):** $835.41 (National)
4. **Valuation Method:** Production Function
5. **Geographic Area of Study:** The Peconic Estuary System within Suffolk County, New York
6. **Reference:** Johnston, R.J., Grigalunas, T.A., Opaluch, J.J., Mazzotta, M., Diamantedes, J. 2002. Valuing Estuarine Resource Services Using Economic and Ecological Models: The Peconic Estuary System Study. Coastal Management. 30. 47-65.
7. **Methodology Description:** The productivity value estimates include both values due to food web productivity and values related to habitat. Results are provided for the 1) Marginal value of existing wetlands and riparian areas, and 2) the marginal value of restored wetlands and riparian areas. The annual value is the sum of the food web values and the habitat values for a year.
8. **Calculation: (All values in 2011 USD):** No additional calculation was made.
9. **Qualification:** A director and research professor at Clark University, Johnston has

authored many publications on the subject of ecosystem services and economics. Johnston collaborated with several respected authors for this study, including Marisa Mazzotta, who has also authored studies in the same field.[31] This study captures the value within five different areas with existing riparian buffers. These study consider different population densities where one region is nearby a small farm and others are located near parks that allow access to recreational fishing. This variation in surroundings allows for the comparability among many different land lands types within the U.S., offering the ability for the values above to be applied nationally.

10. **Future Analysis Needed: T**his value is likely an underestimate of riparian value nationally. The high value of salmon riparian habitat should be a regional addition in future analysis and could separate riparian areas into two categories, those that support salmon habitat or do not support salmon habitat. Other regions have similarly specific riparian habitat values not included in this study. A regional approach could improve these values. FEMA should consider how best to define riparian areas, in many areas it extends far into the floodplain and would be very important to FEMA while many local jurisdictions define the riparian area as a fifty foot buffer no matter the physical floodplain shape.

Value 27: Biological Control in Riparian Areas

1. **Land Cover:** Riparian
2. **Ecosystem Service:** Biological Control (Pest Control)
3. **FEMA Value (Geographic Region):** $163.68 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study:** Elkhorn Slough Salt Marsh Wetland in California
6. **Reference:** Rein, F. 1999. An Economic Analysis of Vegetative Buffer Strip Implementation. Case Study: Elkhorn Slough, Monterey Bay, California. Coastal Management. 27. 4. 377-390.
7. **Methodology Description:** Rein used avoided cost to analyze the ecosystem service benefits to both farmers and the local community. The author showed that buffers act as a strip of protection against invasive weeds. With a healthy riparian buffer, crop growers avoid the cost of having to spray their field borders with herbicides. Rein also demonstrated how society also benefits of mosquito abatement. Riparian buffers prevent soil erosion, which would otherwise cause sediment build-up downstream, creating mosquito breeding grounds. In some cases, both of these values will be present and they would be additive. A conservative approach is to assume that one or the other of these services are provided, thus an average of weed and mosquito abatement provides a more general number for national use. This figure conservative because there are many other insect, fungus, plant, and animal pests not included here.

[31] Mazzotta, M. 1996. Measuing Public Values and Priorities for Natural Resources: An Application to the Peconic Estuary System. University of Rhode Island.

8. **Calculation: (All Values in 2011 USD)**
   - Weed Control: $303.56
   - Mosquito Abatement: $23.80

   [$303.56+$23.80]/2 = $163.68 per acre per year
9. **Qualification:** The instances of biological control in Rein's study are extremely common where riparian areas exist in the U.S. These services are prevalent, especially where farmers live. Farmers and regular citizens are often studied separately but both groups benefit greatly from the existence of healthy riparian buffers. The marriage of these groups is rare under ecosystem service analysis. This study was published in the Coastal Management Journal is cited in many publications.

10. **Future Analysis:** The Department of Agriculture has looked at a number of benefits for biological control of riparian buffers both for weed and insect pest control. The financial benefits of these riparian areas could be calculated from the substantial physical data available. In addition, the pest control value for urban riparian areas clearly holds value and should be examined in greater detail.

Value 28: Erosion Control in Riparian Areas

1. Land Cover: Riparian Areas
2. Ecosystem Service: Soil Retention (Erosion Control)
3. FEMA Value (Geographic Region): $11,447.30 (National)
4. Valuation Method: Avoided Cost and Replacement Cost
5. Geographic Area of Study: Elkhorn Slough Salt Marsh Wetland in California
6. Reference: Rein, F. 1999. An Economic Analysis of Vegetative Buffer Strip Implementation. Case Study: Elkhorn Slough, Monterey Bay, California. Coastal Management. 27. 4. 377-390.
7. **Methodology Description:** All values below were based on the avoided cost methodology both to private farmers and to society. Without a buffer system, river systems introduce invasive growth, eventually reaching roadways and causing damage. Farmers are held financially responsible for the clean-up costs to public roadways and tax payers bear the cost of road construction. Farmers also take on damages from maintenance and construction to bordering riparian areas that can be avoided with the installment of a wider buffer. Conservatively measured by Rein, extensive damages to existing habitat in wetlands can occur when soil is deposited downstream. A riparian buffer can reduce damage mitigation costs and recreational losses, preserving wetland values. The total avoided damages to public roads were calculated by estimating reduced road repairs and maintenance overtime. Finally avoided dredging costs for shipping channels downriver were found to be extremely valuable in this case study. These costs are included in the value below. Though this is a localized value, dredging costs exist for most of the land area of the US because these lands generally drain to river deltas where ports exist. Consider the Mississippi, Columbia, Colorado, Great Lakes, California, New England, Mid-Atlantic and South Atlantic River Basins. These

basins all require significant dredging costs at the associated coastal ports. This includes the vast majority of the land area of the continental US. The avoided sediment value provided by riparian areas in Iowa or Louisiana reduces dredging costs at the mouth of the Mississippi River, for example. Ecosystem services are valued at the site of their provisioning. Thus, the erosion control value of riparian area in Iowa or throughout the Mississippi Basin should be counted on site, though the national benefits will realized at the mouth of the river. The US Army Corps of Engineers conducts dredging throughout the coastal US, including many smaller watersheds with relatively small rivers and ports. A list of dredging contracts is available to give an idea of how universally this value can be applied across the US and a list of let contracts for 2012 provides an idea of the quantity of dredge materials removed.[32]

8. **Calculation: (All Values in 2011 USD)**

    - Farm damage: $3,275.43
    - Short-term road maintenance: $1,487.45
    - Long-term road maintenance: $218.56
    - Harbor Dredging: $26,941.07
    - Loss of downstream wetland: $37.95

    **($3,275.43 + $1,487.45)/2 + ($218.56+$37.95+$26,941.07)/3
    =$11,447.30 per acre per year**

9. **Qualification:** Harbor dredging accounts for the highest costs resulting from soil erosion upstream. Although freight shipping lines are primarily located along ocean systems, several major rivers are used by cargo ships for national traveling. Clearing costs from soil erosion are also found in river and creek systems of all sizes, even those that do not support cargo ships. The US Army Corps of Engineers has detailed and available cost data for dredging throughout the US. Due to the limited number of studies on the cost of sediment clearing in river systems, the value above will be used as a proxy for all river systems that enable cargo transportation and those that do not. This study represents the only analyses found of both farmer and societal costs from soil retention reduction with lost riparian buffer. Published in the Coastal Management Journal, the paper was cited in many publications. Farmers and citizens are often considered separately. This study represents a better choice for a national value because it reflects public and private, avoided costs and avoided damages.

