Ecosystem Service Valuation of Cockpit Country

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December 2011

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Executive Summary

Jamaica's Cockpit Country is recognized nationally and internationally for its unique biodiversity, its cultural heritage, and for the ecosystem services it provides to central-west Jamaica, This ecosystem is under imminent threat from bauxite mining and limestone quarrying. In the past, the Government of Jamaica (GoJ) has not considered indirect costs such as loss of biodiversity, risks to ecosystem services and costs to communities, in its decision process, which emphasizes short-term, foreign exchange benefits.

One way to improve decision-making is to develop an economic case for the conservation of Cockpit Country. The purpose of this research ecosystem service valuation project is to measure Cockpit Country Ecosystem service values using a recognized non-market valuation technique. The estimates of value can be used to guide decisions as to the optimal use of the area. This report uses a recognized stated preference valuation survey method, the Contingent Valuation Method, to estimate the economic benefit or consumer surplus: that is, the value of maintaining the Cockpit Country in its current state.

To estimate the non-market benefits associated with the ecosystem services of Cockpit Country, we conducted an in-person survey of the general population of Jamaica during October to November 2011. Of the over two thousand respondents interviewed, half were asked their willingness to pay a hypothetical, mandatory, one-year tax while the other half were asked their willingness to contribute to a fund.

Based on our analysis we estimate that the value of maintaining the Cockpit Country in its current state is approximately **J$2.6 billion** per annum (US$29.8 million).

We also estimate the value of carbon sequestration services at **J$896** million per annum. This was based on the existing forest cover and the median social cost of carbon, as recommended by Inter-governmental Panel on Climate Change (IPCC). It is important to note there are other market-based values such as water, timber and other forest products (honey etc.), bauxite and limestone that were not accounted for in this study.

Table of Contents

List of Tables

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Introduction

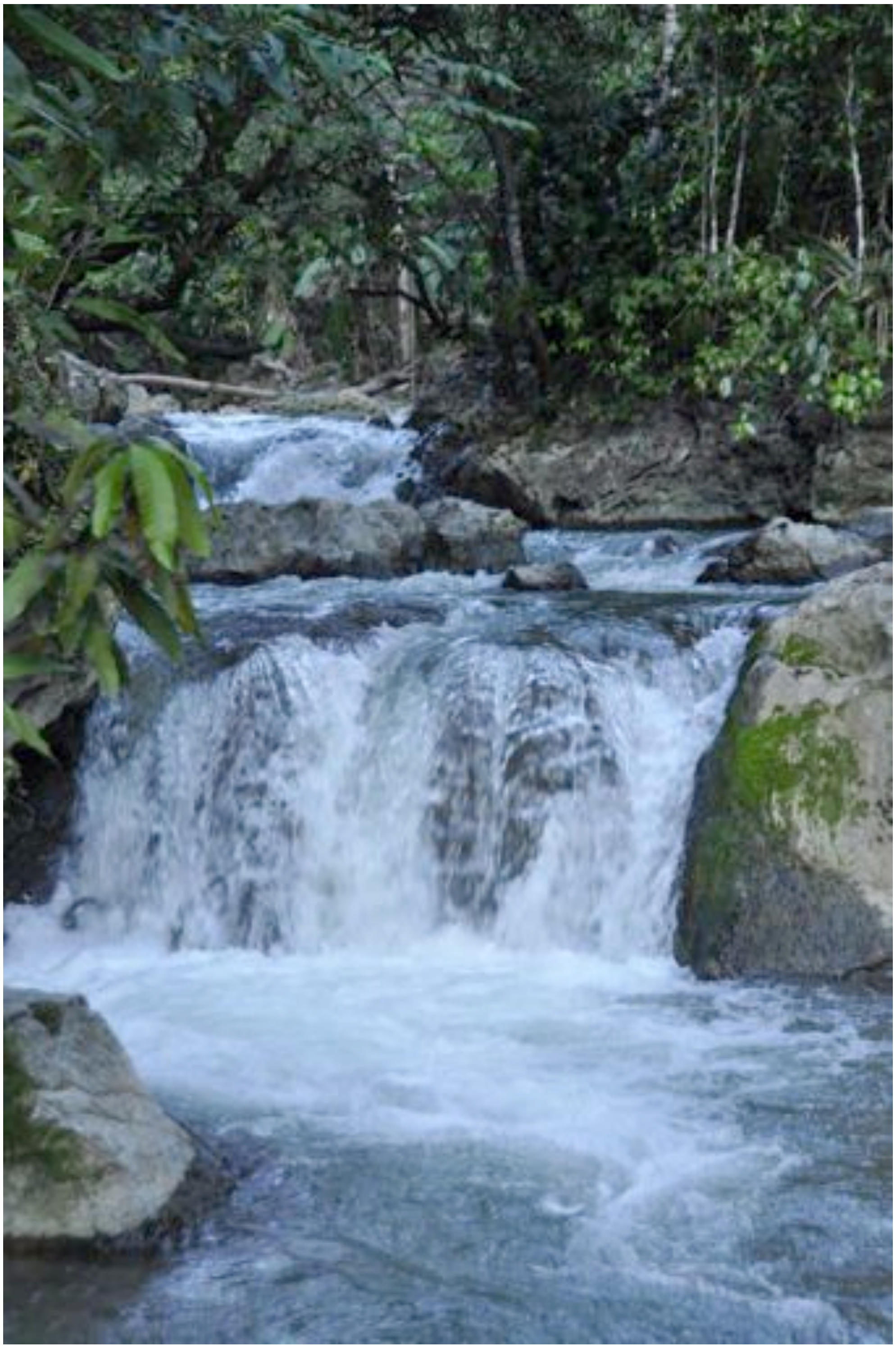
Cockpit Country is one of two large remaining areas of primary forest in Jamaica and is a last refuge for many of Jamaica's endemic plants and animals. It is an island-within-an-island, surrounded by a sea of agriculture and rural communities. Cockpit Country provides essential ecosystem services including water filtration, carbon storage, wildlife habitat, recreational opportunities and scenic beauty. However, because no market exists in which to trade many of these services, it is difficult to quantify the benefits they provide. Ecosystem services are those things that nature provides that are of direct benefit to humans. The purpose of the research summarized in this report is to provide an estimate of the value of ecosystem services provided by Cockpit Country.

Ecosystem Services

Ecosystem services are the direct or indirect contributions that ecosystems make to human well-being. Although ecosystem processes and functions exist whether or not humans benefit from them, these relationships generate ecosystem services only if they contribute to human well-being. The Millennium Ecosystem Assessment (MEA 2005) divides these services in to four categories: supporting, regulating, provisioning, and cultural services. Brown et al. (2007) distinguish between ecosystem structure, ecosystem processes, and ecosystem goods and services. Ecosystem structure includes the physical and biological components of the ecosystem itself, such as the quantity of water in a reservoir, the soil characteristics, or the density of trees. Ecosystem processes link the components of structure with function. For example, water supply and wildlife growth are ecosystem functions that depend on the underlying ecosystem structure. Ecosystem processes support the production of ecosystem goods and services.

Distinction can also be made between ecosystem goods and ecosystem services. Ecosystem goods are the tangible products of nature, such as timber, minerals, water, and wildlife. Ecosystem goods are more easily identified as the direct benefits to society. In other words, people can "see" what they are getting. On the contrary ecosystem services are less recognized aspects of nature's services. For example improvements or maintenance of the condition of ecosystem services such as cleansing, recycling and renewal, which provide many intangible aesthetic and cultural benefits, are difficult to "value".

It should be noted that ecosystem services are dependent on underlying ecosystem structure and function that may or may not be recognized by society. We acknowledge the distinction between ecosystem goods and ecosystem services, but for brevity, in this report we will refer to these collectively as ecosystem services.



Background

Cockpit Country occupies a large geographical space that consists of a relatively roadless area of well-developed karst limestone. The area measures approximately 1160 square kilometers, and is centered in the parish of Trelawny, with extensions into St. James, St. Elizabeth, St Ann and Manchester. The region's rugged terrain makes access difficult, and this inaccessibility has provided some protection to the forest. The area is protected as a series of forest reserves administered by the Forestry Department. However, there are a few access roads that penetrate Cockpit Country to varying degrees from the "Ring Road", which encircles the largest Forest Reserve in the area (TNC, 2007).

Cockpit Country is the "type location" for cockpit karst, consisting of white limestone that erosion and chemical dissolution have sculpted into a dramatic topography of rounded peaks and steep-sided, bowl-shaped, closed depressions. These depressions ("cockpits") have concave bottoms covered with rock rubble and soil that floods have redistributed into a flat floor. Cockpit bottoms drain by percolation through porous bedrock or through sinkholes connected to a complex, subterranean network of caves and passages. Hilltops and slopes have thin, humus-poor, clay soils.

The TNC report highlights that the vegetation of the area is the largest and most intact example of wet limestone forest in Jamaica. The variety of the identified flora confirms the very high level of endemism of the Caribbean. For example, of 856 vascular plant species recorded from Cockpit Country, 67 are endemic to it (Proctor, 2007). Ferns offer another example of the importance of the area as a Biodiversity Hotspot - most of Jamaica's 579 native ferns grow in Cockpit Country; many are endemic to Jamaica and one is endemic to Cockpit Country itself. Relative to its area, there are more species of fern in Cockpit Country than in any other tropical forest in the world (TNC, 2007). The wet limestone forest also includes distinctive plant communities associated with spatially restricted ecological conditions or localized evolutionary and ecological histories.

The scope of our study is limited to the 1160 square kilometers that encompass Cockpit Country. Using the Millennium Ecosystem Assessment approach, we identified eight types of ecosystem services that Cockpit Country area provides:

- **Gas and climate regulation**: Cockpit Country contributes to mitigating climate change by regulating carbon, ozone, and other chemicals in the atmosphere.

- **Water quantity and quality**: Cockpit Country captures, stores and filters water, mitigating damage from floods, droughts, and pollution and providing water for agricultural and domestic use.
- **Soil formation and stability**: Cockpit Country vegetation stabilizes soil and prevents erosion.
- **Pollination**: Cockpit Country provides habitat for important pollinator species which naturally perpetuate plants and crops.
- **Habitat/refugia**: Cockpit Country provides living space to wild plants and animals.
- **Timber and forest product provision**: Cockpit Country provides raw materials for many uses.
- **Recreation**: Cockpit Country provides a potential place for recreation.
- **Aesthetic, cultural and passive use**: Cockpit Country provides scenic value and many people have a positive existence value for forestland. Unique communities such as the Maroons have deep connections to the area.

For a more detailed examination of the range and types of ecosystem services found in Cockpit Country see Appendix 6. This detailed list of services was generated based on a workshop of ecological and economics experts that was held in Kingston in May, 2008. The relevant ecological endpoints were organized into the four main ecosystem service categories (regulation, supporting, provisioning and cultural), as outlined by the Millennium Ecosystem Assessment.

The Economic Value of Natural Resources

Non-market valuation techniques are extensively applied over a wide range of goods and services and their use as a tool for natural resource management policy is now fairly common across many countries. There are only a few examples where results of these studies have been used to support decisions on the implementation of user fees for national parks and marine protected areas (Chase et al., 1998). Common to most of these studies is the estimation of consumer surplus or welfare, often expressed as willingness to pay (WTP). It is frequently applied in the context of public goods such as air and noise pollution. It is also used in damage assessments and cost benefit analyses for various types of development projects (Bateman et al., 2002).

Non-market valuation techniques have also gained traction in valuing quasi public goods, in particular determining values associated with recreation. These studies typically estimate the recreational values associated with a range of environments and activities, including hiking, mountain climbing, boating, river rafting. The techniques have also been applied to studies on marine-based recreational activities such as beach use, snorkelling, scuba diving and sport fishing. There are a variety of techniques used to elicit non-market values for environmental amenities and these can be classified in general terms as stated preference (SP) or revealed preference (RP) techniques.

Much of the recreational economic valuation literature is dominated by RP methods, for example travel-cost studies. These studies use observable data such as, for example, travel and time costs, to estimate demand curves that allow for the determination of economic benefits of a particular location (Bockstael, 1995; Boyle, 2003; Parsons, 2003). The hedonic pricing method is another RP technique used to estimate economic values for ecosystem or environmental services that directly affect market prices. It is most commonly applied to variations in housing prices that reflect the value of local environmental attributes. This method has the potential for use in Jamaica, particularly with respect to sectors such as bauxite mining (noise, air pollution), electric power generation (noise, air pollution), solid waste management (air, water pollution) among others.

By contrast SP techniques are useful in the absence of observable data for hypothetical or real changes in quality of a particular environmental good (Adamowicz et al., 2001; Mercado, 2001; Bateman et al., 2002; Smith, 2006). The valuation of a resource with multiple attributes is probably best captured through the use of a survey instrument with a contingent valuation (CV) and/or choice experiment (CE) framework (Bateman et al., 2002). This technique has been utilized for a number of years and the method has evolved and has become increasingly accepted as a valid method of environmental valuation. For the aims and objectives of this study, the contingent valuation was selected as the most appropriate for capturing values associated with ecosystem services of a unique area such as Cockpit Country.

Other valuation approaches

There are other valuation approaches that can be considered as tools for improving resource management decisions and policy making. The damage cost avoided, replacement cost, and substitute cost methods are related methods that estimate values of ecosystem services, based on either the costs of avoiding damages due to lost services, the cost of replacing ecosystem services, or the cost of providing substitute services (Ecosystem Valuation, 2007). It should be noted that these methods do not provide strict measures of economic values, which are based on peoples' willingness to pay for a product or service. Instead, they assume that the costs of avoiding damages or replacing ecosystems or their services provide useful estimates of the value of these ecosystems or services. This is based on the assumption that, if people incur costs to avoid damages caused by lost ecosystem services, or to replace the services of ecosystems, then those services must be worth at least what people paid to replace them. Thus the methods are most appropriately applied in cases where damage avoidance or replacement expenditures have actually been, or will actually be, made. Some examples of cases where these methods might be applied include:

- Valuing improved water quality by measuring the cost of controlling effluent emissions.
- Valuing erosion protection services of a forest or wetland by measuring the cost of removing eroded sediment from downstream areas.
- Valuing storm protection services of coastal wetlands by measuring the cost of building retaining walls.
- Valuing fish habitat and nursery services by measuring the cost of fish breeding and stocking programs.

