Carbon valuation applied to the Brazilian Cerrado [1]

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Terrestrial carbon sequestration is the process of capture and long-term storage of atmospheric carbon dioxide (CO_2) by forests, grasslands, wetlands and other terrestrial ecosystems; it is an important ecosystem service that has been a primary focus of climate change mitigation efforts.[2] Here, we develop a framework to monetize the relative difference in carbon sequestration under different land use scenarios in the Brazilian Cerrado; we do not aim to measure absolute values or to calculate the number of carbon reduction credits that can be traded on the market.

This document summarizes the economic valuation approach for our study area in southeastern Brazil. The parameter values used in the biophysical carbon model are provided in a separate document at the The Nature Conservancy (TNC) website provided above.

Overview of carbon valuation methods

In order to place a monetary value on carbon sequestration by habitats, most studies use either carbon market prices or an estimate of the marginal value for the social damages from emissions (Ferraro et al, 2012). The advantages of using the former method are that it is relatively simple in terms of data requirements and implementation and is based on observed market behavior. For example, Naidoo & Ricketts (2006) use the market value of carbon to value changes in the aboveground biomass in Paraguay.[3]

However, a common criticism of this approach is that the existing carbon market prices do not necessarily reflect the social value of avoiding carbon emissions, but rather what project proponents earn based on policy decisions regarding political commitments on emissions reductions and allowances for pollution (Convery & Redmont, 2007). For this reason, carbon market prices tend to be lower than the estimated social marginal costs of carbon. Moreover, although CO_2 is a uniformly mixing pollutant, voluntary carbon reductions behave as an impure public good in that their price may reflect preferences for a broader set of characteristics in

[1] In our analyses we focus exclusively on carbon sequestration and do not consider other greenhouse gas emissions (e.g. NO_x), which may be affected by land conversion and transitions away from livestock grazing.
[2] We use the terms "carbon storage" and "carbon sequestration" interchangeably to refer to the carbon accumulated by biomass or by soil.
[3] The prices in their study range between USD $1.8 and USD $25.50; the main analysis used a price of $2.5 USD per ton of CO_2, which is USD $9.17 for ton of carbon. The market prices were obtained from the Ecosystem Marketplace (http:// ecosystemmarketplace.com).

addition to the marginal costs (Conte & Kotchen, 2010).[4] The market valuation approach also ignores transaction costs, such as costs associated with certification, monitoring and trading, which may be significant (Michaelowa, Stronzik, Eckermann, & Hunt, 2003).

To circumvent some of the issues arising from imperfect carbon markets, previous studies have suggested using an estimate of the social marginal damage cost based on a climate change damage function for CO_2 emissions. Reviewing the literature on the social marginal damage cost of carbon, Tol (2005) finds that the average value is about USD $50/tC as the upper bound, with an average of USD $43/tC. Valuing changes in the above and belowground biomass, soil and harvested wood products, Nelson et al (2009) used the average value reported in Tol (2005) of USD $43/tC. A more recent version of Tol (2005) adjusts the mean value to $105/tC (Tol, 2009). The most recent estimates from the White House suggest a value of USD $135.68/tC or USD $37/t$CO_2$ in 2007 USD.[5] Focusing on national estimates for the above and belowground biomass as well as the soil organic carbon, Bateman et al (2013) use the official UK non-market marginal abatement carbon cost to obtain values for the non-traded carbon prices; these are the constant costs of abatement according to the UK Government's domestic carbon reduction target.[6] The main drawback of using estimates of the social marginal damage cost for carbon valuation is that they are sensitive to the modeling assumptions (e.g. Pearce, 2003, Tol, 2005).[7]

Following previous studies (e.g. Naidoo et al, 2009), we use both the market-based and social marginal damage approaches to provide lower and upper bounds for the monetary value of the additional carbon sequestration across our planning scenarios.

Current state of the carbon markets in Brazil

Brazil's National Climate Change Policy (NCCP) law, adopted in 2009, commits to 668 MtCO_2e/year mitigation in 2020 from deforestation reduction in the Amazon and in the Cerrado areas; 83-104 MtCO_2e/year mitigation from the recovery of degraded pastures, 22 MtCO_2e/year from reduced livestock emissions, 20 MtCO_2e/year from zero tillage and 16-22 MtCO_2e/year mitigation in 2020 from biological fixing (EDF 2013). One way to achieve the targeted 40% reduction in the Cerrado deforestation relative to the baseline (set at 1999-2008) and to promote the forest planting is through the implementation of the UN Clean Development Mechanism (CDM) under the Kyoto Protocol (EDF 2013). Brazil has not yet created its own countrywide cap-and-trade system (EDF 2013).[8,9]

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[4] Because carbon reduction programs, especially in developing countries, may be supplemented by poverty alleviation and conservation initiatives, the demand for carbon reduction in this case may also reflect preferences for these additional characteristics (Conte & Kotchen, 2010).