10. **Future Analysis Needed:** Few riparian valuation studies exist. Differentiating further between private and public costs borne by farmers, firms and local citizens would enhance the results. Most flood areas have farms, roads, harbors and wetlands downstream, however, there could be deltaic or other riparian areas where no farms exists downstream of the riparian area. This study makes some assumptions about the relationship between riparian areas and erosion prevention. This physical relationship is different based upon soils, land cover, and rainfall patterns. There is now more physical

[32] See Army Corps website at for a list of dredging costs http://www.ndc.iwr.usace.army.mil//dredge/dd11cos2.htm, and for a list of current contracts and the cubic yards to be dredged throughout the US see: http://www.ndc.iwr.usace.army.mil//dredge/dredge.htm

information on riparian areas and erosion prevention. With better physical erosion data, better more regionally specific calculations of this value could be produced, however, they do not exist in the academic literature at this time, except in Europe. The US Army Corps of Engineers maintains very detailed data on the cost of dredging for US every port or river mouth where they are active. The cost/cubic yard of material ranges from $2.31/CY to $17.64/CY. In addition, the volumes dredged materials range widely from the Mississippi River to relatively small rivers. The information exists to enable a more specific calculation of this value on a state, basin, or watershed scale.

Value 29: Recreation in Riparian Areas

1. **Land Cover:** Riparian Areas
2. **Ecosystem Service:** Recreation
3. **FEMA Value (Geographic Region):** $15,178.07 (National)
4. **Valuation Method:** Replacement Cost
5. **Geographic Area of Study:** Elkhorn Slough Salt Marsh Wetland in California
6. **Reference:** Rein, F. 1999. An Economic Analysis of Vegetative Buffer Strip Implementation. Case Study: Elkhorn Slough, Monterey Bay, California. Coastal Management. 27. 4. 377-390.
7. **Methodology Description:** Uncontrolled erosion and nutrient deposition were found to be significant threats to ecotourism resources in the Elkhorn Slough region. Recreational activities included kayaking, boating, nature tours, fishing, birding and biking. Rein based these costs on the lost recreation due to diminished resources that attract tourists. Uncontrolled nutrient deposition and sedimentation of the Slough damages downstream habitat and reduces recreational benefits. The implementation of riparian buffer decreased the rate of erosion and nutrient deposition by 50%. This provides measurable downstream recreational economic benefits.
8. **Calculation: (All Values in 2011 USD):** No additional calculation was made.
9. **Qualification:** This paper is one of few publications analyzing the recreational benefits of riparian buffers. Nearly all studies on recreation in natural water systems are attributed to rivers and lakes, not riparian areas. This study examined the benefits of avoided sediment build-up and nutrient deposition on downstream recreational values dependent upon habitat quality for recreational use.
10. **Future Analysis Needed:** The recreational benefits of rivers are largely dependent on the stability and health of riparian buffers. Recreational activities such as fishing, rafting, and swimming are threatened by the diversion of instream flows. Most recreational fishing takes place with fishers standing on the bank (in the riparian area). All recreation benefits dependent on riparian health are realized by recreation in rivers. Under future analysis, recreational benefits of rivers should be a factor of riparian buffer health.

Ecosystem Service Value Qualifications – Forests

Value 30: Erosion Control in Forests

1. **Land Cover:** Forests (Restored Forests) – West Coast Marine Forest, Western Forested Mountains, East Coast Temperate
2. **Ecosystem Service:** Erosion Control
3. **FEMA Value (Geographic Region):** \$62.22 per acre per year (National)
4. **Reference:** Dodds, W.K., Wilson, K.C., Rehmeier, R.L., Knight, G.L., Wiggam, S., Falke, J.A., Dalgleish, H.J., Bertrand K.N., 2008. Comparing ecosystem goods and services provided by restored and native lands. BioScience 58, 837-845.
5. **Valuation Method:** Value Transfer
6. **Geographic Area of Study:** Forested Mountain Regions – East and West Coast
7. **Methodology Description:** "The authors produced an ecosystem service value for erosion control with regards to restored forestland. They provide the restoration value of three forest regions. Monetary values derived from the literature across different years were collected. Most of the monetary values were derived using willingness-to-pay methods. In cases where several literature values were reported for a parameter, they used the median of the estimates.[33] Soil erosion control values were acquired by comparing the amount of soil lost from degraded land, restored land, and native land. The values for soil loss from restored and native land were each compared with the amount of soil lost from degraded land in the same ecoregion. These fractions were multiplied by the annual cost of soil erosion per hectare in the United States, which is \$196.[34] This monetary value presents the value of soil conserved in restored or native habitat per hectare of land."[35]
8. **Calculation:** Average of the below values:

   \$70.12 per acre per year for West Coast Marine Forests
   \$46.42 per acre per year for Western Forested Mountains
   \$70.12 per acre per year for East Coast Temperate Forest
   [\$70.12 + \$70.12 + \$46.42]/3 = \$62.22 per acre per year
9. **Qualification:** This study was chosen because it incorporates the values of many ecosystem service valuation studies from many different publications. This sample of multiple studies assists the authors in representing a regional ecosystem service value for erosion control. It should be noted the reference is for the value of restored forests, but the study provides values for native forests as well. The restored forest value

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[33] Dodds, W.K., Wilson, K.C., Rehmeier, R.L., Knight, G.L., Wiggam, S., Falke, J.A., Dalgleish, H.J., Bertrand K.N., 2008. Comparing ecosystem goods and services provided by restored and native lands. BioScience 58, 838.
[34] Pimentel D, et al. 1995. Environmental and economic costs of soil erosion and conservation benefits. Science. 267: 117-757.
[35] Dodds, W.K., Wilson, K.C., Rehmeier, R.L., Knight, G.L., Wiggam, S., Falke, J.A., Dalgleish, H.J., Bertrand K.N., 2008. Comparing ecosystem goods and services provided by restored and native lands. BioScience 58, 837-845.

provides most landowners using the FEMA BCA Tool with an opportunity to restore forests that have been impacted by human activity. According to this study, less than 10% of native ecosystems remain within the U.S. This is why the restoration value is more appropriate to areas were FEMA has mitigation projects.