The use of these methods will require incorporating the inventory of existing ecosystem services using some form of environmental accounting methodology. It should be noted that while there are some advantages to this approach such as;

- These methods may provide a rough indicator of economic value, subject to data constraints and the degree of similarity or substitutability between related goods
- Data or resource limitations may rule out valuation methods that estimate willingness to pay.

there are some notable disadvantages, in particular;

- These approaches assume that expenditures to repair damages or to replace ecosystem services are valid measures of the benefits provided. However, costs are usually not an accurate measure of benefits.
- Just because an ecosystem service is eliminated there is no guarantee that the public would be willing to pay for the identified least cost alternative merely because it would supply the same benefit level as that service. Without evidence that the public would demand the alternative, this methodology is not an economically appropriate estimator of ecosystem service value.

Value of carbon sequestration

Another approach for producing monetary estimates of ecosystem service flows is estimating the value of sequestered carbon and other greenhouse gases by forest ecosystems such as Cockpit Country. An outline of this methodological approach will be explored in greater detail in a later section of this report.

Contingent Valuation Method

Contingent valuation involves constructing a hypothetical market for the purpose of eliciting people's preferences for public goods. The market typically defines the good of interest, the *status quo* level of provision and the offered improvement or decline therein, the institutional structure under which the good is provided and payment vehicle for said good. In the survey the respondent is asked to reveal his/her willingness to pay (Mitchell and Carson, 1989; Mercado, 2001).

Contingent valuation has been utilized for a number of years and the first recognized use of this kind of SP technique is credited to Robert Davis who investigated the benefits of outdoor experiences to recreational users. This study was conducted in 1963. Since then the method has evolved and has become increasingly accepted as a valid method of environmental valuation. Its acceptance as a valid method gained credibility following its use to value environmental damage after the Exxon Valdez oil spill in Alaska (Boyle, 2003). Following this event a number of books and articles were published on this issue (Cummings et al., 1986; Mitchell and Carson 1989). In fact, the National Oceanic and Atmospheric Administration conducted a Blue Ribbon panel in 1993 to review the method and came up with a set of recommendations which have become almost an "industry standard" (NOAA, 1993). The panel received several opinions on studies for and against the use of CV in measuring non-use values associated with oil spills. The panel concluded that carefully designed and implemented CV studies convey useful information for judicial and administrative decisions involving non-use and existence values (Loomis, 1999).

A proper CV study should at least have the following basic components. Firstly, it requires that there is a carefully defined market scenario with a well-defined good. Critical to this is the selection of an appropriate payment vehicle that should be directly tied to the good or service being valued. Secondly, an appropriate method to elicit the respondent's value must be selected. This could be conducted using a variety of formats including open-ended questions, payment cards, bidding games and referendum or voting questions. Studies have shown that the dichotomous choice (DC) referendum question format to be very effective at providing the data that can be used to generate estimates of welfare (Haab and McConnell 2002; Bateman *et al*., 2002).

One criticism of SP techniques or the CV method is that hypothetical referenda may not be incentive compatible. Incentive compatible institutional mechanisms should provide individuals with incentives to truthfully and fully reveal their preferences (Cummings et al., 1997). Therefore it is important that the valuation scenario be carefully crafted to reduce the effects of hypothetical bias. There are methods that have been used to mitigate this problem. These include using laboratory experiments to conduct "calibration" of hypothetical bias (Cummings et al., 1997; Blackburn et al., 1994; Fox et al., 1999). Another way of trying to reduce this bias is to use a "cheap talk design" for the CV questions (Cummings and Taylor, 1999). This design involves providing the respondent with an explicit discussion on what hypothetical bias is and why it might occur. In the study by Cummings and Taylor they were able to use this design to reduce bias in their experimental scenario. For this study a cheap talk script was utilized in the design of the valuation scenario.

Thirdly a reasonable and effective method of administering the survey must be selected. This may vary with the requirements of the researcher, the budget and time limitations of the study. Typical methods of data collection include, in-person interviews, telephone surveys, mail and internet surveys. These different methods have different rates of success and often depend on the budget and personnel limitations of the research team (Dillman, 2007).

The fourth component involves actually determining the sample population and randomly selecting respondents to survey. Finally once the data are collected and organized, the necessary statistical analyses are conducted including the estimation of willingness to pay so that economic valuation can be reported.

History of Jamaican non-market valuation studies

Jamaica does not have an extensive published record of non-market valuation studies. While there have been studies that applied some form of economic or socio-economic analysis of natural resources, those applying the valuation methods described above are fewer in number. A literature review of Jamaica-focused socio-economic studies and their potential policy relevance was recently produced (WRI, 2011) and an adapted list is shown below in Table 1. However, as mentioned above, of this list, there were only a few studies that could truly be classified as non-market valuation studies. In addition the vast majority of these valuation studies were based on marine or coastal natural resources and in some cases were activity specific (diving, snorkeling etc.). Very few could be considered to be "terrestrial based" applications.

Non market valuation of Cockpit Country

For this particular study, we developed a stated choice survey based on the Contingent Valuation method to collect original data to estimate aesthetic and non-use values of our study area. To estimate aesthetic and non-use values, we conducted an in-person household survey of the general population of Jamaica between the months of October and December 2011. The survey contained background information on forests and ecosystem services and asked respondents about their familiarity with Cockpit Country and the issues surrounding mining and conservation. Respondents were also asked about general awareness of environmental issues, preferences for public regulation of forested land, and socio-demographic characteristics. In addition, each respondent was asked a contingent valuation question. For this question, the respondent was invited either to participate in a hypothetical referendum on a tax or a hypothetical contribution to a fund. They were told that their decision would affect the future of Cockpit Country and from the results we are able to estimate an individual's mean willingness to pay (WTP) for preserving the ecosystem services of Cockpit Country.

Based on the estimated per person values we can then derive an aggregate total value for the population of Jamaica who are of voting age. We assume that this corresponds to the current voters list that has 1,612,065 eligible voters. Aggregate value is therefore obtained by multiplying this number by the estimated per person economic values.

Table 1 Economic studies and potential policy relevance for Jamaica

#	Case Study	Study Site	Ecosystem	Ecosystem Services	Policy Relevance	References
Policy Applications: Raising awareness of ecosystem value; justifying stricter regulations and investment in better management						
1	Current value of Jamaica's reef fishery and estimated losses from lack of management over 25 years.	Discovery Bay	coral reefs	fisheries	Estimates US$1.3b in lost revenues from reef fisheries due to poor management over 25 years. Argues for implementing and enforcing strong fisheries regulations	Sary et al. (2003)
2	Socioeconomic assessment of fishing and tourism associated with the reserve.	Montego Bay	coral reefs	tourism and fisheries	Assesses the level of social and economic dependence upon Montego Bay Marine Park (e.g. volume of reef tourism, hotel use; fisheries revenues). Results can inform policies and justify investment in management of the park.	Bunce and Gustavson (1998)
3	Financial analysis of reef-associated fisheries and tourism; avoided damages from shoreline protection.	Montego Bay	coral reefs	tourism, fisheries, shoreline protection	The high value of services associated with the park (NPV US$381 m, 10% discount rate) can be used to justify greater investment in management. Many jobs and businesses in MoBay rely upon the health of the park.	Gustavson (1998)
4	Financial analysis of reef-associated fisheries and tourism; avoided damages from shoreline protection.	Ocho Rios	coral reefs, coastal resources more broadly	fisheries, tourism, shoreline protection, biodiversity	Estimated value of ecosystem services provided by ORMP is US$245m/yr. The study also estimates losses to the tourism sector if ecosystem quality degrades further. Management interventions are needed to avoid financial losses in the future.	Env. Management Unit (2001)
5	Consumer surplus associated with use of Montego Bay Marine Park.	Montego Bay	coral reefs	tourism	Results suggest moderate taxes or user fees would not reduce visitor numbers to the Montego Bay area.	Reid-Grant and Bhat (2009)

#	Case Study	Study Site	Ecosystem	Ecosystem Services	Policy Relevance	References
6	Value of many ecosystem services provided by Portland Bight. Includes scenarios of future tourism.	Portland Bight	coral reefs and mangroves	fisheries, forestry, tourism, carbon fixation, coastal protection, biodiversity	Study estimates US$40 -53 m/yr value from services associated with Portland Bight Protected Area. Results could justify greater investment in the reserve.	Cesar et al. (2000)
Policy Application: Setting Taxes or Fees to Finance Management of Coastal Resources						
7	Sustainable financing for coastal management in Jamaica	Jamaica	coral reefs and beaches	tourism / recreation	Tourists to Jamaica have a high consumer surplus and are willing to pay an environmental tax. Coastal zone management could be completely financed by a $2 pp tax.	Edwards (2009)
8	Visitor willingness to pay for park management.	Montego Bay	coral reefs	tourism	Results can help set entrance fees to the park. Authors recommend $5 fee/wk. Revenue maximizing would be $10/wk but could reduce visitors to the area.	Dharmaratne et al. (2000)
9	Capturing ecotourism benefits from national parks.	Montego Bay	coral reefs	tourism	Uses 2 valuation studies from Montego Bay to recommend a voluntary hotel room fee of US$1 per bed-night.	Huber (2005)
10	Local and tourist willingness to pay (WTP) for improvements in coral diversity.	Montego Bay	coral reefs	biodiversity	Survey results could be used to set entrance fees or taxes for coral reef management (avg. WTP $3.25). The author cautions that ethical stance does affect willingness to pay.	Spash (2000)
11	Fisheries and tourism values associated with Negril's coral reefs; potential losses if reefs degrade.	Negril	coral reefs	tourism and fisheries	Tourists using Negril's coral reefs had a relatively high consumer surplus ($18); suggests they would be willing to pay an park fee, especially if assured the $ went to managing the reefs.	Cesar et al. (2003)

#	Case Study	Study Site	Ecosystem	Ecosystem Services	Policy Relevance	References
12	Consumer surplus of tourists using Negril's coral reefs; potential losses if reefs degrade.	Negril	coral reefs	tourism	Estimated loss of visitor welfare of $31 if reefs decline. CV survey results support a $5 - $15 environmental tax to finance management of MBMP.	Wright (1995)
Multiple Applications						
13	Total economic value of coral reefs in Montego Bay Marine Park	Montego Bay	coral reefs	tourism, fisheries, shoreline protection, biodiversity, pharmaceutical use	Total value of services associated with the park ($407m NPV) as well as per ha value estimates can be used to set fees, justify greater investment in management, and assess losses from degradation.	Ruitenbeek and Cartier (1999)
14	Cost-effectiveness of different MPA management interventions	Montego Bay	coral reefs	NA	"Fuzzy logic" model can be used to weigh the cost-effectiveness of different management options for Montego Bay Marine Park.	Ruitenbeek et. Al. (1999)
15	Compares the tourism industry's contribution to GDP to the environmental costs of the industry (fresh water use, sewage treatment, CO^2 storage).	Jamaica	terrestrial, freshwater, and coastal ecosystems	NA	Looking at replacement cost for just 3 ecosystem services, environmental impacts more than cancel out the tourism industry's contribution to GDP. Results could support requirements for the tourism industry to compensate the public for some of these losses.	Thomas-Hope and Jardine-Comrie (2007)

Adapted from: *Coastal Capital Literature Review: Economic Valuation of Coastal and Marine Resources in Jamaica*. World Resources Institute (2011)

Theoretical rationale for contingent valuation

The design of CV experiments can follow a random utility model (RUM) framework (McFadden, 1974). The general theoretical rationale for this study is the application of a valuation method that is appropriate for providing information that has the potential to contribute to policy development and implementation for various areas of focus including management for protected areas, coastal resource management, health, agriculture and other examples of public policy.

In our case, the policy scenario being valued is the prevention of a decline and/or resultant improvement in the ecosystem services of Cockpit Country as a result of adequate environmental management. A hypothetical choice experiment is offered to respondents in which they face a trade-off between environmental goods, other goods and services, and cost. If constructed carefully, the valuation scenario can reveal individuals' willingness to trade off environmental goods with other goods and services and provide insight into the relative values.

The impact of different payment vehicles on consumer surplus

In most CV surveys all respondents are faced with making tradeoffs based on the given policy scenario and one type of payment vehicle. Survey participants are typically presented with a distinct incentive-compatible institutional mechanism associated with the payment vehicle. By incentive-compatible, we mean that the scenario presented to the respondent provides a reasonable incentive to make a decision about whether or not to make a willingness to pay decision. In this case we examine the effect of offering two distinctly different institutional contexts for deciding respondents' WTP. One half of the respondents were asked their willingness to pay a mandatory tax to pay for the protection of the Cockpit Country. The payment scenario for the tax version read as follows;

Suppose because of the need to raise funds to manage Cockpit Country the government of Jamaica was considering adding a "Special Consumption Tax" on top of the existing GCT. This means you would face increased costs on all goods that now attract GCT. These increased costs would only be in effect for only one (1) year. The funds generated from the special tax would ONLY go towards the agencies involved in the conservation activities described previously. Not to central Government.

Suppose, in order to implement the new policy the government had to call a national referendum where all persons of voting age (over 18) were asked to vote on the amount of the increase. If the majority of persons vote for the increase then it would be implemented for one year.

WTP Question: If the proposed one year tax were to cause your household expenses to increase by $XXX or in other words $XX extra per month for one year. How would you vote?

The other half of respondents were asked to consider contributing to a fund. The scenario presented was as follows;

Suppose because of the need to raise funds to manage the Cockpit Country you were asked to make a contribution to a "Special Save Cockpit Country Fund". This would be a one-time contribution and you would be asked to pay one lump sum or 12 monthly installments to the fund. The money generated from the special fund would ONLY go towards the agencies involved in the conservation activities described previously and not to central Government.

WTP Question: If you were asked to make a one-time contribution of $XXX or in other words $XX per month for one year. Would you be willing to contribute to the fund?

The hypothetical bid amounts that were offered to respondents differed across various surveys. The amounts varied between $10 per month ($120 per year) and $200 per month ($2,400 per year) on both versions of the survey. This allows us to estimate a demand curve for the non-market values (or consumer surplus) for maintaining the ecosystem services of Cockpit Country. See Appendix 1 for a full version of the survey instrument.

Econometric theory and model

The CV data were analyzed using a random utility model. This is essentially an econometric analysis of the binary choice data from the valuation questions on the respondents' decision pay or not to pay the tax or contribution. This would be a YES or NO answer or otherwise known as a dichotomous choice response (DC).

Random utility theory, in this context, models an individual's choice of paying to conserve Cockpit Country or not. Implicit in these choices are the relative values of the environmental characteristics of the area.

