<u>The Feasibility of Conserving Gabon's Nature Reserves</u>.

Diego Ponce de Leon Barido.

Professor Sarah West
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“I think the human species is what it is. It evolved to extract as many resources as it possibly could from the environment to survive better and better. That's kind of what humans are programmed to do. And to do the opposite of that, to conserve, I think is a very difficult thing for people to even comprehend, let alone enact. It's kind of counter-evolutionary, and I think it takes a lot of education and a lot of foresight. If humans want to survive on this planet without having some kind of catastrophic event take out large percentages of the population someday in the future, then they're going to have to make that shift today”

Michael Fay, the conservationist who persuaded the Gabonese government to protect and preserve 10 percent of the countries forests in an interview with the National Geographic Society on August 9th 2001.[1]

[1] http://news.nationalgeographic.com/news/2001/08/0809_mikefayinterview.html

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Introduction

In 2002 the Government of Gabon agreed to create twelve new nature reserves throughout different regions of the country. In the last three years since their creation no papers have studied the feasibility of creating these nature reserves. Previous papers that have studied the feasibility of creating nature reserves in Africa have diverged in their conclusions mainly because of the way in which the costs and the benefits of conservation are calculated. The importance of accurately quantifying and monetizing the *value* of national parks, nature reserves and the environment is rising. As developing countries strive to meet the needs of their increasing populations in terms of food, health, education and economic growth the natural resources and ecosystems in such countries are overly exploited and in some, endangered. However, the importance of accurately monetizing these ecological values could present these countries with enough reasons to conserve and protect the rich diversity of their land. By presenting these countries with new alternative options of attaining and increasing government revenue, ecotourism and the health of people and the environment it could be possible to convince governments in such countries to protect biodiversity.

This paper will study the theory behind determining the feasibility of creating the nature reserves in Gabon. The paper will use a present value ratio determination and a differential between present value net benefits (PVNB) and present value net cots (PVNC) of conservation to determine the feasibility of conserving these nature reserves. The ratio between PVNB and PVNC will be compared to 1 and the differential will be compared to zero. I used methods that have been used in other papers to measure user benefits (revenues from ecotourism and forestry) and potential user benefits (carbon sequestration and pharmaceuticals) but the paper also includes the increase in foreign aid towards conservation due to the creation of the nature reserves. I also used a method applied by Wilkie et al (2001) to calculate the capital costs of nature reserves and added the opportunity costs of the revenues that could have been generated by illegal hunting, bushmeat, mineral extraction and agricultural production had the reserves not been created. I decided to use potential user benefits as a proxy for existence benefits since potential user benefits portray a more realistic set results of conserving Gabon's rainforests than the existence benefits (an individual's satisfaction from knowing that the rainforests exist).

The paper first introduces the theory behind my approach and explains how I determined the values given to the benefits and costs of conservation in order to calculate the ratio. It then clarifies the results and suggests ways in which they faltered and could be improved. Finally, the conclusion comments on the feasibility of conserving Gabon's nature reserves and proposes comments for their future success.

Theory:

In order to develop a cost-benefit analysis for the creation of Gabon's nature reserves I had to find ways to measure the costs and benefits of preserving the reserves. This paper uses a benefit-cost ratio (*PresentValueNetBenefits/ PresesentValueNetCosts)* to determine the feasibility of conservation. The ratio is compared to 1, if the ratio exceeds 1; this conservation program is considered a feasible solution; if not, the conservation program should be rejected (Callan and Thomas 2004). What this ratio communicates is that feasibility is implied if the benefits associated with a policy proposal outweigh the costs incurred (Callan and Thomas 2004).

This paper also uses a differential *PVNB* – *PVNC* to determine the feasibility and the net gains to society from the conservation of the nature reserves. The differential of the present values is compared to zero, if the differential exceeds 0; the environmental initiative is considered a feasible solution; if not, the conservation program should be rejected. This differential presents excess benefits, and thus it directly communicates the gain to society.

When deciding on the feasibility of the project I took into account both the differential and the ratio because both show a clear contrast between the *PVNB* and *PVNC* of conservation. With using the differential there is less room for uncertainty when observing this contrast since no matter where the costs and benefits are allocated the difference between them will be the same. However, using a ratio incorrectly by misallocating benefits and costs can lead to an inaccurate set of results (by changing the ratio and thus the comparison of the ratio to 1). Nevertheless, in the end, both sensitivity analyses revealed the same results; success or failure in the implementation of the policy.

In order to perform a sound present value determination for both benefits and costs I chose different discount rates that reflected the opportunity costs to society from carrying through this environmental initiative. The discount rate is the most important factor in determining the present value determination for an environmental project. Lower rates favor large projects with distant benefits and higher rates favor staged investments with quick payback. For this project, the present value determination will be calculated with three different discount rates (the three discount rates chosen are 0.5, 0.7 and 0.9) in order to make a sound and empirical observation on the feasibility of conserving Gabon's nature reserves.

