BRAZILIAN SUGARCANE ETHANOL PRODUCTION: INTEGRATION OF ECONOMIC, ECOLOGICAL, AND SOCIAL ASPECTS, AND THE FUTURE OF THE MARKET

by

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ABSTRACT

Should the U.S. and others open their economies to importation of Brazilian ethanol? How would this impact the Brazilian economy, ecosystems, and people? Policy makers in the U.S., Europe, and other places have considered reducing barriers to trade as they are working to reduce their dependence on fossil fuels. Brazilian sugarcane ethanol is more efficient in terms of energy, land use, and production costs than other renewable fuels, making it a logical choice for these countries. This dissertation addresses these questions with three studies. The first (Chapter 2) is a cost-benefit analysis of the Brazilian Forest Code, legislation that has been largely unenforced, mandating that agricultural producers set aside 25-30% of their land as forests and fallow areas to protect ecological health. The second (Chapter 3) asks stakeholders their priorities in the impending increases in sugarcane and ethanol production drawing on interviews and surveys in São Paulo, the state accounting for 60% of Brazil's sugarcane and ethanol production, with special attention paid to land use and protection of natural resources, and the impacts of increased production on labor markets. The third study (Chapter 4) examines possible future scenarios for the market, which will depend mainly on petroleum prices, the technology for renewable biomass to replace products currently coming from petroleum refineries and the ability of firms to adopt and adapt to these changes, and whether or not other countries will open their economies to importation of ethanol and any future products the Brazilian cane-energy sector may produce. The findings are that this increased production could be extremely positive for Brazilian development if private industry, government, and citizens can remain diligent in enforcing existing legislation for environmental protection and food security, and education can improve, from primary school through professional and technical training, to provide healthy and lucrative jobs as well as the workers who can drive Brazil's innovation to become one of the most advanced economies in the world.

PREFACE

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APP	Area of Permanent Preservation
ATR	Total Recovered Sugar
BFC	Brazilian Forest Code
BRIC	Brazil, Russia, India, and China
BSI	Better Sugarcane Initiative
CDM	Clean Development Mechanism
CRP	Conservation Reserve Program (US)
CTBE	Bioethanol Science and Technology Center
CTC	Center for Cane Technology
EISA	Energy Independence and Security Act (US)
EPA	Environmental Protection Agency (US)
ESALQ	The Luiz Queroz School of Agriculture (USP)
FAO	Food and Agriculture Organization
FFV	Flex Fuel Vehicle
GHG	Greenhouse Gas
GIS	Geographic Information Systems
HDI	Human Development Indicators
IEA	Agricultural Economics Institute (SP)
ILUC	Indirect Land Use Change
LFS	Land and Food Systems (UBC)
LR	Legal Reserve
MDI	Municipal Development Index
MGY	Million Gallons per Year
MST	Landless Workers Movement (Brazil)
NGO	Non-Government Organization
NPV	Net Present Value
PECEGE	Center for Continuing Education in Economics
PES	Payments for Ecosystem Services
R$	Real (Brazilian currency)
REDD	Reduced Emissions from Deforestation and Forest Degradation
RF	Rainforest (i.e., Amazon RF or Atlantic RF)
RFA	Renewable Fuel Association (US)
RFS	Renewable Fuel Standards (US)
RSB	Roundtable on Sustainable Biofuels
SDI	Sustainable Development Index
SP	Sao Paulo
tC	tonne of Carbon
UBC	University of British Columbia
UNICA	Brazilian Industry Association
USP	University of Sao Paulo
WTO	World Trade Organization

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1. Introduction

As governments strive to achieve decreased reliance on finite fossil fuels through measures such as the U.S. Renewable Fuel Standards (RFS), there is considerable debate over the potential benefits of crop-based biofuels. For some, a domestically produced, renewable fuel holds environmental, economic, and even stragtegic advantages that merit biofuels production (Goldemberg, 2007, Daschle, 2007). People advocating environmental benefits point to the potential for biofuels to reduce greenhouse gas emissions (GHGs) (Macedo et al., 2008, Smeets et al., 2008). Others question whether biofuels will generate substantial GHG reductions as forests may be cleared to make room for more cropland (Nepstad et al., 2008; Searchinger et al., 2008). Still other stakeholders argue that biofuels have the potential to meet the added objectives of creating much needed jobs in rural areas (Martenelli et al., 2011). This too is questioned, particularly in Brazil, where increasing mechanization and industrialization are leading to a reduction in the number of jobs in the cane-energy sector even as production increases (Azanha, 2007).

In discussions with stakeholders in the Brazilian sugarcane-energy sector, two phrases were common responses to questions about changes underway: "Algums vão ser deixados por atrás" ('Some will be left behind'), and, "É a realidade" ('It's the reality'). But who, or what, might be left behind? Complex, healthy ecosystems replaced by less resilient sugarcane monocultures? Agricultural workers left behind by mechanization? An entire sector made obsolete in the quickly changing global energy matrix? Or will none of these be left behind as all benefit from increased production of cane and ethanol, with demand driven in large part by importation from the United States, China, Europe, and others? Accepting as reality that some will be left behind does not necessarily reflect resignation to an unfortunate fate over which people have no control. These phrases could represent a pragmatic, forward-looking perception of an increasingly important aspect of Brazil's economy. Thus, biofuels have the potential to meet multiple objectives, while simultaneously presenting multiple threats.

Brazil's ethanol program, the oldest and until 2005 largest producer of renewable transportation fuels (Figure 1.1), provides an ideal case study to test the effectiveness of biofuels to achieve these multiple policy objectives. This dissertation addresses a broad question: What are the major economic, ecological, and social implications for Brazil if foreign markets such as the United States open their economies to increased importation of Brazilian ethanol and other sugarcane-energy products? This question is narrowed to more detailed questions and analyzed in three studies focused on São Paulo (SP), the state accounting for approximately 60% of Brazilian cane and ethanol production (Figures 1.1 and 1.2).

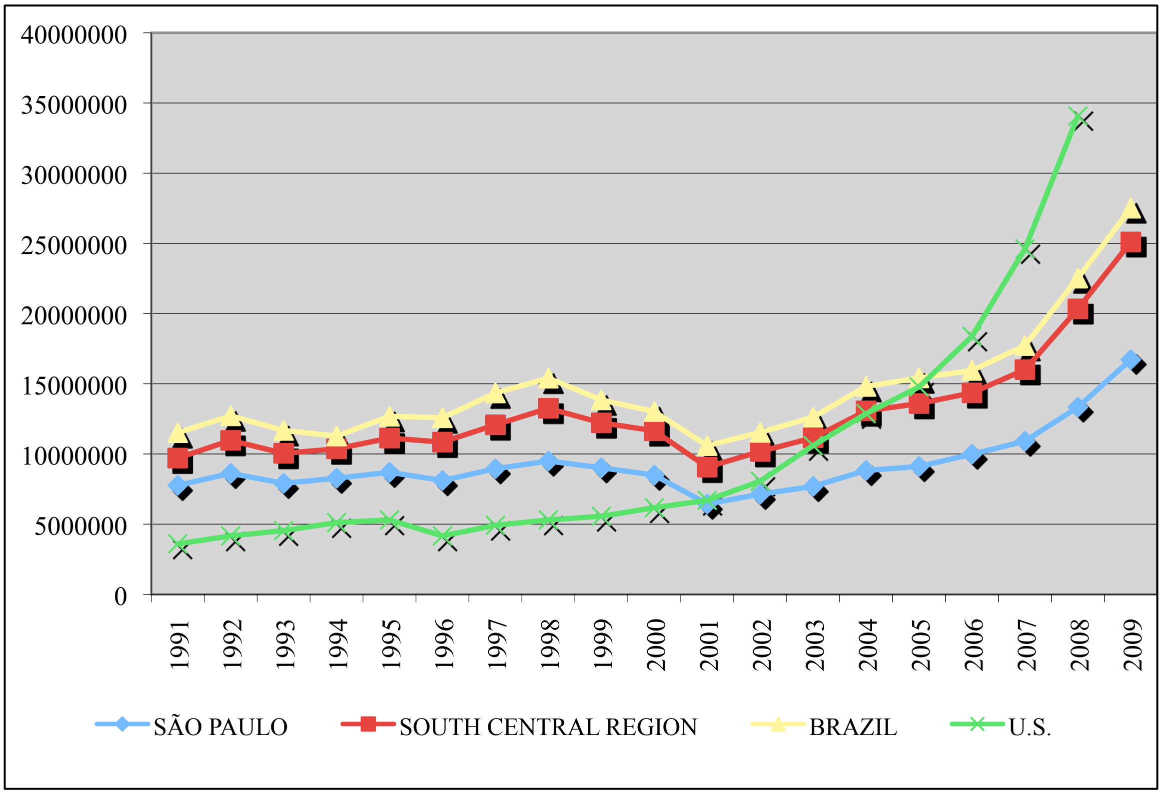

Figure 1.1. Brazilian and U.S. ethanol production. US, Brazil, São Paulo, and Center-South Region production of ethanol, in liters. Source: Brazilian data come from the São Paulo Sugarcane Growers Union (UNICA); U.S. data come from the Renewable Fuels Association (RFA).

This research is presented in an interdisciplinary dissertation that examines the economic, ecological, and social aspects of Brazilian ethanol production as it stands today and what may likely occur in the future. Motivated initially by the objective to assess the environmental implications of increased cane production for ethanol, preliminary research revealed the importance of paying close attention to Brazil's people, particularly the sector's workforce as the sector industrializes. The increased costs that could be incurred with greater environmental or social protections mandated the inclusion of all three—the environmental, the social, and the economic—addressed in a single dissertation. The chapters that follow each employs all three of these disciplines to investigate different aspects of the Brazilian sugarcane-energy sector. Chapter 2 provides a cost benefit analysis of the Brazilian Forest Code (BFC), which mandates that producers set aside portions of their land as forest and/or fallow land. The increased private economic costs of production imposed by compliance with the code are weighed against the ecological and social benefits, identifying private and public mechanisms to compensate producers and thus to balance private costs with social benefits. Given the wide range of possible effects from Brazil's ethanol production, in Chapter 3 stakeholders in SP are asked to rank their priorities to address the potential positive and negative externalities incurred by Brazil's cane-energy sector—economic, ecological, social, and others including food security, development of infrastructure, or improving institutions—as production is projected to increase, especially to meet the demand for export. Respondents are also asked what they see as the preferred means of reaching these priorities and these means are examined for feasibility and potential effectiveness. Since this increase in international demand and resulting Brazilian production are uncertain in the rapidly changing global energy matrix, Chapter 4 examines what may drive or inhibit increased demand for and the future of the cane-energy sector based on the most likely future scenarios.

This introduction continues with background on the Brazilian ethanol sector, and the U.S. Renewable Fuel Standards are then discussed as a current and tangible example of potential increased foreign demand for Brazilian sugarcane ethanol. Next, the research questions and hypotheses or objectives for each of the three chapters are presented within the context of the rationale and justification for asking these questions, as well as each chapter's methodological approach and a brief synopsis of the results. This overview is followed by the integrated framework that connects the three main chapters. The relevant academic literature is discussed throughout the introduction, and the literature review specific to each of these aspects is expanded in the chapters that follow. Though all three chapters are focused on the Brazilian cane-energy sector, each is unique in its objectives and its approach. The contribution to existing literature is therefore discussed within the context of each chapter.

Figure 1.2. Brazil and São Paulo**.** São Paulo (shaded), Brazil's largest cane and ethanol producing state, accounting for approximately 60% of production in each. Source: Raphael Lorenzeto de Abreu.

1.1. Background on Brazilian Ethanol

Brazilian ethanol production began in earnest in the 1970's under the PROALCOOL program. The international oil crises, combined with a domestic currency devaluation and sagging sugar prices, created a highly unfavorable balance of trade for Brazil (Goldemberg, 2006), which at that time imported approximately 80% of its petroleum (Valdes, 2007). Ethanol served to replace some of that imported oil while boosting demand for sugarcane. Subsidies were initially employed to boost the fledgling market, first to cane and ethanol producers and refineries, and later to automakers to produce flex fuel vehicles (FFVs) capable of running on any proportion of ethanol or gasoline. Those FFVs have been key to Brazil's achievement of energy independence in 2005, in part because ethanol now provides 50% of its transportation fuel (Ferreira et al., 2010). After nearly three decades of government intervention, ethanol is now traded on an almost completely free market, with the exception of blending mandates of approximately 20% and, until March, 2010, a 20% tariff on imported ethanol (Martines-Filho et al., 2006).

To explain the effectiveness of the Brazilian system, we can contrast it with the United States, where corn ethanol is blended at levels of 5-10% due to limited existence of engines capable of burning higher concentrations. In the U.S. vehicle fleet, FFVs accounted for approximately 6% of light-duty vehicle sales in 2008 (US DOE, EERE, 2009). In Brazil, on the other hand, 100% ethanol is readily available at almost every gas station, and the vehicle fleet consists of 71% FFVs (ANFAVEA, 2009), with 87.2% of new vehicle sales in 2008 consisting of FFVs (F.O. Licht, 2009). Therefore, in 2008, or any time when gasoline prices rise higher than ethanol prices[1], drivers can simply switch to ethanol. This contrasts with the United States, where ethanol's availability almost exclusively as a blend means that demand rises and falls together, with drivers having little choice between these two transportation fuels.

As countries such as the United States implement legislation mandating increasing use of biofuels now and in the coming decade, much of the demand for increased Brazilian ethanol production could likely come from abroad. The U.S. Renewable Fuel Standards (RFS) serves as a current, tangible example of foreign demand as the United States strives to increase the proportion of renewables in their energy matrix to gain the flexibility and advantages that Brazil has achieved. Along with increasing efforts towards reducing reliance on petroleum imports, there is also growing awareness of and pressure on issues such as climate change and corporate social responsibility. Consequently, importing companies and countries may pay greater attention to the environmental and social impacts of their energy consumption. These factors combine to forge projections of increasing Brazilian ethanol exports, from 5.1 BL in 2008 (UNICA, 2009), to as much as 36 billion liters (BL) in 2017 (InfoFNP, 2008). Brazilian and international researchers, as well as the U.S. EPA have established that Brazilian cane ethanol is the most efficient renewable transportation fuel available today in terms of land use, GHG emissions, and fossil fuel inputs (Macedo et al., 2008; Smeets et al., 2008; EPA, 2010). But arable land is still a finite resource, and displacement of food production, deforestation, and job creation and advancement are important issues to

[1] This is accounting for the fact that ethanol contains approximately 70% the energy content of gasoline by volume.

consider if the United States, China, Europe, or others are considering increased reliance on Brazilian ethanol.

1.2. Potential Increased Demand and Constraints for Brazilian Ethanol

Today, just under 20% of Brazilian ethanol is exported, with the United States being the largest importer (Table 1.1), importing over 1.5 BL in 2008, or almost 30% of 5.1 BL total exports (UNICA, 2009). Brazilian production of ethanol reached 27.5 B L in 2009, approximately 60% of which came from São Paulo (see Figures 1.1 and 1.2), while sugarcane production reached 558 million tonnes (MT) on 7.3 million hectares (Mha) nationally (IGBE, 2009). Approximately 11.6% of permanent cropland in the Center-South region, where São Paulo sits, was dedicated to cane production in 2008 (CONAB, 2008). Brazilian land used for cane production is projected to increase to 11.8 Mha by 2018, caused in part by the United States and other countries seeking to fulfill their own biofuels mandates. Brazil's already robust cane-energy sector is a logical source for ethanol as the United States has little domestic arable land available for increased biofuels production (Searchinger et al., 2008), and still lacks the commercial viability of advanced biofuels from cellulosic and other feedstocks, as evidenced by the US EPA's reduction of the 2011 advanced biofuel requirements from 100 million gallons per year (MGY) to only 6 MGY (EPA, 2010).

This potential increased demand is causing mounting concerns in Brazil regarding how subsequent changes in land use will affect important issues such as food security and forest cover (Sparovek et al., 2008). To address these concerns, in September of 2009 the Lula administration established Agro-Ecological Zoning regulations mandating that no food producing land be converted to sugarcane for ethanol, and also ensuring protection of sensitive areas such as the Amazon Rainforest (AEZ, 2010). It remains to be seen whether or not efforts such as these will be sufficient to ensure the continued protection of resources such as soil and water necessary for cane production (Mendonca, 2011; Moreira, 2007).

Though the Brazilian government cites ample land for increased agricultural production (EMBRAPA, 2009), there is mounting concern about pressure on the Center-South Region's Atlantic Rainforest, listed in the top five most important sites on the planet for biodiversity conservation, less than 8% of which survives today (Myers et al., 2000). As sugarcane and ethanol production increase in the area of the Atlantic Rainforest, how valuable is this ecological resource, and what should be done to preserve and restore it? These factors are addressed directly in the second chapter, a cost benefit analysis of the Brazilian Foest Code and its economic and ecological implications for sugarcane production. The discussion of these factors is continued in the third chapter, where stakeholders are asked to rank prioritization of environmental as well as socio-economic concerns. The fourth chapter takes these into account while assessing possible future scenarios for the Brazilian cane-energy sector.