In this study an individual *i* faces J alternatives where $j = 1, 2$. Each alternative gives an individual some utility defined as by:

(1) $$U_{ij} = \beta z_{ij} + \varepsilon_j$$

where the term z_{ij} is a vector which represents a combination of the individual's characteristics and some quality measure or ecosystem attribute of Cockpit Country, β is a vector of parameters to be estimated and ε_{ij}, is a random component of preferences known to the respondent but unknown to the researcher. The determinants of utility are y_j, the j^{th} respondent's income and A_j are the tax (or voluntary contribution) presented in the Dichotomous Choice (DC) question, while z_{ij}, and ε_{ij} are as described above. The indirect utility is therefore deterministic to individuals but random to the researcher.

The choice situation based on the model cited above can be explained by the equations below.

(2) $$U_1 = \alpha z_j + \beta(y_j - A_j) + \varepsilon_1 \qquad \textit{(utility associated with quality } q_1\textit{)}$$

$$U_0 = \alpha z_j + \beta y_j + \varepsilon_0 \qquad \textit{(utility associated with quality } q_0\textit{)}$$

where U_1 is the utility derived from choosing to pay the tax and U_0 is the utility derived from not paying the tax. Note that paying the tax will result in the ecosystem services being preserved (q_1) while not paying the tax will result in a reduction in environmental quality and by extension reduced ecosystem services (q_0). β is the marginal utility of income and α is the marginal utility of individual characteristics and environmental quality. The utility difference ($U_1 - U_0$) can therefore be used as a proxy for estimating the WTP (Haab and McConnell, 2002).

Given the model outlined above each respondent will provide a yes response to the DC question if and only if the perceived utility derived from paying the tax exceeds the utility of not paying the tax. Take for example the case of paying the tax; to derive an expression for the probability that the j^{th} respondent answers yes to the DC question. The utility function is first separated into additively separable deterministic and stochastic components. This is shown below as,

(3) $$\Pr(yes_j) = \Pr[v_1(y_j - A_j, z_j,) + \varepsilon_1 > (v_1(y_j, z_j,) + \varepsilon_{0j})]$$

If you assume that the error terms (e_{ij}) are distributed type I extreme values then equation (3) takes the form,

(4)

where α_0 is an estimated intercept, b is an estimated parameter on the monetizing variable and αz_j is a vector of all other relevant and observed determinants (Hanemann and Kanninen, 1999; Haab and McConnell, 2002). Equation 4 describes the linear logistic form which can be used to estimate mean WTP in the sample as well as to inform the effects of various characteristics on the probability of providing a yes (affirmative) response to the DC question (Freeman, 2003; Haab and McConnell 2002; Neter et al., 1996).

The linear model described above has been widely used in CV because of its simplicity (Hanemann and Kanninen, 1999). It is also readily estimated with standard econometric software to produce parameter estimates that can be used in welfare estimation and predicting behavior.

Note that in the case of linear utility functions (such as the one utilized in this study), the mean and median WTP with respect to random preferences are assumed to be equal (Haab and McConnell, 2002). Using the linear model as described in equation 4 the willingness to pay would be described by;

(5) $$\text{WTP} = -(\alpha_0 + \alpha z)/\beta$$

This equation therefore represents a Kaldor-Hicks-based measure of consumer surplus, typically used in policy analysis.

Findings

Descriptive Statistics

During the course of sampling over 2,000 persons agreed to participate in the surveys. These persons were randomly selected by household and were interviewed by a trained surveyor. After data cleaning 1,035 special tax surveys were used while 1,049 fund contribution surveys were utilized in this analysis. The data showed that approximately 50% of respondents were female, average age was 41 years old, average household annual income was J$747,331 while respondents stated they were responsible for taking care for (on average) a little more than 1 child. Table 2 below shows mean values for selected variables used in the econometric analysis.

Table 2 Variables used in the analysis

Variables	Mandatory Tax	Voluntary Fund
Number of respondents	1,035	1,049
Age	42	41
Female (%)	48	50
Male (%)	52	50
Average Annual Household Income	$755,673	$736,579
Average Number of Children	1.4	1.3
Community Group Member	167	184

Figure 1 Map of cities and towns where surveys were administered

Parish breakdown

Versions of the two surveys were administered across the entire island (see figure 1 on the previous page). The table below is based on respondents who indicated their parish of residence. More respondents were sampled in Trelawny, St James and St Ann (near to Cockpit Country), while a fairly equal number of respondents were targeted in other parishes. See Appendix 2 for a detailed list of towns where the surveys were administered.

Table 3 Geographic distribution of surveys

Parish	Number of Respondents
Portland	169
St Mary	49
St Ann	244
St James	166
Trelawny	266
Hanover	129
Westmoreland	109
St Elizabeth	114
Manchester	111
Clarendon	112
St Catherine	118
St Andrew	185
Kingston	81
St Thomas	131

Education

Of the 2,023 persons who provided information on the highest educational level they achieved eight (8) persons indicated that they had no formal schooling (or did not complete elementary school). The largest percentage indicated that they had completed secondary schooling while no persons were sampled with Doctorates or PhD degrees. The table below shows the detailed breakdown.

Table 4 Description of highest educational level completed by respondents

Highest Level of Schooling	Number
No school	8
Elementary	491
High school	1181
Post-Secondary	305
Masters	28
Professional Degree	10
Doctorate	0

Employment

Of the 2,046 individuals that provided information on their employment status 44%percent indicated that they were employed in some form, 30% indicated they were self-employed while 15% indicated that they were unemployed. Table 5 below gives a more complete breakdown of the employment information.

Table 5 Description of employment status

Employment Status	Respondents	Percentage
Employed	897	44%
Self employed	605	30%
Out of work	303	15%
Homemaker	74	4%
Student	47	2%
Retired	109	5%
Other	11	1%

Marital Status

Of the 2,063 persons who provided information on their marital status, 28% indicated that they were married while 43% indicated that they were never married. Table 6 below shows more details on the marital status of surveyed individuals.

Table 6 Marital status of respondents

Marital Status	Respondents	Percentage
Married	572	28%
Common law	460	22%
Widowed	60	3%
Divorced	39	2%
Separated	49	2%
Never married	883	43%

Econometric analysis and welfare estimation

Parametric analysis was conducted on the binary choice (Yes/No) data from the DC question on the respondents' decision to pay a tax or make a contribution to a Cockpit Country Fund. The varying dollar amounts randomly allocated across the sample of respondents allows for the econometric estimation of a demand-like relationship between the probability of a ''yes'' response and the offered bid value. The econometric analysis of the DC questions involved using a maximum likelihood method applied to a normal distribution. This produces estimates that can be used to predict the distribution of the percentage of ''yes'' responses as the bid amount increases.

Econometric analysis – tax and fund surveys

Table 7 and Table 8 show the results from the parametric analysis of the two survey data sets. A linear logistic regression was conducted for each survey data set. A reduced model (Model I) was estimated where the dependent variable was regressed against the bid coefficient as well as an expanded model (Model II) which included key explanatory covariates. This was done for both versions of the survey.

The estimation results presented in Table 7 and Table 8 are generally consistent with empirical findings suggesting that the internal validity of the study is sound. In particular the bid coefficient (Bid) is negative and highly significant in Models I and II for both tax and fund surveys. This confirms *a priori* expectations of a downward sloping demand relationship between increasing bid levels and the probability of a "yes" response. The only other highly statistically significant parameter across both survey types was on income (95%). The negative and statistically significant income coefficient suggests that as respondents' income increases the probability of saying yes to any type of payment mechanism will increase. For the other variables the coefficients were shown to have a low level of statistical significance and there was no consistency with respect to the signs on the coefficients. For example for the tax version the sign on the coefficient for age was positive while for fund it was negative with a 90% level of statistical significance. For the fund version, this suggests that the older the respondent the lower the probability of contributing to the fund.

Table 7 Model I - Multivariate logit regression (Reduced model)

	Tax		Fund	
Variables	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Bid	-0.0006208	0.0000	-0.0005038	0.0000
Constant	0.9845924	0.0000	1.30014	0.0000
Log likelihood	-662.005	—	-620.212	—
Number of observations	1035	—	1049	—

Table 8 Model II – Multivariate logit regression (Expanded model)

	Tax		Fund	
Variables	**Coefficient**	**P-value**	**Coefficient**	**P-value**
Bid	-0.0006995	0.000	-0.0005691	0.000
Age	0.0003866	0.944	-0.0150899	0.011
Male	0.1361214	0.370	0.1503718	0.355
Income (‘000)	0.0006691	0.000	0.000496	0.001
Children	-0.0430169	0.437	-0.0225252	0.715
Community Group	0.1070568	0.623	0.5357282	0.022
Constant	0.631949	0.023	1.643028	0.000
Log likelihood	-514.078	—	-460.423	—
Number of observations	843	—	836	—

Combined data econometric analysis

The data from the two samples were combined and a multivariate logit regression was conducted in order to evaluate the effect of the different ''payment mechanisms'' (special consumption tax versus voluntary contribution to a fund). A dummy variable for the tax version survey was created to test the statistical difference between the samples. The coefficients and standard errors from the logistic regression are shown in Table 9. Based on the representative-ness of the sample and high response rate, the parameter r estimates presented in Table 9 and Table 10 can therefore be used to make generalized inferences about the total Jamaican population.

Like the previous analyses, when the data is combined the bid coefficient has a negative sign and is highly significant, re-confirming *a priori* expectations of a downward sloping demand relationship between increasing bid levels and the probability of a ''yes'' response. The dummy variable for the tax version (Payment mechanism) is negative and highly significant at the 99% level and this suggests there is a significantly different and lower WTP for consumption tax than compared to a voluntary contribution to a fund. The importance of this will be explained in later sections of this report.

Table 9 Model I - Combined data econometric analysis

Variables	Coefficient	P-value
Bid	-0.0005632	0.000
Payment mechanism	-0.40774	0.000
Constant	1.347944	0.000
Log likelihood	-1277.04	—
Number of observations	2074	—

Table 10 **Model II - Combined data econometric analysis**

Variables	Coefficient	P-value
Bid	-0.0006283	0.000
Payment mechanism	-0.4731279	0.000
Age	-0.006647	0.099
Male	0.1319441	0.233
Income ('000)	0.0005914	0.000
Children	-0.0297382	0.468
Community Group	0.3006241	0.057
Constant	1.337252	0.000
Log likelihood	-975.34	—
Number of observations	1673	—

Table 10 also confirms the expectation of a downward sloping demand curve (negative and highly significant bid coefficient). The signs on the additional coefficients show that the probability that a respondent is willing to pay decreases as age increases (older people less likely to pay) while income coefficient is positive and confirms that as income increases the probability of saying "Yes" to the payment mechanism increases. The results show that males are more likely to be willing to pay: however this result is not statistically significant. Likewise the results show that the more children the respondent has (or is responsible for) the lower the probability of WTP but again, this coefficient is not statistically significant. Membership in some kind of community organization, club or group is likely to increase the probability of contributing to preserve the ecosystem services of Cockpit country and this showed a 95% level of statistical significance.

It should be noted that an analysis of differences for WTP across parishes was conducted. The econometric analysis showed that there were no statistical differences between parishes observed in this national sample.

Welfare estimates

The WTP estimates for both tax and fund survey data are shown below. These results are based on the estimated coefficients from the linear logistic regressions. Confidence intervals were calculated using the Krinsky-Robb procedure (5000 iterations). These were used to calculate the lower and upper bound values for both the mean and median values of welfare. The welfare estimates for the basic tax survey econometric model was $1,586.03 (95% C.I. Lower Bound $1,343.02 to Upper Bound $1,931.28) while for the expanded model with covariates the mean WTP was $1,699.44. (95% C.I. $1,439.27 - $2,105.17). The estimated consumer surplus for contribution to the Cockpit fund was $2,508.69 (95% C.I. $2,123.52 -$3,423.18) for the basic model and $2,705.17 (95% C.I. $2,205.49 - $3,423.18). As expected the parametric analysis also shows that WTP_{Tax} is less than WTP_{Fund}. The econometric analyses above suggest that this difference is highly statistically significant, thus confirming our hypothesis that the type of payment vehicle you use in a valuation survey matters.

Table 11 Comparison of per person willingness to pay estimates, tax versus fund

Special Tax	**Willingness to Pay ($J)**	**Lower Bound ($J)**	**Upper Bound ($J)**
Model I - WTP_{Tax}	**$1,586.03**	$1,343.02	$1,931.28
Model II - WTP_{Tax}	**$1,699.94**	$1,439.27	$2,105.17
Cockpit Fund			
Model I - WTP_{Fund}	**$2,508.69**	$2,123.52	$3,423.18
Model II - WTP_{Fund}	**$2,705.17**	$2,205.49	$3,423.18

Aggregated results

As stated previously, we can derive an aggregate total value for the population of Jamaica for WTP. We assume that this corresponds to the current voters with 1,612,065 eligible voters. Aggregate value is therefore obtained by multiplying this number by the estimated per person economic values. The results below are based on the mean WTP of the reduced econometric model for both versions of the survey.

Table 12 Aggregate values for ecosystem services of Cockpit Country

Payment Mechanism	Jamaican $ Per Annum	US $ Per Annum
Special Tax	$2.56 billion	$29.4 million
Voluntary Cockpit Fund	$4.2 billion	$47.8 million

Aggregating the consumer surplus (WTP) is based on the assumption that adults or voting-age individuals are able to think critically about making a trade-off between their budget and some environmental good. The representative nature of our sample allows us to extrapolate the mean per person willingness to pay to the wider Jamaican population. Table 11 shows that society's value for preserving Cockpit Country is 2.56 billion Jamaican dollars per year if you base this on a special consumption tax. This is compared to an estimated annual value of 4.2 billion dollars that is based on respondents trading off between a voluntary fund and their personal expenses in order to preserve Cockpit Country.

This value can be considered the non-use value associated with Cockpit Country. It should be noted that this non-use value includes values that individuals have for their own potential use of the area, values for keeping the area preserved for future generations as well as values associated with their own use or indirect uses of the ecosystem services associated with Cockpit Country for example, water supply, clean air or fuel wood.

Other Ecosystem Service Values – Carbon Sequestration

Introduction

Ecosystems such as tropical limestone forests contribute to climate regulation by storing carbon in biomass (e.g., vegetation and soils). This section of the report summarizes calculations on the amount of carbon that is stored within the Cockpit Country boundary (under land use conditions mapped in 1998 and 2001; Appendix 5, Figure 1) and the annual increase in carbon stock. The methodology is identical to that used for Meteorological Services report on Jamaica's Greenhouse Gas Emissions Inventory 2000 to 2005 (Jamaica Meteorological Service, 2008) and reported in the Second national Communication of Jamaica to the UN Framework Convention on Climate Change -UNFCC (GOJ, 2011) and based on 2006 IPCC Guidelines. The document identifies and reports on six land use categories: Forest Land (FL), Cropland (CL), Grassland (GL), Wetland (WL), Settlements (SS) and Other Land (OL).