Within the nature reserves of Gabon the present value net benefits of conservation ($PVNB_{Conservation}$) will be regarded as :

$PVNB_{Conservation} = PVB_{Direct\ Values} + PVB_{Potential\ User\ Values}$ (Norton Griffiths 1995).

The direct values are assumed to be dollar revenues (in 2005 prices) generated from ecotourism, forestry and the increase in financial aid towards environmental conservation in Gabon through 10 years. I used 10 years as a time frame on which to value the costs and benefits because it allowed time for both benefits and costs to develop and be able to be evaluated. The potential user values will be regarded as the net dollar value (in 2005 prices) given to the total amount of carbon sequestration and the probability of pharmaceutical success inside the nature reserves. I do not take into account existence values for this study since I believe that the monetization of these benefits do not offer a tangible monetized quantitative figure that supports the cost-benefit analysis. As an alternative, I believe that using potential user values give a clearer monetized figure of the benefits of conserving Gabon's rainforests.

Similarly, I define the net costs of conservation ($PVNC_{Conservation}$) to be equal to the sum of the present value opportunity costs of conservation ($PVOC_{Conservation}$) and the direct present value capital costs of creating the reserves ($PVCC_{Conservation}$)(Norton-Griffiths 1995). The opportunity costs of conservation are equivalent to the net benefits from the forgone production potential of agriculture, bushmeat revenue, illegal game hunting and extraction of minerals inside the reserves. Following the same expression as above I have that:

$PVNC_{Conservation} = PVOC_{Conservation} + PVCC_{Conservation}$

The costs of conservation in Gabon

Capital costs

Africa Resources Trust based in Zimbabwe, using accounting data from several Central and Southern African protected areas has developed a set of equations to estimate the costs to effectively manage protected areas based on the size of each area (David S. Wilkie et al 2001). The number of park guards/km^2 required to monitor resources used within a protected area is estimated to be,

$$G = \sqrt{A}$$

Where A is the size of the protected area in km^2 and assuming that as the area of the nature reserve increases, the number of guards required to protect the reserve from illegal logging, poaching and hunting will be increasing at a diminishing rate.

In the same way I have that the number of Toyota 4 x 4 vehicles[2] required to bring tourists and to monitor the movement of animals in the stations depends on the size of the nature reserves and equivalently, on the number of guards in the station. The number of trucks/km^2 required to monitor resources and tour the visitors is estimated to be,

$T = (\sqrt{A})/10$ Which is also equal to $T = G/10$

Where A is the size of the protected area in km^2 and assuming that the number of trucks/station has to be a tenth of the number of guards working in the reserve. As area

[2] Toyota 4 x 4 's are the most commonly used means of transport in the Loango Station, Gabon. http://www.operation-loango.com/operation_loango/gabon_national_parks.html

increases the number of trucks will also increase (more resources to monitor) but at a much slower rate than guard numbers since not every guard needs a truck[3].

Similarly, total capital costs/km^2 are assumed to be,

C_c = *US$FIXED COSTS [1+ (1/A) +(1/*$\sqrt{A}$*)]*

Where fixed costs are given two different possible values. The fixed costs of creating the reserve are considered as the costs of creating a conservation and tourism station[4], buying one rifle per guard (an expensive or a cheap rifle) and the number of Toyota 4 x 4 trucks needed for each station (an expensive or a cheap 4x4). The equation which models fixed costs is then:

$$\text{Fixed Costs} = (P_{Rifle} \times G) + (P_{truck} \times T) + \text{Creation}$$

where P_{Rifle} and P_{Truck} vary if I calculate the highest or the lowest fixed costs, G and T increase as the area of the reserve increases and *Creation* is the cost of creating a conservation station of the same characteristics in every station. To complete the explanation of the cost equation I have:

$$\text{Variable Costsm} = (\text{FIXED COSTS} /A) +(\text{FIXED COSTS} /\sqrt{A})]$$

Where the variable costs will increase or decrease according to the size of the reserve. Thus, this shows that as the area of a reserve increases, the fixed costs will increase more rapidly than the variable costs.

3 Please see Appendix 1 for the number of guards and trucks per station. This will show us that in average ,every station uses 1 truck for every 10 workers that it has in the station.