Table 1.1. U.S. Importation of Brazilian ethanol, in thousands of liters. See footnote for sources.[2]

2002	2003	2004	2005	2006	2007	2008
0.0	0.0	341,822.7	118,104.8	1,695,473.8	782,189.0	1,519,425.5

1.3. US Renewable Fuels Standards

The U.S. Renewable Fuel Standards (RFS), signed into law in 2007 with the Energy Independence and Security Act (EISA), call for increasing the amount of renewable fuels, mainly ethanol, to 136 BL (36 B gals) in 2022 (Figure 1.3). As the name of the EISA suggests, the RFS represent an effort to replace a portion of imported petroleum with renewable fuels, perhaps 20% in 2022 depending on total transportation fuel use, with these renewable fuels preferably being domestically produced. But it is important to note that the specific language of the EISA mandates only the "use," and not the domestic production, of these fuels (see Appendix 1). A U.S. tariff of $0.54 per gallon on imported ethanol helps to protect domestic producers, namely corn producers and corn ethanol refineries, and yet even with that tariff Brazil's ethanol is sufficiently cost competitive with corn ethanol that the U.S. is still the largest importer. In the long term, the aim of the RFS is to cap corn ethanol production at 56.8 BL (15 Bgals) in 2015, mandating increasing amounts of cellulosic and other "advanced biofuels," defined as those renewable fuels that reduce GHGs by at least 50% relative to gasoline. These mandates

[2] Data for U.S. imports, 2002-2007, come from U.S. Renewable Fuels Association, and data for 2006-2008 come from UNICA. As RFA and UNICA have slightly different figures for 2006 and '07 (UNICA: 1749.2 ML and 849.7 for 2006 and '07, respectively; RFA: 1641.7 and 714.7) the figures for those two years are averaged.

have already become problematic as it does not appear to be feasible to produce domestically the 3.6 BL of advanced biofuels mandated for 2010. These regulations were recently updated in the EPA's "Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis," and the advanced biofuels mandate was dropped from 380 ML (100 M gals) to only 24.6 M L (6.5 M gals) (EPA, 2010).

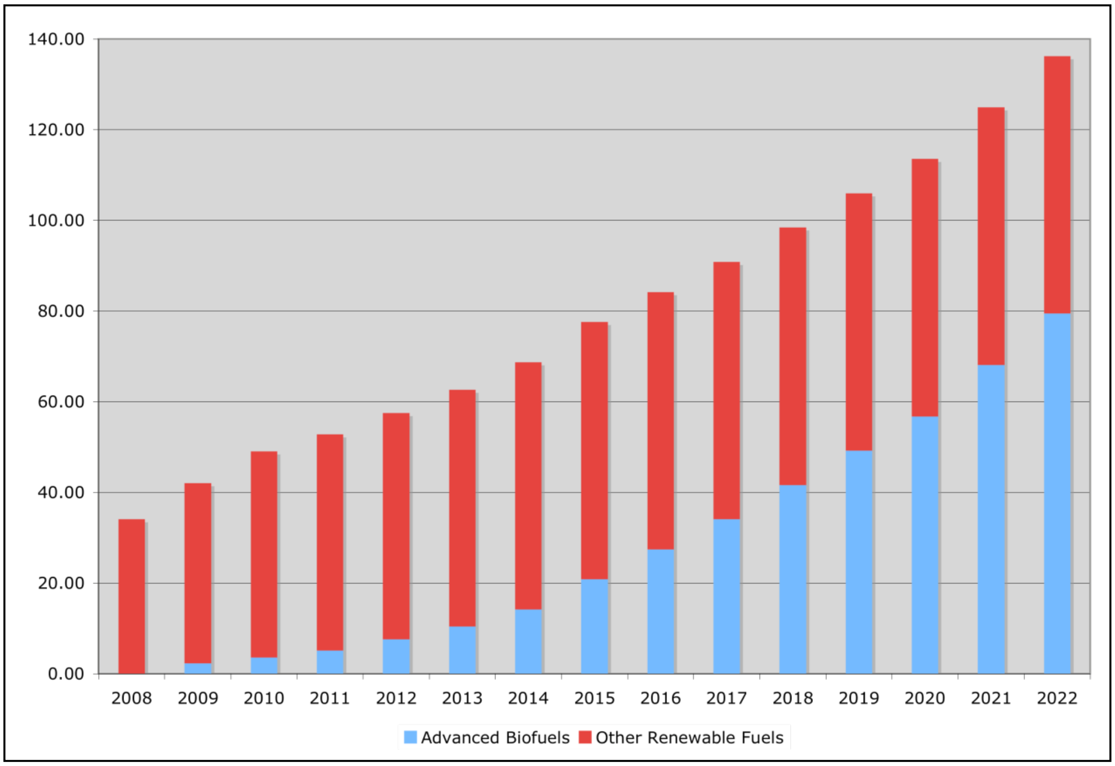

Figure 1.3. U.S. Renewable Fuel Standards. "Advanced" and other biofuels, in billions of liters.

RFS2 also clarifies the legalities of an ongoing debate, finally stating that, despite some estimates placing corn ethanol's GHG reductions at up to 70% compared to gasoline (Liska et al., 2009), corn ethanol is legally established at providing 33% GHG reduction, meaning it cannot meet these advanced requirements. These standards are officially met by Brazilian cane ethanol, however, which achieves a 61% reduction in GHG emissions according to the EPA's RFS2 (EPA, 2010; RFA, 2010). It is also interesting to note that included in the EPA's document is the statement that, "we expect that imported ethanol to the U.S. will likely come from sugarcane" (2010, p.17). In fact, over the past year and a half UNICA and the California Air Resources Board (CARB) have been in protracted negotiations to identify the proper parameters and coefficients for accurate accounting of cane ethanol's lifecycle GHGs, presumably to determine if and how much Brazilian ethanol should be imported into California (UNICA, 2009; CARB, 2009). With challenges to meet cellulosic and advanced biofuels mandates domestically (Westcott, 2009), some say the best alternative is to lower the tariff on imported ethanol and increase the proportion of Brazilian ethanol in the U.S. fuel supply (Judd (US Sen, R NH), 2008). Questions remain, however, regarding the implications of this increased demand for Brazil, and how the resulting increased production would affect economic, ecological, and social considerations.

1.4. Chapters 2-4: Research Questions, Hypotheses or Objectives, Contribution to Existing Literature, Synopsis of Methods, and Synopsis of Results

1.4.1. Chapter 2: Sugarcane Ethanol in Brazil: Producer Costs and Social Benefits of Existing Forest Set-Aside Legislation

The initial focus for this dissertation on the impact of increased cane production on Sao Paulo's forests came from conversations with Carlos Bacha, economics professor at the University of Sao Paulo's (USP) agricultural campus in Piracicaba. In his 2005 study, he found that the number of Sao Paulo's (SP) landowners registering legally required forest reserves on their land had fallen from 18.2% in 1972, to just 6.4% in 1998. On the national level that number had dropped from 9.8% to 7.0% during the same time period (Bacha, 2005). According to the Brazilian Forest Code (BFC), implemented in 1965, landowners in SP are required to leave 20% of their land as a forest, or Legal Reserves (LRs), and are also required to establish fallow areas, called Areas of Permanent Preservation (APPs), along waterways and other ecologically sensitive areas, usually accounting for another 5-10% of each parcel of land. The history and ecological importance of Brazil's Atlantic Rainforest, much of which previously occupied areas now covered by sugarcane in SP, has global significance (Rodrigues et al, 2009; Meyers et al., 2000). Research has indicated significant negative environmental externalities from monoculture sugarcane production in the form of soil erosion and damage to water quality, and that these externalities can be ameliorated by protecting riparian corridors and forests that protect soil, air, water, and biodiversity (Momoli, 2006; Momoli et al., 2007; Rodrigues et al., 2009). Preserving these lands in forest, however, raises costs to producers. Listening to and reading various opposing viewpoints regarding the feasibility of LRs and APPs (Jank, 2009), however, exposed areas of contention that warranted further investigation, thus leading to the questions that direct the second chapter:

1. What are the public and private benefits that could be achieved with BFC compliance?
2. What are the private opportunity costs of BFC compliance?
3. What factors most affect the differences in opportunity costs?
4. What mechanisms, both domestic and international, can help to compensate producers for the private costs incurred to achieve the benefits compliance with BFC regulations could achieve, thereby aligning public and private benefits and costs?

Sources of compensation, both public and private, are identified so that landowners and cane producers would not lose income if it were deemed sufficiently necessary and effective to internalize the negative environmental externalities and to protect Brazil's water, soil, air, and biodiversity with Legal Reserves and Areas of Permanent Preservation. As there was no such cost benefit analysis using empirical data found, the chapter contributes to existing literature by filling this gap, identifying the opportunity costs of BFC compliance as well as mechanisms to compensate producers for these private costs.

1.4.1.1. Synopsis of Methods

The benefits of BFC compliance were examined through a review of existing literature regarding the benefits of forests to agricultural land, specifically soil and water quality, as well as biodiversity and carbon mitigation. To establish the private opportunity costs for LRs and APPs, production costs for sugarcane and ethanol are compared between five different production scenarios, three compliant with BFC regulations and two non-compliant scenarios, without LRs and APPs. Three farm scenarios begin and continue with cane production while two convert to cane production, incurring higher costs for this conversion. Cane and ethanol production cost data come from a series of studies covering four consecutive sugarcane growing seasons, published by PECEGE, The Continuing Education Program in Economics and Business Administration at the University of Sao Paulo. These studies are Marques et al. (2009), describing costs for the 2007/08 harvest season; Xavier et al. (2009) for 2008/09; Xavier et al. (2010) for 2009/10; and Xavier et al. (2011) for 2010/11. Marques et al. (2009) and are specific to SP state and the center-south region in which it lies. Potential revenue streams for producers, such as sale of selectively harvested timber, and payments for carbon sequestration and other payments for ecosystem services are then examined for their potential to compensate producers for BFC compliance. The cost of implementing and maintaining forests are from Rodrigues et al. (2009), as are potential profits from timber collection legally permitted on LRs.

1.4.1.2. Synopsis of Results

The opportunity costs are highest for the farm scenario in the expansion region, as are profits for both the compliant and non-compliant scenarios in the expansion region, which are the scenarios that convert to cane production in the first year. The opportunity costs are highest for the expansion independent producer at R$3805.69, discounted to NPV, or R$84.57 averaged over the 45 years. To make up this difference several revenue streams and other sources of funding are identified. Private sources that can be pursued by producers include timber revenues, carbon sequestration payments, and other payments for ecosystem services. The Brazilian and Sao Paulo governments may affect the difference by either carrot or stick measures, or a combination of the two, rewarding producers for compliance or providing punishments such as fines for failure to comply. After Brazil has taken the first steps to encourage compliance domestically, then there are several international options available. Specifically, the recently signed Reduction in Ecosystem Destruction and Deforestation (REDD) policy could provide payments, as could the Clean Development Mechanism (CDM) established as part of the Kyoto treaty.

1.4.2. Chapter 3: Increasing Brazilian Sugarcane Production for Ethanol: Stakeholders' Priorities for their Environment, Economy, and Society

While many in the developed world may focus on the environmental implications of biofuels production (Searchinger et al., 2008; Fargione et al., 2008), it remains an open question if this is a priority for stakeholders in SP. Indeed, President Lula reinforced this concern with a statement about foreign intervention in Brazil's environmental affairs: "They don't need to come here and give us advice" (The Economist, 2010b). Much of the strength of the U.S. Economy is founded on extractivist industries such as agriculture that replaced forests and prairies with monocultures of corn, soy, and other crops. Now that the U.S. economy has grown past the crest of the Kuznets curves (Figure 1.4) so often employed in environmental economics, preservation of ecological health has become a more affordable priority. In Brazil, however, a lack of jobs, indicated by unemployment rates of 7.6% in March, 2010 (8.2% in SP), down from 12.9% in March, 2002 (13.8% in SP) (IBGE, 2010), causes many to question whether or not forests are really a priority on land where much needed jobs could be created by agriculture.

Furthermore, the rise in food prices in 2008, caused in part by diversion of corn to ethanol (Abbot et al., 2009), indicates another potential priority that stakeholders in Brazil may or may not find more important than forests and ecological health: the potential impacts on food prices of more land dedicated to cane and ethanol production. Preliminary stages of this research also indicated possible priorities including building infrastructure and/or institutions. All five main priority areas are listed in Figure 1.5. Based on these priorities, it was important to ask another set of questions:

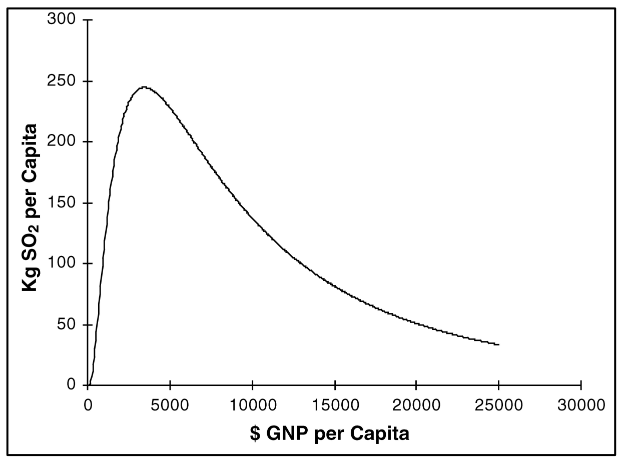

Figure 1.4. The Environmental Kuznets Curve. According to the Kuznets Curve, environmental degradation is greatest in poorer countries, but as income rises, a country is better able to develop its economy with fewer negative impacts on the environment. The example above relates specifically to sulfer pollution (From Panayotou, 1993, reprinted in Stern, 2004).

1. What are the socio-economic and environmental priorities for the sector's future growth among stakeholders in Sao Paulo (SP), Brazil's main sugarcane- and ethanol-producing state?

2. In which methods and administrative bodies—private, public, NGOs, or others—do stakeholders have the most confidence to encourage their priorities?

Several hypotheses were proposed to be tested by surveys and interviews with stakeholders.

A. From the Surveys:
   1. Job creation would be the most important priority held by stakeholders, followed by protection against displacement of food production, with protection of natural resources the least important priority;

   2. The Brazilian government and domestic private sector would be the preferred administrative bodies to oversee the pursuit of these priorities.

- **Infrastructure** (education, health, physical infrastructure, etc.)
    - Education; Health; Roads and other physical infrastructure; Other
- **Job Creation**
    - More jobs; Jobs with higher pay; Safer, healthier jobs; Jobs requiring higher education; Other
- **Protection Against Displacement of Food Crops**
    - Food production for domestic consumption; Food production for export
- **Protection of Natural Resources**
    - Air quality; Soil quality; Water quality; Amazon Rainforest; Atlantic Rainforest; Biodiversity; Other
- **Institutions** (rights, security, research, etc.)
    - Legal System; Research; Strengthened democracy; Combat crime; Combat corruption; Other
- **Other Aspect** (Brief explanation: ________________________________)

Figure 1.5. Main and sub-priorities. Main priorities are in bold and respondents were first asked to rank these 1 (most important) through 5 (least important) or 6 if they marked "Other," which 8 of the 119 respondents did. Respondents were then asked to rank sub-priorities independently for each main priority. For example, within "Infrastructure," they may have ranked "Education" as #1, Health as #2, etc., and would then start again for the sub-priorities for "Job Creation."

B. From the Interviews:
   1. Respondents would view increasing mechanization and industrialization negatively and as a threat to independent producers, arguing that the environmental and socio-economic priorities would be impacted negatively by these processes and, even though the processes may reduce costs, the priorities should be placed before lowered costs potentially offered by larger firms and economies of scale;

2. Conglomerate firms would either disagree outright with the need to place the other priorities above lowered costs, or would argue that they are better positioned to accomplish these other priorities as well as generate greater profits for themselves and revenues for Brazil;

3. Researchers and others outside the private sector would be opposed to increased cane production and particularly intensification due to potential negative environmental and socio-economic problems arising with the sector's growth, negating the achievement of the priorities outlined above.

The third chapter contributes to the literature by offering a broad assessment of the state accounting for the largest amount of sugarcane and ethanol production, gathering and analyzing the viewpoints of over 130 stakeholders in Sao Paulo's sugarcane-energy sector regarding their priorities for how the cane-energy sector could and should impact Brazil's economy, ecosystems, and people.

1.4.2.1. Synopsis of Methods

Stakeholders in SP's cane and energy sector were first identified to assess priorities for the future of the sector. Piracicaba, SP, was established as a base for the research due to its location in the heart of SP's cane producing region and because it hosts several ideal private and public cane and ethanol related institutions, including the Center for Cane Technology (CTC, in Portuguese), perhaps the world's leading private sugarcane research center; The Luis Queroz School of Agriculture (ESALQ in Portuguese), the University of Sao Paulo's agricultural campus; Coplacana, an independent sugarcane producers cooperative; and many more. These institutions as well as previous contacts granted access to more individuals and organizations, such as UNICA, the highly influential producer's industry association; and executives inside Cosan, Copersucar, and Louis Dreyfus, three of the world's largest cane ethanol firms. Taken together, these provided an ideal sample from the population inside industry, academic research, and others.

Once this sample was identified, the process continued with secondary research of existing literature as well as primary research in the form of informal interviews with cane and ethanol producers, academic researchers, and others. These eventually progressed to surveys and more formal, semi-structured interviews. Surveys were chosen as the most efficient means to reach the largest sample to rank their priorities and means to achieve these priorities. Semi-structured interviews were chosen as a means to maintain focus on the questions relevant to this research while still allowing subjects the liberty to discuss issues that may have been beyond the initial scope of the questions in the surveys.

Surveys were designed using priorities ranked numerically so as to allow for statistical analysis and to establish definitive differences between priorities and their administration (Fowler, 1995). Secondary research and several preliminary interviews were conducted first, with surveys and full interviews occurring later. An initial set of 20, draft surveys were administered in four rounds of five surveys each to university professors and later to graduate students, all of whom are familiar with qualitative research and/or cane and ethanol production. This was done to ensure that the surveys were clear and included all relevant potential responses for subjects to mark. As survey results were analyzed it was possible to ask interview respondents about these results, thus putting more detailed information, as well as faces and voices, to the data gathered throughout the survey process.

1.4.2.2. Synopsis of Results

The results indicate that there is widespread optimism about the ability of the cane-energy sector to fulfill the priorities outlined here, provided there is continued monitoring and enforcement of existing legislation and ongoing public and private participation in the programs to further environmental and socio-economic goals. The first survey hypothesis was largely rejected, as protection of natural resources was the highest ranked priority, yet protection of the Amazon and Atlantic Rainforests, areas frequently discussed in the literature, were less important to stakeholders surveyed than were protection of water, air, soil, and biodiversity. Job creation, which I had hypothesized would be the most important priority, was virtually tied with building of infrastructure as the next most important, and, again perhaps somewhat surprising to people outside of Brazil, protection against displacement of food production, which I hypothesized would be the second most important priority, was the least important concern. The second hypothesis was accepted, as the Brazilian government was the highest ranked body for enforcement of priorities, followed by the Brazilian private sector.