Within FL and CL there are four sub-categories: Tropical Rain Forest, Tropical Moist Deciduous Forest, Tropical Dry Forest, Tropical Mountain Systems. These categories are based on groups of Holdridge Life Zones (Appendix 5, Figure 2). Annual growth rates (carbon sequestration) for these different subcategories of forest are given in the communication (GOJ, 2011).

Only FL and CL categories are considered to be net contributors to CO_2 emissions.

Land use and Forestry Department data are segregated by national classes, which can be grouped into equivalent categories (Appendix 5, Table 1).

The areas of different land use categories were extracted from the most recent data available, which is based on satellite images taken in 1998 and on aerial photographs taken in 2001. Although these data are ten years old, the results are considered to represent today's values because Jamaica's annual rate of deforestation is approximately 0.1% (Evelyn and Camirand, 2003) and anecdotal evidence suggests that forest areas around Cockpit Country may even be increasing.

Methodology

The boundary of Cockpit Country is still being debated: this report uses that defined by Cockpit Country Stakeholders Group (Appendix 5, Figure 1).

Land Use data was obtained from Forestry Department: coarse-scale land-use data (LU_98) from 1998 LandSat 30m images is available for the entire Island but a high-resolution analysis of the area within the Martha Brae Watershed (MBW_LU_2001), using 2001 aerial photographs, was also available. This report therefore combines the two, using 2001 high resolution as far as possible and uses lower resolution data for the areas outside of the MBW.

Those Land Use shapes contributing to carbon emissions (i.e. FL components and CL)) were clipped and sorted according to the different Holdridge Life Zones (Appendix 5, Figure 2) and the appropriate growth rate calculations were applied as per JGHGI Appendix 10 p.10-590 (Jamaica Meterological Service, 2008). It should be noted that, while reasonable figures for lumber extraction are available for FL categories, there are no useful data on CL; consequently, JGHGI used IPCC default values. These defaults are based on FAOSTAT figures but were clearly incorrect in the Jamaican context, being seventeen times greater than the observed rate of deforestation. As noted in the JGHGI pp.4-11 "*For the calculations of fuel wood removal, the FAO figures will therefore be divided by 17 and further reduced by one half*". The same methodology was applied to Cockpit Country Cropland.

Social cost of carbon

The social cost of carbon (SCC) is the marginal cost of emitting one extra tonne of carbon (as carbon dioxide) at any point in time. It is usually estimated as the net present value of climate change impacts over the next 100 years (or longer) of one additional tonne of carbon emitted to the atmosphere today. It is the marginal global damage costs of carbon emission and is usually estimated using integrated assessment models (IAMs), which jointly model the climate and the economy. This estimate reflects the marginal economic effects of CO_2 emissions and derives from multiple studies researching the welfare effects of climate change in terms of crop damage, coastal protection costs, land value changes, and human health effects (Tol, 2009).

To calculate the social cost of carbon, the atmospheric residence time of carbon dioxide must be estimated, along with an estimate of the impacts of climate change. The impact of the extra tonne of carbon dioxide in the atmosphere must then be converted to the equivalent impacts when the tonne of carbon dioxide was emitted. In economics, comparing impacts over time requires a discount rate. This rate determines the weight placed on impacts occurring at different times.

Estimating the SCC raises a number of related questions: what is social value and how should we measure the social cost when it occurs? In addition, we need to decide what rate of discount to apply to these future utility levels (Hope and Newberry, 2006). A component of this discount rate, the rate of pure time preference, δ, measures the weight to attach to future levels of well-being solely because they are enjoyed later in time. The discount rate is critical when dealing with long time periods as with climate change. For the purpose of this analysis we use a discount rate of 1.4%.

According to economic theory, if SCC estimates were complete and markets perfect, a carbon tax should be set equal to the SCC. Emission permits would also have a value equal to the SCC. In reality, however, markets are not perfect, and SCC estimates are not complete (Parry et al, 2007).

An amount of CO_2 pollution is measured by the weight (mass) of the pollution. Sometimes this is measured directly as the weight of the carbon dioxide molecules. This is called a tonne of carbon dioxide and is abbreviated "tCO_2". Alternatively, the pollution's weight can be measured by adding up only the weight of the carbon atoms in the pollution, ignoring the oxygen atoms. This is called a tonne of carbon and is abbreviated "tC". Estimates of the dollar cost of carbon dioxide pollution is given per tonne, either carbon, $X/tC, or carbon dioxide, $X/$tCO_2$. One tC is equivalent to 3.67 (44/12) tCO_2.

Estimates of the SCC are highly uncertain. The literature on SCC estimates show that estimates of the SCC for 2005 had an average value of $43/tC with a standard deviation of $83/tC. (Parry et al, 2007). The wide range of estimates is explained mostly by underlying uncertainties in the science of climate change (e.g., the climate sensitivity, which is a measure of the amount of global warming expected for a doubling in the atmospheric concentration of CO_2), different choices of discount rate, different valuations of economic and non-economic impacts, treatment of equity, and how potential catastrophic impacts are estimated. IPCC Summary for Policy Makers showed a range of values from $10/tC ($3/tCO_2) to $350/tC ($95/tCO_2). For the purposes of this report we will use the IPCC recommended median value of $43/tC (~$12 /tCO_2).

Potential value of sequestered carbon

Based on the methodological approach outlined above, the Forest Land (FL) category within the CC boundary was determined to contain a stock of carbon estimated at 11,013,909 tonnes (equivalent to 40,384,335 tCO_2) (Appendix 5, Table 3). In addition, the FL category category absorbs 319,392 tC per year (equivalent to 1,171,106 tCO_2). The

Crop Land category within the CC boundary emits 282,146 tCO_2 per year (76,949 tC) (Appendix 5, Table 4).

By summing Forest and Crop Land categories, the net contribution of Cockpit Country to Jamaica's CO_2 emissions under current land use conditions is (1,171,106 - 282,146) = 888,960 tCO_2 absorbed per year which is also equivalent to 242,444 tC.

Based on this estimate of yearly carbon absorption the carbon sequestration ecosystem service contribution of Cockpit Country is

242,444 tC x US$43 = $10,425,092 per annum.

Table 13 below provides a comparison of the potential value of the carbon sequestration services of Cockpit Country. The table shows a comparison between the IPCC recommended median price per tonne of carbon of US$43 and the lower and higher bound of carbon prices. The table also shows the net present value calculations over a 100 year time frame and represents the value over time of keeping the forest intact. The discount rate used in this example is 1.4%. However sensitivity analyses can be conducted to compare a range of discount rates, for example 0.1% to 5%.

Table 13 Value of carbon sequestration- annual and net present values (100 years)

Cockpit Country		**Annual Value**	**Annual Value**	**Net Present Value**	**Net Present Value**
Carbon (tonnes)	242,444	US$	JM$	US$	JM$
Median $/tC	$43	**$10,425,092**	**$896,557,912**	**$561,789,559**	**$48,313,902,067**
Low $/tC	$10	$2,424,440	$208,501,840	$130,648,735	$11,235,791,178
High $/ tC	$350	$84,855,400	$7,297,564,400	$4,572,705,712	$393,252,691,246

Net present value calculated over 100 years at a discount rate of 1.4%.

The values presented above can be compared to potential earnings from bauxite mining. Jamaica accounts for 6.5 per cent of the world's bauxite reserves, according to a recent United States geological survey (Jamaica Gleaner, December 2011). Some reports suggest that there are more than one billion tons which are easily accessible; this is enough to last 100 years at current rates of production. However in 2004 the chairman of the Jamaica Bauxite Institute (JBI), Dr Carlton Davis, stated that the existing reserves of bauxite ore were about 700 million tonnes and this was equivalent to "only 50 years of bauxite life." (*The Sunday Gleaner*, May 23, 2004, page A1) as quoted in Anthony R.D. Porter's article in the Sunday Gleaner August 2 2009.

Bauxite mining began in 1952, with an initial output of half a million tons per year and increased to a maximum output of 15 million tons by 1974. In 1993, bauxite total exports were 11.1 million tons. In 1992, the total "Net Foreign Exchange Inflows" equaled US$185 million. The industry has been affected by the slow-down in the global economy. Gross foreign exchange earnings fell from a high of US $898.7M in 2003 down to $133.6M in 2007 and to approximately less than $40M per annum in 2009 (Jamaica Gleaner, Feb 2009).

More recently, the bauxite-alumina sector earned the third-highest foreign exchange for the island at US$531.5 million in exports for 2010 (Jamaica Gleaner, 2011). Remittances and tourism, respectively, earn the highest for the island. However, Jamaica appears on track to exceed 2010's earnings, with alumina exports at US$293.2 million and an additional US$68.4 million from bauxite over the first six months of 2011. The numbers reflected improved half-year performance of 73 per cent for alumina and 10 per cent for bauxite, according to latest balance of payment statistics published by the Bank of Jamaica.

While these earnings are based on existing mining activity, we can compare the annual value of carbon sequestration as well as the future value of carbon over a 100 year life span (similar to the current bauxite reserves). Even at the median value of US$43 per tonne of Carbon, this basic analysis shows that the value of carbon sequestration services is substantial. The net present value of carbon over 100 years of J$49 billion dollars needs to be included in any decision making process regarding the management of the area. One important caveat must be expressed however. Given the general slow-down of the world carbon market this value should be considered to be the "potential" monetary value of carbon sequestration services.

The World Bank report (2011) noted that while the international regulatory environment remains uncertain, national and local initiatives have noticeably picked up and may offer the potential to collectively overcome the international regulatory gap. These potential opportunities include California's cap-and-trade scheme, which is expected to begin operating in 2012. The report also highlighted that there are other low-carbon initiatives, including domestic emission reduction targets, clean energy certificate programs, voluntary and pre-compliance domestic offset trading programs, and carbon exchanges, that have gained increasing traction in developing economies such as Brazil, China, India, and Mexico. These initiatives signal that, one way or another, solutions that address the climate challenge including voluntary carbon markets will emerge in the medium-term.

Conclusions

Ecosystem Services and non-market values

Conservation of forest ecosystems such as Cockpit Country contributes to the protection of sensitive, threatened, endangered and other species. Economists and ecologists have long debated the feasibility and practicality of valuing biodiversity in economic terms. Multiple categories of economic value are potentially relevant to Cockpit Country, including:

- Use value – Relates to the direct or indirect use of the resources found in Cockpit Country. This includes both consumptive use of animals and plants, such as hunting, harvesting and passive use, such as wildlife viewing.
- Option value – The preference for preserving the ecological integrity of the area for potential future use
- Bequest value – The preference for preserving species and habitat as an environmental legacy for future generations
- Existence value – Value derived from the knowledge of the species' or habitats' continued existence

The use of the contingent valuation approach for this study captures all of these measures of value. Based on our survey data we are able to estimate individuals' bundled use and non-use (option, bequest, existence) values.

Payment mechanism and valuation estimates

Based on a representative survey of Jamaicans, we estimate per person values for preserving Cockpit Country that ranged from J$1,600 to J$2,500. We tested two slightly different payment mechanisms in the survey and we found a statistically significant difference between a mandatory special consumption tax and voluntary payment to a conservation fund. Using payment mechanisms such as voluntary contributions has the tendency to produce valuation estimates that suffer from hypothetical bias. These "feel good/warm glow" economic estimates will tend to produce estimates that are biased upwards or over inflated (Cummings and Taylor, 1999; Fox *et al*, 1999). Our findings confirm that it is more appropriate to use incentive-compatible payment mechanisms such as a mandatory tax when designing the survey instrument. These estimated values are more conservative and based on previous research represent a more accurate assessment of the public's consumer surplus for the non-market good in question.

Non-market values

Using the number of voting age individuals in the island we show that the aggregate value for Cockpit Country ecosystem services is J$2.6 billion dollars per annum. This study demonstrates that the Jamaican population has a high consumer surplus associated with preventing a decline in the environmental quality of Cockpit Country. This implies that the average Jamaican is willing to forgo a small portion of their annual income to see that Cockpit Country ecosystem services are at least maintained in their current state.

Carbon value

Based on the estimate of forest cover and related carbon sequestration ecosystem services, we have shown that the value of carbon is considerable when compared to current annual earnings from bauxite mining. This value is shown to be J$917 million per year or a net present value over 100 years of J$49 billion. If the Jamaican government is able to participate in the emerging international carbon market then this ecosystem service could potentially provide well-needed revenue for supporting natural resource protection. Even in the absence of an existing market, the social cost of carbon should still be considered in national planning and decision making.

Policy Context

Despite the usefulness of economic valuation, there are still many challenges to its practical application. Economic valuation can produce only a partial estimate of total ecosystem value, as natural limits on our knowledge of technical, economic, and ecological knowledge prevents us from ever truly identifying, calculating, and ranking all of an ecosystem's values. This is why some environmental economists are cautious of grandiose estimates of Total Economic Value.

However, valuation estimates are extremely useful and should be used as part of a larger decision-making "toolbox" rather than being relied upon in a vacuum. In particular, valuation studies need to take into account the local context—both social and biological—and be undertaken with an eye toward the bigger picture (Kushner et al, 2011). Despite the challenges, economic valuation provides a powerful tool to target key decision-makers, while make the economic case for greater investment in conservation efforts.

This study uses two approaches of a suite of possible natural resource valuation methods. We believe that based on the policy context (bauxite mining versus forest conservation) the use of a non-market approach supported by a market based valuation method shows that the long term benefits of maintaining ecosystem services are greater than the short term economic gains of extracting a non-renewable mineral resource.

It is important to note that this island-wide ecosystem service valuation survey is the first of its kind to be conducted in Jamaica. Previous non market valuation surveys in Jamaica have tended to be limited to a particular geographic region or user group (for example, tourists, persons living near Black River etc.). For these previous studies sampling was typically restricted to intercepts of individuals (respondents) located in in airports, towns, specific cities and in a few cases adjoining parishes in a particular region. This study achieved a random sample of persons distributed all 14 parishes across the island of Jamaica. This means therefore that the estimated values for mean per person willingness to pay presented here can be extrapolated (and aggregated) to the wider Jamaican population with a high level of confidence.

This study demonstrates an approach that could be used as part of the policy framework for resource protection and sustainable management of important ecosystems and natural resources in a developing country. The welfare estimates presented in this study may be used in benefit transfer studies to similar Caribbean islands or other developing countries with similar ecosystems (limestone rainforest) or resource management challenges (non-renewable resource extraction). Please note any benefit transfer applications should take into consideration the possible differences across countries with respect to environmental quality as well as institutional frameworks governing environmental management and protection.