4 Please see Appendix 1 for how the costs of creating a station are calculated.

Opportunity Costs

Revenues generated from agricultural production

In a similar study Norton Griffiths et al (1995) analyzed the revenues that could have been generated had nature reserves in Kenya been used for growing cash crops (cocoa, coffee, sugar) and average crops (palm oil, wheat, maize) and found that the revenues generated from cash crops were $412 ($397 in 2005 prices) per hectare and $151 ($145 in 2005 prices) per hectare for average crops. Since Gabon and Kenya grow similar cash crops and average crops[5], the same values for cash crops and average crops per hectare were used in this study. Thus, there were two results for the revenues that could have been generated from agriculture in Gabon's 2666550 hectares of reserve; the revenues generated from growing only cash crops and the revenues generated from only growing average agricultural production.

Revenues generated from illegal game hunting

Game hunting in Gabon is illegal and is punished with high fines and time in jail. However, the Wild Life Conservation Society has recorded an average of eleven elephants killed every year as part of illegal game hunting and ivory trade. Illegal hunters charge foreigners $10,000 for hunting an elephant and $3000 extra for keeping the tusks[6] (2005 prices).

Revenue from Bushmeat

Global Forest Watch (2001) did a research on the importance of logging and bushmeat on the economy of Gabon and found that although not reflected in national accounts, the

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5 http://www.cia.gov/cia/publications/factbook/geos/gb.html

6 www.wcs.org, http://whyfiles.org/043elephant/main3.html

total value of the bushmeat trade was of $50 million annually ($48 million 2005 prices). This value takes into account the price of meat, skin sold and illicit ivory trade. Counting the illicit ivory trade is not considered as double counting because this trade is not the same as allowing foreign hunters to keep the tusks.

Revenues from fuel, ferrous metals and precious metals

Gabon is heavily dependant on its oil trade and its ferrous metal trade. The National Geographic Society[7] has found that not one of the nature reserves created is located in a place where there are oil deposits[8] since most of the oil deposits of Gabon are far out at sea or near the coast of the country. Thus, no revenue from oil would be lost due to the creation of the reserves. Although Gabon has the potential to begin the exploitation of diamond and gold resources it has just begun the process of selling permits to foreign industry to search for these precious metals. However, there are four nature reserves where there are deposits of ferrous metals (columbium and iron ore) out of seven places in the country where they can be found. Since the current market prices of Columbium and Iron Ore are $8.17/pound[9] and $35/pound[10] (2005 prices) respectively and total reserves of Columbium and Iron Ore in these 4 reserves are 9215[11] and 30864[12] pounds respectively. I calculated that the revenue that could be generated by the government from these reserves would be equal to the tax generated (35 corporate tax) from companies selling all of them at current market prices (using a present value determination for 10 years).

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[7] www.mapmachine.nationalgeographic.com

[8] Please see appendix two to see where the mineral resources of Gabon are located compared to the nature reserve areas.

[9] http://www.metalprices.com/FreeSite/metals/cb/cb.asp

[10] http://www.metalprices.com/FreeSite/metals/steel/steel.asp

[11] http://minerals.usgs.gov/minerals/pubs/country/2002/gbmyb02r.pdf

[12] http://minerals.usgs.gov/minerals/pubs/country/2002/gbmyb02r.pdf

The Benefits of Conservation in Gabon

User Benefits

Forestry

Global Forest Watch (2001) has calculated that the revenue that could be generated from conserving Gabon's nature reserves is $37.2 million dollars a year ($35.8 million in 2005 prices). This value is calculated from the revenues generated by the government from taxing wood firms at $248,000 per hectare ($239,142 in 2005 prices) and from selling permits to study and clear certain areas of forest. Forestry is considered a benefit since the main wood export (okoume timber) is a very fast growing and renewable type of timber. Thus, protecting the soil and wood reserves of the country is considered a benefit.

Ecotourism

The Loango conservation station has created an activity plan with all its prices for tourists. The activities include gorilla trekking, visiting regional villages, whale watching and there is a limit of 30 people per station for 10-day trips to the station[13]. Assuming all of Gabon's reserves create a station exactly like the one in Loango I calculated two different sets of results (not all stations have been built but they are all being planned)[14]. The highest revenues would be generated if there was full occupation in all stations throughout 10 years and the lowest revenues *considered* would be generated if there was half occupation in every station throughout the whole 10 years.

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[13] Please see Appendix 1 in order to see a detailed price list for staying and tourist activities inside the station.
[14] www.gabonsnationalparks.com

Increase in Aid due to the creation of the nature reserves

When President Bongo signed the legislation creating Gabon's 12 new nature reserves Conservation International promised $72.5 million ($69 million in 2005 prices) as commitment to protect forests in Gabon during the course of 4 years[15]. At the same time the United States promised $53 million ($51 million in 2005 prices) to support the creation of the reserves[16] through 4 years. In 2002 the World Bank Board of Directors also approved an International Bank for Reconstruction and Development (IBRD) loan of US$15 million ($14.46 million in 2005 prices) to support the Government of Gabon's efforts towards improved management of natural resources over the course of 4 years[17].