10. **Future Analysis:** The erosion control provided by forests is dependent upon the hydrology, soils, slope and other aspects of the area. Modeling efforts are underway which can better estimate the erosion control value of forested areas. In the future, FEMA could use a model in conjunction with valuation studies to determine this value in the BCA Tool.

Value 31: Climate Regulation from Forests

1. **Land Cover:** Forests
2. **Ecosystem Service:** Climate Regulation
3. **FEMA Value (Geographic Region):** $395.23 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study:** New Jersey and Ontario, Canada
6. **Reference 1:** Mates, W.J., Reyes, J.L. 2006. The Economic Value of New Jersey State Parks and Forests. New Jersey Department of Environmental Protection. Available at: www.nj.gov/dep/dsr/economics/parks-report.pdf

   Reference 2: Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services. David Suzuki Foundation, Vancouver, Canada. Available at: http://www.davidsuzuki.org/publications/downloads/2008/DSF-Greenbelt-web.pdf
7. **Methodology Description:** Both studies estimate the value of carbon sequestration and carbon storage using market based international trading schemes such as the European Union Emissions Trading Scheme and the Chicago Climate Exchange. The market trading systems, such as the European Union Emissions Trading Scheme, are based on trading values, which are influenced by economic conditions and other factors. They only partially represent the full public costs of climate change due to increased storm damages, rising water levels and damages to the agricultural industry. Mates and Reyes detailed differences in the carbon storage capabilities among trees of different species. These factors allowed them to base the ecosystem service value on a range of varying carbon storage amounts. Wilson's use of the CITYgreen software to provided extensive calculations on the tree characteristics that determine carbon storage that are often difficult to capture, like tree canopy cover.
8. **Calculation: (All Values in 2011 USD)**
   - Mates and Reyes: $118.48 (uptake) + $316.15 (sequestration)
   - Wilson: $14.52 (uptake) + $341.31 (sequestration)

   ([118.48 + 316.15] + [341.31 + 14.52])/2 = $395.23 per acre per year
9. **Qualification:** The use of both studies provides a sample the wide variety of tree species from different biomes in the U.S. The northern boreal trees in Canada closely

resemble those found in the northern states in central and northwest U.S. New Jersey resides the eastern deciduous forest region, covering much of the U.S. east coast.

10. **Future Analysis:** The information on carbon sequestration and forests is rapidly improving. There are now studies for the carbon sequestration of very specific forest types, densities, age structures and more. Thus, this value could be better provided on a regional and local basis pulling specific carbon sequestration/forest type data together with valuation information. In addition, carbon values, particularly in the voluntary Chicago market have been more volatile than most markets. There are new valuation methodologies specifically intended to provide more accurate and smooth values.

Value 32: Air Purification in Forests

1. **Land Cover:** Forests
2. **Ecosystem Service:** Air Quality (Air Purification)
3. **FEMA Value (Geographic Region):** $225.65 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study:** New Jersey
6. **Reference:** Mates, W.J., Reyes, J.L. 2006. The Economic Value of New Jersey State Parks and Forests. New Jersey Department of Environmental Protection. Available at: www.nj.gov/dep/dsr/economics/parks-report.pdf
7. **Methodology Description:** Mates and Reyes value air quality based on three things: the physical amount of air pollution removed by forests annually, the dollar value per pound of pollution removed, and the number of acres of forest. The pollutants they examined include nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone, and particulate matter. Each of these pollutants has a different suite of health impacts. There is a clear link between increased particulate matter and higher asthma rates and death rates, for example. The economic benefits documented in their report include increased health costs and the imputed value of lost years of life due to pollution-related illness. Wilson utilized the CITYgreen software to estimate the value of removing the same list of pollutants.
8. **Calculation:** No change to the single value provided.
9. **Qualification:** Air purification benefits in New Jersey are important considering the dense population and industrial activity within the state. A majority of the forest systems are located in city parks and extend outside the city limits, offering a wide variety of data in urban and rural areas. This report was conducted on behalf of the New Jersey Department of Environmental Protection, a collaborative effort among 16 staff within the Department. The use of the CITYgreen software provides a systematic methodology that could be used for more localized values.
10. **Future Analysis:** The value of air quality for forests ranges quite widely. Forests that are rural, with few people, will naturally provide less dollar value than an urban forest in a city that already exceeds regulated particulate levels. Providing more localized data on these values would benefit the BCA Tool.

Ecosystem Service Value Qualifications – Agricultural Lands

Value 33: Pollination Services in Croplands

1. **Land Cover:** Agricultural Lands (Croplands**)**
2. **Ecosystem Service:** Habitat (Nursery)
3. **FEMA Value (Geographic Region):** $900.85 per acre per year (National)
4. **Valuation Method:** Production Function
5. **Geographic Area of Study:** Rural New Jersey and Pennsylvania
6. **Reference:** Winfree, R., Gross, B., Kremen, C. 2011. Valuing Pollination Services to Agriculture. Ecological Economics. 71, 80-88.
7. **Methodology Description:** "In this paper, we first unify the replacement value and production value approaches conceptually by demonstrating that each is a special case derived from the same general equation. Next, we address the problematic issues raised above through a modification of the production value approach. The choice to focus attention on the production value method is supported by three considerations: it is the most common method employed, the calculations are simple, and it is relatively easy to acquire the necessary data. We illustrate this improved approach, which we term the attributable net income method, using a data set on watermelon Citrullus lanatus pollination by native bees and honey bees, and compare the resulting values to those obtained by using the two traditional methods."[36]
8. **Calculation: (All values in 2011 USD):** No additional calculation beyond an inflation correction was made.
9. **Qualification:** The value of pollination is both of universal importance and varies dramatically from one location or crop to another. Pollination by wind (coniferous forests), by native pollinators (Mason bees), or by European honeybees is essential to forestry and agricultural productivity. Valuing pollination services is a new area, and it is expected that improved studies will be completed in the next few years. This study addresses some of the difficult issues around pollination and utilizes a better approach, the attributable net income method, as opposed to cost avoidance. This study also analyzes the value of honeybee pollination in both a residential region and agricultural setting. This study provides at least an initial marker value for the benefit of pollination.
10. **Future Analysis:** Future research can examine the cost replacement approach and could differentiate between various crops. Ongoing research on the value of pollination is being conducted and will provide greater data and analysis for use in the future.

[36] Winfree, R., Gross, B., Kremen, C. 2011. Valuing Pollination Services to Agriculture. Ecological Economics. 71, 80-88.