For interview results, the first hypothesis was also largely rejected as most interviewees, including several representing small, independent cane growers and ethanol refineries welcomed the industrialization and mechanization of the industry, while only five of 29 responded as was hypothesized, that smaller producers will be better able to create jobs and protect natural resources. The second interview hypothesis was supported as representatives from larger firms saw their companies as completely capable of generating jobs for less educated Brazilian workers as well as protecting natural resources, and viewed each of these as highly important while pointing to several recently enacted programs that would allow them to fulfill environmental and socio-economic priorities. Interviewees did, however, see a place for independent producers in the sector's future, and did not see their continued growth and coexistence as mutually exclusive. The third hypothesis was rejected as academics and all but one of the stakeholders outside the private sector saw great potential for the cane-energy sector to contribute positively to the five main priority areas provided there is continued monitoring and enforcement of recently enacted government legislation as well as continuation of private sector programs and discussed in the chapter itself.

1.4.3 Chapter 4: The Brazilian Sugarcane-Energy Sector: Possible Future Market Scenarios

As early research progressed and the above questions began to be answered, many of the responses hinged on uncertainty about the future direction of the Brazilian cane-energy sector in particular, and the global energy matrix in general. Stakeholders in SP were uncertain that there would be sufficient long-term demand for ethanol. In terms of the potential for export, volatile petroleum prices coupled with the policy environment in the U.S. and other markets have not engendered confidence to increase production and investment in cane and ethanol infrastructure. Domestically, vast petroleum reserves have only recently been found off the coasts of SP and Rio de Janeiro, but more doubts were expressed about the ability to extract that petroleum safely and efficiently (Beltrão et al., 2009). Technological innovation was at times pointed to as a way to move beyond fossil fuels to renewables such as biofuels, solar, wind, and Brazil's main provider of electricity, hydro power (EPE, 2010). At other times technology was discussed for its potential to deliver abundant and inexpensive fossil fuels for generations to come. The necessity to consider the many dimensions of crop production and energy markets simultaneously has been addressed previously in terms of biofuels (Acosta-Michlik et al., 2011). The various perspectives and predictions led the research further into examining the future of the Brazilian cane-energy sector. More questions needed to be asked to examine the sector in ways that would help shed light on the research in the first two chapters.

~ What are the main drivers for the potential directions of the sector?

~ Given these drivers, what are the potential future scenarios for the sector, and how would the most likely scenarios affect current strategic planning for the priorities identified in Chapter 2?

This fourth chapter contributes to existing literature by combining academic and industry literature with interviews of industry and government officials as well as academic and private researchers.

1.4.3.1. Synopsis of Methods

Based on a framework devised by Porter (1990, 2002), the main drivers likely to impact the future of the Brazilian cane-energy sector were identified, leading to four likely scenarios for the sector's products and its orientation, either continuing to be largely domestic or having a greater presence in the markets of foreign economies. The methods for this portion of the research project were helped greatly by work with Peter Zuurbier, professor of business at Wageningen University (Netherlands); author of *Sugarcane Ethanol: Contributions to Climate Change Mitigation and the Environment* (2008); and visiting professor at ESALQ. The structure of the research process was modeled after private scenario building projects such as Shell Oil's "Global Scenarios" (2002, 2005, 2008, 2011) and academic assessments of agribusiness such as Boehjle's

"Structural Changes in the Agricultural Industries: How do we measure, analyze, and understand them?" (1999). According to the methods employed in these studies, drivers for change, the factors that would have the greatest impact on the Brazilian cane-energy sector, were identified along with the different scenarios where these drivers would lead.

1.4.3.2. Synopsis of Results

Three main factors were identified that would have the greatest impact on the future of the sector: 1) market conditions, particularly supply and demand of petroleum prices, but also sugar and sugarcane; 2) technology development, including agriculture, biorefining, petroleum extraction, and vehicle fleets; and 3) policy, both domestic encouragement or inhibition of cane and ethanol production and consumption, and international barriers or incentives to importation of biofuels. To a slightly lesser extent, corporate governance of individual firms in the sector, and the sector as a whole in shared institutions such as UNICA and CTC, will also play an important role in the sector's future.

Figure 1.6. Possible scenarios. These four are not envisioned as absolute or mutually exclusive, but as potential directions for the Brazilian cane-energy sector.

Figure 1. Scenarios. Possible Scenarios for the Brazilian Cane-Energy Sector.	
1. Domestic Focused: Sugar remains on the international market, but ethanol, the sole other dominant product from the sector, remains largely on the domestic market.	**2. Domestic Diversified:** The cane-energy sector moves into production of ethylene and other, high-value products previously limited to the petroleum refinery, but, other than sugar, sales are largely limited to the domestic market.
3. Export Focused: The cane-energy sector continues its focus on sugar and ethanol production, but gains entrance to international markets and exports substantial portions of its ethanol.	**4. Export Diversified:** In addition to sugar and ethanol, other high-value products such as ethylene are exported to various international markets.

These factors will determine the market orientation of the cane-energy sector for decades to come, either focused on its current products or diversified to other products that may replace more of the goods derived from fossil fuels, and whether these products continue to be largely domestically consumed or if they will be distributed through export markets. These scenarios are described in Figure 1.6 below. Assessing these scenarios led to detailed assessments of supply and demand for cane and ethanol products, their complements and substitutes, including the dominant competitor, petroleum, and the technology and policy that may provide future advantages for one or the other.

1.5. Integrated Framework for an Interdisciplinary Approach

The program for which this dissertation has been written is called Integrated Studies in Land and Food Systems (LFS), an interdisciplinary program at the University of British Columbia (UBC). I was drawn to this program in particular as it offered the opportunity to transcend typical academic disciplines and apply several of them, through an integrated framework, to an essential issue in food and agriculture. The term "sustainability" is rarely used in this study as it has become a buzz word, a cliché sometimes used without a clear definition. Still, the "triple bottom line" of economic, social, and environmental sustainability provides a framework from which to assess the issues at hand. Additionally, avoiding use of the term "sustainability" is not a judgment on whether or not the ethics behind it are important. Much of the motivation for this dissertation is to assess how cane and ethanol production will affect livability for future generations in SP and Brazil. Assessing all three in a single dissertation is motivated by the belief that all three pillars of sustainability are indeed essential, and to examine the interactions between them. The difficulty in attempting to rank these three pillars illustrates the necessity of examining all three at the same time, as well as the importance of asking local stakeholders which of these and other issues they see as most important in terms of the cane-energy sector in SP.

Because the study addresses the work of private firms in the capitalist Brazilian economy, the firms must be economically viable, first and foremost. For any of their work to be done, for these firms to have any impact, positive or negative, on the environmental and social aspects of Brazil or the rest of the world where their products may be consumed, they must remain financially solvent and profitable. That said, ecological economics, particularly the work of Daly and Farley (2004), explains that, as much as we may place economics first for very practical reasons, the economy is a subset of the ecosystem. The discussion in the second chapter illustrates this quite well, as Rodrigues et al. (2009), Sparovek and Schnug (2001) and Momoli (2006) show that economic returns for cane producers are dependent on the health of soil and water. As David Suzuki put it far more succinctly and bluntly, "The ecosystem doesn't give a shit about your economy[3]."

The excerpt below from the US EPA describing the objectives and rationale for the Renewable Fuel Standards also captures all three of these pillars.

> "The revised renewable fuel standards are expected to reduce dependence on foreign sources of crude oil, increase domestic sources of energy, and diversify our energy portfolio to help in moving beyond a petroleum-based economy, while at the same time providing important reductions in greenhouse gas emissions such as carbon dioxide that affect climate change. The increased use of renewable fuels such as ethanol, biodiesel and other renewable fuels is also expected to have the added benefit of providing an expanded market for agricultural products such as corn and soybeans and open new markets for the development of cellulosic feedstock industries and conversion technologies."[4]

The US regulations outline the socio-economic objectives of increasing demand for agricultural products and creating jobs in rural economies. They also clearly state the environmental goal of reducing GHGs associated with petroleum-based fuels. Similarly, this dissertation addresses each of these areas as they are all impacted by sugarcane production for ethanol in Sao Paulo, Brazil.

A course called "Ecosystem Approaches to Health" at UBC in 2008 also brought home the necessity of and provided further guidance for the integration of economics, ecology, and social or human considerations. Placed in the context of the present study, the issue of water quality discussed in later chapters, ostensibly or initially an ecological issue, is obviously a social consideration as water pollution affects people, and then quickly takes on economic importance when we consider lost working days by laborers due to sickness or the healthcare costs incurred as people seek treatment. The increased costs incurred to avoid pollution or to clean water after it has been tainted again brings

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[3] Said in his introduction of Al Gore when the former U.S. Vice President was in Vancouver to give his "Inconvenient Truth" presentation.

[4] Office of Transportation and Air Quality EPA-420-F-09-023, May, 2009

these often separate disciplines back together. The social pillar is also important when we step back and realize that the focus of the study is human actors, with our activities being those that cause the problems in the first place, and also who must work to avoid or resolve them.

None of this is meant to suggest that examining any of these in isolation is unnecessary. Quite the contrary, scanning the bibliography for this dissertation shows that focusing on each of the three areas, and many very specific aspects within each, is essential to gaining a full understanding of the details in an area as complex as the global energy matrix, even when focusing on bioenergy and one particular feedstock from one state in one country. It is the objective of my dissertation to bring together these many excellent studies and combine them with further primary research in order to provide a complete, aerial view of a very important aspect of Brazil's economy and social and natural environment, and an issue of increasing environmental, economic, and social concern to the future of our planet and its people.

2. Sugarcane Ethanol in Brazil: A Cost Benefit Analysis of Compliance with Existing Forest Set-aside Legislation

2.1. Introduction

Brazil and The United States are two of many countries striving to increase the proportion of renewable fuels in their energy matrix. They are the two leading producers of ethanol, made from corn in the United States and sugarcane in Brazil. For some, economic and ecological advantages such as increased demand in the agricultural sector from domestic, renewable fuels are sufficient to justify their production. For others, tradeoffs for fuel versus food (Eaves and Eaves, 2007; Elobeid and Hart, 2007; Runge and Senauer, 2007) and the potential negative impacts of monoculture (Pereira and Ortega, 2010; Groom et al., 2008; Danielson et al., 2008) may outweigh the proposed advantages. As the biofuels debate continues, production and use of ethanol continue to climb, especially in Brazil, which is the largest exporter and until 2005 was the world's leading producer of ethanol.

If a major motivation for biofuels is environmental benefits such as greenhouse gas (GHG) mitigation, this benefit may be reversed if forests are cleared, either directly or through indirect effects, to make way for feedstock production (Lapola et al., 2010; Searchinger et al., 2009). For this reason, integrating biofuels production with reforestation, afforestation, and anti-deforestation measures seems an appropriate step to move biofuels closer to accomplishing their key environmental objectives. The need to ensure forest protection is particularly pressing in São Paulo state (SP), where nearly 60% of Brazilian cane and ethanol are produced (Martinelli and Filoso, 2008), and where only 8% of the ecologically essential Atlantic Rainforest remains (Rodrigues et al., 2009) (see Fig 2.1). The Brazilian Forest Code (BFC), passed in 1965, mandates that producers in SP set aside 25-30% of each parcel of agricultural land, posing a potential solution to environmental issues associated with monocultures. The high opportunity cost of land, however, has largely been prohibitive, enforcement has been minimal, and fewer than 10% of producers have complied with the BFC (Bacha, 2005). Now, as mechanisms such as payments for environmental services (PES) and other non-regulatory measures have become more prevalent, the potential for adoption has been growing. Therefore, this chapter addresses two main questions:

1. What are the additional costs for sugarcane producers of complying with Forest Code legislation; and

2. What mechanisms, both domestic and international, could be employed to pay producers to compensate them for this increase in production costs?

This study uses detailed, empirical data on the costs of cane production as well as forest implementation and maintenance in SP to develop five farm scenarios comparing productions costs of landowners who do (or do not) comply with BFC legislation. Sensitivity analysis is performed on the results to learn which aspects of production and which variations in payments could make compliance more or less cost effective. As there was no such cost benefit analysis using empirical data found, the chapter contributes to existing literature by filling this gap, identifying the opportunity costs of BFC compliance as well as mechanisms to compensate producers for these private costs.

This chapter continues with a literature review and background discussion on cane production and some of its constraints, how forests may ameliorate some of these constraints, and methods such as PES and carbon sequestration payments that could encourage forest implementation. Section 3 presents an explanation of data and methods, including the five farm scenarios employed in this study, and the cane and forest costs involved. Section 4 describes the results of the above scenarios as well as sensitivity analysis. Section 5 provides delineates methods to compensate producers for the change in costs revenues with BFC compliance and concludes the chapter.

2.2. Background and Literature Review

Sugarcane production in Brazil increased from just under 4.3 million hectares (Mha) in 1990, to 6.2 Mha in 2005, an increase of over 44%, much of which came from intensification—increasing yields per unit of land—as well as extensification—expanding the amount of land dedicated to sugarcane (Figure 2.1). During the same time period, SP experienced an increase in production of 77%, from 1.9 Mha to 3.3 Mha (Brazilian Ministry of Agriculture, 2010). With these increases in production also came progression in reducing the costs (van den Wall Bake et al., 2009).

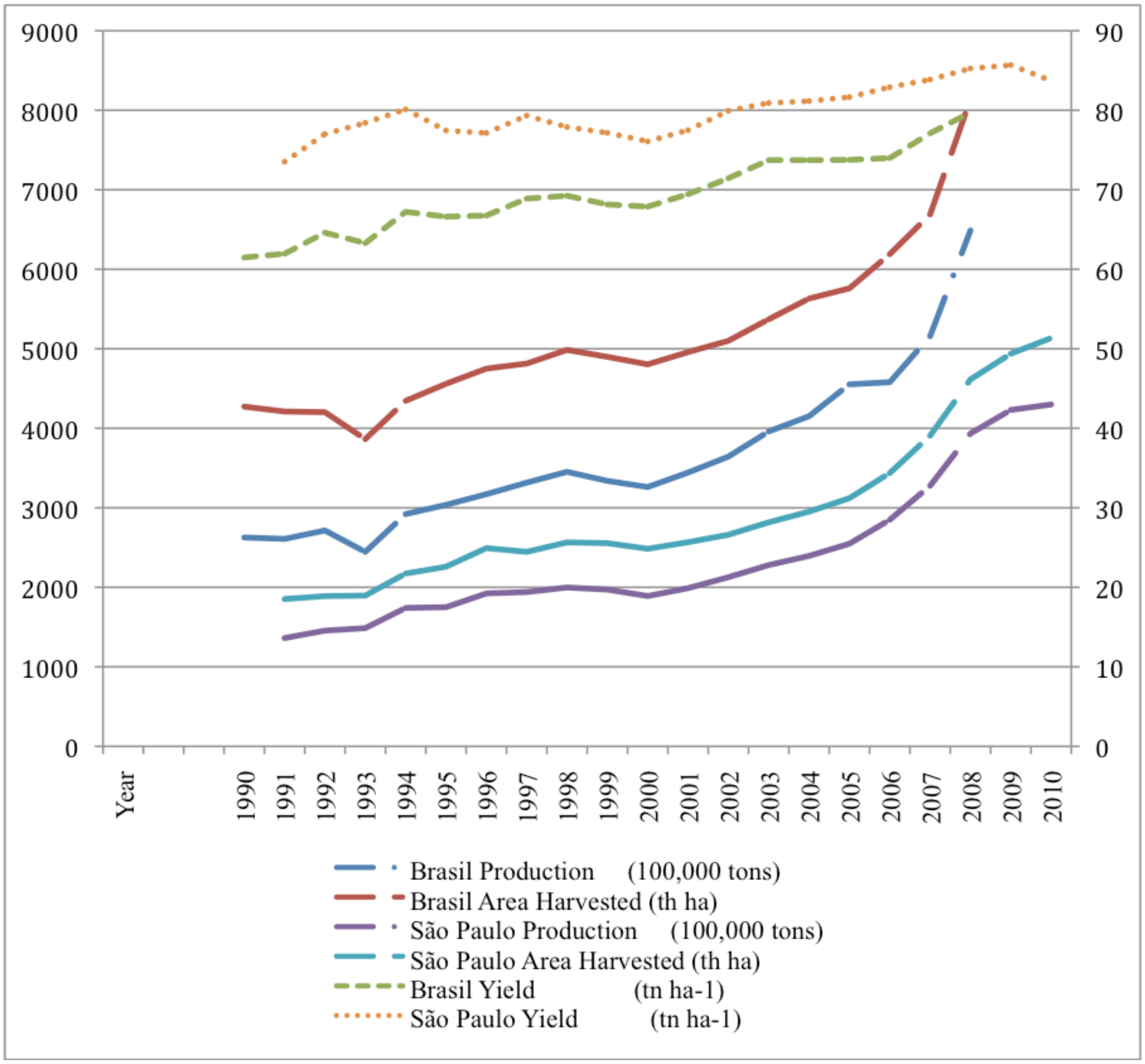

Figure 2.1. Area dedicated to sugarcane, total production, and yields, Brazil and SP. Production in 100,000s of tons and thousands of hectares harvested are on the left axis. Yields in tons per hectare are on the right axis. Source: Brazilian Ministry of Agriculture, available at http://www.agricultura.gov.br/. 2005-'10 SP figures are from IEA (http://ciagri.iea.sp.gov.br/bancoiea/subjetiva.aspx?cod_sis=1&idioma=1). 2006--'08 BR figs from BR Min of Ag Cane Stats Yearbook (2009). See Appendix 3 for table of figures.