[5] Available here: http://www.whitehouse.gov/blog/2013/11/01/refining-estimates-social-cost-carbon.

[6] The authors used the Department of Energy and Climate Change prices which differentiate between the traded and non-traded carbon prices. In doing this, DECC assumes that the traded and non-trade carbon are two different commodities.

[7] A lot of uncertainty exists about what the climate change damage function should look like (e.g.,Tol, 2005).

[8] However, 19 states have adopted climate change laws, many of which include the creation of markets for carbon credits (EDF 2013). Sao Paulo, for example, has proposed to launch its own emissions trading system, which has not yet been implemented, however.

[9] The Brazil Emissions Trading Scheme is currently under consideration (World Bank, 2013).

The majority of the Brazilian carbon trading has taken place through the CDM (EDF 2013).[10] Certifiable Emission Reductions (CERs) are traded on commodities and futures exchanges authorized by the Brazilian Securities and Exchange Commission (Bolsa Verde de Rio de Janeiro (for the state of Rio de Janeiro) and BMF/Bovespa environmental asset exchanges); they operate as stock exchanges for voluntary emission reduction permits and hold auctions for CERs and voluntary carbon units, with the BMF/Bovespa connected to the Stock Exchange of Rio de Janeiro (EDF 2013). The exchange relies on private entities and has primarily dealt with CDM (EDF 2013). For the forestry sector the CDM mechanism allows for only reforestation and afforestation projects to generate carbon credits (Smith & Scherr, 2003); avoided deforestation or projects aiming to improve forest health are not considered.[11] The natural regeneration of secondary forests is also currently not included in the CDM (Olscheweski & Benitez, 2005). CDM targets both permanent and temporary carbon reductions.

Most of the forest carbon and REDD-related emission reductions are traded on the voluntary carbon market (World Bank, 2013).[12,13] While the carbon prices there are lower than those for CERs, they are less volatile.[14] For example, the market-wide average for forest carbon in 2011 was US$9.2/t$CO_2$; in 2013 it has varied between US$7-8/t$CO_2$ (World Bank, 2013).[15,16] Outside the forest carbon market, existing REDD+ payment schemes can also be used to place value on carbon storage. For example, Norway's International Climate and Forest Initiative has provided payments of US $5/t$CO_2$ for the Brazilian Amazon Fund (World Bank, 2013).

Carbon valuation application [17]

Additionality, which relates to the choice of baselines, is an important consideration in quantifying carbon emission reductions (e.g., Murray et al, 2006; VCS 2013; Conte & Kotchen, 2010). It highlights the importance of choosing a relevant baseline against which the reductions in emissions are compared (e.g., Busch et al., 2011). The choice of baseline depends on the research question: For example, in many of our comparisons we use sugarcane production without compliance with Brazil's Forest Code (No Forest Code scenario) as a baseline. While this is not a realistic option for the large agricultural producer modeled in our scenarios, it allows us to calculate the *additional* carbon sequestered due to compliance with the Forest Code, i.e. the carbon sequestration that would not take place in the absence of the Forest Code.

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[10] As of early 2013, Brazil holds 269 CDM projects, which is 4.1% of the world total (EDF 2013). However, currently there are two reforestation projects enrolled in the CDM; both are proposed by private companies (Planter S/A and AES Tiete) and have a crediting period of 30 years (Ribeiro, Jacovine, & Vilar, 2013).

[11] The latter can be included in a REDD+ scheme, however, and can generate carbon credits to be traded in a voluntary market (Putz & Nasi, 2009).

[12] As of 2009, there was only one forestry project certified under CDM and several under VCS (Sills et al, 2009); there are 70 projects associated with Agriculture, Forestry, Land Use in 2013 under VCS (Source: VCS (2013): https://vcsprojectdatabase2.apx.com/myModule/Interactive.asp. Accessed October 8, 2013).