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Appendices

Appendix 1 – Cockpit Country Survey

Cockpit Country Survey

ALL INSTRUCTIONS TO INTERVIEWERS ARE IN CAPITALS

NOTE SOME QUESTIONS ARE LINKED TO INFORMATION PROVIDED OR PICTURES

CARE MUST BE TAKEN TO ASK THE RELEVANT QUESTIONS

IF A RESPONDENT REFUSES TO ANSWER A QUESTION INDICATE WITH THE LETTERS“RF”. DO NOT LEAVE BLANK

FILL IN THE BOXES WITH A TICK OR WRITE IN INFORMATION IF REQUIRED

NOTE IT IS VERY IMPORTANT THAT THE INTERVIEWER APPEAR AS UNBIASED AS POSSIBLE. THE RESPONDENT MUST NOT BE COAXED TO PROVIDE THE “DESIRED” ANSWER. WE ARE ASKING FOR THEIR HONEST OPINION.

[INTRODUCE YOURSELF AS FOLLOWS]

Hello and Good Day, sir/madam my name is ____________________________

I am part of a team from _________________ and we are conducting a survey on behalf of the Windsor Research Centre regarding the status of the Cockpit Country

You were randomly chosen to participate in this research project. Your help is voluntary and your answers are completely confidential. Your name will not be written on the survey, this means, none of the results of this survey can be linked to you directly. The survey will take approximately 20 minutes to complete. Your time and cooperation in completing this questionnaire are greatly appreciated.

IF RESPONDENT REFUSES THANK THEM AND MOVE ON. IF INTERESTED THANK THEM AND FIND A QUIET COMFORTABLE SPOT IN THE SHADE AND CONTINUE.

Location: ____

Interviewer Code Number

Interview start time _______________ Interview end time ________________

READ OR PARAPHRASE THE TEXT BELOW. THE INTERVIEWER MUST ENSURE THAT THEY CONVEY THE INFORMATION STATED IN THE LAST THREE SENTENCES (IN BOLD)

Mining for bauxite was recently suspended in the Cockpit Country. The Jamaican Government and Conservation Groups have been debating the best use of Cockpit Country. We need your assistance with this research. Your opinions will help us to improve our understanding of how to better use the resources of the Cockpit Country.

This is not a test. There are no wrong answers. Your opinion is what counts

A REMINDER: ONE QUESTIONNAIRE PER RESPONDENT AND THE RESPONDENT HAS TO BE 18 YEARS OR OLDER. PREFERABLE WE NEED ADULTS NOT IN SCHOOL.

START HERE

1. Have you heard about the issues facing the Cockpit Country before this?

Yes

No

2. If Yes where did you get your information about the Cockpit Country issues?

(*Check all that apply*)

□ Newspaper articles

□ Radio

□ Television

□ Internet

□ Community Meetings

□ Other ________________________________

3. How much impact (good or bad) do you think that this issue might have on you personally? (*Check one only*)

□ A big impact　□ Fairly significant impact　□ Some impact

□ Very little impact　□ Absolutely no impact at all

4. Depending on the impact, how might this affect how you feel about the issue?

□ Concerned　□ No concern at all

GIVE THE RESPONDENT THE CARD WITH THE MAP OF COCKPIT COUNTRY

READ TEXT BELOW. THE INTERVIEWER SHOULD CONVEY INFORMATION SHOWN BELOW AND ON THE FOLLOWING PAGE. IT IS NOT NECESSARY TO READ EVERY WORD BUT THE INFORMATION FOR EACH BULLET MUST BE CONVEYED ACCURATELY

In order to answer the next set of questions please consider the following issues.

Cockpit Country constitutes about a tenth of the land area of Jamaica. It is located in West-Central region of the island. Cockpit Country contains thousands of hills and deep valleys. This vast area is home to many plants and animals that are not found anywhere else in the world except in Jamaica.

Benefits

The Cockpit Country currently provides different types of benefits such as:

- Forests that create a large, safe habitat for many special, endemic (only-found-in Jamaica) plants and animals (e.g. bats, birds, snakes, crabs, insects, and more) to breed and grow. The area can support ecotourism activities and provide natural products that can be harvested for a source of income.
- Historical, archeological and cultural areas such as Taino (Arawak) and Maroon sites as well as more-recent memories of "grounds" and communities.
- Its Limestone geology serves as a large underground aquifer that supplies water for agriculture, domestic, tourism and industrial use for most of Western Jamaica and the forest cover maintains the rainfall and regulates water absorption.
- Contains significant volumes of bauxite ore which has the potential to be mined and exported to make Aluminum. The mining activities can create jobs and earn foreign exchange.
- Contains significant amounts of limestone which can be mined and used for construction activities such as roads and houses.

[ABOVE TEXT SHOULD BE ACCOMPANIED BY LAMINATED PAGE WITH PICTURES]

Conflicts [SHOW PICTURES AND CONVEY INFORMATION]

The need for economic development and the need for environmental protection described above can result in conflicts. The forested areas of the Cockpit Country could be affected as a result of development activities. The impacts include:

- Deforestation from lumber harvesting and charcoal burning for fuel.
- Deforestation because of bauxite mining. The strip mining process would result in the area being changed permanently.
- Decreased water supply due to reduction in the capacity of the area to store underground water.
- Loss of cultural and archeological artifacts and sites and loss of potential ecotourism revenues.

It is important to note that there are two sides to the story. Conservation activities in the Cockpit Country, for example like stopping activities such as bauxite mining, could result in the loss of valuable foreign exchange and jobs.

5. What would you say was your general level of awareness of the information discussed previously? (*Check one only***)**

□ Very aware

□ Somewhat aware

□ A little aware

□ Not at all aware

6. As far as you can tell, do you think the information provided is a fair assessment of the situation?(*Check one only***)**

□ Yes

□ No

□ The information was too complicated

NOW SAY TO THE RESPONDENT – "NOW I AM GOING TO SPEAK ABOUT SOME TYPICAL CONSERVATION ACTIVITIES THAT TAKE PLACE IN THE COCKPIT COUNTRY". ONCE AGAIN, PARAPHRASE IF NECESSARY BUT ACCURATELY CONVEY THE INFORMATION BELOW

Conservation Activities

Environmental management in the Cockpit Country is typically the responsibility of National Environment and Planning Agency and Forestry Division with help from local Community-based and Non-Governmental Organizations. These organizations require funding to sustain activities such as:

- Environmental and Forest Wardens - To: monitor activities in the area; work with local residents to reduce deforestation; promote forest preservation.
- Joint Programs with other agencies - To: reduce deforestation; address river pollution; improve agricultural practices; limit bauxite mining in sensitive areas.

Conservation activities require money to be effective. However, because of the challenging economic conditions that the country faces, very often the government is not able to dedicate the adequate amount of funds required to properly manage areas such as Cockpit Country.

If these management activities were implemented, it is expected that the Cockpit Country would be preserved in its current state. Environmental management activities would result in reducing or total stoppage of bauxite mining in the area.

DESCRIBE THE MAIN CHARACTERISTICS BELOW THAT WOULD BE AFFECTED BY CONSERVATION. THE INTERVIEWER SHOULD BE FAMILIAR WITH THE ISSUES

Characteristics	**Benefits or Negative Impacts**
Forest, animals and plants	Endemic (local) species preserved, agricultural products, soil
Cultural and heritage site preservation	Preserved existing Taino (Arawak) and Maroon sites
Aquifer services or Water supply	Preserve current volume of water supply,
Eco tourism jobs/ activities	Create eco-tourism jobs, recreational activities e.g. caving
Bauxite jobs	Possible jobs lost per annum

[INTERVIEWER READS] **Please carefully consider the following hypothetical plan to protect the Cockpit Country**

Suppose because of the need to raise funds to manage the Cockpit Country the government of Jamaica was considering adding a "Special Consumption Tax" on top of the existing GCT. This means you would face increased costs on all goods that now attract GCT. These increased costs would only be in effect for only one (1) year. The funds generated from the special tax would ONLY go towards the agencies involved in the conservation activities described previously. Not to central Government.

Suppose, in order to implement the new policy the government had to call a national referendum where all persons of voting age (over 18) were asked to vote on the amount of the increase. If the majority of persons vote for the increase then it would be implemented for one year.

7. If the proposed one year tax were to cause your household expenses to increase by $[X] for the year or in other words $[Y] extra per month for one year. How would you vote?

READ SCRIPT BELOW EXACTLY AS WORDED

Before you proceed, I want to talk to you about a problem that we have in studies like this one. Because this is a hypothetical situation, people tend to behave differently when they know they won't have to dig into their pocket and pay money. We often find if the decision they are being asked to make involves something that is "good" like protecting the environment the typical reaction is to agree to pay. But if it were a real situation they would be faced with the option of spending money on this or something else. So, I am asking you to consider what decision you would really make if you had to spend the extra money, given your current budget.

□ YES to this increase

□ No to this increase → *IF NO, PLEASE GO TO THE NEXT PAGE*

→→ *IF THEY ANSWERED "YES", PLEASE ASK THEM TO INDICATE BELOW THE REASONS FOR PAYING THE TAX.*

____

→→ *REMINDER IF YES SKIP THE NEXT PAGE. PLEASE GO DIRECTLY TO PAGE 7*

A REMINDER

IF THE RESPONDENT ANSWERED "YES" TO THE PREVIOUS QUESTION SKIP THIS PAGE AND PROCEED TO THE NEXT PAGE. THESE TWO QUESTIONS ARE ONLY IF THEY SAID "NO" TO THE INCREASE.

8. If you answered NO to the question on the previous page, please state your reason: (*Check all that apply*)?

□ This increased tax would be too expensive for me

□ I don't trust the government to give the money to the environmental agencies

□ Other reasons (please specify below)

____

____

A REMINDER SKIP THE QUESTION BELOW IF THEY ANSWERED "YES" TO THE QUESTION ON THE PREVIOUS PAGE

9. If the increased expenses shown on the previous page were too high for you, what is the most you might instead be willing to afford?

Instead of $X I would be able to afford $__________________/per month

Please proceed to the next page

[READ] **Finally here are a few questions about you that will help us to interpret our results. As a reminder the information you provide is completely confidential and is only needed for our statistical analysis.**

10. INDICATE GENDER OF RESPONDENT □ Female □ Male

11. Please state the year of your birth Year ______________

12. In which Parish is your home located? _______________________

13. What is your current employment status

□ Employed for wages

□ Self employed

□ Out of work

□ Homemaker

□ Student

□ Retired

□ Other ______________________________________

14. What is (or was) your occupation? ______________________________

15. In which Parish do you work/farm? ______________________________

(*Not applicable if unemployed*)

Please proceed to the next page

16. What is the highest level of school you have completed?

□ No formal schooling

□ Elementary school

□ High School

□ Associate degree/Bachelor's degree

□ Master's degree

□ Professional degree (MD, PE, LLB)

□ Doctorate degree (Ph.D.)

17. Are you an active member of an environmental group or club?

□ Yes □ No WRITE NAME(S) ___________________________

18. Are you a member of a community group or club?

□ Yes □ No WRITE NAME(S) ___________________________

19. What is your current marital status?

□ Now married

□ Live with partner (common law)

□ Widowed

□ Divorced

□ Separated

□ Never Married

20. If you have any children how many of them are you responsible for supporting?

__________ children in my direct care or responsible for supporting

[READ] Last question…Once again this information will only be used for our statistical analysis. Remember your name or anything that can be used to identify you personally is not on the survey.

21. Which category best describes how much you and other members in your household earn or bring in per month? In other words combined household income (*Check one*).

□ Less than $10,000

□ $10,000 – $30,000

□ $30,001 – $50,000

□ $50,001 – $70,000

□ $70,001 – $90,000

□ $90,001 – $150,000

□ $150,001 – $200,000

□ $200,001 – $300,000

□ More than $300,000

IF PERSON CAN READ THE INTERVIEWER CAN HAND THE SURVEY AND PENCIL TO RESPONDENT FOR THEM TO CHECK APPROPRIATE BOX. THEN INTERVIEWER CAN TAKE SURVEY WITHOUT LOOKING AT THE ANSWER.

END INTERVIEW AND THANK RESPONDENT FOR THEIR TIME AND CONTRIBUTION TO THE SURVEY EFFORT.

SURVEY CODE CVTAX

FOR INTERVIEWER

IF THE RESPONDENT WISHES TO FOLLOW UP ETC, PROVIDE THEM WITH A CARD/LEAFLET WITH WINDSOR RESEARCH CENTRE CONTACT INFORMATION

TO BE COMPLETED BY INTERVIEWER RIGHT AFTER COMPLETING INTERVIEW

1. Were other people present and listening in on the interview with this respondent?

□ Yes □ No

2. Did the respondent have difficulty with understanding the information provided

Not at all Extreme Difficulty

1 2 3 4 5 6 7 8 9 10

3. Did the respondent have a big issue with the hypothetical tax?

Not at all Extreme Difficulty

1 2 3 4 5 6 7 8 9 10

4. Were there any questions that were particularly difficult for the respondent to answer or comprehend? Please note the question numbers below.