Value 34: Soil Erosion in Croplands

1. **Land Cover:** Agriculture
2. **Ecosystem Service:** Soil Erosion
3. **FEMA Value (Geographic Region):** $127.14 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study:** U.S. National Studies
6. **Reference:** Pimentel, D., Harvey, C., Resosudarmo, P., Sinclair, K., Kurz, D., McNair, M., Crist, S., Shpritz, L., Fitton, L., Saffouri, R., Blair, R. 1995. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. Science: 267, 1117-1123.
7. **Methodology Description:** Soil erosion protection benefits in croplands exist when proper soil conservation farming techniques are implemented. Pimentel et al. show that poor farming practices contribute to soil erosion on croplands, suggesting that higher ecosystem services exist with better farming techniques. The authors modeled multiple factors that influence soil erosion rates in the U.S. and globally, including slope of land, soil composition, and extent of vegetative cover. Physical data was used and models calibrated. The authors used national and international data from a 20-year period to confirm that water, nutrient, and soil loss are heavily influenced by conversion of soil into croplands (or from forests into grasslands), also by animal grazing. The figures below are calculated from on-site costs and show that erosion costs in the U.S. are above the global average.
8. **Calculation: (All Values in 2011 USD)**
   - Ground Water Replacement: $19.46
   - Diesel Fuel Expenditure: $42.81
   - Fertilizer Replacement: $64.87

   $19.46+$42.81+$64.87 = $127.14 per acre per year
9. **Qualification:** This study is a robust analysis of the effects of soil erosion of several land types, including grasslands, pastures, and agricultural lands. Large amounts of data were collected to capture the variables affecting soil erosion. Out of this data and analysis, Pimentel et al. provided national cost averages of soil erosion that are cited in many other reports. This provides a very general national value for soil erosion. The data exist to utilize available data within the US to provide far higher resolution valuation information based on the actual soil type, slope, and other physical attributes of the properties considered for mitigation investments. In addition, crop prices have risen more sharply than anticipated in this study. All indications from the United Nations Food and Agricultural Organization are that food crop prices will continue to rise more quickly than inflation. This indicates that the loss in present value of future crops due to soil erosion is significantly underestimated here.
10. **Future Analysis:** Various types of farmland provide different ecosystem service benefits. Corn and soybean products provide different levels of soil erosion protection than wheat, for example. The variation in crops would add greater specificity to the values. Contour farming provides soil erosion protection for many farm crops. In

addition, cultivation of the same crop may vary. For example, "no till" wheat farming (direct seeding) reduces erosion dramatically compared to traditional plowing, even if both utilize contour farming. There are additional values not included in this erosion value that indicate this value is highly conservative. For example, the eroded soils end up in drainage ditches that must be dredged at significant cost by local drainage districts. Eventually, this material also is deposited in river mouths where the US Army Corps of Engineers is responsible for dredging in ports. Future work could also include a better estimate of future food prices for estimating the value of reduced soil erosion.

Value 35: Biological Control in Croplands

1. **Land Cover:** Agricultural Land
2. **Ecosystem Service:** Biological Control
3. **FEMA Value (Geographic Region):** $14.29 (National)
4. **Valuation Method:** Benefit Transfer
5. **Geographic Area of Study:** Global
6. **Reference:** Costanza, R., dArge, R., deGroot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., Oneill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., vandenBelt. M., 1997. The value of the world's ecosystem services and natural capital. Nature: 387, 253-260.
7. **Methodology Description:** Costanza et al. derived the pest control value as the avoided cost of using pesticides to eliminate pest threats to crops. Several studies were cited, allowing the benefits to be applied globally. Natural pest control provides a great deal of value to farmers and for public health. Hedgerows (shelterbelts) and farmland set aside as conservation lands or other open space provide several ecosystem services including reduced soil erosion, habitat for pollinators, travel corridors for wildlife, and natural pest control values. These agricultural lands serve as a natural pest control because they harbor pest control insects, wildlife (such as swallows), and buffer the perimeter of farms against pests from outside the area. Though not all of the pest control values have been fully measured, partial measurements provide useful values. Crop loss due to pests was estimated to have damaged 37% of crops in the U.S. in 1991, causing 6 billion dollars of damage.[37]
8. **Qualification:** The authors' publication applied ecosystem service values at the national and international scale and is one of the most cited papers in ecological economics.[38] However, the paper was also criticized as not being specific enough in spatial, temporal or vegetation type and for overestimating the value of some ecosystem services. These are valid criticisms and demonstrate that this value could be greatly improved by examining classes of croplands, for example corn, grains, row crops, and

[37] Pimentel, D., Wilson, C., McCullum, C., Huang, R., Owen, P., Flack, J., Trand, Q., Saltman, T., Cliff. B., 1997. Economic and Environmental Benefits of Biodiversity. BioScience 47, 747-757.
[38] Cited in: Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services. David Suzuki Foundation, Vancouver, Canada.

fruit. It is very likely that this particular value underestimates the value of pest control because the value of crops has risen more rapidly than expected, thus reducing damage to crops has also risen in value more quickly. In addition, our understanding of natural pest control has improved since the 1990s and is recognized as more significant than previously understood. The study is outdated in both methodology and timing, and is a low value. Several research efforts are under way that would improve this figure and enable values that are more specific based on geographic location, crop-type, and pest type and could improve related health benefits (for example reduction of mosquitoes and dengue Fever).

9. **Future Analysis:** There are more recent international studies for biological control. For example, Boyles et al. show how bats, a predator of nocturnal insects, provide $3.7 billion per year.[39] The US Agriculture Department has far more specific pest-loss data, but has not attributed the dollar value to the biological pest control of associated farmland buffers and other attributes. These studies could provide better crop- or regionally-based values.

Value 36: Carbon Storage in Croplands

1. **Land Cover:** Agricultural Lands
2. **Ecosystem Service:** Carbon Sequestration
3. **FEMA Value (Geographic Region):** $51.48 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study:** U.S. National Studies
6. **Reference:** Manley, J., van Kooten, C., Moeltner, K., Johnson, D. 2005. Creating Carbon Offsets in Agricultural Through No-Till Cultivations: A Meta-Analysis of Costs and Carbon Benefits. Climate Change. 68. 41-65.
7. **Methodology Description:** The value of carbon storage in agricultural lands was derived from a collection of U.S. studies across several farm types. Manley et al. conducted a meta-analysis on the net value of no-till farming versus conventional tilling practices. The meta-analysis collected 28 studies from 14 different states, accounting for 220 total observations. The meta-analysis provided tons of carbon stored per acre, but not a dollar value of this stored carbon. The study provided a great deal of detail on different crops and their measured carbon storage. Other studies looked at carbon storage capacity, which would overestimate actual carbon sequestration values. There are many potential prices for carbon storage. There are several different approaches to pricing carbon based on voluntary and involuntary carbon markets as well as estimates of the total social costs not included in market transactions (Stern Review). Based on values from the European Union Trading Emissions Scheme, the Clean Development Mechanism and Joint Implementation CO2 credit sales, and the Chicago Climate Index,

[39] Boyles, J.G., Cryan, P.M., McCracken, G.F., Kunz, T.H. 2011. Economic Importance of Bats in Agriculture. Science. 332(6025). 41-42.

an average carbon sequestration value was derived (see #8 below).[40] This average is justified because the voluntary Chicago Climate Index does not include the full external costs of carbon emissions and value of sequestration. The European (and soon California) markets provide better estimates when more actors are required to participate in a carbon market. Finally, in order to annualize the carbon benefits (given that carbon storage benefits can cover up to a 20 year period), the carbon benefits were average over 20 years under a 5% discount rate, a method used in many publications.[41] This discounting method was used by Wilson (2008).