Van den Wall Bake et al. (2009) use an experience curve to examine and explain the history and trajectory of Brazilian cane and ethanol production costs. A more recent study performed by Crago et al. (2010) uses survey data from cane producers in SP. Each of these studies points to increasing efficiencies gained with economies of scale as well as improvements in machinery and other technologies as production has increased. Further increases in cane and ethanol production by as much as ten fold could be met by a combination of intensification as well as expansion of cane production into new areas (Goldemberg et al., 2007). Macedo et al. (2008) predict yield increases of nearly 10% by

2020, and Friberg (2009) cites ample, arable land that is either unused or underused, and is not presently forested, where sugarcane could likely be produced.

Despite these favorable conditions, continued increases in cane production face several potential ecological constraints. Pereira and Ortega (2010) advocate a "support area" of forest consisting of at least 70% of each hectare of sugarcane-producing land in order to ensure proper soil retention and regeneration as well as adequate water cycling. This could be met at least in part by increased compliance with the BFC. Momoli (2006) also found that failure to protect riparian corridors, planting sugarcane right up to the edge of a municipal reservoir in Iracemapolis, SP, led to erosion that damaged water quality, increasing costs of water supplies. Her studies show the benefits of forests to both soil and water, not just ecologically, but in terms of human health as well. Furthermore, as almost all sugarcane production in Brazil is rain fed, there is a pronounced need for healthy water cycling on and near sugarcane producing land. Moreira (2007) shows that cane runoff from fertilizers and other agricultural inputs as well as effluent from ethanol refining pose greater risks to water quality in São Paulo than elsewhere in Brazil. This will be discussed in greater detail below, but for now, Moreira (2007) points to reforestation and, specifically, to APPs, as effective but underutilized measures to limit erosion and water quality damage. Table 2.1 below provides more of the benefits that can be provided by healthy forests.

Table 2.1. Service and environmental function of the forest. From Costanza et al. (1997), reprinted in Andrade and May (2009).

Service and environmental function of the forest	Examples
Climate regulation through storage and sequestration of Carbon	Ameliorate the factors that increase surface temperature caused by the greenhouse effect
Water resource regulation through flow control	Reduces peak flows in flood and drought periods
Water supply through storage and retention of water during the dry season	Reduces the risk of lack of water during the long dry season
Control of erosion and sedimentation of rivers through soil retention	Avoids filling of rivers and loss of soil nutrients carried by rainfall
Research and exploitation of genetic resources assured by maintenance of genetic diversity	Medicinal products, genetic material for use in agriculture
Contribute to growth of an extractivist economy based on production of wood and non-timber forest products	Madeira, borracha natural, sementes para fabricação de adornos, frutos, castanhas, etc.
Opportunities for recreational and leisure use	Ecotourism, adventure sports, observation of fauna and flora, etc.

Sparovek and Schnug (2001) show not only that sugarcane plots have a much higher rate of erosion than forests, but also that cane yields will decrease over time as erosion increases in intensively cultivated fields. This erosion is not only a problem in and of itself, but has implications for water quality as well. The BFC mandates 25-30% of each parcel of agricultural land in SP set aside, 20% as forest (Legal Reserve, or LR) and another 5-10% as fallow areas along riparian corridors and other ecologically sensitive areas (Areas of Permanent Preservation, or APP). There are several reasons why, however, even if it runs counter to their own interests, farmers may continue with practices that can harm water quality and reduce soil health and productivity, including high discount rates, poor property rights, or asymmetric information with farmers not realizing the erosion happening on their lands. (Wiebe and Gollehon, 2006). Add to these the costs incurred to plant forests and the opportunity costs of replacing lucrative sugarcane with forests and there are several barriers to compliance.

These points indicate that while the cane industry is growing in Brazil and specifically in SP, there are potentially both direct and indirect, external costs to typical cane production practices. The degradation of biodiversity resulting from monoculture production is another issue of great concern (Danielsen et al., 2009). Groom et al. (2007) concludes that “Biofuels will only be beneficial if they are cultivated under sustainable, biodiversity-friendly practices,” though, they point out, such eco-friendly methods are not often practiced (p.7). The reforestation methods used by Preiskorn et al. (2009), using native species to re-vegetate land previously planted with sugarcane, have been shown to conserve biodiversity (Rodrigues et al., 2009). Costs incurred to achieve the benefits enjoyed by society at large for these forests, however, are currently paid by producers and may exceed the direct benefits (Mueller and Alston, 2007). The broader social benefits of increased water, air, and soil quality, increased biodiversity, and other benefits that are difficult or impossible to quantify financially, may justify reforestation/afforestation on lands where sugarcane is grown. There are direct costs to producers for compliance in the form of reforestation costs as well as opportunity costs of dedicating land to forest rather than more lucrative sugarcane. And while there are some direct benefits to producers in the form of decreased erosion and increased water and nutrient cycling (Moreira, 2007), these benefits may not outweigh costs. There are larger societal benefits, however, in the form of increased water quality downstream (Momoli, 2006) and maintaining or increasing biodiversity (Groom et al., 2007). Brugnaro (2010) developed a quantitative model to value riparian corridors in SP by assessing people's willingness to pay for environmental benefits delivered by reforestation along riparian corridors, finding that 58% of SP residents surveyed were not willing to pay increased taxes to support reforestation. On the other hand, Bacha (2006) found that there is social demand for reforestation policies, but that past programs have been inadequate to meet this demand in a cost effective manner. Therefore, the objective of this chapter is to identify the difference in costs to comply with BFC legislation and then to identify other sources of revenue so that the costs incurred to increase societal benefits are borne by society at large.

Figure 2.2. Brazil's biomes and locations of sugarcane production. The Brazilian savannah includes the Pantanal grasslands and area to its east, north of the state of São Paulo Source: Smeets et al. (2008).

The Atlantic Rainforest ecosystem is one of the top five most important ecosystems in terms of diversity, containing nearly 3% of all species worldwide (Myers et al., 2000). As was mentioned above, APPs, which are mandated as buffer zones along waterways and are thus potentially continuous, contiguous ecosystems free of cultivated monocultures, have the potential to serve each of these purposes, protecting water quality and biodiversity while also guarding against erosion, allowing the cane energy sector to continue to flourish in an ecosystem that can provide the services necessary to sustain it.

Another benefit of forests is their ability to sequester carbon, and deforestation, or forest clearing, is one of Brazil's largest sources of carbon emissions (Vieira et al., 2005). Indeed, many recent discussions have named forests as a key and highly cost effective method to preserve the stability of the planet's climate, and have highlighted Brazil's importance and potential effectiveness in these efforts (Fearnside, 1998; Gouvello, 2010). There also appears to be public support for reforestation and afforestation as means to combat climate change, as evidenced by articles in the popular media that have been singing the praises of healthy forests (*The Economist*, 2009a; Barrionuevo, 2009), especially on agricultural land (*The Economist*, 2009b; Rosenthal, 2009). This could illustrate support in the English speaking North, but in the South and in the tropics, where many of the largest remaining forests are most threatened, support is less robust, and questions remain regarding who should pay, how, and how much, to ensure that land owners preserve these essential ecological features, while also creating jobs and achieving the other benefits of LRs and APPs discussed above.

Dedicating land to forests, particularly land that has been planted with agricultural crops, could put increased pressure on available land, potentially creating changes in more ecologically sensitive areas as land availability becomes limited. While availability of suitable arable land is not a constraint in Brazil in the foreseeable future, land use change is Brazil's main source of GHG emissions today, and "deforestation remains the key driver of Brazil's future GHG emissions through 2030 (Gouvello, 2010). Much of this deforestation would likely occur in the Amazon Rainforest, where commercial cane production is not viable due to climatic and soil quality constraints. However, cane production or increasing forests on and around cane plantations in Brazil's Center-South could still contribute to this distant deforestation through indirect land use changes

(ILUCs). There is considerable debate in the literature regarding the existence and extent of these ILUCs, Some contend that as sugarcane and ethanol production continue to increase in SP, direct land use changes have been occurring as pasture land is converted to grow cane (Sparovek et al., 2008), likely leading to forest being cleared in sensitive places such as the Amazon and Brazilian *Cerrado* to account for the reduction in available pasture in SP (Nepstad et al., 2008). US biofuels production may also be inducing ILUCs, as 30% of the U.S. corn harvest was dedicated to ethanol in 2009, rising prices and the gap in the food supply may induce farmers in other parts of the world, where land is much less productive, to convert more land to corn production (Searchinger et al., 2008). Tyner et al. (2011) provide important if not definitive insight on the question of ILUC assessment in the US context:

> "Some argue it is impossible to measure such changes [ILUCs]. Others argue that failure to measure the land use changes and the consequent GHG emissions would lead us to incorrect policy conclusions. After working on this topic for over two years, we come out between these extremes. First, with almost a third of the US corn crop today going to ethanol, it is simply not credible to argue that there are no land use change implications of corn ethanol. The valid question to ask is to what extent land use changes would occur. Second, our experience with modeling, data, and parameter estimation and assumptions leads us to conclude that one cannot escape the conclusion that modeling land use change is quite uncertain."

This assessment may or may not apply to cane ethanol in Brazil, where some (Cerqueira Leite et al., 2009; Goldemberg, 2007; others) argue that there is more than enough unused and underused land for increased cane production through intensification and extensification, leaving ample land for food and fiber production, as well as forests. Others (Nepstad et al., 2008; Altieri, 2009) argue that ILUCs are indeed a concern relevant to increased cane ethanol production in Brazil.

Understanding that ILUCs are important impacts that are also presently difficult or impossible to measure, and also slightly beyond the scope of this chapter, they remain important to consider in the present discussion. While the BFC mandates 20% of each parcel of land in SP be dedicated to forest as Legal Reserves, it requires 80% of each parcel to be forested in Amazonian states, and 35% in the Cerradoof Central Brazil (Mueller and Alston, 2007). Therefore, illustrating that the BFC can be cost effective in SP, where land is more valuable and productive, can set the example for less developed regions in Brazil to follow in protecting their forests. This is closely related to the problem of leakage, or increased emissions elsewhere because of these efforts to reduce GHGs through creating incentives for biofuels. Leakage may be less of a problem if Brazil were able to enforce legislation such as the BFC and Agro-Ecological Zoning nationwide.

Clearly, replacing sugarcane monoculture with forests can provide multiple values, but displacing lucrative cane production with forests, even given potential agricultural activities on LRs permitted by BFC legislation, could impose considerable direct costs on cane producers, in addition to the lost sugar cane revenue. Bacha (2006) analyzed several programs used to incentivize landowners towards reforestation for timber collection in the 1970's and 19080's, finding a range of US$ 67.56 to US$ 1266.45 (nominal dollars) paid per hectare of homogenous forest. Andrade and May (2009) estimate the cost of reforestation in the state of Mato Grosso, an Amazonian border state to the northwest of SP, at between R$2500 and R$4000 ha^{-1} (p.14). Martins (2004) describes reforestation efforts in SP and finds costs of R$2330 ha^{-1} compared with the data used for the present study, which cites implementation costs of R$6920 (Rodrigues et al., 2009), using methods that will allow for healthy succession of native species as well as selective timber harvest in later years. Adding the opportunity cost landowners incurred by forgoing the revenues from crop production or pasture for livestock, Andrade and May (2009) contend, the costs of the BFC are largely prohibitive.

2.2.1. Payments for Ecosystem Services

Several methods employed in other areas of Latin America present opportunities for cane producers to receive revenues and other compensation for having forests on their land and being compliant with BFC regulations. One market-based method would be the selective harvesting and sale of timber from LRs as outlined by Rodrigues et al. (2009). Another method is payments for ecosystem services (also known as payments for environmental services, or PES) such as government incentives based on part or all of the opportunity costs of foregoing cane production. A third possibility is payments for carbon sequestered by forests (Friberg, 2009; Benitez and Obersteiner, 2006; Persson, 2009). Such methods would help to match the external or societal benefits of healthy forests with those paying the costs to realize these benefits, sharing the responsibility with landowners who will realize some but not all of these benefits.

Two important aspects of PES defined by Engel et al. (2008) are additionality and voluntary participation. Additionality is also mandated under the Clean Development Mechanism, meaning that the service or land use would not happen under the status quo, ensuring that landowners are not being paid for something they would do without the payments. Since there are limited reforestation efforts (Moreira, 2007), few producers are compliant with BFC regulations (Bacha, 2005), and carbon payments are not currently in place (Friberg, 2009), the measures proposed under the present study would qualify for this additionality. Others have argued that producers who have already adopted more environmentally-friendly practices should be eligible for payments for their efforts (Classen et al., 2001), which would make Farm Scenario 1 below eligible for such payments.

It is true that the BFC is existing legislation that could on its own, if enforced, provide the ecological benefits listed above. As previously noted, however, producers are not currently adhering to it. As Engel et al. (2008) found in their study, echoed by Andrade and May (2009), a combination of market based PES in tandem with command and control mechanisms such as increased enforcement of the BFC may be far more effective than either one on its own. Landell-Mills and Porras (2002) also point out that a combination of government intervention and market based incentives are often more effective than either method used on its own.

One concern with set asides and related incentives such as PES is the potential decrease in demand for labor, the adverse effects of which could outweigh the environmental benefits (Engel et al. 2008). The specific BFC regulations outlined in the present study are less susceptible to this concern as at least 75% of the sugarcane cultivation on a participating landowners' property remains in sugarcane production, and the area dedicated to LR can be used for silviculture, bee keeping, fruit collection, or other activities demanding labor. This possible diversification of labor into other agricultural activities is even more important in light of the fact that mechanization is quickly replacing manual harvesting of sugarcane for a variety of reasons[1], with mechanization possibly reducing the direct demand for labor by 52-64% (Smeets et al., 2008). Indeed, Table 2.2 below shows a steady reduction in labor in the Brazilian agricultural sector, from 1.42M agricultural laborers in 1970 to 914,954 in 1995, and 873,087 in 2006. In the sugarcane sector the figures are at least as bleak, with a 23% reduction in the number of people employed between 1992 and 2005, with a 55% increase in cane production during the same time period (Azanha, 2007).

Table 2.2. Brazilian land use and agricultural labor. Cropland, pasture, and forest, by year, in hectares. Data from 2006 Agricultural Census, Brazilian Ministry of Agriculture.

Year	**1970**	**1985**	**1995**	**2006**
Brazil				
Cropland	33,983,796	52,147,708	41,794,455	76,697,324
%	13.81	16.28	13.32	21.98
Pasture	154,138,529	179,188,431	177,700,472	172,333,073
%	62.7	55.9	56.6	49.4
Forest	57,881,182	88,983,599	94,293,598	99,887,620
%	23.5	27.8	30.1	28.6
Total	**246,003,507**	**320,319,738**	**313,788,525**	**348,918,017**
# Employed in Ag. (all of Brazil)	1,420,040	1,357,113	914,954	873,087

[1] Manual harvesting is being phased out in Sao Paulo for four main reasons: protection of harvesters' and rural citizens' health against air pollution from cane burning, a push to certify labor which is driving up its cost, an increase in domestic production of tractors and other farm machinery which is decreasing the cost of mechanization, and increased demand for bagasse for electicity cogeneration in ethanol refineries and possible production of cellulosic ethanol in the future. Manual harvesting of cane requires burning of the fields prior to harvest in order to clear sugarcane leaves, or trash or *bagasse*, as well as dangerous animals such as snakes, spiders, and scorpions. These animals are dangerous for the cane cutters, but so is the smoke and soot left in the wake of the burning, for workers and nearby citizens alike (Arbex et al., 2007). These health concerns, as well as reports of low wages and other forms of worker exploitation have led to increased enforcement of labor regulations, monitored mostly by the usinas themselves, resulting in increased costs to hire and certify labor (Novaes, 2007). Meanwhile, the strength of the Brazilian currency, the Real (R$), and increasing industrialization in Brazilian agriculture, have led to companies such as Caterpillar and Case International placing factories in Sao Paulo, lowering the costs of mechanization. Finally, not burning the cane trash, or bagasse, in the field means that it is increasingly burned in the usinas in order to generate electricity, in a process known as "cogeneration," meaning burning in the field creates the loss of a valuable commodity. These factors combine to make bans on sugarcane burning, which have been tried with low levels of success for years, much easier to implement and enforce, with all burning in Sao Paulo projected to end in by 2017 (Macedo et al., 2008).

The recent, pronounced move to mechanization in the wake of the "Green Initiative" to eliminate cane burning in São Paulo by 2017 (Macedo et al., 2008), and thus all manual harvesting, means that the demand for agricultural laborers in the cane sector is bound to decrease even further in the coming years. This is a double edged sword for Brazilian rural development, where it is difficult to witness the loss of jobs in a country where each position is precious[2], yet it could be best for Brazil's development to move away from the low pay and dangerous conditions involved in cane harvesting as the new jobs ushered in by industrializing agriculture, though fewer, are more highly skilled, safer, and higher paying (Table 2.3). This could bring Brazil to surer socio-economic footing in the 21st Century. Therefore, the reforestation/afforestation methods and revenue-generating mechanisms proposed here may provide ecological and economic benefits for Brazilian landowners and workers alike.

Table 2.3. Agricultural wages in Piracicaba, Sao Paulo. Figures are in 2008 reais (R$). Data from Agriclutural Economic Institute of Sao Paulo).

Occupation	Low Wage	Avg. Wage	High Wage
Daily Laborer	14.83	26.4	30
Monthly Laborer	410	495.83	600
Tractor Driver	570	716	1000
Foreman	500	695	1100

Another potential barrier to PES discussed by Engel et al. (2008) is the transaction costs that can be incurred with monitoring and quantification of environmental services provided. To avoid this problem, landowners in Mexico have been compensated for the opportunity costs of potential revenues foregone in order to preserve forests, eliminating the need for monitoring the precise ecological or economic impacts of the services provided (Munoz-Pena, et al., 2008). The present study similarly analyzes input-based payments conditional on landowners implementing forests on a portion of their land, rather than output-based payments such as quality and quantity of water. This input based method is also used in Asquith et al. (2008), where the actual environmental services provided by forests on agricultural land in Bolivia are neither quantified nor even certain. Because outputs on biodiversity are extremely difficult to measure, this is a specific

[2] In 2009 Brazil had an unemployment rate of 8.2% and SP 9.4% (Banco Central do Brasil, 2011)

example of a program that did not attempt to measure the output, but based payments on the act of preserving a forest. In that program, several environmental services were bundled and landowners who implemented forests were paid in-kind services such as technical training. An exception to this lack of a need for quantification is payments for carbon sequestration, which necessitate measurement. Several studies from Sao Paulo are employed to estimate the sequestration capabilities of the forests that could be implemented.