□ Yes □ No Question numbers, ________________________________

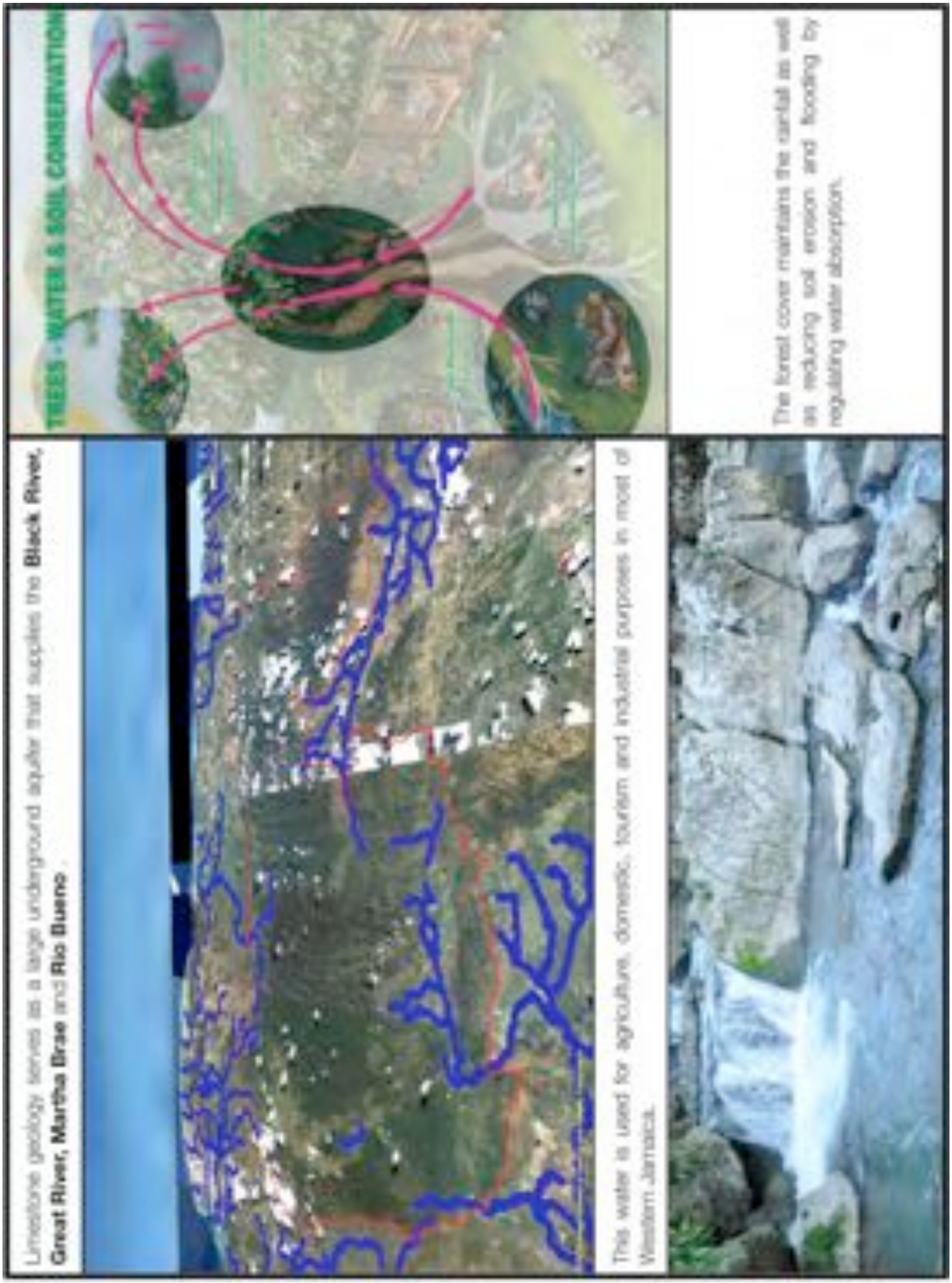
5. Any other comments about this particular interview.

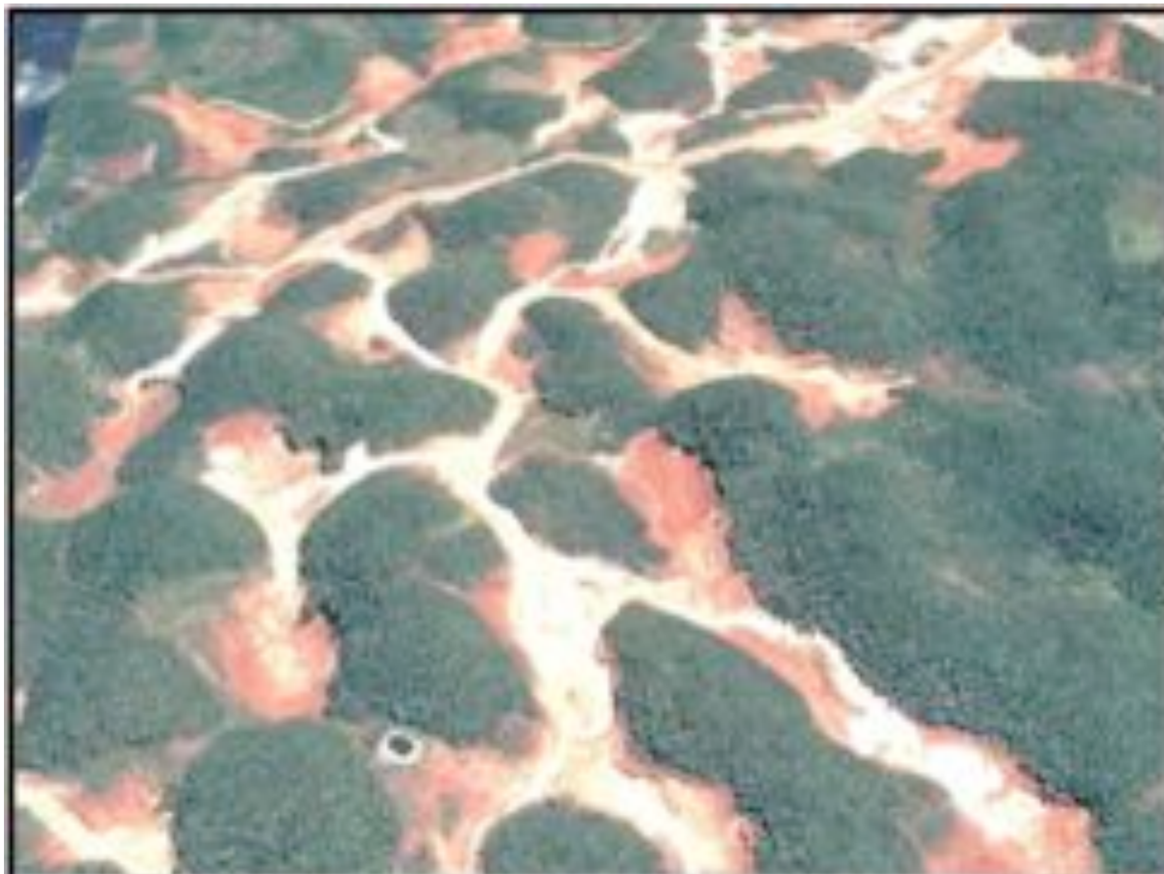
Pictures and figures used as part of the in-person survey exercise.


There are approximately 1,500 different plant species in Cockpit Country.
65 of these are found only in Cockpit Country.
The Cockpit Country forest is a stronghold for about half of Jamaica's special , endemic (only found here) animal species, including snails, frogs, crabs, snakes, birds, bats, butterflies that are not found anywhere else in the world.
The area can support ecotourism activities and provide natural products that can be harvested for a source of income

Historical, archeological and cultural areas such as Taino (Arawak) and Maroon sites as well as British military sites.

There are also more-recent memories of "grounds" and communities.


Limestone geology serves as a large underground aquifer that supplies the Black River, Great River, Martha Brae and Rio Bueno.
This water is used for agriculture, domestic, tourism and industrial purposes in most of Western Jamaica.
TREES - WATER & SOIL CONSERVATION
The forest cover maintains the rainfall as well as reducing soil erosion and flooding by regulating water absorption.



Cockpit Country contains significant volumes of bauxite ore which could be mined and exported to make Aluminum. The mining activities can create jobs and earn foreign exchange.

Cockpit Country also contains significant amounts of limestone which can be mined and used for construction activities such as roads and houses.

Appendix 2 – Survey administration locations

Locations of sampling by county

Cornwall	Middlesex	Surrey
Negril	St. Ann's Bay	Kingston
Wakefield	Discovery Bay	Buff Bay
Grange Hill	Ocho Rios	Port Antonio
Savannah la Mar	Port Maria	Moore Town
Clarks Town	Steer Town	Morant Bay
Coxheath	Brown's Town	Yallahs
Maroon Town	Christiana	Albion
Cascade	Trout Hall/Frankfield	Harbour View
Lucea	Mandeville	Golden Spring
Aberdeen	Melrose Hill	Seaforth
Albert Town	Hayes	Long Bay
Falmouth	May Pen	
Black River	Spanish Town	
Montego Bay	Portmore	
Stewart Town	Old Harbour	
Montpelier	Alexandria	
Duncans	Moneague	
Middle Quarters		
Content		
Adelphi		

Appendix 3 - Full Descriptive Statistics

Table of descriptive statistics

Variable	Observations	Mean	Std. Dev	Min	Max
mechanism	2074	0.4966249	0.5001092	0	1
ywtp	2074	0.6576663	0.474605	0	1
bid	2074	820.9065	788.4587	120	3600
age	2037	40.52234	14.17898	18	88
male	2056	0.5092412	0.5000362	0	1
inc000	1758	747.3311	639.3285	108	3600
income	1758	747331.1	639328.5	108000	3600000
children	1989	1.358472	1.360075	0	10
enviro	2066	0.0130687	0.1135966	0	1
commgrp	2066	0.1660213	0.3721898	0	1
noschool	8	1	0	1	1
elementary	491	1	0	1	1
highsch	1181	1	0	1	1
postsec	305	1	0	1	1
masters	28	1	0	1	1
professnl	10	1	0	1	1
doctorate	0				
employed	1492	0.6012064	0.4898143	0	1
selfemployed	1328	0.4555723	0.4982099	0	1
outofwork	1176	0.2576531	0.437528	0	1
homemaker	1066	0.0694184	0.2542836	0	1
student	1048	0.0448473	0.2070675	0	1
retired	1082	0.1007394	0.3011225	0	1
other	1032	0.0106589	0.1027401	0	1
married	572	1	0	1	1
commonlaw	460	1	0	1	1
widowed	60	1	0	1	1
divorced	39	1	0	1	1
separated	49	1	0	1	1
nevermarried	883	1	0	1	1

Appendix 4 - Econometric Analyses

Tax Version – Reduced Model

Logistic regression	
Log likelihood	-662.00532
Number of obs	1035
LR chi2(1)	56.98
Prob > chi2	0.000
Pseudo R2	0.0413

	Coefficient	Std. Err.	z	P>z	[95% Conf.	Interval]
bid	-0.0006208	0.000084	-7.39	0.00	-0.0007853	-0.0004562
constant	0.9845924	0.0971088	10.14	0.00	0.7942627	1.174922

Expanded Model

Logistic regression	
Log likelihood =	-514.07765
Number of obs	843
LR chi2(6) =	75.24
Prob > chi2 =	0.000
Pseudo R2 =	0.0682

	Coefficient	Std err	z	P>z	[95% Conf. Interval]	
bid	-0.0006995	0.0000978	-7.15	0.000	-0.0008913	-0.0005077
age	0.0003866	0.0055209	0.07	0.944	-0.0104341	0.0112073
male	0.1361214	0.1517584	0.9	0.370	-0.1613195	0.4335623
inc000	0.0006691	0.0001435	4.66	0.000	0.0003877	0.0009504
children	-0.0430169	0.0552982	-0.78	0.437	-0.1513993	0.0653655
commgrp	0.1070568	0.2177732	0.49	0.623	-0.3197709	0.5338845
constant	0.631949	0.2789617	2.27	0.023	0.0851942	1.178704

Conservation Fund – Reduced Model

Logistic regression	
Log likelihood	-620.21162
Number of obs	1049
LR chi2(1)	38.28
Prob > chi2	0
Pseudo R2	0.0299

	Coefficient	Std. Err.	z	P>z	[95% Conf.	Interval]
bid	-0.0005038	0.0000814	-6.19	0	-0.0006634	-0.0003442
constant	1.30014	0.102269	12.71	0	1.099697	1.500584

Expanded Model

Logistic regression	
Log likelihood	-460.42352
Number of obs	836
LR chi2(6)	52.93
Prob > chi2	0.000
Pseudo R2	0.0544

	Coefficient	Std err	z	p	95% Conf. Interval	
bid	-0.0005691	0.000098	-5.81	0.000	-0.0007613	-0.000377
age	-0.0150899	0.0059507	-2.54	0.011	-0.026753	-0.0034268
male	0.1503718	0.1624704	0.93	0.355	-0.1680643	0.468808
inc000	0.000496	0.0001479	3.35	0.001	0.0002062	0.0007859
children	-0.0225252	0.0615909	-0.37	0.715	-0.1432412	0.0981908
commgrp	0.5357282	0.2343547	2.29	0.022	0.0764014	0.995055
constant	1.643028	0.3212521	5.11	0.000	1.013385	2.27267

Combined Surveys – Reduced Model

Logistic regression	
Log likelihood	-1277.0454
Number of obs	2074
LR chi2(2)	111.29
Prob > chi2	0
Pseudo R2	0.0418

	Coefficient	Std. Err.	z	P>z	[95% Conf.	Interval]
bid	-0.0005632	0.0000585	-9.62	0.000	-0.0006779	-0.0004485
payment mechanism	-0.40774	0.0954539	-4.27	0.000	-0.5948263	-0.2206538
constant	1.347944	0.0882204	15.28	0.000	1.175035	1.520853

Expanded Model

Logistic regression	
Log likelihood	-975.34541
Number of obs	1673
LR chi2(7)	135.57
Prob > chi2	0
Pseudo R2	0.065

	Coefficient	Std err	z	P>z	[95% Conf.	Interval]
bid	-0.0006283	0.0000688	-9.14	0.000	-0.0007631	-0.0004935
payment mechanism	-0.4731279	0.1104307	-4.28	0.000	-0.6895682	-0.2566877
age	-0.006647	0.0040319	-1.65	0.099	-0.0145493	0.0012553
male	0.1319441	0.1106663	1.19	0.233	-0.0849578	0.3488461
inc000	0.0005914	0.0001028	5.76	0.000	0.00039	0.0007929
children	-0.0297382	0.0410046	-0.73	0.468	-0.1101058	0.0506294
commgrp	0.3006241	0.1577412	1.91	0.057	-0.0085429	0.609791
constant	1.337252	0.2199622	6.08	0.000	0.9061339	1.76837

Appendix 5 – Cockpit Country Greenhouse Gas Quantification

Table 1: Areas of National Land Use Classes making up Forest Land, classified by Holdridge Life Zone within the Cockpit Country boundary

	Premontane Moist Forest (PMF)		Premontane Wet Forest (PWF)		Tropical Dry Forest (TDF)		Tropical Moist Forest (TMF)		
	Inside MBW (ha)	Outside MBW (ha)	Inside MBW (ha)	Outside MBW (ha)	Inside MBW (ha)	Outside MBW (ha)	Inside MBW (ha)	Outside MBW (ha)	**TOTAL (ha)**
BF*0.25	0	14.74	0	152.11	0	72.94	0	7.92	**247.71**
BS*0.25	0	0.12	0	0	0	0	0	0	**0.12**
CS*0.25	3.61	442.01	166.17	230.16	63.39	7.95	182.74	666.20	**1,762.22**
HP	0	0	6.06	0	0	0	0	0	**6.06**
PP	0	0	41.58	0	0	0	0	0	**41.58**
PF	35.41	6,748.85	6,096.86	3,137.33	0	0	571.15	100.92	**16,690.5**
SC*0.75	1,547.99	2,199.37	2,480.86	530.53	1,226.58	437.42	1,470.98	750.75	**10,644.5**
SF	3,539.48	4,236.41	18,078.96	6,693.78	2,885.73	1,500.36	6926.83	7,386.68	**51,248.2**
SL	0	0	80.97	0	95.11	0	89.06	0	**265.14**
SW	0	0	0	0	19.66	0	11.97	0	**31.63**
WL	0	0	242.20	0	738.67	0	354.74	0	**1,335.61**
Total	**5,126**	**13,642**	**27,194**	**10,744**	**5,029**	**2,019**	**9,607**	**8,912**	**82,273**