8. **Calculation: (All Values in 2011 USD)**
   - Average amount of carbon stored per acre: 9.9774 sequestered tons carbon/acre
   - Average market price of carbon stored/sequestered[42]: $64.30
     *9.9774 * 64.30 = $641.55 per ton.*
   - Converted to annual benefit (using 20 year span at a 5% discount rate[43]):
     $51.48 per acre per year
9. **Qualification:** An approach providing values specific to the region, crop, and cultivation method, would provide would provide stronger values for the specific mitigation sites where FEMA would be applying these values. Some site-specific data could be derived from this meta-analysis. With the goal of providing a single national value, this is a good study because it averages the values across many States with observations from each State representing data from different cropland types. Disaggregating this data for values more specific to regions and crops would not be difficult and would improve these values. Several agricultural crops were analyzed under the meta-analysis, including wheat, corn, and soybean. Prairies were also included, as well as a vegetation type labeled “other,” which was not specified in the study. All authors came from Economics departments in different regions of North America, including the University of California at Berkeley, University of Victoria, and the University of Nevada. The Stern Review, one of the most widely quoted economic reports on climate change, established a social cost value of $85/ton for carbon sequestration. The Review examines the evidence on the economic impacts of climate change and the economics of stabilizing greenhouse gas concentrations in the atmosphere. The economic costs of the impacts of climate change were analyzed in three different ways. First, by considering the physical impacts of climate change on the economy, human life and the environment, and the associated resource costs of different technologies and strategies to reduce greenhouse gas emissions. Second, by using economic models and macroeconomic models that represent the costs and benefits of the transition to low-carbon energy systems for the economy as a whole. Third, by comparing the current level and future trajectories of the social cost of carbon

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[40] Mates W.J., Reyes, J.L. 2004. The Economic Value of New Jersey State Parks and Forests. Prepared for the New Jersey Department of Environmental Protection. 32.
[41] Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services. David Suzuki Foundation, Vancouver, Canada.
[42] Average market price for carbon was calculated by converting all market values to short tons in 2011 dollars, then averaged between the four sources above.
[43] Formula: $641.55 = \Sigma\, x/(1+5\%)^i$, years, where x = $51.48

with the marginal abatement cost. This value was not utilized here, and provides a higher estimate for the economic value of carbon sequestration, indicating that the suggested value is a conservative estimate.

10. **Future Analysis:** Given that the carbon storage capabilities of agriculture vary between land types, slopes, crops, cultivation methods, and other factors, future analysis should consider carbon values based on these attributes. This would provide FEMA with more spatially specific valuation data. In addition, the 20-year period for discounting the carbon sequestration value is short by most BCA approaches. However, this is consistent with other work in the literature. A longer period of analysis, 100 years would be stronger. Carbon is an area where values have risen rapidly, but also been highly volatile dependent upon global economic output and regulatory schemes. Thus, up-dating this value more often would provide more accurate figures. If the higher social rate is adopted, then market variability would be less important. This carbon sequestration value does not double count the carbon sequestration value provided for riparian areas. However, as FEMA adds further values to the BCA Tool, adopting a classification system for these values in line with other Federal agencies would be helpful. Currently, there is no single accepted classification system. However, the EPA is currently developing a classification.

Value 37: Soil Formation in Croplands

1. **Land Cover:** Agricultural Lands
2. **Ecosystem Service:** Soil Formation
3. **FEMA Value (Geographic Region):** $109.47 (National)
4. **Valuation Method:** Avoided Cost
5. **Geographic Area of Study:** U.S. National Studies
6. **Reference:** Pimentel, D., Harvey, C., Resosudarmo, P., Sinclair, K., Kurz, D., McNair, M., Crist, S., Shpritz, L., Fitton, L., Saffouri, R., Blair, R. 1995. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. Science 267, 1117-1123.
7. **Methodology Description:** Soil creation, the addition of soil, is a distinct value from soil erosion prevention (prevention of soil loss). Pimentel et al. show that, under agricultural conditions, it takes approximately 500 years for soil biota (all organisms in soil) to form 25mm of soil. Mechanical mixing from agricultural machinery speed up the process, bringing more nutrients to the surface. The authors calculated this benefit by estimating the added value of topsoil, otherwise slowly produced by soil biota. Multiple physical measures of soil biota and soil quality were included in the analysis from US soil sample data, including estimates on populations of anthropods, enchytraeids, microbes, bacteria, and fungi, along with extensive data on soil composition and extent of influences on vegetative cover and soil fertility.
8. **Qualification:** This study provides a good basis for a single national value. A more regional and soil-specific approach would provide greater valuation specificity. The study conducted a data-rich analysis on the effects of soil biota in several land types, including grasslands, pastures, and agricultural lands. The value was derived from three agricultural land types which are all considered “agricultural lands”: crops, grasslands,

and pastures. Separating this into three values and including a question in the BCA Tool to distinguish between croplands, pasture, or hay/grasslands would provide more specific values. Large amounts of data were collected to include many attributes of and influences on soil formation. Pimentel et al. provided national cost averages of soil formation that are cited in several reports, but emphasized that the values are conservative. Soil creation and its benefits to agriculture were estimated for the common scenario and did not analyze the rare case of rich soils in specific regions of the United States.

9. **Future Analysis:** This national approach is better than the assumption of no value; however, the physical and spatial data that the study relies upon are rich, the US Agriculture Department has further and more up-dated soil. The US Geological Survey also has strong soil mapping. Therefore, without much additional effort, data that is more specific to the crop, spatial location, and soil conditions could be developed, providing FEMA with potential for more specific values.