A more specific, user-pays scenario could be implemented in cases such as those farms upstream from a hydro-electric plant. Hydro power is Brazil's largest source of electricity, accounting for just over 13% of its primary energy production, compared with 40% by petroleum (almost exclusively for transportation) and 9% from natural gas (EPE, 2009). If reforestation or afforestation upstream were to improve water quality as it was shown to do in the Momoli (2006) study, then those hydroelectric plants could be induced to make payments to landowners whose forestry practices benefitted their operations.

Though carbon sequestration payments require more monitoring that these, input based methods, studies have been performed by Martins (2004) and Ferez (2010) on the amount of carbon sequestered by areas reforested or afforested with native species in SP. Martins (2004) finds that areas forested with native species contain a stock of approximately 78 tons of carbon (tC) in their above ground biomass, continuing sequestration at a rate of 2.2 to 2.8 tons of carbon per year (tC yr^{-1}). Ferez measures the difference in carbon sequestered between plots that follow a more typical fertilization regime versus those that are more intensely fertilized, and finds a range of 1.1 to 3.4 tc yr^{-1} for the typical fertilization, and 3.7 to 4.8 tc yr^{-1} with higher fertilization.

Others have examined the potential for carbon payments to reduce GHG emissions in Brazil (Friberg, 2009) and elsewhere (Benitez and Obersteiner, 2006; Sohngen and Sedjo, 2006; Persson, 2009). Benitez and Obersteiner examine payments in the range of $US10-30 per ton of carbon sequestered, while Persson contends that it may take as much as $100 per ton to make a substantial and necessary difference from the status quo. Both the Brazilian Mercantile and Futures Exchange Commission, and the Brazilian National Development Bank have been working on implementation of carbon trading markets though these have not yet been monetized (Friberg, 2009).

2.2.2. The Brazilian Forest Code

The BFC mandates LRs on 20% of each agricultural plot in SP and other states of the Center-South region. In states in the area of the Amazon Rainforest, such as Amazonas and Pará, the requirement for forests on each plot is 80%. But, as of 1998, only 6.4% of producers had registered LRs Legal Reserves (LRs), down from 18.2% in 1972, and those numbers in Amazonas are even more discouraging, at 42.1% and 1.6% in 1972 and 1998, respectively (Bacha, 2005). Some agricultural activity, such as fruit collection or selectively thinned timber harvesting, is allowed, so long as the forest remains permanently in place. Areas of Permanent Preservation (APPs) are fallow areas mandated along waterways and other ecologically sensitive areas, usually accounting for another 5-10% of each plot of land, and no activity is allowed in these areas. The balance between both of these types of forest set aside is very important, completing essential, interwoven threads of São Paulo's economic, social, and ecological tapestry.

APPs may not provide the short term economic benefits possible on LRs, though they are at least as important due to their potential to connect ecologically diverse corridors throughout Sao Paulo (Groom et al., 2008), and may subsequently provide these economic benefits in the longer term (Paese et al., 2010). As recognized in R.H. MacArthur and E.O. Wilson's landmark publication, *The Theory of Island Biogeography* (1961), there is substantial evidence that isolated fragments of healthy ecosystems such as nature preserves, or in this case, LRs, may provide little ecological benefit (Soule and Simberloff, 1986), and that far reaching, continuous corridors are essential to environmental health. In his book furthering the work of MacArthur and Wilson, *Song of the Dodo: Island biogeography in an age of extinctions* (1996), David Quammen gives the example of a six foot by six foot, fine Persian rug, cut into 36, one foot squares:

> "Have we got thirty-six nice Persian throw rugs? No. All we're left with is three dozen ragged fragments, each one worthless and commencing to come apart. […] An ecosystem is a tapestry of species and relationships. Chop away a section, isolate that section, and there arises the problem of unraveling" (p. 11).

APPs along waterways throughout São Paulo have the potential to connect essentially interrelated ecosystems long since disconnected by development and increasing use of land for agriculture and other purposes. These connecting threads could be valuable for environmental services, maintaining the health of São Paulo's water (Momoli, 2006; Moreira, 2007), soil (Sparovek and Schnug, 2001), and climate (Fearnside, 1999), especially in an economy that is highly dependent on the functioning of these resources. But implementation of LRs and APPs has met with resistance. In February, 2009, Marcos Jank, President of The Brazilian Sugarcane Industry Association (UNICA), the influential sugarcane and ethanol producers' union in São Paulo, wrote an article published in one of the state's most widely read newspapers, *O Estado de São Paulo*, condemning Legal Reserves, arguing that the costs are prohibitive (Jank, 2009). As Asquith et al (2008) points out, the current situation of command and control could be greatly improved if it were complemented with economic incentives such as those assessed in this chapter. Andrade and May (2009) assess the situation in Mato Grosso, a state bordering Sao Paulo and one where much future expansion of sugarcane production will likely take place:

> "Until today, few cases of legal reserve compensation within protected areas have actually taken place. In Mato Grosso, the number of cases is no more than a dozen, while an additional number have been stalled from going ahead since 2005. This possibility should be better studied to identify the principal limitations, as it opens up an important opportunity for rural landowners to resolve their environmental responsibilities through compensation at a relatively lower cost than other options presented. Besides this, it would allow for new protected areas to be created, guarding these areas against further deforestation" (p.15).

If examples can be established to illustrate that agriculture can be both ecologically responsible and cost effective for producers, especially in a high profile sector such as biofuels in São Paulo, it could have a significant impact in motivating similar practices in other sectors and other land uses. This study analyzes detailed, empirical data regarding costs of sugar cane production. This analysis includes costs of forest implementation and maintenance to compare costs of sugarcane production under different scenarios, including non-compliance with the Brazilian Forest Code, as is common in the status quo, with the costs of compliance. Using these results, various policy measures are quantified and compared, identifying feasible measures to compensate producers for the increased costs of BFC compliance.

2.3. Data and Methods

To compare the economic differences between compliance and non-compliance with Forest Code legislation, producer revenues and production costs per hectare and per liter of ethanol are calculated for five model farms (Table 2.4). Using data from four consecutive sugarcane growing seasons as well as reforestation costs and relevant prices, I construct model farms that either comply with the forest code, with 75% of land dedicated to cane, 20% forested as LR, and 5% forested as APP[3]; or do not comply, with 100% of land dedicated to cane production. To explore the effect of reforestation and cane-planting costs, cost and revenue estimates are calculated for each scenario and type of producer and then applied to a 45-year horizon, which is the length of the reforestation study horizon used for this chapter. Cane producers are either "refineries," which produce the cane themselves for their sugar and ethanol refineries; or "independent producers," which are independent firms or individuals that produce sugarcane and sell to refineries.

Table 2.4. Farm scenarios. Scenarios have either of land dedicated 100% sugarcane production (noncompliant with BFC legislation), or 75% dedicated to cane, 20% to Legal Reserve (LR), and 5% as Areas of Permanent Preservation (APP).

Farm 1	Begins and continues in compliance: 75% cane, 20% LR, 5% APP
Farm 2A	Begins and continues with 100% cane
Farm 2B	Begins with 100% cane, moves to 75% cane, 20% LR, 5% APP
Farm 3A	Moves to 100% cane in Year 1.
Farm 3B	Moves in Year 1 to 75% cane, 20% LR, 5% APP

Refineries and independent producers show different costs and yields (Table 2.5), so are considered separately for each of the five scenarios. Three of the scenarios (1, 2A, and 2B) operate on land traditionally planted with sugarcane, while the other two (3A and 3B), operate on land newly planted with sugarcane. Data used for this chapter show that these also have different costs and yields, and as sugarcane is expanding to areas not previously planted with sugarcane it is also important to include each of these in the

[3] According to BFC law, only the 20% set aside as a Legal Reserve (LR) is mandated to be forests; Areas of Permanent Preservation (APPs) need only be fallow. All of these territories are forested in the scenarios for this article as several studies (Rodrigues et al, 2009; Preiskorn, et al., 2009, Momoli, 2006; others) have shown the positive ecological, and potential human health and economic benefits of forests along riparian corridors.

study for complete results. The BFC is applied equally to each of these types of producers, as a matter of law and for this chapter, but as they have different costs and yields the opportunity costs of compliance are different, which is why each of these scenarios must be considered.

Detailed data on sugarcane production costs are from Marques et al. (2009), describing costs for the 2007/08 harvest season; Xavier et al. (2009) for 2008/09; Xavier et al. (2010) for 2009/10; and Xavier et al. (2011) for 2010/11. This was a series of studies published by PECEGE, The Continuing Education Program in Economics and Business Administration at the University of Sao Paulo. Costs for the model are based on the averaged total costs from the four years and for each type of producer examined in these studies. The costs for these years range from R$2711.38 ha^{-1} (R$45.70 tc^{-1}) to 3757.94 ha^{-1} (R$59.58 tc^{-1}). Forest costs and revenues are from Rodrigues et al. (2009), which are based on empirical studies on land formerly planted with sugarcane in SP.

Table 2.5. Year-by-Year breakdown and four year averages of costs and yields. Costs and yields for sugarcane production after initial planting and ATR prices in Brazil's Center-South Region on land operated by refineries ("Refinery") and by independent producers ("Ind. Prod."). For costs of initial planting (applied to expansion scenarios 3A and 3B) see Table 2.6 below which lists costs of conversion to sugarcane production.

	Traditional			Expansion			
	R$ ton^{-1}	R$ ha^{-1}	Kg ATR ha^{-1}	R$ ton^{-1}	R$ ha^{-1}	Kg ATR ha^{-1}	ATR R$ kg^{-1}
2007/08							
Refinery	43.71	2916.00	12490.27	47.31	3128.00	12162.63	0.259
Ind. Prod.	48.11	2995.00	12167.94	43.66	2772.00	12984.12	
2008/09							
Refinery	46.30	2943.93	11484.96	46.79	2852.64	11236.51	0.257
Ind. Prod.	51.45	3083.04	12887.43	45.7	2711.38	11922.72	
2009/10							
Refinery	45.07	3392.9	10031.48	45.72	3360.56	11433.33	0.310
Ind. Prod.	56.43	3643.46	10505.20	49.72	3406.37	10949.54	
2010/11							
Refinery	51.72	3541.43	11416.44	45.65	3205.93	11590.31	0.361
Ind. Prod.	59.58	3757.94	11756.47	49.74	3564.84	12775.73	
2007-11 Avg.							
Refinery	46.70	3198.57	11355.78	46.37	3136.78	11605.70	0.286
Ind. Prod.	53.89	3369.86	11829.26	47.21	3113.65	12158.03	

A study by Van den Wall Bake et al. (2009) found a cost of US$ 14.90 per tonne of cane (tc^{-1}) for 2000-2004, projecting a reduction to US$ 9-12 tc^{-1} in 2020. A more recent study, also focused on SP (Crago et al., 2010) uses survey data from cane producers in SP to identify a cost of R$3074 per hectare ($ha^{-1}$), compared with R$3447 ha^{-1}, in the data used for the present study. These differences could be explained by any number of factors, including the fact that their data come largely from refinery-operated cane-producing land, while the data for this study involve a mix of both refineries and independent producers.

2.3.1. Farm Scenarios

To compare the difference between compliance with Forest Code legislation and non-compliance, producer revenues and production costs per hectare and per liter of ethanol are calculated under five different scenarios (Table 2.4, above) as follows. Farm 1 begins and continues in compliance with Brazilian Forest Code (BFC) regulations with 75% of its land dedicated to cane production, and the other 25% forested (20% RL, and 5% APP) with native vegetation as described in Rodrigues et al. (2010). Farm 2A begins and continues with 100% cane; Farm 2B begins with 100% cane and moves to compliance in year 1, with 75% cane, and 25% of its land dedicated to forest. Farm 3A moves to 100% cane in year 1; Farm 3B moves to 75% of its land dedicated to cane and 25% forested using the same methods as Farm 2B. Farms 2A and 3A are the most likely scenarios in the status quo, providing realistic comparisons for the costs of BFC compliance under different regimes. Scenario 3 is included because the costs to transition into cane production, similar to forest implementation costs, are considerably higher than a typical year of continued cultivation. The revenues are measured per year, discounted to 2008 at a rate of 0.06, the long term interest rate for that year (Banco do Brasil, 2011) to produce the discounted net present value (NPV) of profits. Production cost per liter (L) of ethanol per year is also measured, and averaged over the entire 45 years.

Costs and revenues vary by year for several reasons. Sugarcane is a perennial crop, harvested yearly, lasting an average of six years, with the highest costs incurred during the initial planting year, illustrated in scenarios 3A and 3B. For previously existing cane farms the costs are averaged as sugarcane does not follow a mechanistic, six year-cycle. Farmers may have different areas of land under different stages of production at any given time, depending on weather, varietals of sugarcane, and access to and application of fertilizers and other chemical inputs. Forest costs also follow a similar pattern, with higher costs for implementation, falling in years 2 and 3, and 20% of first year costs incurred every 10 years.

The rest of this section proceeds with a discussion of sugarcane data and production costs, broken in to three parts: cane production itself; an explanation of ATR, or total recoverable sugar (açucar total recuperável, in Portuguese); and finally the refinery stage of ethanol production. This is followed by a discussion of data sources and calculations for forest implementation and maintenance costs. The section finishes with the equations used for each scenario.

2.3.2. Sugarcane Production Costs

For sugarcane production costs, empirical data are from the PECEGE series of studies described above, performed on the four consecutive growing seasons, starting with 2007/'08 (Marques et al., 2009), and continuing with 2008/'09 (Xavier et al., 2009), 2009/'10 (Xavier et al., 2010), and 2010/'11 (Xavier et al., 2011). The annual costs for the four years are averaged. These are allowed to vary in the sensitivity analysis that follows results. In the case of land converted to cane from other uses, the FNP Anuario (InfoFNP, 2008) is used since, rather than averaging the costs per year, as is the case in Marques et al., FNP provides detailed figures for the first year of planting (Table 2.6). After the initial planting year, the Marques yearly averages for land newly converted to cane production ("Expansion") are used. Operating costs for sugarcane production include machinery, labor, inputs such as fertilizer and pesticides, and administration (Tables 2.4 and 2.5). Costs of land are not included in cane production costs since these costs are incurred whether the land is planted with cane or forested. Depreciation and cost of capital are also included, all calculated ha^{-1}. Costs are divided between two types of land operators, refineries, or *usinas*, and independent producers (Table 2.7), referred to in Portuguese as *fornecedores*, or producers.

Table 2.6. Refinery costs for sugarcane production. Figures for sugarcane production costs are in Reais (R$) per hectare. Conversion data are from FNP Anuario (2007). Traditional, Expansion, and Northeast data are from Marques et al. (2009). "Traditional" refers to the states of São Paulo (except the far western portion), Paraná and Rio de Janeiro; "Expansion" refers to western São Paulo, Mato Grosso do Sul, and Minas Gerais; NorthEast includes Pernambuco and Alagoas (see map in Apendix B).

	Conversion	**Traditional**	**Expansion**	**Northeast**
Cost Items				
Machinery	1100.76	673	626	716
Labor	456.88	463	629	868
Inputs	1057.23	755	766	687
Land	266	266	199	107
Administration	315	315	277	498
Operat. Costs	**3195.87**	**2,471**	**2,497**	**2875**
Depreciation	482	482	579	294
Total Oper. Cost	**3677.87**	**2,953**	**3,075**	**3169**
Cost of land	187	187	153	121
Cost of capital	228	228	251	165
Total Cost	**4092.87**	**3,368**	**3479**	**3455**

Table 2.7. Independent producer costs for sugarcane production. Figures for sugarcane production costs are in Reais (R$) per hectare. Traditional, Expansion, and Northeast data are from Marques et al. (2009)."Traditional" refers to the states of São Paulo (except the far western portion), Paraná and Rio de Janeiro; "Expansion" refers to western São Paulo, Mato Grosso do Sul, and Minas Gerais; NorthEast includes Pernambuco and Alagoas (see map in Apendix B).

Cost Items	**Traditional**	**Expansion**	**Northeast**
Machinery	922	986	623
Labor	479	619	806
Inputs	712	677	690
Land	158	153	56
Administration	376	193	268
Oper Costs	**2,647**	**2,629**	**2,442**
Depreciation	325	172	156
Tot Oper Cost	**2,972**	**2,802**	**2,598**
Cost of land	294	199	172
Cost of capital	181	125	98
Total Cost	**3,447**	**3,126**	**2,868**

Due to the high costs of transportation and low transportability of sugarcane, refineries in the Marques et al. study have an average radius of 22 km from which they draw their cane. A portion of this land is owned by the refinery, a portion leased and operated by the refinery, with the rest of the land in that radius owned and operated by the independent producers. The ratio of land owned and/or operated by the refinery, versus operated by the independent producers, varies widely for each refinery, with an average of 64% owned or leased by the refinery and the other 36% in their catchment area owned and operated by independent producers (Macedo et al., 2008). Because costs of production and cane yields vary significantly between refineries and independent producers, results are reported separately for each. The cost of converting and preparing land for cane production reported by the FNP Annuario are the same for both refineries and independent producers.

2.3.3. ATR and The Ethanol Refinery (*Usina*)

Total recoverable sugar (*Açúcar Total Recuperável*, or ATR) is measured at the refinery to compensate producers appropriately for the quality, and not just the quantity, of their sugarcane, and as a means of revenue sharing between producers and refineries. A liter of ethanol requires 1.73 kg of ATR, averaged between 1.77 kg for anhydrous ethanol and 1.69 kg for hydrous ethanol (CONAB, 2009). Hydrous ethanol may contain up to 7% water and is sold to consumers at 100% ethanol pumps, as opposed to anhydrous ethanol, which is permitted to contain no more than 0.7% water and is blended into gasoline at rates of 20-25% ethanol (Marques et al., 2009).