[13] The most feasible voluntary certification scheme is the Voluntary Carbon Standard (VCS). The other certification schemes are the Brazilian Social Carbon standard and the Gold Standard (World Bank, 2013). The latter pertains to clean household device distribution projects, however.

[14] The 2013 price has fallen by 11% since 2012 (Ecosystem Market Place, 2013). This is in contrast to the CER market where the price plummeted from January 2012 to December 2012 (World Bank, 2013).

[15] Note that this value does not necessarily reflect international market averages as it includes domestic-only pricing incentives and requirements (World Bank, 2013).

[16] The exact price depends on the volume, level of advance payments, and the environmental and social co-benefits.

[17] Typically, the carbon prices are reported in USD. In order to convert to Brazilian $R, we use the exchange rate of 1 $R=0.44 USD (as of 11/1/13).

Under the assumption that all of the sequestered carbon can be traded on a voluntary market, we use the historic price for voluntary carbon reductions of \$5.9/tCO_2, which translates into USD 21.64/tC (Peters-Stanley & Yin, 2013).[18] We use the voluntary markets for the valuation because: (1) the voluntary carbon prices tend to be more stable (Ecosystem Marketplace, 2013), (2) most of the forest carbon is currently traded on these markets (World Bank, 2013) and (3) the voluntary markets are preferred by The Nature Conservancy (a leading conservation organization) in this region. For our analyses, we do not use prices from the CDM market because it is limited to only afforestation/reforestation projects, may have high transaction costs barring eligible projects from being enrolled, and is plagued by meager demand, unstable prices and unclear requirements for monitoring (World Bank, 2013). As an upper bound for the value of carbon, we use the average social price of USD 152.44/tC from the most recent White House estimates.[19] We do not consider any transaction costs that may be incurred during certification, monitoring and trading. We also ignore any distributional considerations (i.e., to whom the benefits are going to accrue) given that carbon sequestration is considered a globally-distributed ecosystem service (de Groot et al, 2010).

We discount the value of carbon using the average interest rate for Brazil for the market values and the social discount rate for the marginal social damage estimates. For the former, we use a weighted average of the five-year interest rates from the Brazilian Central Bank (Source: http://www.bcb.gov.br/Pec/Copom/Ingl/taxaSelic-i.asp#notas).[20] For the social discount rate we use 2% for medium-run future projects (Weizman, 2001).[21]

For every new hectare of natural habitat in our study area, the net present value of the sequestered carbon is calculated as: $NPV = price * \frac{total\ sequestration}{t_1 - t_0} \sum_{t_0}^{t_1} \frac{1}{(1+r)^t}$, where t designates the duration (in years) for which the credits are generated and r is the discount rate.[22] Note that unlike some previous studies (e.g. InVEST 2.5.5; Interagency Working Group on the Social Cost of Carbon, US Government 2010, 2013), we use a constant price rather than attempting to model carbon price dynamics. The reason is that the price in carbon markets has been volatile; the social cost of carbon is also very uncertain and depends on the assumptions made in models.

We can use the formula and parameters above to calculate the value of additional carbon sequestered under the different land use planning scenarios. For example, assuming a conversion of one hectare of pasture to forest and the lower bounds of the for the two categories (see Table 1

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[18] Note that the conversion factor for CO_2 t/ha to tC/ha of carbon is 0.2727 (InVEST v 2.5.5).
[19] http://www.whitehouse.gov/blog/2013/11/01/refining-estimates-social-cost-carbon. Note that the original study reports the social cost of carbon in 2007 USD. To convert it to 2013 values, we used the US Consumer Price Index from the Bureau of Labour and Statistics (http://data.bls.gov/cgi-bin/cpicalc.pl?cost1=135.68&year1=2007&year2=2013.
[20] We used rates for 2008-2013, giving more weight to the values in 2013. The final value used in our models is 10.32%
[21] This is the value for the medium-term future (26-75 years from now). In truly perpetual time frames (i.e. more than 300 years), the social discount rate should be 0% (Weitzman, 2001).
[22] As a simplification, we use t_0=0 (current year).

in the Carbon Parameter Summary), we calculate carbon emission reductions of 54.44 tC/ha (i.e. the difference between the carbon in the soil, above and belowground biomass for cerradao and pastures). Using a time period of thirty years (t_1-t_0=30 in the NPV formula above), we find that carbon stored by the additional hectare of cerradao is worth between USD 397.74 and 6,435.47 for the market and social values, respectively.

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