Potential User Benefits

Carbon sequestration

The net benefits from carbon sequestered in forests can be expressed in terms of the damage carbon would do if released in the atmosphere as carbon dioxide (Norton Griffiths 1995). Brown et al (1992) give values of $320-1600 per hectare per year ($205 and $1028 hectare/year in 2005 prices) as the global costs of converting tropical forests to agricultural use (they are considered global costs because carbon is a perfect mixiing pollutant). Thus, these costs reflect the monetized benefits of denominating a certain area of tropical rainforest a nature reserve. I have presented two different results for the present value benefits of carbon sequestration, the present value benefits with the greatest

[15] http://www.globalenvision.org/library/1/673/
[16] http://www.globalenvision.org/library/1/673/
[17] www.gabonsnationalparks.com

amount of carbon sequestration and the present value benefits with the least amount of carbon sequestration.

Pharmaceuticals

The Net benefits from biodiversity in terms of value of pharmaceutical discoveries reflect differences between present biodiversity values and future values (Lugo et al 1993). That is, the value that a hectare of rainforest has due to the probability of having a potential medicine that could be marketed in future years but has not yet been discovered. Although there is very little data that researchers use to monetize the benefits of pharmaceuticals, Pearce et al (1993) suggest ranges in values between $0.01 and $21 per hectare of rainforest ($0.009 and $18.9 per hectare in 2005 prices). Again, I use these two ranges to monetize the greatest and lowest pharmaceuticals present value benefits generated from dedicating 2666550 hectares to Gabon's nature reserves.

Results

Using all the different values for benefits and costs that were made explicit in the theory section I determined the feasibility of Gabon's creation of twelve nature reserves by comparing the present value net benefit-cost ratio to 1 and comparing the differential of the PVNB and PVNC to zero. Values of the ratio greater than 1 determine feasibility and values of the ratio less than 1 suggest rejection of this environmental initiative. Values of the differential greater than 0 determine feasibility and values of the differential less than zero suggest rejection of the creation of the nature reserves. The range of results for the present value net benefits ($PVNB_{Conservation}$) of conservation were calculated according to the highest possible value and lowest possible value that could be given to them:

Lowest Present Value Net Benefits ($LPVNB_{Conservation}$)

$LPVNB_{Conservation} = PVB_{lowest\ potential\ user\ values} + PVB_{lowest\ user\ values}$

Highest Present Value Net Benefits ($HVNB_{Conservation}$)

$HPVNB_{Conservation} = PVB_{highest\ potential\ user\ values} + PVNB_{highest\ user\ values}$

Table 1. Benefits of Conservation in Nominal Value

Benefits	**Lowest ($)**	**Highest ($)**
Forestry	35,800,000	35,800,000
Ecotourism	53,125,020	106,250,040
Foreign Aid	33,800,000	33,800,000
Carbon Sequestration	546,642,750	2,741,213,400
Pharmaceuticals	23,998	50,397,795
Total	669,391,769	2,967,461,235
Average	1,818,426,502	

Table 2. Present Value Net Benefits of Conservation using different Discount Rates

	Present Value Net Benefits $		
Discount Rate	**Lowest**	**Highest**	**Average**
0.5	243,414,746	1,079,074,851	661,244,798
0.7	205,966,591	913,064,520	559,515,555
0.9	178,322,861	791,322,861	484,913,651

Similarly, the range of results for the present value net costs ($PVNC_{Conservation}$) of conservation were calculated according to the highest possible value and lowest possible value that could be given to them:

Lowest Present Value Net Costs ($LPVNC_{Conservation}$)

$LPVNC_{Conservation} = PVCC_{Capital\ Costs} + PVOC_{lowest\ opportunity\ costs}$

Highest Present Value Net Costs ($HPVNC_{Conservation}$)

$HPVNC_{Conservation} = PVCC_{Capital\ Costs} + PVOC_{highest\ opportunity\ costs}$

Table 3. Costs of Conservation in Nominal Value

Costs	Lowest ($)	Highest ($)
Capital Costs	2,008,809	2,242,149
Revenues from Agriculture	386,649,750	1,058,620,350
Revenues from game hunting	143,000	143,000
Revenues from Bushmeat	48,000,000	48,000,000
Revenues from Oil	0	0
Revenues from Gold/Diamonds	0	0
Revenues from ferrous metals	1,617,777.7	1,617,777.7
Total	438,419,336.7	1,110,623,276

Table 4. Present Value Net Costs of Conservation with different Discount Rates

	Present Value Net Benefits ($)		
Discount Rate	**Lowest**	**Highest**	**Average**
0.5	159,424,923	403,862,275	281,643,599
0.7	134,898,187	341,730,061	238,314,124
0.9	116,911,803	238,314,124	206,538,980