Table 2.8. Ethanol production costs. Refinery costs listed by region, as presented in Marques et al. (2009).

Cost Items (R$ ton^{-1} of cane)	**Traditional**	**Expansion**	**Northeast**
Cane	40.53	44.09	49.08
Labor	3.67	3.67	3.28
Inputs	2	2.04	2.24
Maintenance	4.14	4.14	3.83
Administration	3.51	3.24	4.72
Industrial	*0.5*	*0.5*	*0.5*
Assess. of admin	*3.01*	*2.74*	*4.22*
Operat. Costs	**53.84**	**57.18**	**63.15**
Depreciation	3.2	3.2	3.2
Total Oper. Cost	**57.04**	**60.38**	**66.35**
Cost of capital	5.31	5.31	5.31
Total Cost	**62.35**	**65.69**	**71.65**

The ATR yield per hectare (ha^{-1}) varies among years, types of producer, and region, with the highest reported yield coming from independent producers in expansion territory during the 2007/'08 season, with 12984.12 kg ATR ha^{-1}. The lowest average annual yield reported in the PECEGE studies is from refineries during the 2009/'10 growing season in areas previously planted with sugarcane, with 10031.48 kg ATR ha^{-1} (Table 2.5 above). Revenues for cane producers as calculated in this study are based on the ATR content for each type of land, either traditional or expansion fields, and by type of producer, either refinery or independent producer. Refinery costs are not included in the results for this study as the intent is to determine compensation for cane producers since they face the higher cane production costs from setting their land aside for APPs and RLs. Refining costs differ depending on the region, with the costs of each listed below in Table 2.8.

Other important aspects of the sugar and ethanol refineries relevant to this discussion include the influence refineries have had on industry regulation and the move from manual to mechanized harvesting. As mentioned in the footnote above regarding the move from manual to mechanized harvesting, there has been a substantial increase in monitoring and enforcement of labor regulations in the Brazilian agricultural sector, and the refineries have been essential in helping to monitor labor certification, greatly improving efforts to ensure that all sugarcane laborers are paid adequately and work in safe, healthy conditions (Novaes, 2007). This has not always been the case, as Martinelli and Filoso (2008) discuss, but there has been much attention paid to labor conditions that have recently been improving (Azanha, 2007). Hence, the refineries may be able to provide the monitoring and enforcement of BFC regulations where their cane is grown to certify compliance and eligibility for the payments discussed in Section 5.

2.3.4. Forest Implementation and Maintenance Costs

Empirical data for costs of reforestation/afforestation and forest maintenance are from *Pacto Pela Restauração Da Mata Atlântica : Referencial dos conceitos e ações de restauração florestal (Agreement for the Reforestation of the Atlantic Rainforest: Reference for concepts and actions in forest restoration*), edited by Roberto Rodrigues (2009). Forest implementation costs for the first year are higher, at R$6920.00 per hectare, than second or third year costs, at R$1123.00 and R$789.00 per hectare, respectively. Forest maintenance costs of R$1384 ha^{-1}, 20% of first year costs, are incurred again every ten years. These costs are higher than those found in other studies mentioned above (Martins, 2004; Andrade and May, 2009), but are used here as the methods in the Rodrigues et al. (2009) create healthy succession of native species on land formerly dedicated to sugarcane monocultures and allow for selective harvesting and sale of timber as well as potential revenue data from these sales. The studies by Martins (2004) and Andrade and May (2009) do not necessarily involve native species that can be harvested in a consistent and profitable fashion. The Rodrigues (2009) study is therefore used because it specifically provides for this harvesting as well as estimated profits from sales of selectively harvested timber. The higher figures also provide a more conservative (higher) estimate of the opportunity costs incurred with BFC compliance.

2.3.5. Farm Scenario Profit and Cost Equations

The revenues for the profit functions below are calculated as the kilograms of ATR generated per hectare (kg ATR ha^{-1}), multiplied by the proportion of land on which cane is grown, multiplied by R$0.286, which is the average price of ATR per kg over the four growing seasons used for this study, from 2007/08 to 2010/11 (UNICA, 2011). Production costs are calculated as the cost of cane production ha^{-1} multiplied by the proportion of land on which cane is planted, added to the costs of forest implementation and maintenance where applicable.

Cane production costs for Farms 1, 2A, and 2B are R$3198.57 ha^{-1} for refineries and R$3369.86 ha^{-1} for independent producers, which are the costs of sugarcane production on traditional cane-producing land averaged over the four seasons (Marques et al., 2009, for 2007/08; Xavier et al., 2009, for 2008/09; Xavier et al., 2010, for 2009/10; and Xavier et al., 2011, for 2010/11). First year cane production costs for Farms 3A and B, which convert to cane production from another land use are considerably higher, at R$4092.87 per hectare (InfoFNP, 2008). These higher costs are attributed to activities such as leveling and terracing the land, which are necessary when preparing land for sugarcane cultivation. After the first year, production costs are R$3113.65 and R$3136.78 ha^{-1} yr^{-1} for independent producers and refineries, respectively, which are the costs of production on land to which cane has newly expanded (Marques et al., 2009). For Farm 1, cane costs are added to forest maintenance costs of R$1384 ha^{-1} incurred every 10 years. Farms 2B and 3B incur forest implementation costs of R$6920 ha^{-1} in year 1, R$1123 in year 2, R$789 in year 3, and R$1384 ha^{-1} for maintenance costs every 10 years. Farm scenario equations are presented in Figure 2.2, with cost functions per hectare included in scenario profit functions.

Figure 2.3. Farm scenario profit and cost functions.

Cane for ethanol production cost functions: $C_{EtOH} = [\text{Cost ha}^{-1}] / [\text{L EtOH ha}^{-1}]$

Farm 1A $\Pi = \Pi F_{1A} = [0.75(Q_{ATR}) * P_{ATR}] – [0.75C_{ST} + 0.25C_{FY}]$

Farm 2A $\Pi = \Pi F_{2A} = [Q_{ATR} * P_{ATR}] - C_{ST}$
Farm 2B $\Pi = \Pi F_{2C} = [0.75(Q_{ATR}) * P_{ATR}] – [0.75C_{ST} + 0.25C_{FY}]$

Farm 3A $\Pi = \Pi F_{3A} = [Q_{ATR} * P_{ATR}] - C_{SE}$
Farm 3C $\Pi = \Pi F_{3C} = [0.75(Q_{ATR}) * P_{ATR}] – [0.75C_{SE} + 0.25C_{FY}]$

Where
C_{EtOH} = Cost of sugarcane in 1 liter of ethanol
Q_{ATR} = Quantity of ATR yielded per ton of cane
P_{ATR} = Price of ATR
C_{ST} = Cost of sugarcane production per hectare on traditional cane land
C_{SE} = Cost of sugarcane production per hectare on cane expansion land
C_{F3} = Cost of Forest for year 3
C_{FY} = Cost of Forest for year t, changes by year
R_{ST} = Revenues per hectare from sugarcane on traditional cane land
R_{SE} = Revenues per hectare from sugarcane on cane expansion land

2.4. Results

The objective of this chapter is to calculate the costs of compliance with the Brazilian Forest Code (BFC), and, later, to identify means of compensating producers for these increased private costs in order to align the costs with the environmental benefits outlined in Section 2.2 above. The costs are higher for Farm 3B in the expansion region, as are profits for both 3B and 3A, which is its non-compliant counterpart in the expansion region. The costs are highest for independent producer 3B at R$3805.69, discounted to NPV, or R$84.57 averaged over the 45 years. As is discussed in the sensitivity analysis in the next section, when ATR prices fall and cane production is not profitable, it becomes advantageous to be in compliance with the BFC. Other than these times, the net private costs of compliance create a disincentive. Mechanisms to compensate producers for the increased costs are discussed in Section 2.4.2.

Table 2.9. Opportunity costs of BFC compliance. Comparison of identical scenarios and producers, with only difference being noncompliance with BFC regulations (A Scenarios), and compliance (B Scenarios). Difference per year is 45 year scope of scenarios, discounted to present value using the Brazilian long-term interest rate of 6%.

		A	B	Difference	Diff. Year^{-1}
Farm 2 Refinery	Avg. Costs	3198.57	2478.75	**719.82**	**16.00**
	Avg. Revenues	3246.86	2435.15	**811.72**	**18.04**
	Disc. NPV of Profit	791.29	-1971.91	**2763.20**	**61.40**
Ind. Prod	Avg. Costs	3369.86	2607.22	**762.64**	**16.95**
	Avg. Revenues	3382.24	2536.68	**845.56**	**18.79**
	Disc. NPV of Profit	202.85	-2413.24	**2616.09**	**58.14**
Farm 3 Refinery	Avg. Costs	3158.03	2448.34	**709.69**	**15.77**
	Avg. Revenues	3318.32	2488.74	**829.58**	**18.44**
	Disc. NPV of Profit	2018.06	-1051.84	**3069.89**	**68.22**
Ind. Prod	Avg. Costs	3135.41	2431.38	**704.03**	**15.65**
	Avg. Revenues	3476.24	2607.18	**869.06**	**19.31**
	Disc. NPV of Profit	4961.24	1155.55	**3805.69**	**84.57**

For land operated by refineries, Farm 3A, which converts to 100% cane production in the first year, achieves the lowest costs, at R$0.4703 for the cane required for a liter of ethanol (Table 2.10) and highest profits at R$2018 (Table 2.12) for all refinery scenarios. It earns revenues on 100% of its land, and despite the higher costs of cane implementation in the first year, lower costs relative to yields provide it with the greatest advantages over the long term. Refinery Farm 3B has the next lowest costs, followed by 2A (noncompliant), 1 (compliant), and 2B (noncompliant). The highest refinery profits are also achieved by the noncompliant producers, Farms 3A and 2A, respectively, followed by Farm 1, which begins in compliance (75% cane, 25% forest), then 3B and finally 2B. Because Refinery Farm 3B is producing on only 75% of its land, it incurs much lower costs per hectare, but compliance also results in less production, hence the negative profits shown in Table 2.10.

Table 2.10. Refinery sugarcane costs by year with compliance. Costs for refinery-produced sugarcane in 1L EtOH, averaged between 1.77 kg ATR L^{-1} of anhydrous EtOH and 1.69 kg ATR L^{-1} of hydrous EtOH, based on data from CONAB (2008).

Farm:	1	2A	2B	3A	3B
Year					
1	0.5570	0.4868	0.8378	0.6095	0.9530
5	0.4868	0.4868	0.4868	0.4671	0.4671
10	0.5570	0.4868	0.5570	0.4671	0.5358
45	0.4868	0.4868	0.4868	0.4671	0.4671
Yearly Avg:	**0.4946**	**0.4868**	**0.5030**	**0.4703**	**0.4861**
Increased Cost of Compliance:			**0.0162**		**0.0158**

Table 2.11. Refinery profits by year with compliance**.** Profits are discounted to net present value using the 2009 Brazilian long term interest rate of 6% (Banco do Brasil, 2011).

Year / Farm:	1	2A	2B	3A	3B
1	-309.78	48.30	-1693.78	-774.56	-2310.92
5	27.07	36.09	27.07	135.65	101.74
10	-172.98	26.97	-172.98	101.37	-117.18
45	3.32	4.43	3.32	16.65	12.49
Disc. NPV	**-147.50**	**791.29**	**-1971.91**	**2018.06**	**-1051.84**

Before examining the independent producers, it is important to discuss in greater detail the differences in costs and productivity between them and the refineries. As discussed above, though the BFC is applied equally to all producers in Sao Paulo, the differences in production costs and yields result in different opportunity costs. Refineries have slightly higher production costs in areas traditionally planted with cane (Farms 1 and 2), but have lower costs in lands newly converted to cane production, and also have higher productivity in expansion areas (Table 2.12). Marques et al. (2009) hypothesize that independent producers have lower costs because refineries typically make higher cost investments in new cane operations such as ferti-irrigation systems that pump *vinasse*, a potassium-rich byproduct of cane processing. This byproduct is likely not sufficient to boost cane productivity on the whole since this ferti-irrigation is generally limited to the land adjacent to the refinery (Macedo et al., 2008). The vast expanses of most refinery-operated cane apparently do not allow for the careful cultivation that is possible on the independent producers' smaller plots, which could explain the differences in productivity.

Table 2.12. Costs and yields. Figures for refineries and independent producers in traditional and expansion areas averaged across all four seasons used in this chapter, 2007/'08-2010/'11.

	Traditional	Expansion
Refineries		
Cost ha^{-1}	3198.57	3136.78
ATR ha^{-1}	11355.78	11605.70
Ind. Prod's.		
Cost ha^{-1}	3369.86	3113.65
ATR ha^{-1}	11829.26	12158.03

Furthermore, it could be that intensive cultivation practices diminish the fertility of soil, making land newly planted to cane more productive than land that has had cane planted for several previous cycles (Marques et al., 2009; and pers comm. with author Leonardo Zilio). If these hypotheses are in fact valid, they highlight the need for greater soil and ecosystem health discussed in the background section above as potentially being provided by forests on and around cane plantations. Further exploring the differences between different types of producers as well as between subsequent years is certainly interesting and important, but is beyond the scope of this study, which focuses on investigating the different economic outcomes of compliance and non compliance with BFC regulations.

In terms of cane production costs for ethanol, independent producers in expansion areas have higher yields of ATR ha^{-1} than independent producers on traditional cane land, equating to the two lowest costs for Farm 3A at R$0.4457 and 3B at R$0.4608 (Table 2.13). Farms 2A, 2B, and 1 are third, fourth, and fifth, respectively, for independent producers. Because costs for cane production are so high on traditional land, Farm 1 actually gains an advantage over Farm 2A and can produce at a lower cost (R$0.4840) despite dedicating 25% of its land to forest. This advantage is not enough to overcome the high cost of forest implementation, however, so that Farm 2A produces at a lower average cost (R$0.4896) than 2B (R$0.5047).

Table 2.13. Independent producer sugarcane costs by year with compliance. Costs for sugarcane in 1L EtOH, averaged between 1.77 kg ATR L^{-1} of anhydrous EtOH and 1.69 kg ATR L^{-1} of hydrous EtOH, based on data from CONAB (2008).

Year / Farm:	1	2A	2B	3A	3B
1	0.5831	0.4923	0.8293	0.5818	0.9097
5	0.5128	0.4923	0.4868	0.4426	0.4426
10	0.5831	0.4923	0.5597	0.4426	0.5082
45	0.5128	0.4923	0.4923	0.4426	0.4426
Yearly Avg:	**0.5206**	**0.4923**	**0.5079**	**0.4457**	**0.4608**
Increased Cost of Compliance:			**0.0155**		**0.0151**

Independent producer profits follow almost the same pattern as costs, with the high yields on expansion land giving Farm 3A the highest profits at R$4961 (Table 2.14). Those high yields also benefit Farm 2A, which has the third highest profits at R$120.29, due to dedicating 100% of its land to cane. Forest implementation and maintenance costs hold Farm 2B to the lowest profits of independent producers, at R$33.21, with Farm 1 fourth at R$73.75. Farm 3B has the second highest profits, followed by 3B, 2A, 1, and finally 2A. Farm 3B is the only compliant producer which is profitable over the scope of the 45 year horizon.

Table 2.14. Independent producer profits by year with compliance. Profits are discounted using the 2009 Brazilian long-term interest rate of 6% (Banco do Brasil, 2011).

Year / Farm:	1	2A	2B	3A	3B
1	-336.71	12.38	-1720.71	-616.63	-2192.47
5	6.94	9.25	6.94	270.95	203.21
10	-188.02	6.91	-188.02	202.47	-41.35
45	0.85	1.14	0.85	33.26	24.94
Disc. NPV	**-588.83**	**202.85**	**-2413.24**	**4961.24**	**1155.55**

2.4.1. Sensitivity Analysis

As is typical with agricultural cost, price, and yield data, many of the production costs used for this chapter come from case study estimates and are subject to variation. Sensitivity analysis is performed to determine which aspects could most affect the results, as well as affecting the cost-effectiveness of compliance with BFC regulations. Changes in ATR prices, the discount rate, and labor and machinery prices were employed under a variety of scenarios, and are discussed here in that order.

Based on the results above, an elasticity[4] of refinery revenues and profits with respect to the price of ATR can be found in Table 2.15. Elasticity results for independent producers can be found in Table A3.5 in the Appendix. When comparing between the low and high ATR prices experienced during the four years for this chapter, elasticity of revenue with respect to ATR is close to 1 for all five scenarios (1.02 for the traditional region scenarios 1 and 2, and 0.90 for expansion scenarios 3). These are identical by region because they have the same revenue structure, but because costs are different based on whether they convert to compliance or convert to cane, elasticities of profit with respect to ATR price are unique for each scenario and much lower, ranging from 0.004 to 0.007 for undiscounted profits.

[4] "Elasticity" is the defined as "The ratio between the proportional change in one variable and the proportional change in another" (Black, 2009).

Table 2.15. Elasticity of refinery revenues and profits with respect to ATR price.

ATR:	2007/08 0.2587	2008/09 0.2569	2009/10 0.3102	2010/11 0.3613	Max-Min 2010/11-2008/09
Farm 1					
Cane					
Revenues		0.0816	3.7966	0.5062	1.0211
PROFITS		0.0061	0.0325	-0.0635	-0.0318
Disc. Profits		**0.0059**	**0.0390**	**-0.0652**	**-0.0382**
FARM 2A					
Cane					
Revenues		0.0816	3.7966	0.5062	1.0211
PROFITS		0.0072	-0.0044	-0.0537	0.0043
Disc. Profits		**0.0072**	**-0.0044**	**-0.0537**	**0.0043**
FARM 2B					
Cane					
Revenues		0.0816	3.7966	0.5062	1.0211
PROFITS		0.0048	0.0723	-0.0740	-0.0707
Disc. Profits		**0.0024**	**0.1461**	**-0.0935**	**-0.1428**
FARM 3A					
Cane					
Revenues		0.0858	0.9075	0.9116	0.9018
PROFITS		0.0023	0.0077	0.0352	0.0026
Disc. Profits		**-0.1718**	**-0.0477**	**0.0295**	**-0.0177**
Farm 3B					
Cane					
Revenues		0.0858	0.9075	0.9116	0.9018
PROFITS		0.0861	-0.1276	0.0131	-0.0427
Disc. Profits		**-1.0589**	**-0.2846**	**-0.0143**	**-0.1052**

The uncertainty generated by unknown future prices and the effects it has on farmers' decisions whether or not to enroll land in a US environmental protection program, the Conservation Reserve Program (CRP) is examined by Isik and Yang (2004), who find that this uncertainty significantly reduces willingness to enroll in programs such as the CRP and BFC, where enrollment is irreversable. These price variations are therefore important to consider for the uncertainty they may create in cane producers. These results indicate that higher ATR prices decrease the incentive to protect forests and the aspects of ecosystems protected or improved by having forests on cane land.