Abbreviations used in Tables 1 & 2

BF= Bamboo & Secondary Forest

BS = Bauxite Extraction & Secondary Forest

CS = Fields & Secondary Forest

HP = Other species Plantations

PP = Pine Plantations

PF=Closed broadleaved forest (Primary Forest)

SC = Secondary Forest & Fields

SF= Disturbed broadleaved forest (Secondary Forest)

SL = Open dry forest (Short)

SW = Swamp Forest

WL = Open dry forest (Tall)

Table 2: Carbon stock contained in Forest Land within the Cockpit Country boundary[1]

National Class	Area (ha)	Volume (m3) / ha	Average density (t / m3)	Biomass Expansion Factor	Above-ground biomass (tonnes d.m. /ha	Ratio of Below-ground to Above-ground biomass	Below-ground biomass (tonnes d.m. / ha)	Total Dry Matter	Carbon fraction of dry matter	CARBON STOCK	C to CO2 conversion	CO2 Equivalent
BF*.25	247.71	66	0.60	3.9	155.34	0.24	37.28	47,713	0.47	22,425	3.67	82,226
BS*.25	0.12	66	0.60	3.9	155.34	0.24	37.28	23	0.47	11	3.67	39
CS*.25	1,762.22	66	0.60	3.9	155.34	0.24	37.28	339,435	0.47	159,535	3.67	584,960
HP	6.06	148	0.60	2.6	230.59	0.24	55.34	1,732	0.47	814	3.67	2,986
PP	41.58	119	0.51	1.3	79.18	0.23	18.21	4,049	0.47	1,903	3.67	6,978
PF	16,690.52	194	0.60	2.2	255.66	0.24	61.36	5,291,242	0.47	2,486,884	3.67	9,118,574
SC*.75	10,644.48	94	0.60	3.2	179.74	0.24	43.14	2,372,470	0.47	1,115,061	3.67	4,088,556
SF	51,248.23	165	0.60	2.4	238.27	0.24	57.19	15,141,663	0.47	7,116,582	3.67	26,094,133
SL	265.14	23	0.60	6.6	90.29	0.24	21.67	29,684	0.47	13,951	3.67	51,155
SW	31.63	181	0.60	2.3	250.15	0.24	60.04	9,811	0.47	4,611	3.67	16,908
WL	1,335.61	38	0.60	5.1	115.57	0.27	31.20	196,026	0.47	92,132	3.67	337,818
Total	**82,273**									**11,013,909**		**40,384,335**

[1] The various factors used in this table are taken from Jamaica's GHG Emissions Report, 2000 - 2005, Appendix 10, p10-548. BF and BS categories are assumed equivalent to CS.

Table 3: Annual Increase in Carbon Stock for Forest Land (FL) within the Cockpit Country boundary[2]

GHG Inventory Class	Area Inside CCMBW (ha)	Area Outside CCMBW (ha)	Total Area (ha)	Annual above-ground increase (tonnes d.m. / ha /yr	Ratio of Below-ground to Above-ground biomass	Annual above-ground and below-ground increase (tonnes d.m. / ha /yr)	Carbon fraction of dry matter	Annual increase in biomass carbon	Conversion from C to CO2 = 44/12	Annual CO2 absorbed (Tonnes / yr)
Tropical Rain Forest (Natural Forest)	27,146	10,744	37,890	7	0.37	9.59	0.47	170,781	3.67	626,198
Tropical Rain Forest (Plantations: Other Species)	6	0	6	15	0.37	20.55	0.47	59	3.67	215
Tropical Rain Forest (Plantations: Pine)	42	0	42	16.24	0.23	19.9752	0.47	390	3.67	1,431
Tropical Moist Deciduous Forest (Natural Forest)	9,607	8,912	18,520	5	0.24	6.2	0.47	53,967	3.67	197,879
Tropical Dry Forest	5,029	2,019	7,048	2.4	0.28	3.072	0.47	10,176	3.67	37,312
Tropical Mountain Systems (Natural Forest)	5,126	13,642	18,768	7.5	0.27	9.525	0.47	84,020	3.67	308,072
Total	46,957	35,317	**82,273**					**319,393**		**1,171,107**

Equivalence between GHG Inventory classes and Holdridge Life Zones

Tropical Rain Forest	=	Tropical Wet Forest	+	Premontane Wet Forest	+	Lower Wet Forest	+	Lower Montane Rain Forest
Tropical Moist Deciduous Forest	=	Tropical Moist Forest						
Tropical Dry Forest	=	Tropical Very Dry Forest	+	Tropical Dry Forest				
Tropical Mountain Systems	=	Premontane Moist Forest	+	Premontane Rain Forest				

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[2] The various factors used in this table are taken from Jamaica's GHG Emissions Report, 2000 - 2005, Appendix 10, p.10-590. BF and BS categories are assumed equivalent to CS.

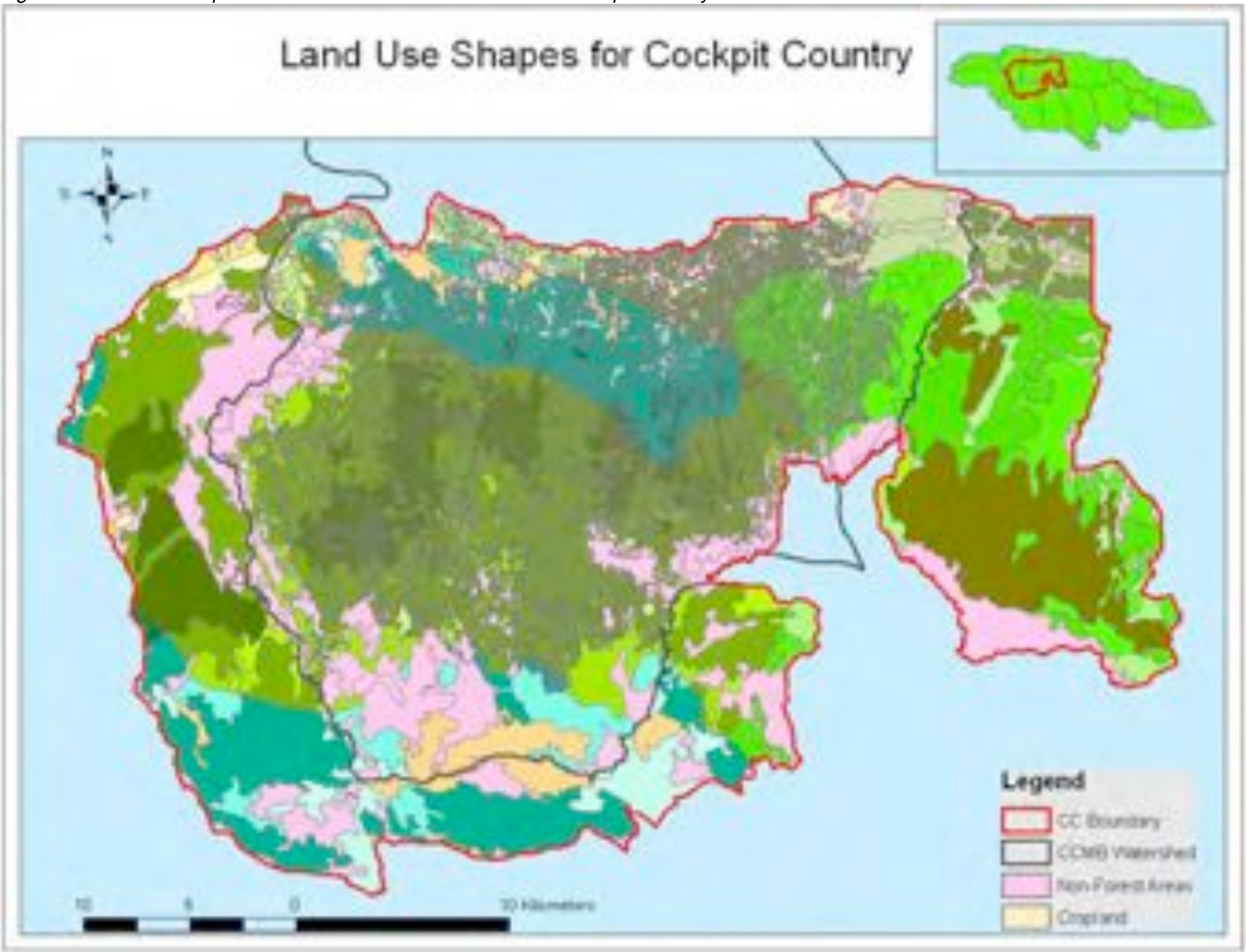
Table 4: Annual Change in Carbon Stock for Cropland (CL) within the Cockpit Country boundary[3]

GHG Inventory Class	Area (ha)	Annual growth rate of perennial woody biomass - tonnes C / ha / yr	Annual carbon stock in biomass removed - tonnes C / ha / yr	Annual change in carbon stocks in biomass - tonnes C / ha / yr	Annual increase in biomass carbon - tonnes C / yr	Conver sion from C to CO2 = 44/12	Annual CO2 absorbed - tonnes CO2/ yr
Tropical Rain Forest	22.3	10.00	50.00	-40.00	-893.75	3.67	-3,277.08
Tropical Moist Deciduous Forest	3,589	2.60	21.00	-18.40	-66,039.35	3.67	-242,144.30
Tropical Dry Forest	1,379	1.80	9.00	-7.20	-9,929.00	3.67	-36,406.33
Tropical Mountain Systems	4.72	2.60	21.00	-18.40	-86.80	3.67	-318.28
Total	**4,995**				**-76,949**		**-282,146**

[3] The various factors used in this table are taken from Jamaica's GHG Emissions Report, 2000 - 2005, Appendix 10, p.10-609. BF and BS categories are assumed equivalent to CS.

Figure 1: Holdridge Life Zones and Cockpit Country Boundary

Figure 2: Land use shapes within Martha Brae Watershed and Cockpit Country boundaries



Appendix 6 – Adapted list of Ecosystem Services of Cockpit Country

Cockpit Country Ecosystem Services Workshop: May 11-13, 2008. Kingston, Jamaica

Functions	Ecosystem process and components	Descriptor	Cockpit-Country-specific: large, closed-canopy tropical forest = dark, humid, stable temperatures, little wind, almost continuous canopy (ref Lovejoy et al 1986)
1. Regulation	***Maintenance of essential ecological processes and life support systems***		
1.1. Gas regulation	Role of ecosystems in biogeochemical cycles (CO_2-O_2 balance, ozone layer)	UV-b protection by O_3 (preventing disease)	
		Maintenance of (good) air quality (Partially) stabilizing influence on climate	Forest size & CO_2-O_2 estimates
1.2. Climate regulation	Influence of land cover and biological mediated processes on climate	Maintenance of favorable climate (temp, precipitation, etc) for, eg human habitat, health, agriculture	
		Maintenance of regional or local precipitation patterns	Closed-canopy forest and relationship to soil moisture and evapo-transpiration:: deforestation = less water vapour flux into the atmosphere, with consequent decreased local rainfall Closed-canopy forest: mediating effects against predictions of climate models - Caribbean likely to experience significant summer drying trend
		Moderation of temperature extremes	Absorption of solar radiation in forest canopy and energy retention / dissipation; comparison of circadian patterns in urban, pasture, and forest
		Maintenance of relative humidity patterns	High relative humidity defines CC ecosystem; soil micro-organisms (mycorrhizal fungi scavenge hard-to-access nutrients and pass them along to trees) and leaf litter invertebrates (detritivores = nutrient recycling) particularly depend on high humidity to prevent dessication & death; microclimate edge gradient in tropical forest can extend 25-30m. Pattern of bauxite mining would be to access every bottomland-glade - entire landscape becomes "edge".
		Moderation of the force of winds	Breeze not felt in the closed cockpit bottomlands but is experienced on hilltops or in cleared, large glades; fragmentation = changes in patterns of wind damage to tree limbs,

Functions	Ecosystem process and components	Descriptor	Cockpit-Country-specific: large, closed-canopy tropical forest = dark, humid, stable temperatures, little wind, almost continuous canopy (ref Lovejoy et al 1986)
			with consequence for increased fungal and insect infestation Fragmentation (notably by mining & road network) of CC predicted effects on microclimate: desiccation at forest edges from increased sunlight and wind; decreased protection from wind damage to branches, leaves & flowers
		Fire protection	Lightning strikes associated with heavy rain storms: natural fires are extremely rare -- fires are started by humans. Fragmentation: increased sensitivity to fire at drier edges (see below: Alien Species as a second positive feedback mechanism); also must factor for climate change models predicting increased drought cycles and increased fire risk for the Caribbean
1.3. Disturbance regulation & prevention	Influence of ecosystem structure on dampening environmental disturbances	Storm protection	Topography & aspect with regards to hurricane damage: only part of any individual cockpit hill is damaged - relevant for both hurricane *resistance* and post-hurricane ecosystem *resilience*
		Flood mitigation / protection (eg by wetlands and forests)	Bauxite deposits may be up to 30-40m deep and are part of the aquifer (percolation, rates of infiltration and storage capacity)
1.4. Water regulation	Role of land cover in regulating runoff and river discharge	Drainage and natural irrigation	Mining: extensive road network, either paved or heavily compacted marl (changes in run-off and infiltration patterns); removal of bauxite component of the aquifer; altered sinkhole drainage; contrast to buffered filtration of rain by above-ground vegetation, root systems, and soil
		Medium for transport	See Recreation: rafting & small motorized boat eco-tourism
1.5. Water supply	Filtering, retention, and storage of fresh water (eg in aquifers)	Provision of water for consumptive use (eg drinking, irrigation, industrial use, aquaculture)	Water quantity: rainfall, evapotranspiration, surface water runoff, ground water discharge, exploitable surface water run-off, exploitable ground water Karst hydrology associated with bedrock, elevation, and tectonic uplift history of Jamaica Water quality: suspended sediments, oxygen-depleting substances, nutrient-loading, chloro-organo phosphates, pathogens / parasites, etc. == costs to replace water purification services with man-made filtration systems; CC: general trend observed that water quality declines from