Value 38: Aesthetic Value of Croplands

1. **Land Cover:** Agricultural Lands
2. **Ecosystem Service:** Aesthetic Value
3. **FEMA Value (Geographic Region):** $51.87 (National)
4. **Valuation Method:** Contingent Valuation and Hedonic Analysis
5. **Geographic Area of Study:** South Carolina
6. **Reference:** Bergstrom, J.C., Dillman, B.L., Stoll, J.R. 1985. Public Environmental Amenity Benefits of Private Farmland: The Case of Prime Agricultural Land. Southern Agricultural Economics Association. 139-149.
7. **Methodology Description:** The valuation of aesthetic benefits was derived under a two-step process. First, Bergstrom et al. conducted a survey in and around Greensville County, South Carolina, sampling 600 households. The survey asked a series of economic questions on the willingness to pay (WTP) to preserve the current agricultural land from being developed for commercial, residential, and industrial purposes. Second, the authors used the data to conduct an econometric analysis in order to correctly weigh the WTP figures with the attributes of each farm characteristic. With the inclusion of these characteristics in the model, WTP values were derived for the aesthetic benefit of the agricultural lands without the influence of other attributes.
8. **Calculation: (All Values in 2011 USD)**
    - WTP for 18,000 acres: $84.79 per acre
    - WTP for 36,000 acres: $50.44 per acre
    - WTP for 54,000 acres: $39.98 per acre
    - WTP for 72,000 acres: $33.26 per acre
    Average of four values: $51.87
9. **Qualification:** Agricultural lands have aesthetic value. Therefore, the BCA is improved by replacing the assumption of zero value with a minimal national value. However, aesthetic value is one of the most spatially sensitive environmental benefit values

because aesthetic value is highly dependent upon location. The national value proposed here is a crude estimate for a national value – it would be similar to taking a local housing value in South Carolina and applying it across the nation. Agricultural lands in rural Iowa or Arizona would not have the same aesthetic value as agricultural lands near more dense housing areas or major road corridors. Farming areas visually accessible from parts of New York City or Los Angeles may have significantly higher aesthetic values. The survey used by Bergstrom et al. was based on widely used methodologies of contingent market questionnaires.[44,45] The range of households sampled in the study was very broad. The region represents several different agricultural land types including livestock, corn, cotton, beans, and wheat farms. Some farms reduce aesthetic and property values. Intensive livestock farms, for example, have been known to decrease home values where the externalities of smell, water pollution, or increased truck traffic exist. Less intensive farms based on pastures can have positive aesthetic values. To avoid providing a positive value for farming aesthetic value where there is intensive livestock operations, a question in the BCA Tool could separate animal from plant production to provide a value to crop farms.

10. **Future Analysis:** Providing more regionally- and spatially-specific aesthetic values is critical to improving this value in the future. This could be accomplished by reviewing a series of studies from around the country and setting up a simple model to incorporate regional differences. Separating the values according to the type of farm and farm products would also improve this value. Farms that have greater conservation areas with trees, wetlands, and buffers have higher aesthetic value. Organic farms may have greater aesthetic value. In addition, some farming practices contribute to air quality reduction or health damages. Setting out a simple model for valuation based on a greater number of studies, the type of farm, and proximity to variables that affect aesthetic value could provide a more spatially specific approach and better values in the future.

Bibliography for Ecosystem Services Values

Allen, J., Cunningham, M., Greenwood, A., Rosenthal, L., 1992. The Value of California Wetlands: An Analysis of their Economic Benefits. Campaign to Save California Wetlands, Oakland, California.

Bergstrom, J.C., Dillman, B.L., Stoll, J.R. 1985. Public Environmental Amenity Benefits of Private Farmland: The Case of Prime Agricultural Land. Southern Agricultural Economics Association. 139-149.

Bolitzer, B., Netusil, N.R. 2000. The Impact of Open Spaces on Property Values in Portland, Oregon. Journal of Environmental Management. 59.

[44] Rowe, R., R. d'Arge and D. Brookshire. "An Experiment on the Economic Value of Visibility." J. Environ. Econ. Manag., 7(1980):1-19.
[45] Brookshire, D., A. Randall, and J. Stoll. "Valuing Increments and Decrements in Natural Resource Service Flows." Amer. J. Agr. Econ., 62(1980):478-88.

Breffle, W.S., Morey, E.R., Lodder, T.S. 1998. Using Contingent Valuation to Estimate a Neighborhood's Willingness to Pay to Preserve Undeveloped Urban Land. Urban Studies. 35(4). 715-727.

Butler, L.D., Workman, J.P. 1993. Fee Hunting in the Texas trans Pecos Area: A Descriptive and Economic Analysis. The Journal of Range Management. 46(1). 38-42.

Costanza, R., dArge, R., deGroot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., Oneill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., vandenBelt. M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253-260.

Costanza, R., O. Perez-Maqueo, M.L. Martinez, P. Sutton, S.J. Anderson, and K. Mulder (2008). The Value of Coastal Wetlands for Hurricane Protection. *Ambio* 37(4): 241-248.

Costanza, R., Wilson M., Troy A., Voinov A., Liu S., D'Agostino, J., 2006. The Value of New Jersey's Ecosystem Services and Natural Capital. Institute for Sustainable Solutions, Portland State University, Portland, Oregon.

Council on Environmental Quality, Updated Principles and Guidelines for Water and Land Related Resources Implementation Studies, accessed July 29, 2011, http://www.whitehouse.gov/administration/eop/ceq/initiatives/PandG

Dodds, W.K., Wilson, K.C., Rehmeier, R.L., Knight, G.L., Wiggam, S., Falke, J.A., Dalgleish, H.J., Bertrand K.N., 2008. Comparing Ecosystem Goods and Services Provided by Restored and Native Lands. BioScience 58, 837-845.

Doss. C. R., Taff, S.J. 1996. The Influence of Wetland Type and Wetland Proximity on Residential Property Values. Journal of Agricultural and Resource Economics. 21(1). 120-129.

Duffield, J. W., Neher, C.J., Brown, T.C., 1992. Recreation Benefits of Instream Flow - Application to Montana Big Hole and Bitterroot Rivers. Water Resources Research 2, 2169-2181.

Everard, M. 2009. Using Science to Create a Better Place: Ecosystem Services Case Studies. Environment Agency. Available at: http://publications.environment-agency.gov.uk/PDF/SCHO0409BPVM-E-E.pdf

Everard, M., Jevons, S. 2010. Ecosystem Services Assessment of Buffer Zone Installation on the Upper Bristol Avon, Wiltshire. Environment Agency. Bristol. Available at: http://publications.environment-agency.gov.uk/PDF/SCHO0210BRXW-E-E.pdf

Harris, D., Crabtree, B., Newell-Price, P. 2006. Economic Valuation of Soil Functions Phase 1: Literature Review and Method Development. Prepared for Department of Environment, Food and Rural Affairs. UK. Available at: http://www.cjcconsulting.co.uk/pdfs/FINALEcon%20Valuation%20of%20Soil%20Functions%20Rept%20Phase%20I_0806.pdf

Jenkins, W. A., Murray, B. C., Kramer, R. A., & Faulkner, S. P. 2010. "Valuing Ecosystem Services from Wetlands Restoration in the Mississippi Alluvial Valley." Ecological Economics, 695, 1057.

Johnston, R.J., Grigalunas, T.A., Opaluch, J.J., Mazzotta, M., Diamantedes, J. 2002. Valuing Estuarine Resource Services Using Economic and Ecological Models: The Peconic Estuary System Study. Coastal Management. 30. 47-65.