The range of results for the present value net benefit-cost ratio analysis contains 5 possible scenarios. Taking into account all the possible values considered for the PVNB and PVNC of conserving Gabon's nature reserves we compared 5 different ratios with the same values to 1. By calculating these 5 different ratios I was allowed to make a sound decision on the feasibility of conserving Gabon's nature reserves since I was taking into account all the possible situations that could occur (regarding benefits and costs) from conserving the reserves. Thus, the ratios calculated were:

$LPVNB_{Conservation}/LPVNC_{Conservation}$

$HPVNB_{Conservation}/HPVNC_{Conservation}$

$LPVNB_{Conservation}/HPVNC_{Conservation}$

$HPVNB_{Conservation}/LPVNC_{Conservation}$

$AVGPVNB_{Conservation}/AVGPVNC_{Conservation}$

Table 3. Benefit-Cost Ratio Analysis

Benefit Cost Ratio	Ratio	Feasibility
Low / Low	1.5	Yes
Low / High	0.6	No
High / Low	6.7	Yes
High / High	2.7	Yes
Avg / Avg	2.3	Yes

The range of results for the differential contains 3 different scenarios, each with five different sets of results. Contrary to the range of results found when using the ratio, the differential communicates the net gains to society from carrying through with this environmental initiative. The differential explicitly showed me how using a different discount rate for every present value determination changes the net gains to society from carrying through the creation of the nature reserves. Thus, the differentials used were (using the values for the PVNB and PVNC with the three different discount rates respectively):

$LPVNB_{conservation} - LPVNC_{Conservation}$ $LPVNB_{conservation} - HPVNC_{Conservation}$

$HPVNB_{conservation} - LPVNC_{Conservation}$ $HPVNB_{conservation} - HPVNC_{Conservation}$

$AVGPVNB_{conservation} - AVGPVNC_{Conservation}$

Table 4. Differential between PVNB and PVNC using three different Social Discount Rates

Social Discount Rate	Low-Low $	Low-High $	High-Low $	High-High $	Avg-Avg $
0.5	83,989,823	-160,447,529	919,649,928	675,212,576	379,601,199
0.7	71,068,404	-135,763,470	778,166,333	571,334,459	321,201,431
0.9	61,592,638	-117,661,715	674,411,058	495,156,705	278,374,671
Feasibility	**Yes**	**No**	**Yes**	**Yes**	**Yes**

Results Interpretation

The benefit-cost ratio is greater than 1 in all cases except in the case where I weighed the lowest benefits against the highest costs. Although the paper have a varied range of results it is difficult to determine the likelihood of one of these scenarios occurring over another. That is, I do not know the probability of one of these scenarios occurring over another. However, the results show that it is probably more likely that the benefits of conservation will be greater than the costs.

The differential shows three different possible case scenarios. With the lowest social discount rate I found that the net gains to society are much greater than with the other two social discount rates. The reason for this is solely based on the importance that the social discount rate gives to a sensitivity analysis. Very low rates favor large projects with distant benefits, which is the case of the nature reserves in Gabon. Using very low discount rates may lead a country to undertake massive projects while ignoring current needs. Very high rates favor staged investments with quick payback; using very high discount rates may prevent a country from ever undertaking large infrastructure investments.

The differential, as well as the ratio shows that the government should not carry through the project if it's expected that the PVNC are greater than the PVNB of conservation. However, both sensitivity analysis show that there is a higher probability that in 10 years time the benefits of creating the nature reserves will be greater than the costs.

Since only one conservation/tourism station has been constructed in Gabon (Loango conservation Station) it is very difficult to determine what will be the actual capital costs for every station. It might be that the actual capital costs of creating a conservation station for every nature reserve are much greater than what is proposed here. The costs of building the stations were avoided, and by doing so, the wages, prices of construction materials, rental of buses or helicopters to carry construction materials and price of land were avoided. I have not taken into account the compliance costs of paper work, bureaucracy and corruption in a country such as Gabon.

The benefits are also likely to be higher than what is proposed here. As mentioned before, I avoided the use of contingent valuation methods for species and existence values because I wanted to focus the benefit-cost ratio on more tangible and monetizable figures. Nevertheless, if I were to take them into account, I would find that the net benefits would increase and in turn, the benefit-cost ratio would also increase. The only other countries in Africa which offer all the range of activities that Gabon offers (mainly gorilla trekking and whale watching) are the countries in the Congo Basin plus Uganda and Rwanda. However, most of these countries are in constant political turmoil that scares potential "eco-tourists" away. Contrary to its neighbors in the Congo Basin, Uganda and Rwanda, Gabon has experienced peace and economic growth due to its large offshore oil deposits. Thus, as tourism flees these regions, it is very likely that most of this tourism will be looking for similar experiences in Gabon (once all the stations are finally organized and constructed).