Accordingly, a change in the price of ATR was found to have the largest impact on the results for profits across scenarios. The price was varied from the model price of

R$0.286 to the 2007/08-2010/11 low of R$0.242, and the high price of R$0.389 (Table 2.16). The move to the season's high caused the largest change of 9732% in refinery Farm 1. That adjustment advantaged all scenarios dedicating land to forest, moving refinery Farm 1 from the third highest average annual profit of R$147.50 to the highest profit, or least losses of all refineries, of R$-6331.82. The high ATR price gave larger advantages to un-forested Farms 2A and 3A, increasing their profits by R$19139 and R$19561, respectively.

Varying each of the two largest cost items for cane production, labor and machinery, by 29% up and down, which is the variation in labor costs in the two main cane-producing regions in SP (Piracicaba and Riberao Preito) for the 2007/08 growing season, we find that machinery costs have a slightly larger impact on results. These two are also particularly important because of the aforementioned move to mechanization and mending elimination of manual harvest. This illustrates the potentially increasing volatility of cane and ethanol production costs with fluctuations in fuel and machinery prices. Further investigation is certainly merited, but is not possible with available data nor is it within the scope of the present study.

For the discount rate, three different figures were used. The base model figure is the 2009 long term Brazilian interest rate of 6% (Banco do Brasil, 2011). The low figure is provided by the U.S. discount rate of 4% used by Crago et al. (2010) for their comparison of US corn ethanol and Brazilian cane ethanol production costs. The higher figure comes from the 2005 Brazilian long-term interest rate of 9.5% (Banco do Brasil, 2011). This variation did not affect ranking for refineries nor for independent producers, and had little noteworthy impact.

Table 2.16. Refinery profit sensitivity analysis. Discount rate ranges from 2008 rate of 6%, the US rate of 4% (Crago et al., 2010), and the 2005 Brazilian rate of 9% (Banco do Brasil, 2011). ATR Price ranges from the four year average, the low, and the high for the same period (UNICA, 2011). Wages for agricultural laborers in SP varied by an average of 29% during the 2007/08 season (IEA, 2011), leading to the range of 29% above and below the labor costs presented in Marques et al. (2009). As detailed machinery costs were not available, that cost was allowed to vary by the range presented for wages. A similar table for Independent Producers is in the appendix in Table A3.6.

	Discount Rate (0.06)		**ATR Price (Avg 0.286)**		**Labor Cost**		**Machinery Cost**	
	0.04	**0.095**	**L (0.242)**	**H (0.389)**	**-29%**	**29% +**	**-29%**	**29% +**
Farm 1								
Base	-147.50	-147.50	-147.50	-147.50	-147.50	-147.50	-147.50	-147.50
New	-135.81	-163.36	-6331.82	14207.42	1281.54	-1576.54	4299.75	-4594.75
Difference	11.69	-15.86	-6184.32	14354.92	1429.04	-1429.04	4447.25	-4447.25
% Change	7.9%	-10.8%	-4192.8%	9732.2%	968.8%	-968.8%	3015.1%	-3015.1%
Farm 2A								
Base	791.29	791.29	791.29	791.29	791.29	791.29	791.29	791.29
New	1040.79	547.34	-7454.47	19931.19	2696.68	-1114.10	6720.96	-5138.37
Difference	249.50	-243.96	-8245.77	19139.89	1905.39	-1905.39	5929.66	-5929.66
% Change	31.5%	-30.8%	-1042.1%	2418.8%	240.8%	-240.8%	749.4%	-749.4%
Farm 2B								
Base	-1971.91	-1971.91	-1971.91	-1971.91	-1971.91	-1971.91	-1971.91	-1971.91
New	-1972.13	-1968.26	-8156.23	12383.01	-542.87	-3400.95	2475.34	-6419.16
Difference	-0.22	3.65	-6184.32	14354.92	1429.04	-1429.04	4447.25	-4447.25
% Change	0.0%	-0.2%	-313.6%	28.0%	72.5%	-72.5%	225.5%	-225.5%
Farm 3A								
Base	2018.06	2018.06	2018.06	2018.06	2018.06	2018.06	2018.06	2018.06
New	2955.81	1101.12	-6409.18	21579.17	4133.27	-97.15	6407.48	-2371.36
Difference	937.76	-916.94	-8427.23	19561.11	2115.21	-2115.21	4389.42	-4389.42
% Change	46.5%	-45.4%	-417.6%	969.3%	104.8%	-104.8%	217.5%	-217.5%
Farm 3B								
Base	-1051.84	-1051.84	-1051.84	-1051.84	-1051.84	-1051.84	-1051.84	-1051.84
New	-535.86	-1552.92	-7372.26	13619.00	534.57	-2638.24	2240.23	-4343.90
Difference	515.98	-501.08	-6320.43	14670.83	1586.41	-1586.41	3292.07	-3292.07
% Change	49.1%	-47.6%	-600.9%	1394.8%	150.8%	-150.8%	313.0%	-313.0%

Sensitivity analysis on labor and machinery costs is the most complex of these variations due to the diversity of production regimes (manual vs. mechanized harvest), positions employed (harvester, tractor driver, foreman, etc.), and wages paid to these different positions. Also, as was explained above, there is an ongoing movement from mostly manual harvesting to what Macedo et al. (2008) predict will be an eventual phase out of all manual harvest in the coming years. The data in Marques et al. (2009) present farms ranging from 100% manual to 100% mechanized harvest, even from land producing cane for a single refinery. Their data are not, however, sufficiently detailed to allow for accurate disaggregation. Therefore, likely scenarios are presented using wage data from the Instituto Economia Agricola (Agricultural Economics Institute) (IEA, 2011) in Sao Paulo. Their figures show an average range of +/-29% among same year wages for the same agricultural occupation in within municipalities. Labor costs from Marques et al. (2009) were therefore lowered and raised by this amount to see the result on annual average profits, presented in Table 2.16. Machinery costs were also varied by 29% because similar detailed, reliable data on machinery costs were not available. The specific elasticities of labor and machinery with respect to both revenues and profits (similar to how the elasticities of ATR are presented above) can be found in the Appendix in Tables A3.7-A3.10.

The scenarios in Table 2.16 are meant only for comparison under hypothetical circumstances as it is not possible to determine how many of each type of occupation would be used by individual landowners, nor which proportion of land will be under mechanized versus manual harvest. The calculations are further complicated by differences in machinery costs under each harvest regime, as well as differences in revenues, as these may currently come from refineries able to sell electricity back in to the grid when it is generated by burning sugarcane leaves (*bagasse*) that must be burned in the field prior to manual harvest. Manual harvest necessitates the burning of the cane prior to harvest to make collection easier for workers, but this burning is not necessary with mechanized harvest. As efficiencies in these operations improve, more electricity can be generated, and it may soon be possible to extract sugars for additional ethanol production from *bagasse* that is harvested mechanically rather than burned in the field. All of this gives refineries with more land under mechanized harvest increasing advantages over time, though the economic magnitude of these advantages is as yet undetermined.

A change in labor costs of 29% had the greatest impact on Farm 1's average annual profits by nearly 1000%, from the model calculation of R$-147.50 to R$1281.54 with a reduction labor costs, or down to R$-1576.54 with a 29% increase in costs. Disregarding percent change and looking only at the change in magnitude of profits, noncompliant scenarios 2A and 3A experienced the largest changes in profits due to incurring greater labor costs since 100% of their land is planted with cane and requires maintenance. The changes due to varying machinery are similar among refinery scenarios, with Farm 1 experiencing the largest percentage change of just over 3000%, and the noncompliant scenarios 2A and 3A experiencing the largest change in profit figures as they require more machinery on 100% of land planted with cane than those scenarios that plant on only 75% of their land. All independent producer sensitivity analysis figures are in Table A3.6 in the appendix.

As we see two changes, ATR prices and machinery costs, having substantial impacts on the comparative profitability of farm scenarios, two conclusions can be drawn from this sensitivity analysis, neither of which is very surprising. The first is that higher ATR prices advantage those producers with a greater proportion of their land dedicated to sugarcane production, while lower prices advantage BFC compliant producers who dedicate land to forest. The second conclusion is that higher labor costs disadvantage producers employing more labor-intensive production regimes. For the cane-energy sector as a whole, it could mean less cost volatility as producers more to greater mechanization, but only if mechanization is not subject to similar fluctuations in cost.

2.4.2. Potential Payments to Producers.

Three potential revenue streams were identified in the literature for producers who comply with BFC regulation. Payments based on opportunity costs are perhaps the most straightforward possibility (Asquith et al., 2008; Munoz-Pena et al., 2008) as they do not rely on measurement of outputs but can be calculated as a proportion of revenues lost due to dedicating land to forest rather than sugarcane. Payments for carbon sequestration have also been discussed (Friberg, 2009; Persson, 2009), presenting another possibility. Finally, revenues from sale of selectively harvested thinned timber is another, market-based method discussed in detail by Rodrigues et al. (2009).

If payments for ecosystem services like those described in (Engel et al., 2008) or payments for hydrological services discussed in (Munoz-Pena et al., 2008) are provided to cover part or all of the opportunity costs forgone with compliance with BFC regulations, then calculating appropriate sizes for these payments can be based on the figures in Table 2.9 above. Two other forms of compensation include payments for carbon sequestration or revenues from timber sales as discussed in Rodrigues et al. (2009). The results of these payments on profits and costs, as well as comparisons with noncompliant scenarios 2A and 3A are presented in Tables 2.17 and 2.18.

Table 2.17. Refinery profits with forest revenues added. Timber payments are averaged between optimistic and conservative projections (Rodrigues et al., 2009) and are entered into model from Year 1 for Farm 1, and Year 6 for Farms 2B and 2C. Carbon sequestration payments begin in year 1 for all compliant ("Compl."), forested farms (1, 2B, 3B).

	Farm 1	Farm 2A	Farm 2B	Farm 3A	Farm 3B
Base Profits (NPV)	**-147.50**	**791.29**	**-1971.91**	**2018.06**	**-1051.84**
Avg. Timber Rev's	8625.64		6082.51		6082.51
C Seq (US$20 tC^{-1})	342.34		342.34		342.34
End Profits (NPV)	**8820.48**	**791.29**	**4452.94**	**2018.06**	**5373.01**
	Compl	No Compl.	Moves to Compl.	Moves to Cane, No Compl.	Moves to Cane and Compl.

Table 2.18. Independent producer profits with forest revenues added. Timber payments are averaged between optimistic and conservative (Rodrigues et al., 2009), entered into model from Year 1 for Farm 1, and Year 6 for Farms 2B and 2C. Carbon sequestration payments begin in year 1 for all forested farms (1, 2B, 3B).

	Farm 1	Farm 2A	Farm 2B	Farm 3A	Farm 3B
Base Profits (NPV)	**-588.83**	**202.85**	**-2413.24**	**4961.24**	**1155.55**
Avg. Timber Rev's	7742.98		6082.51		6082.51
C Seq (US$20 tC^{-1})	342.339		342.339		342.339
End Profits (NPV)	**7496.49**	**202.85**	**4011.61**	**4961.24**	**7580.40**
	Complies	No Comply	Moves to comply	Moves to Cane, No Compl.	Moves to Cane and Compl.

Though results indicate that timber sales could make compliance more profitable than noncompliance, selective timber harvest from Legal Reserves is not currently used in the status quo, and therefore it cannot be assumed that it will be adopted without either further incentives, increased enforcement of BFC legislation, or both, which is why other methods such as the two described here must be included in the discussion.

Using the average of optimistic and conservative rates of timber growth as presented in Rodrigues et al. (2009), these revenues can compensate an annual average of R$135 ha^{-1} those producers (2B and 3B) planting forests in Year 0, or R$198.00 for the Farm 1 scenarios with existing forests, accounting for an average of nearly R$0.04 L^{-1} (Tables 2.15, 2.17). For these and figures below, revenues from timber sales are measured over the 45 year timeframe, and averaged over that period. As was stated above, it cannot be expected that this practice will be readily adopted by producers even with these potential revenues. A study by Valdivia and Poulos (2009) on farmers' willingness to plant forests on agricultural land as part of the US CRP found that knowledge of forest farming as well as perception of environmental problems were the largest determinants of adoption, and that payments were not as influential. If these findings are also valid in the Brazilian context, state and federal agencies may benefit not only from increased enforcement of the BFC and payments matching a portion of timber revenues, but also education regarding some of the private costs incurred with soil and water quality degradation, as well as forestry options.

The methods for and benefits of these reforestation practices are described in Preiskorn et al. (2009), Rodrigues et al. (2009), and Momoli (2006; et al., 2007). Thinning practices involve extracting rows of trees that mature at different rates, thus serving varying stages of ecological succession while also providing consistently extractable resources without inhibiting ecological function.

Table 2.19. Refinery cane costs minus forest revenues. Production cost for the amount of cane in 1L of ethanol, with timber revenues averaged between optimistic and conservative growth projections (Rodrigues et al., 2009), beginning in Year 1 for Farm 1 and Year 6 for Farms 2B and 3B. Carbon sequestration payments (C Seq) begin in Year 1 for all forested farms (1, 2B, 3B).

	Farm 1	**Farm 2A**	**Farm 2B**	**Farm 3A**	**Farm 3B**
Base Cost	**0.4946**	**0.4868**	**0.5030**	**0.4703**	**0.4861**
Avg. Timber Rev's	-0.1105		-0.0958		-0.0675
C Seq (US$20 tC^{-1})	-0.0042		-0.0042		-0.0041
End Cost	**0.3799**	**0.4868**	**0.4030**	**0.4703**	**0.4145**
	Complies	No Comply	Moves to comply	Moves to Cane No comply	Moves to Cane Moves to Comply

For new forests, as in the case of Farms 2B and 3B, forest revenues do not begin to accrue until the year 6, when trees are adequately mature for harvest. The reforestation practices involved in these empirical studies as well as the selective thinning leading to timber revenues are in compliance with BFC regulations. If forests can be implemented over time, it would defray the substantial initial planting costs and likely lead to less pronounced initial losses for Farms 2B and 3B, and, with discounting, higher average profits over time. For full details, both conservative and optimistic timber revenues, refineries and independent producers, and profits and cost of cane for ethanol, see Table 2.21 and Tables A3.11 – A3.13 in the appendix.

Carbon sequestration payments account for far less revenues at R$342 ha^{-1} (Tables 2.17, 2.19) at US$20 per ton of carbon ($tC^{-1}$), or R$0.004 L^{-1} of ethanol. Even if payments are increased to US$100 tC^{-1}, these revenues still only account for changes in average annual profits of R$1117 ha^{-1} (Tables 2.19 and 2.20), or just over R$0.02 L^{-1} (Tables 2.29 and 2.30), and it is difficult to see under what conditions such high prices could occur. Though efforts by the Brazilian Mercantile and Futures Exchange Commission and others are continuing, these payments have rarely been monetized (Friberg, 2009), so the present study uses the central figure of US$20 per ton used by Benitez and Obersteiner, with sensitivity analysis performed to find what level of payment could be necessary to induce landowners to implement forests on their land. The more likely but still uncertain price of US$20 tC^{-1} has minimal impact on prices or profits, indicating a need for some form of government intervention to offset the opportunity costs of BFC compliance.

Table 2.20. Independent producer cane costs minus forest revenues. Production cost for cane in 1L of ethanol, with timber revenues averaged between optimistic and conservative timber growth projections (Rodrigues et al., 2009), beginning in Year 1 for Farm 1 and Year 6 for Farms 2B and 3B. Carbon sequestration payments begin in Year 1 for all forested farms (1, 2B, 3B).

	Farm 1	Farm 2A	Farm 2B	Farm 3A	Farm 3B
Starting Cost	**0.5206**	**0.4923**	**0.5079**	**0.4457**	**0.4608**
Avg. Timber Rev's	-0.1105		-0.0919		-0.0894
C Seq (US$20 tC^{-1})	-0.0042		-0.0041		-0.0040
End Cost	**0.4059**	**0.4923**	**0.4119**	**0.4457**	**0.3674**
	Complies	No Comply	Moves to comply	Moves to Cane No comply	Moves to Cane Moves to Comply

In light of the volatility illustrated in the sensitivity analysis, both refineries and independent producers could benefit from the hedge provided by diversifying their revenue streams. Whether with timber revenues, other agricultural activity permitted on Legal Reserves, or carbon sequestration or other payments for ecosystem services, revenues from forests and different forms of PES could provide a strong incentive to move beyond dependence solely on cane and ethanol production.

Table 2.21. Net present value of refinery profits with timber sales. Conservative (Cons) and Optimistic (Opt) projections are based on timber growth rates, with middle column presenting the average between the two.