Kozak, J., Lant, C., Shaikh, S., and Wang, G. (2011). The geography of ecosystem service value: The case of the Des Plaines and Cache River wetlands, Illinois. Applied Geography 31, 303-311.

Leschine, T.M., Wellman, K.F., Green, T.H. 1997. The Economic Value of Wetlands: Wetlands Role in flood Protection in Western Washington. Department of Ecology.

Manley, J., van Kooten, C., Moeltner, K., Johnson, D. 2005. Creating Carbon Offsets in Agricultural Through No-Till Cultivations: A Meta-Analysis of Costs and Carbon Benefits. Climate Change. 68. 41-65.

Mates, W.J., Reyes, J.L. 2006. The Economic Value of New Jersey State Parks and Forests. New Jersey Department of Environmental Protection. Available at: www.nj.gov/dep/dsr/economics/parks-report.pdf

McPherson, E.G., Scott, K.I., Simpson, J.R. 1998. Estimating Cost Effectiveness of Residential Yard Trees for Improving Air Quality in Sacramento, California, Using Existing Models. Atmospheric Environment. 32. 1. 75-84.

Mississippi River/Gulf of Mexico Water Nutrient Task Force, 2007. Gulf Hypoxia Action Plan. Available at www.epa.gov/msbasin/taskforce/pdf/2008draft_actionplan.pdf

Murray, B.C., Jenkins, W.A., Kramer, R.A., Faulkner, S.P., 2009. Valuing Ecosystem Services from Wetlands Restoration in the Mississippi Alluvial Valley. Report No. 09-02, Nicholas Institute for Environmental Policy Solutions. Duke University. Available at: http//www.nicholas.duke.edu/institute/msvalley.pdf

Pimentel, D., Harvey, C., Resosudarmo, P., Sinclair, K., Kurz, D., McNair, M., Crist, S., Shpritz, L., Fitton, L., Saffouri, R., Blair, R. 1995. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. Science 267, 1117-1123.

Pimentel D., Wilson, C., McCullum, C., Huang, R., Dwen, P., Flack, J., Tran, Q., Saltman, T., Cliff, B. 1997. Economic and Environmental Benefits of Biodiversity. BioScience. 47. 11. 747-757.

Potter, S.R., Andrews, S., Atwood, J.D., Kellogg, R.L., Lemunyon, J., Norfleet, L., et al., 2006a. Model Simulation of Soil Loss, Nutrient Loss, and Change in Soil Organic Carbon Associated with Crop Production. U.S. Department of Agriculture Natural Resources Conservation Service.
Available at: http://www.nrcs.usda.gov/Technical/nri/ceap/croplandreport

Potter, S.R., Atwood, J.A., Pitts, T.A., 2006b. The National Nutrient Loss and Soil Carbon Database. Texas Agriculture Experiment Station Blackland Research Center.
Available at: ftp.brc.tamus.edu/pub/nnlsc

Qiu, Z., Prato, T., Boehm, G. 2006. Economic Valuation of Riparian Buffer and Open Space in a Suburban Watershed. Journal of the American Resources Association. 42. 6, 1583–1596.

Ready, R.C., Berger, M.C. 1997. Measuring Amenity Benefits from Farmland: Hedonic Pricing vs. Contingent Valuation. Growth and Change. 28. 438-458.

Rein, F. 1999. An Economic Analysis of Vegetative Buffer Strip Implementation. Case Study: Elkhorn Slough, Monterey Bay, California. Coastal Management. 27. 4. 377-390.

Rosenberger, R.S., Loomis, J.B. 2001. Benefit Transfer of Outdoor Recreation Use Values: A Technical Document Supporting the Forest Service Strategic Plan (2000 Revision). For Collins, CO, U.S. Department of Agricultural, Forest Service, Rocky Mountain Station Research Station: 59.

Schuyt, K., Brander, L. 2004. Living Waters: The Economic Values of the Worlds Wetlands. World Wildlife Fund. Switzerland. Available at: assets.panda.org/downloads/wetlandsbrochurefinal.pdf

Trust for Public Land. 2010. The Economic Benefits and Fiscal Impact of Parks and Open Space in Nassau and Suffolk Counties, New York. Available at: http://cloud.tpl.org/pubs/ccpe--nassau-county-park-benefits.pdf

Trust for Public Land. 2011. The Economic Benefits of Seattle's Park and Recreation System. Available at: http://cloud.tpl.org/pubs/ccpe-seattle-park-benefits-report.pdf

U.S. Department of Agriculture-national Agricultural Statistics Service (USDA-NASS) 2009. Quick Stats, State and County Data.
Available at: http//www.nass.usda.gov/QuickStats/Create_County_All.jsp

Wilson, S.J., 2008. Ontario's wealth, Canada's future: Appreciating the value of the Greenbelt's eco-services. David Suzuki Foundation. Vancouver, Canada. http://www.davidsuzuki.org/Publications/Ontarios_Wealth_Canadas_Future.asp

Winfree, R., Gross, B., Kremen, C. 2011. Valuing Pollination Services to Agriculture. Ecological Economics. 71, 80-88.

Woodward, R., and Wui, Y., 2001. "The Economic Value of Wetland Services: A Meta-analysis." Ecological Economics 37, 257-270.

Zhongwei, L. 2006. Water Quality Simulation and Economic Valuation of Riparian Land-use Changes. University of Cincinnati. 257.

APPENDIX C: HAZUS EARTHQUAKE MODEL DEBRIS QUANTITY VALUES BY BUILDING TYPE

Unit Weight (tons/1,000 sq ft) for Structural and Nonstructural Elements for the Model Building Types

#	Model Building Type	Brick, Wood and Other		Reinforced Concrete and Steel	
		Structural	Nonstructural	Structural	Nonstructural
1	W1	6.5	12.1	15.0	0.0
2	W2	4.0	8.1	15.0	1.0
3	S1L	0.0	5.3	44.0	5.0
4	S1M	0.0	5.3	44.0	5.0
5	S1H	0.0	5.3	44.0	5.0
6	S2L	0.0	5.3	44.0	5.0
7	S2M	0.0	5.3	44.0	5.0
8	S2H	0.0	5.3	44.0	5.0
9	S3	0.0	0.0	67.0	1.5
10	S4L	0.0	5.3	65.0	4.0
11	S4M	0.0	5.3	65.0	4.0
12	S4H	0.0	5.3	65.0	4.0
13	S5L	20.0	5.3	45.0	4.0
14	S5M	20.0	5.3	45.0	4.0
15	S5H	20.0	5.3	45.0	4.0
16	C1L	0.0	5.3	98.0	4.0
17	C1M	0.0	5.3	98.0	4.0
18	C1H	0.0	5.3	98.0	4.0
19	C2L	0.0	5.3	112.0	4.0
20	C2M	0.0	5.3	112.0	4.0
21	C2H	0.0	5.3	112.0	4.0
22	C3L	20.0	5.3	90.0	4.0
23	C3M	20.0	5.3	90.0	4.0
24	C3H	20.0	5.3	90.0	4.0
25	PC1	5.5	5.3	40.0	1.5
26	PC2L	0.0	5.3	100.0	4.0
27	PC2M	0.0	5.3	100.0	4.0
28	PC2H	0.0	5.3	100.0	4.0
29	RM1L	17.5	5.3	28.0	4.0
30	RM1M	17.5	5.3	28.0	4.0
31	RM2L	17.5	5.3	78.0	4.0
32	RM2M	24.5	5.3	78.0	4.0
33	RM2H	24.5	5.3	78.0	4.0
34	URML	35.0	10.5	41.0	4.0
35	URMM	35.0	10.5	41.0	4.0
36	MH	10.0	18.0	22.0	0.0