In 1998, the oil and forest sectors contributed 36 percent and 2.5 percent of the country's gross national product, respectively[18]. With the recent glut of oil on the world market and the depletion of Gabon's oil reserves, new hopes are being placed on the forest sector to contribute to the sustainable development of the national economy; there is also a growing awareness in Gabon of the need to manage these forests responsibly to support

[18] www.cia.gov/cia/publications/factbook/index.html

the growing industry of eco-tourism[19]. Thus, as time goes by and the mineral resources of the country become depleted, the opportunity cost of conservation will lessen and the benefits of conservation will most likely increase. This will in turn increase the benefit-cost ratio and the feasibility of the creating the reserves.

Conclusion

Although the results show that the benefits of conserving the newly created nature reserves dominate the costs, Gabon's success of keeping and protecting them is far from given. As long as the bushmeat trade in Gabon stays at current levels and the government does not ban and propose solutions for the bushmeat market, Gabon will not be considered a solid ecotourism destination. This is a very dangerous situation for wildlife and ecotourism in the region.

As the Gabonese government increases the number of logging concessions inside the country, it has to make sure that all taxes are collected and that the firms are abiding by sustainable logging practices. The success of the benefits of conservation increasing over time will depend on the government's influence on finding feasible solutions for the bushmeat trade (which is more of a cultural problem than a livestock problem) and on making sure that the firms to which it has given logging concessions abide by sustainable forestry practices. If the government of Gabon finds ways to deal with these problems and manages to construct all conservation/tourism stations while minimizing costs it could be the best eco-tourism attraction of the Congo-Basin for years to come.

[19] www.globalenvision.org

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Appendix 1

Costs

Costs for the creation of a station in Nominal Terms

http://www.operation-loango.com/operation_loango/gabon_national_parks.html

Equipment	($)
Gorilla Health Research Center	15,000
Research Equipment fund	20,000
ENEF Studentship	200,000
Medical Plant Center	15,000
Surveillance Program	30,000
Artisanal Program	8,000
Salary Endowment	1,000,000
Total	1,288,000

It is assumed that all 12 stations in Gabon will have equal or similar to creating a station as the ones in Loango.

Number of guards used= $\sqrt{A}$ Wilkie et al (2001) Number of trucks used= $\sqrt{A}$ /10

Reserve	km2	Num. Guards	Num. Trucks
Akanda	550	23	2.34
BIROUGOU	690	26	2.62

IVINDO	3000	55	5.47
LOANGO	1550	39	3.93
LOPE	4970	70	7.04
MAYUMBA	80	9	0.89
MINKEZBE	7570	87	8.70
CHRYSTAL MOUNTAINS	1200	35	3.46
MOUKALABA DOUDOU	4500	67	6.70
MWAGNE	1160	34	3.40
BATAKE PLATEAUX	870	29	2.94
WAKA	1070	33	3.27
Total guards		508	
Total trucks			50.82

Fixed Costs
The fixed costs table represents the choice that every station has to take the cheapest or the more luxurious and expensive way of creating the station. This allowed me to have a diverse set of results when doing the sensitivity analysis.

http://www.toyota.com/vehicles/modelselector/index.html?s_van=GM_TN_TRUCKS
http://www.hotflashrefinishing.com/rifles.htm

	Fixed Costs	
	Cheapest ($)	Expensive ($)
Rifle	145	245
4 x 4 Truck	13780	16155
Total Cost Rifles	73660	124460
Total Cost Trucks	702780	823905
Total	716440	948365

Capital Costs

Again, the capital costs are calculated by using the calculations (high and low) for fixed costs (as the equation below exemplifies) and thus allowed me to have a diverse set of results when comparing benefits and costs.

$\mathbf{C_c = US\$FIXED\ COSTS\ [\ 1+ (1/\mathit{A}) + (1/\sqrt{A})]}$ Wilkie et al (2001)

lowest	highest	avg.
2,008,809.587	2,242,149.104	2,125,479.346

Possible revenue generated from agriculture Norton-Griffiths (1995)

In the paper Norton Griffiths calculates that there are $397/hectare generated from cash crops and $145/hectare for avg crops. Thus I used the values below to measure the opportunity forgone from using the reserves land for agriculture instead of conservation.