Functions	Ecosystem process and components	Descriptor	Cockpit-Country-specific: large, closed-canopy tropical forest = dark, humid, stable temperatures, little wind, almost continuous canopy (ref Lovejoy et al 1986)
			interior springs through edge and down-river sampling points (note: sample sizes low for interior sites)
1.6. Erosion control and soil retention	Role of vegetation root matrix and soil biota in soil retention	Maintenance of arable land	
		Prevention of damage from erosion / siltation	1mm per year soil erosion is national average GoJ recommends that hills with slope exceeding 30 degrees remain under natural forest-cover because of susceptibility to erosion
1.7. Soil formation	Weathering of rock, accumulation of organic matter	Maintenance of natural productive soils	Topographic variation of soils in CC: hilltops accumulate leaf litter (acidic humus), slopes tend to be talus-rock limestone (alkaline pH), soils with neutral-to-alkaline pH accumulate in bottomlands (glades).
		SPECIAL COMMENT ABOUT TOPOGRAPHY, FOREST PHYSIOGNOMY, AND CLIMATE	Related to topography and patterns of soil accumulation, the largest trees are found in the glades. In relation to soil moisture, evapotranspiration and climate, one prediction is that the abiotic and biotic components of CC glades contribute disproportionally to the region's characteristic climate. That is, glades may be a "keystone" component of the ecosystem, with the effects of bauxite mining not being linear to "size area mined."
		Maintenance of productivity on arable land	
1.8. Nutrient regulation / cycling	Role of biota in storage and re-cycling of nutrients (eg N, P, & S)	Maintenance of healthy soils and productive ecosystems	About 85% of all plant species, most notably trees, depend on partnerships with nutrient scavenging soil fungi to thrive Almost all organic matter passes through the microbial system in a tropical forest & microorganisms are an important food base for many invertebrate species. Microorganisms and invertebrate detritivores (e.g. earthworms, snails, millipedes) are sensitive to changes in moisture / humidity; their diversity is associated with the heterogeneity of plant composition and the associated chemical and physical nature of leaf litter
1.9. Waste treatment	Role of vegetation and biota in removal or breakdown of xenic nutri-	Pollution control / detoxification of wastes	

Functions	Ecosystem process and components	Descriptor	Cockpit-Country-specific: large, closed-canopy tropical forest = dark, humid, stable temperatures, little wind, almost continuous canopy (ref Lovejoy et al 1986)
	ents and compounds	Filtering of dust particles Abatement of noise pollution	
1.10. Pollination	Role of biota in movement of floral gametes	Pollination of wild plant species	Endothermic nectarivores (e.g. birds, bats) must feed daily/nightly: diverse plant communities (species and life forms) are necessary to ensure nectar/pollen year-round -- either heterogeneity within a habitat OR connectivity / mobility between ecozones. For invertebrates, microclimate and food also must be available for the larval "non pollinator" stage class Research is very limited in Jamaica on legitimate pollinator vs. nectar robbing and pollen predation. It is not known whether any plant species are dependent upon a single legitimate pollinator. Most records are restricted to (a) observations of floral visitors and (b) morphology (flower shape, colour, and fragrance) descriptions to predict the more important pollinators. Farr and Bretting (1986) identified 3 diurnal groupings - butterfly, solitary bee, and hummingbird; 2 nocturnal groups - moth and bat
		Pollination of crops	Dominant agriculture activities on the periphery of CC are yam and sugar cane production: pollination not relevant. Lesser important crops include coffee and fruit trees: papaya (paw-paw), avocado (pear), ackee, mango
1.11. Seed dispersal	Role of biota in movement of seed propagules	Dispersal of wild plant species	Birds and bats are the two major classes of seed-dispersing fauna; the only other native mammal, the coney (hutia) has not been recorded in CC for more than 40 years, despite being common in the fossil record. CC, because of its large size, is notable for supporting one of the richest avian communities on Jamaica: all size-classes of frugivores and omnivores are present; focused research on the role and efficacy of birds-as-seed-dispersers (vs. seed predators) is extremely limited on Jamaica Bats are effective because of rapid gut-passage time (30mins), large distances they can travel in a single night, and they defecate in flight to create a seed shadow (con-

Functions	Ecosystem process and components	Descriptor	Cockpit-Country-specific: large, closed-canopy tropical forest = dark, humid, stable temperatures, little wind, almost continuous canopy (ref Lovejoy et al 1986)
			trast to seed rain under mother tree); Neotropical bats are particularly important for small-seeded pioneering species and forest regeneration Forest conversion (pasture, mining) of glades: break-down in seed dispersal and regeneration because (a) no food or perching substrates for birds and (b) no food, hanging substrates or degradation of physical substrate (vertical structure), with consequences for echolocation abilities of bats
1.12. Biological control	Population control through trophic-dynamic relations	Control of pests and diseases	Aware of only one study in Jamaica, which examined the role of Neotropical migratory birds in controlling coffee berry-borer *Hypothenemus hampei*, the world's primary coffee pest. When Jamaican coffee farmers retain peripheral forest cover (bird and bat habitat), the market value of increased saleable berries provided by predation ranged from US$ 44-105 per hectare. NB, this study did not account for the possible role of bats; other studies have found that insect-control performed by bats was incorrectly ascribed to birds. Eight of Jamaica's 13 species of insectivorous bats occur in CC. Because bats are capable of consuming their body weight in insects each night, they are important for controlling insect populations and crop pests; species will be highly variable in their role of consuming agriculture pests because of characteristics in echolocation signals: insectivores evolved with "closed canopy highly cluttered space" will be restricted to forested environments while those evolved for "uncluttered space" will be able to navigate and forage in agriculture environments. It is predicted that CC bats will play a more important role in controlling insects in the forest than in agriculture.
		Reduction of herbivory (crop damage)	Common complaints of farmers: damage by slugs and caterpillars
2. Habitat Functions	***Providing habitat (suitable living space) for wild plant and animal species***		
2.1. Refugium function	Suitable living space for wild plants and animals	Maintenance of biodiversity: variety of life forms,	**CC: remnant of a forest-type that historically blanketed the central limestone plateau; one of the larg-**

Functions	Ecosystem process and components	Descriptor	Cockpit-Country-specific: large, closed-canopy tropical forest = dark, humid, stable temperatures, little wind, almost continuous canopy (ref Lovejoy et al 1986)
		the ecological roles they perform, the genetic diversity they contain (and thus the basis for most ecosystem functions)	**est closed-canopy forests on Jamaica; Major Biodiversity Hotspot of endemism: recognized stronghold for many "island endemic" species as well as for CC-endemic flora and fauna**
		Large area-size	Near-complete faunal community (including largest species of land-birds) Complete trophic diversity, notably top predators such as the Jamaican Boa Diversity = stability Diversity = resilience following disturbance, esp. hurricane Large viable population sizes = stability + resilience Source to recolonize small patches which are vulnerable to deterministic (eg inbreeding depression) and catastrophic (eg hurricanes) events Capacity of Protected Areas to slow down habitat degradation and to favour habitat restoration is related to size: smaller areas follow the dominant land-use change pattern in which they are embedded.
		Contiguous (non-fragmented) forest patch	Resistance to invasive species: deforestation or the maintenance of corridors (e.g. roads, high-voltage powerlines) facilitates the spread of non-native invasive species. Species of concern include: (a) Giant Bamboo and Asian ferns, which form biologically-sterile monocultures of vegetation and arrest all processes of forest succession (collapse of primary productivity); (b) Shiny Cowbird, a brood-parasite that lays its eggs in the nests of a host -- either first ejects the eggs of the host or the cowbird nestlings out-compete the host's own nestlings for food provisioning; (c) Cane toad, which has toxic glands and is lethal to eg Jamaican Boas if ingested -- mining roads, with associated potholes and rain-filled puddles will provide ideal breeding ponds, which are currently very limited in the porous cockpit karst substrate; and (d) Small Javan mongoose, which presently occurs in low densities in CC in comparison to drier environments -- mining and associated changes in microclimate may contribute to enhancing the environment for mongooses. Related to invasive plants: invasive grasses and ferns are more flammable than woody forest vegetation. Establishment at edges + drier microclimate / soils + flammability = positive feedback for increased vulnerability to fire Maintenance of closed-canopy microclimate: many species require

Functions	Ecosystem process and components	Descriptor	Cockpit-Country-specific: large, closed-canopy tropical forest = dark, humid, stable temperatures, little wind, almost continuous canopy (ref Lovejoy et al 1986)
			100% RH. Example: Jamaican Giant Swallowtail - largest butterfly in the New World, endemic to Jamaica, IUCN Endangered; CC may represent last viable population owing to extremely high rates of egg parasitism in the Blue Mtn. population; symbol used by many businesses -- all stages of life cycle require high humidity. Absence of tracks & road restricts human access Deforestation and fragmentation associated with eg mining will alter natural predator-prey dynamics through changes in vegetation structure at forest edges (eg., increased climbing vines and lianas associated with increased sunlight) or through the creation of permanent "gap" open-canopy habitats Species adapted to closed-canopy conditions will avoid open gaps, potential genetic isolation of species with poor mobility. Bats with echolocation signals that function in a closed canopy "cluttered space" will be unlikely to fly across large, open spaces to access food resources in hilltop forest patches Maintenance of connectivity between terrestrial, subterranean, and freshwater ecosystems, including all flows of energy / nutrient inputs, water filtration, etc.
		Forest physiognomy	Large trees (increasing tree size associated with difficulty-of-access and distance from edge or existing trail network) support diverse and large arboreal epiphytic tank bromeliad communities: critical water reservoirs in a limestone landscape and one of the defining ecosystems of CC, which represent a foundation of the food web. Terrestrial tank bromeliads are predominantly intolerant of full sunlight: large bromeliads are "prime real estate" microcosms for species dependent upon water for some / all stages of their life cycles Every component of the vertical structure: root matrix, ground cover, trunk, subcanopy, canopy, snag, rotting treefall, flaking bark, etc. utilized for foraging, shelter, roosting
2.2. Nursery function	Suitable reproduction habitat	Maintenance of biodiversity	Requires maintenance of microclimate gradients, vegetative structural gradients, access to food resources (spatial relationships), natural predator-prey dynamics, connectivity for effective dispersal of offspring Connectivity required between cave-dwelling bat nursery and terrestrial food resources Many species, such as birds, show very strong annual fidelity to nesting territories / breeding sites "Source/sink" dynamics associated with interior:edge,

Functions	Ecosystem process and components	Descriptor	Cockpit-Country-specific: large, closed-canopy tropical forest = dark, humid, stable temperatures, little wind, almost continuous canopy (ref Lovejoy et al 1986)
			large:small forest size and degree of isolation of forest fragments: altered predator-prey dynamics and patterns of brood-parasitism by Shiny Cowbirds Evolution of high levels of maternal care in CC wildlife -- environment of high rainfall but little surface water Evolution of globally unique maternal care: the Jamaican bromeliad crab is the only known crab in the world with co-operative breeding -- daughters of a previous year's clutch remain in the bromeliad, remain reproductively inactive, and assist their mother in rearing their siblings, including colony defense and food provisioning. Maintenance of diversity = maintenance of variation
		Added Note: Annual budgets for endangered species conservation in Puerto Rico -- total exceeds USD 2 million per annum	
3. Production Functions: Non-renewable	***Provision of non-renewable natural resources***		
3.1. Rocks and minerals		Bauxite; limestone	
3.2. Fossil fuels			
4. Production Functions: Renewable	***Provision of renewable natural resources***		
4.1. Food	Conversion of solar energy into edible plants and animals	Hunting, gathering of fish, game, fruits, etc.	Shooting of gamebirds regulated by NEPA but is illegal within the CC forest reserves
		Small-scale subsistence farming and aquaculture	Aquaculture of non-native (invasive) *Tilapia* spp. particularly relevant for Black River watershed
4.2. Raw materials	Conversion of solar energy into biomass for human construction and other uses	Building and manufacturing (e.g. lumber)	

Functions	Ecosystem process and components	Descriptor	Cockpit-Country-specific: large, closed-canopy tropical forest = dark, humid, stable temperatures, little wind, almost continuous canopy (ref Lovejoy et al 1986)
		Fuel and energy (eg fuel wood, organic matter) Fodder and fertilizer (e.g, krill, leaves, litter)	Collection of bat guano documented to have devastating effects on cave communities: extirpation of bat colonies and loss of guano-dependent invertebrate communities.
4.3. Genetic resources	Genetic material and evolution in wild plants and animals	Improve crop resistance to pathogens and pests	
4.4. Medicinal resources	Variety in (bio)chemical substances in, and other medicinal uses of, natural biota	Drugs and pharmaceuticals Chemical models and tools Test- and assay organisms	
4.5. Ornamental resources	Variety of biota in natural ecosystems with (potential) ornamental use	Resources for fashion, handicraft, jewelry, pets, worship, decoration and souvenirs (e.,g feathers, orchids, butterflies, aquarium fish, shells, etc.)	
5. Information Functions	***Providing opportunities for cognitive development***		
5.1. Aesthetic information	Attractive landscape features	Enjoyment of scenery (scenic roads, housing, etc.)	
5.2. Psychological & social information	Unique landscape features	Recognition of the international significance of Jamaica's natural landscape, flora and fauna: feel good because the world recognizes us	"Little-size" Jamaica and Cockpit Country recognized as a "hotspot" of endemism; Cockpit Country is the "type locality" for cockpit karst; meets criteria of World Heritage Site status
5.3. Recreation	Variety in landscapes with (potential) recreational uses	Travel to natural ecosystems for eco-tourism, outdoor sport, etc.	
5.4. Cultural and artistic information	Variety in natural features with cultural and artistic	Use of nature as motive in books, film, painting, folk-	Maroon heritage

Functions	Ecosystem process and components	Descriptor	Cockpit-Country-specific: large, closed-canopy tropical forest = dark, humid, stable temperatures, little wind, almost continuous canopy (ref Lovejoy et al 1986)
	value	lore, national symbols, architecture, advertising, etc.	
5.5. Spiritual and historic information	Variety in natural features with spiritual and historic value	use of nature for religious or historic purposes (ie., heritage value of natural ecosystems and features)	Maroon - British heritage: key factors: (a) topography facilitated guerilla warfare style used successfully by the Maroons; (b) British attempted to control above-ground river sources
5.6. Science and education	Variety in nature with scientific and educational value	Use of natural systems for school excursions, etc.; use of nature for scientific research	Evolution of unique species (endemism)
			Evolution of unique adaptive behaviours Taxonomic distinctiveness