35	URMM	35.0	10.5	41.0	4.0
36	MH	10.0	18.0	22.0	0.0

Source: FEMA, 2009b

APPENDIX D: MENTAL ILLNESS TREATMENT COST CALCULATION

		Mild or Moderate Mental Health Problems					Severe Mental Health Problems				
		First Course		Refractory			First Course		Refractory		
Type of Mental Health Service	Unit Cost	Units	%	Units	%	Total $	Units	%	Units	%	Total $
Screening											
- In person	$25	1	100%			$25	1	100%			$25
- Telephone	$25	0				$0	0				$0
Assessment											
- In person (mix of specialists)	$100	1	65%			$65	1	65%			$65
- Telephone (Masters degree)	$75	1	35%			$26.25	1	35%			$26.25
Therapy											
- In person (Masters, 1-on-1)	$90	12	8.6%	12	10.5%	$206.28	0				$0
- In person (Masters, group)	$210	12	15.9%	12	19.5%	$892.08	0				$0
- In person (PhD, 1-on-1)	$135	12	37%	12	4.4%	$670.68	12	100%	12	100%	$3,240
- In person (PhD, group)	$245	12	6.8%	12	8.1%	$2,237.34	0				$0
- Telephone (Masters degree)	$47	12	24.5%	12	30%	$307.38	0				$0
- Telephone (PhD)	$67	12	10.5%	12	12.5%	$184.92	0				$0
Medication Management											
- In person (MD provider)	$80	6	30%	6	47%	$369.60	0				$0
- In person (NP-level provider)	$60	6	5%	6	8%	$46.80	0				$0
- In person (psychiatrist provider)	$96	6	15%	6	30%	$259.20	6	100%	6	100%	$1,152
- Telephone (Masters degree)	$50	0				$0	0				$0

		Mild or Moderate Mental Health Problems					Severe Mental Health Problems				
		First Course		Refractory			First Course		Refractory		
Type of Mental Health Service	Unit Cost	Units	%	Units	%	Total $	Units	%	Units	%	Total $
Phone consults to PCP by provider	$70	2	5.3%	2	80%	$119.42	0				$0
Inpatient care, hospital nights	$900	0				$0	5	20%	5	40%	$2,700
Prescription cost per month	$40	6	50%	9	85%	$426	9	100%	12	100%	$840
						$5,835.95					**$8,048.25**
					Ineffective care (16%)	$933.75				Ineffective care (16%)	$1,287.72
					Adequate care (25.1%)	$1,464.82				Adequate care (25.1%)	$2,020.11
					Total care costs	$2,398.58				Total care costs	$3,307.83
					Prevalence (26%)	**$623.63**				Prevalence (6%)	**$198.47**
								$822.10			

Source: Schoenbaum, 2009

<u>Explanation</u>
"First Course" means the initial treatment(s) provided by a mental health specialist.
"Refractory" refers to mental illnesses that resist treatment, and therefore require additional services by a mental health specialist.

The percentages provided in the 4th, 6th, 9th, and 11th columns indicate the percentage of cases in which the specific mental health services are likely to be provided.

APPENDIX E: HISTORIC STRUCTURE REPLACEMENT COST DATA

Typical Home Comparison

Year Built	Style	Quality	Construction	Exterior	Roof	Shape	Replacement Cost	Historic Registry RC	Percent Increase
1975	Ranch	Average	Wood Frame	Vinyl	Asphalt Shingle	Rectangular	$120,000	$151,000	26%
1975	Colonial	Average	Wood Frame	Wood Siding	Architectural Shingle	Rectangular	$253,000	$321,000	27%
1975	Mansard	Above Average	Brick Veneer	Brick Veneer	Architectural Shingle	Rectangular	$563,000	$722,000	28%
1975	European Influenced	Custom	Brick Veneer	Brick Veneer	Concrete Tile	U-shape	$1,032,000	$1,331,000	29%

Specific Home Comparison

Year Built	Style	Quality	Construction	Exterior	Roof	Shape	Replacement Cost	Historic Registry RC	Percent Increase
1920	Vernacular-Folk	Average	Wood Frame	Wood Siding	Asphalt Shingle	Rectangular	$151,000	$191,000	26%
1920	American Four Square	Average	Wood Frame	Wood Siding	Asphalt Shingle	Square	$298,000	$381,000	28%
1920	Victorian	Above Average	Brick Masonry	Solid Brick	Clay Tile	T-Shape	$868,000	$1,114,000	28%
1920	Italianate	Custom	Brick Masonry	Solid Brick	Clay Tile	U-shape	$1,258,000	$1,616,000	28%
1880	American	Averag	Wood Frame	Wood	Asphalt	Square	$161,000	$206,000	28%

	Four Square	e		Siding	Shingle				
1880	Victorian	Average	Wood Frame	Wood Siding	Asphalt Shingle	T-shape	$448,000	$574,000	28%
1880	Italianate	Above Average	Brick Masonry	Solid Brick	Clay Tile	T-Shape	$890,000	$1,141,000	28%
1880	Romanesque	Custom	Stone Masonry	Solid Stone	Clay Tile	U-shape	$1,533,000	$1,971,000	29%
1880	Designed By a Famous Architect	Opulent	Brick Masonry	Solid Brick	Clay Tile	U-shape	$2,141,000	$2,752,000	29%
1780	Vernacular-Folk	Average	Timber post/beam	Wood Siding	Asphalt Shingle	Rectangular	$229,000	$288,000	26%
1780	Georgian	Above Average	Timber post/beam	Wood Siding	Asphalt Shingle	Rectangular	$572,000	$732,000	28%
1780	Georgian	Custom	Brick Masonry	Solid Brick	Clay Tile	Rectangular	$1,048,000	$1,344,000	28%
1780	Neo-Classical	Luxury	Stone Masonry	Solid Stone	Slate	U-shape	$1,708,000	$2,196,000	29%

Source: e2Value