Reserves	Hectares	km2	Rev. Cash Crops	Rev. Avg.Crops
Akanda	550	550	218350	79750
BIROUGOU	69000	690	27393000	10005000
IVINDO	300000	3000	119100000	43500000
LOANGO	155000	1550	61535000	22475000
LOPE	497000	4970	197309000	72065000
MAYUMBA	8000	80	3176000	1160000
MINKEZBE	757000	7570	300529000	109765000
CHRYSTAL MOUNTAINS	120000	1200	47640000	17400000
MOUKALABA DOUDOU	450000	4500	178650000	65250000
MWAGNE	116000	1160	46052000	16820000
BATAKE PLATEAUX	87000	870	34539000	12615000
WAKA	107000	1070	42479000	15515000
Total	2666550	27210	1058620350	386649750
1 ha (0.01 sq km)		Total $=	1058620350	386649750
$397 per hectare(cash crops)				
$397 per 0.01 sq km.		Avg	722635050	
$145 per hectare (avg.crops)				

Possible revenue generated from metals

Stations	Metal
MINKEZBE	Iron Ore/Columbium
CHRYSTAL MOUNTAINS	Iron Ore/Columbium
MOUKALABA DOUDOU	Iron Ore/Columbium
BATAKE PLATEAUX	Iron Ore/Columbium
Metal	Tot Reserves (pounds)
Columbium	9215.4725
Iron Ore	30864.7175
Metal	Revenue from 35% tax ($)
Columbium	105406.5745
Iron Ore	1512371.158
Total	1617777.732

Price of Columbium $8.17/pound
Price of Iron Ore $35/pound
http://www.metalprices.com/FreeSite/metals/cb/cb.asp
http://www.metalprices.com/FreeSite/metals/steel/steee asp
http://minerals.usgs.gov/minerals/pubs/country/2002/gbmyb02r.pdf
http://minerals.usgs.gov/minerals/pubs/country/2002/gbmyb02r.pdf

Benefits

Revenues from eco—tourism

http://www.operation-loango.com/operation_loango/prices.html

Staying ($)	295
10 day tour ($)	2852
Activities	
Whale Watching ($)	60
River trek ($)	60
Dance Sessions local village ($)	20
Gorilla trekking ($)	4,499
Flights ($)	300
Total ($)	8086
Full Occupation	($)
12 stations	
360 people	106,250,040
Half occupation	
180 people	53,125,020

Aid http://www.globalenvision.org/library/1/673/

Aid	4 years ($ millions)	per year ($) milliions
Conservation International	69.9102	187.47755
U.S Government	51	12.75
World Bank	14.46	3.615
Total	135.3702	33.84255

Carbon Sequestration Mt (Million Metric Tons) Brown (1992)

Tot Hectares	lowest ($ per hectare)	highest ($ hectare)
2666550	205	1028
total $	546,642,750	2,741,213,400
avg.	16,432,828,075	

Pharmaceuticals Pearce (1993)

Tot. Hectares	lowest ($/hectare)	highest($/hectare)
2666550	0.009	18.9
Total ($)	23,999	50,397,795
avg	25,210,896.98	

PRESENT VALUE DETERMINATION

For the present value determination of costs I first have to calculate all the nominal value from all the opportunity costs and the capital costs of conservation.

Costs in Nominal Value		
Costs	Lowest	Highest
Capital Costs	2008809	2242149
Revenues from Agriculture	386649750	1058620350
Revenues from game hunting	143000	143000
Revenues from Bushmeat	48000000	48000000
Revenues from Oil	0	0
Revenues from Gold/Diamonds	0	0
Revenues from ferrous metals	1617777.732	1617777.32
Total	438419336.7	1110623276
Average	774521306.5	

These values then have to be transformed to real values (to 2005 prices) this is done by using the equation (where bt= real values and Bt= nominal values) =

$bt = Bt / (1 + p)^t$ where p is the inflation rate (1.5 in 2005) and t is time in years.

Year	**Costs in Real Value ($)**		
	Lowest	**Highest**	**Average**
1	175367734.8	444249310.4	309808522.4
2	70147093.92	177699724.2	123923409
3	28058837.57	71079889.66	49569363.58
4	11223535.03	28431955.87	19827745.43
5	4489414.011	11372782.35	7931098.173
6	1795765.604	4549112.938	3172439.269
7	718306.2417	1819645.175	1268975.708
8	287322.4967	727858.0702	507590.2831
9	114928.9987	291143.2281	203036.1132
10	45971.59947	116457.2912	81214.4453

These values have then to be transformed to present values in 2005 prices. This is done by using the equation :

$PV = bt / (1 + r)^t$ where r is the discount rate (0.5, 0.7 and 0.9 repsectively) and t is time in years.

Lowest Costs	**Present Value of Costs**		
year	0.5	0.7	0.9
1	116911823.2	103157491.1	92298807.79
2	31176486.19	24272350.84	19431327.96

3	8313729.65	5711141.373	4090805.885
4	2216994.573	1343797.97	861222.2917
5	591198.5529	316187.7577	181309.9561
6	157652.9474	74397.11946	38170.51708
7	42040.78598	17505.20458	8035.898333
8	11210.87626	4118.871666	1691.76807
9	2989.567003	969.1462743	356.161699
10	797.2178675	228.0344175	74.98141031
PVNC	159424923.6	134898187.4	116911803.2

Highest Costs			
year	0.5	0.7	0.9
1	296166206.9	261323123.8	233815426.5
2	78977655.18	61487793.83	49224300.32
3	21060708.05	14467716.19	10363010.59
4	5616188.813	3404168.516	2181686.441
5	1497650.35	800980.8274	459302.4086
6	399373.4267	188466.077	96695.24392
7	106499.5805	44344.9593	20356.89346
8	28399.88812	10434.10807	4285.66178
9	7573.303499	2455.084252	902.2445853
10	2019.5476	577.6668828	189.9462285
PVNC	403862275.1	341730061	296166156.3

Average Costs			
year	0.5	0.7	0.9
1	206539014.9	182240307.3	163057117.1
2	55077070.65	42880072.3	34327814.12
3	14687218.84	10089428.78	7226908.235
4	3916591.691	2373983.242	1521454.365
5	1044424.451	558584.2922	320306.1822
6	278513.1869	131431.5982	67432.88046
7	74270.18317	30925.08192	14196.39589
8	19805.38218	7276.489864	2988.714923
9	5281.435248	1712.115262	629.2031417
10	1408.382733	402.8506499	132.4638193
PVNC	281643599.1	238314124	206538979.6

Benefits

Similarly the same present value determination is done for calculating present value benefits. For the present value determination of costs we first have to calculate all the nominal value from all the opportunity costs and the capital costs of conservation.

Benefits in Nominal Value			

Benefits	Lowest	Highest	Average
Forestry	35800000	35800000	1818426502
Ecotourism	53125020	106250040	
Foreign Aid	33800000	33800000	
Carbon Sequestration	546642750	2741213400	
Pharmaceuticals	23998.95	50397795	
Total	669391769	2967461235	

These values then have to be transformed to real values (to 2005 prices) this is done by using the equation (where bt= real values and Bt= nominal values) =

$bt = Bt / (1 + p)^t$ where p is the inflation rate (1.5 in 2005) and t is time in years

Benefits in Real Value			
year	Lowest	Highest	Average
1	267756707.6	1186984494	727370600.8
2	107102683	474793797.6	290948240.3
3	42841073.22	189917519	116379296.1
4	17136429.29	75967007.62	46551718.45
5	6854571.715	30386803.05	18620687.38
6	2741828.686	12154721.22	7448274.952
7	1096731.474	4861888.487	2979309.981
8	438692.5897	1944755.395	1191723.992
9	175477.0359	777902.158	476689.5969
10	70190.81436	311160.8632	190675.8388

These values have then to be transformed to present values in 2005 prices. This is done by using the equation :

$PV = bt / (1 + r)^t$ where r is the discount rate (0.5, 0.7 and 0.9 repsectively) and t is time in years.

Lowest benefits			
Year	Lowest r	Optimal R	Highest r
1	178504471.7	157503945.6	140924582.9
2	47601192.46	37059751.92	29668333.25
3	12693651.32	8719941.628	6245964.895
4	3384973.686	2051750.971	1314939.978
5	902659.6497	482764.9344	276829.469
6	240709.2399	113591.7493	58279.88822
7	64189.13064	26727.47042	12269.45015
8	17117.1015	6288.816569	2583.042137
9	4564.560401	1479.721546	543.7983447
10	1217.216107	348.1697754	114.483862
PVNB	243414746.1	205966591	178504441.2

Highest Benefits	Lowest r	Optimal r	Highest r
1	791322996	698226172.9	624728681.1
2	211019465.6	164288511.3	131521827.6

3	56271857.49	38656120.3	27688805.81
4	15005828.66	9095557.718	5829222.275
5	4001554.311	2140131.228	1227204.69
6	1067081.15	503560.2889	258358.882
7	284554.9732	118484.7739	54391.34358
8	75881.32619	27878.77032	11450.80918
9	20235.02032	6559.710663	2410.696668
10	5396.005418	1543.461333	507.5150881
PVNB	1079074851	913064520.5	791322860.7

Average Benefits

year	Lowest r	Optimal r	Highest r
1	484913733.9	427865059.3	382826632
2	129310329	100674131.6	80595080.42
3	34482754.41	23688030.96	16967385.35
4	9195401.176	5573654.345	3572081.127
5	2452106.98	1311448.081	752017.0793
6	653895.1947	308576.0191	158319.3851
7	174372.0519	72606.12214	33330.39687
8	46499.21385	17083.79344	7016.925656
9	12399.79036	4019.716104	1477.247507
10	3306.610762	945.815554	310.9994751
PVNB	661244798.3	559515555.7	484913650.9

Appendix 2

Nature Reserves

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Minerals and Metals

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TIFF (Uncompressed) decompressor
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Land Use

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[20] http://mapmachine.nationalgeographic.com