	Timber Cons	Timber Avg	Timber Opt
Farm 1			
Base	-147.50	-147.50	-147.50
New	6274.71	8773.14	11271.58
Difference	6422.21	8920.64	11419.08
% Change	-4354.0%	-6047.9%	-7741.8%
Farm 2B			
Base	-1971.91	-1971.91	-1971.91
New	2407.05	4110.60	5814.15
Difference	4378.96	6082.51	7786.06
% Change	-222.1%	-308.5%	-394.8%
Farm 3B			
Base	-1051.84	-1051.84	-1051.84
New	3327.12	5030.67	6734.22
Difference	4378.96	6082.51	7786.06
% Change	-416.3%	-578.3%	-740.2%

2.5. Policy Implications and Conclusions

This chapter has shown that though there can be considerable costs associated with implementing new forests to comply with BFC regulations, there are also multiple options for producers to earn compensation for these costs. Perhaps the most obvious possibility is for the Brazilian government to encourage implementation of Legal Reserves and Areas of Permanent Preservation domestically. Indeed, there is strong aversion to foreign entities putting pressure on Brazil regarding what it ought to do with its forests. There has been considerable discussion among people in the industry as well as academia that these laws may be amended and then enforced. Therefore, the potential policy measures to be outlined here are all voluntary, with producers choosing, based on market-based and other incentives, whether or not to participate in forest preservation and reforestation efforts. If specific areas can be identified as particularly sensitive or higher priority for reforestation or afforestation, those areas should be prioritized for increased incentives to producers to comply with BFC legislation. The Brazilian government could, if there were a change of heart regarding Forest Code legislation, institute a combination of incentives for compliance and penalties for failing to comply, employing a combination of command and control as well as market-based incentives (Landell-Mills and Porras, 2002).

Two potential examples of PES, one domestic and one international, are payments by downstream water users, and cooperation between international companies, such as ethanol importers or petroleum companies, and local organizations such as research facilities or NGOs. The reservoir reforestation project in Iracemapolis, SP (Momoli, 2006), illustrates both the potential negatives and positives of cane producers working with water users to protect this essential resource.

Carbon payments are another possible market mechanism to pay landowners for reforestation. The global climate summit in Copenhagen did not produce the binding agreement some had hoped would come out of the event, but there is still considerable interest in carbon payments The US$ 20 per ton that may or may not be included in a future version of a Waxman-Markey bill would not be enough to cover the differences in revenues under the scenarios in the results of this study, but they would at least contribute to making compliance less costly, and, in conjunction with the other methods outlined here, would aid in allowing producers to remain profitable while in compliance with BFC legislation.

Another possible mechanism to compensate BFC-compliant cane producers lies in product differentiation. Just as consumers are often willing to pay premium prices for organic food or sweatshop-free clothing, a public or private certification system could reward cane and ethanol producers who follow BFC guidelines. This could, however, create a system under which more ecologically-responsible consumption is a privilege of the wealthy. Whatever the combination of government and market-based incentives that might be adopted, the proposed framework must remain a choice for landowners. In the definition of payments for environmental services provided by Engel et al. (2008) discussed above, voluntary participation is a key aspect. Hence, if producers perceive economic or other benefits, they may participate. If not, with present levels of enforcement by local officials, there is no additional pressure put upon them to comply, alleviating the risk of an entitlement trap, as discussed by Wunder (2006). Even in the event that Brazilian government agencies begin to impose fines on noncompliant producers, it is entirely possible that producers will choose to pay these fines and remain non-compliant, which is, in effect, a voluntary system.

3. Increasing Brazilian Sugarcane Production for Ethanol: Stakeholders' Priorities for their Environment, Economy, and Society

3.1. Introduction

As biofuels production continues to rise, there is disagreement in the academic literature regarding the potential positives and perils of increased feedstock production. Specifically, some claim that Brazilian sugarcane ethanol production can and should increase by as much as an additional 100% (Goldemberg, 2007; Macedo et al, 2008). Others are more cautious, contending that land use constraints (Lapola et al., 2010; Nepstad et al., 2008), social issues (Martinelli et al., 2011; Hall et al., 2011), or tradeoffs of food versus fuel (Timilsina et al., 2010; Runge and Senauer, 2007) may outweigh the benefits of increased biofuels production. In either case, demand for biofuel feedstock is expected to continue to rise in the face of government mandates for increasing use of renewable fuels in the US, EU, and other potential importers of Brazilian ethanol. Furthermore, increasing mechanization and industrialization of the sector is bringing larger firms into prominence, possibly pushing out independent producers who, some say (Mendonça, 2011), may be better able to accomplish socio-economic development more effectively than larger firms. The healthy debate among these divergent perceptions can help to push biofuels towards some of their original intentions of being a cleaner, renewable, domestically produced energy resource.

There is, however, a dearth of studies assessing the viewpoints of a diverse array of stakeholders inside the cane-ethanol sector. People in industry, academia, and others who currently and will continue to play a prominent role in determining the sector's direction need to be asked what they see as the perceived benefits and potential disadvantages of the sector, and how these ought to be addressed. Therefore, this chapter addresses two central questions: What are the socio-economic and environmental priorities for the sector's future growth among stakeholders in Sao Paulo (SP), Brazil's main sugarcane- and ethanol-producing state; and, in what administrative bodies—private, public, NGOs, or others—do stakeholders have the most confidence to encourage their priorities?

As Brazilian production of cane and ethanol is poised for a substantial increase, and there is disagreement regarding which are the most pressing priorities that the sector ought to address, it is important to understand the perspectives of stakeholders on the ground in Brazil. Surveys were therefore administered to 119 stakeholders in Sao Paulo, asking respondents to rank their priorities for the development of the sector and their economy in general, as well as concerns regarding potential socio-economic and environmental impacts (Table 3.1 below describes the groups from which these were drawn).

A review of the literature as well as preliminary, informal interviews helped to guide the content of these surveys and the five main priorities and sub-priorities listed in Figure 3.1 and discussed in the literature review below. Surveys were designed according to methods prescribed in Tourangeau, et al. (2000) and Fowler (1995). A second set of 36 semi-structured interviews was conducted (Table 3.2 describes the groups from which these were drawn, and Table 3.13 below provides the full list) after surveys to shed light on and add more complete detail to survey results.

Table 3.1. Survey respondent affiliations. Surveys were anonymous, but were delivered to these groups. ESALQ is the agricultural campus for the University of Sao Paulo. Number is approximate due to potential for undergraduate students to be in graduate classes and vice versa. "Professional Students" refers to working professionals taking weekend and evening graduate courses at USP.

Approx. Number	Group
41	ESALQ Grad. Students
40	ESALQ Undergraduates
28	USP Professional Students
5	ESALQ Professors
5	Cane Prod's, Gov't, NGOs

Based on preliminary interviews, secondary research, and earlier contact with stakeholders, I proposed to test the following hypotheses:

Table 3.2. Interviewee affiliations. A complete list of interviewees and their affiliations is available in Table 3.X below.

Number	Group
5	Cane Producers
9	Ethanol Firm Representatives
11	Academia
6	Industry Organizations
4	Cane Workers and Worker Organizations
1	Government Officials

A. With the Surveys:
   1. Job creation would be the most important priority held by stakeholders, followed by protection against displacement of food production, with protection of natural resources the least important priority;
   2. The Brazilian government and domestic private sector would be the preferred administrative bodies to oversee the pursuit of these priorities, though respondents

may not view these priorities as sufficiently important for their implementation to become mandatory.

B. With the Interviews:

1. Respondents would view increasing mechanization and industrialization negatively and as a threat to independent producers, arguing that the environmental and socio-economic priorities would be impacted negatively by these processes and, even though the processes may reduce costs, the priorities should be placed before lowered costs potentially offered by larger firms and economies of scale;

2. Conglomerate firms would either disagree outright with the need to place the other priorities above lowered costs, or would argue that they are better positioned to accomplish these other priorities as well as generate greater profits for themselves and revenues for Brazil;

3. Researchers and others outside the private sector would be opposed to increased cane production and particularly intensification due to potential negative environmental and socio-economic problems arising with the sector's growth, negating the achievement of the priorities outlined above.

- **Infrastructure** (education, health, physical infrastructure, etc.)
  - Education; Health; Roads and other physical infrastructure; Other
- **Job Creation**
  - More jobs; Jobs with higher pay; Safer, healthier jobs; Jobs requiring higher education; Other
- **Protection Against Displacement of Food Crops**
  - Food production for domestic consumption; Food production for export
- **Protection of Natural Resources**
  - Air quality; Soil quality; Water quality; Amazon Rainforest; Atlantic Rainforest; Biodiversity; Other
- **Institutions** (rights, security, research, etc.)
  - Legal System; Research; Strengthened democracy; Combat crime; Combat corruption; Other
- **Other Aspect** (Brief explanation: ________________________________)

Figure 3.1. Main and sub-priorities. Main priorities are in bold and respondents were first asked to rank these 1 (most important) through 5 (least important) or 6 if they marked "Other," which 8 of the 119 respondents did. Respondents were then asked to rank sub-priorities independently for each main priority. For example, within "Infrastructure," they may have ranked "Education" as #1, Health as #2, etc., and would then start again for the sub-priorities for "Job Creation."

The results indicate that there is widespread optimism about the ability of the cane-energy sector to fulfill the priorities outlined in Figure 3.1, provided there is continued monitoring and enforcement of existing legislation and ongoing public and private participation in the programs to further environmental and socio-economic goals. The first survey hypothesis was largely rejected, as protection of natural resources was the highest ranked priority, yet the specific protection of the Amazon and Atlantic Rainforests, areas frequently discussed in the literature, were less important to the surveyed stakeholders than were the protection of water, air, soil, and biodiversity. Perhaps somewhat surprising to people outside of Brazil, protection against displacement of food production, which I hypothesized would be the second most important priority, was the least important concern. Contrary to the second hypothesis, nearly 80% of respondents (79.8) stated that their top priority should be mandatory (56% reported that their lowest priority should be mandatory), and 40% listed their top priority as more important than firms' profits.

For interview results, the first hypothesis was also largely rejected as most interviewees, including several representing small, independent cane growers and ethanol refineries, welcomed the industrialization and mechanization of the industry. Only five responded as was hypothesized, that smaller producers will be better able to create jobs and protect natural resources. The second interview hypothesis was basically supported as representatives from larger firms saw their companies as capable of generating jobs for less educated Brazilian workers as well as protecting natural resources. The third hypothesis was rejected as academics and all but one of the stakeholders outside the private sector saw great potential for the cane-energy sector to contribute positively to the five main priority areas. This pattern assumed that there is continued monitoring and enforcement of recently enacted government legislation as well as continuation of the private sector programs mentioned above and discussed in greater detail in the results section below.

These results, discussed in greater detail below, as well as the chapter as a whole, are meant to add to existing literature by identifying the most pressing economic, environmental, and social issues discussed in the literature and elsewhere today regarding the Brazilian cane-energy sector, and asking a diverse sample of stakeholders what they view as the most important priorities. This research seeks to assess what institutions these stakeholders see as most able to administer these priorities, and what programs and policies are in place, in both the private and public sectors, to address them. Because renewable fuels are gaining increased attention only recently, and many of the issues and programs discussed below are still inchoate or nascent, this chapter can serve as a benchmark for the issues that will require attention in coming years.

3.1.1. Background and Review of Existing Literature

The Brazilian cane-energy sector, until 2005 the world's largest producer of biofuels, already represents a significant portion of the Brazilian economy and energy matrix (Figure 3.2). Though cane occupies only 1% of Brazilian land use and 3% of its agricultural land including pasture and cropland (Figure 3.3, IBGE, 2007), it accounts for 17% of its agricultural output value (Valdez, 2007).

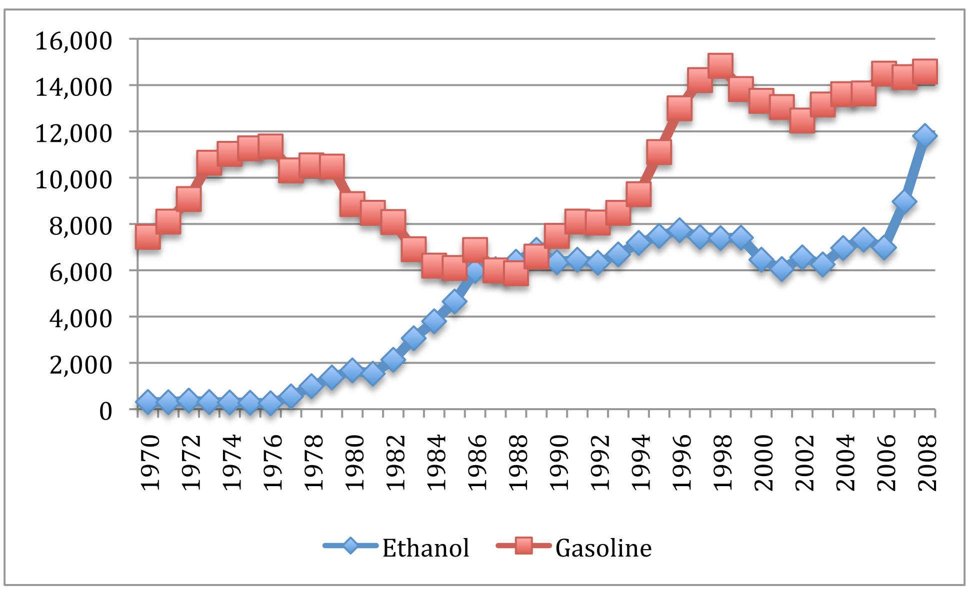

Figure 3.2. Brazilian use of ethanol and gasoline. Listed in thousands of tons petroleum equivalent. Source: Brazilian Ministry of Mines and Energy (https://www.ben.epe.gov.br/BENSeriesCompletas.aspx)

In the past several years, the cane-energy sector has been undergoing major changes not only in terms of increased production (Figure 3.3, Table 3.3), but also industrialization, consolidation of land holdings, and increased attention paid to its treatment of workers and expanding land used for production. In light of this attention, as well as disagreement regarding which of these to prioritize and how to address them, the objective of this study is to identify the priorities of stakeholders in SP's cane-energy sector among a set of issues that, while somewhat separable for a clearer discussion, are in fact inextricably linked. For example, the increasing mechanization of the sector could have positive environmental impacts through decreased cane burning in the field, and more electricity generated by burning the cane leaves (*bagasse*) in the refineries (Macedo et al., 2008). It will likely also have a negative impact on the number of people employed by the cane-energy sector (Azanha, 2007), hence the need to flesh out stakeholders' particular priorities.

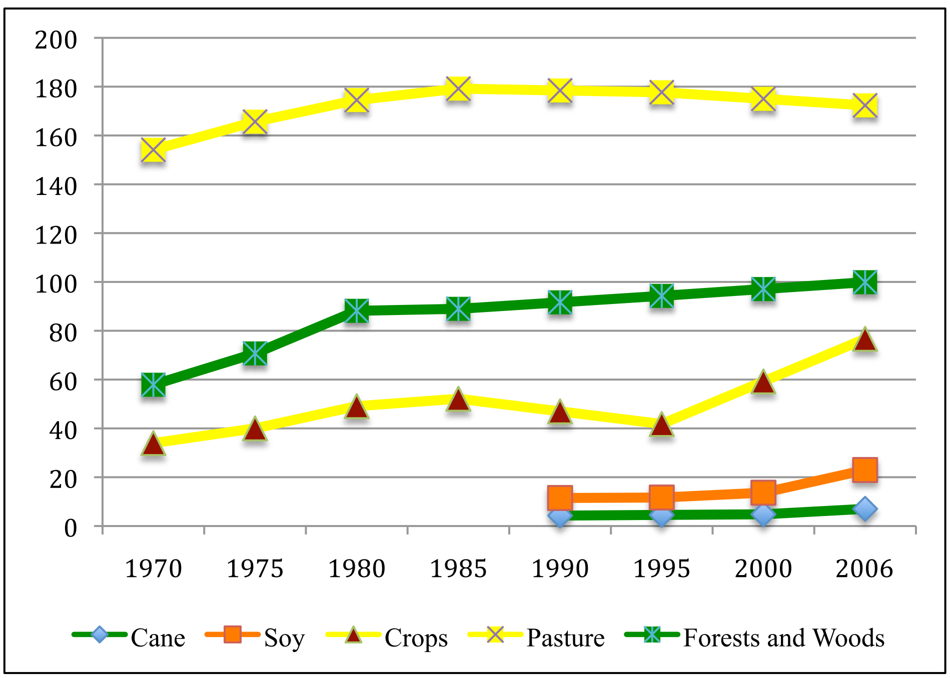

Figure 3.3. Brazilian land use, 1970-2006. Listed in millions of hectares. Source: Brazilian Ministry of Agriculture, 2007.

Martinelli and Filoso (2009) pinpoint the need for balance among these linked issues by illustrating the importance of a healthy agri-business sector to Brazil's economy, representing 25% of the country's GDP. This aspect also recognizes that though these benefits have not been equitably distributed among the population, the cane-energy sector remains positive due to its potential to close the gap between urban and rural incomes. Martinelli and Filoso (2009) conclude that even given these facts, "Continuous expansion will not only jeopardize the mega biodiversity of Brazilian flora and fauna, but also vital functions that ecosystems provide to sustain the same agricultural systems that are so important for the Brazilian economy" (p.24).

Table 3.3. Historical Brazilian cane production**.** Harvest year 2000 refers to 1999/2000 harvest season, etc. Area harvested figures are in millions of hectares (Mha), production in M tons, and yield in tons per ha. Source: 2000-2008 data from IGBE, 2009; 2009-2010 data from CONAB, 2010.

Year	Area Harvested	% Change	Production	% Change	Yield	% Change
2000	4.82		325.33		67.51	
2001	4.96	2.90%	344.28	5.82%	69.44	2.86%
2002	5.1	2.82%	363.72	5.65%	71.31	2.69%
2003	5.37	5.29%	389.85	7.18%	72.58	1.78%
2004	5.63	4.84%	416.26	6.77%	73.88	1.79%
2005	5.76	2.31%	419.56	0.79%	72.83	-1.42%
2006	6.19	7.47%	457.98	9.16%	74.05	1.68%
2007	6.56	5.98%	489.96	6.98%	74.73	0.92%
2008	7.29	11.13%	558.14	13.92%	76.61	2.52%
2009	7.06	-3.16%	571.43	2.38%	80.97	5.69%
2010	7.53	6.66%	612.21	7.14%	81.29	0.40%

The role played by the sector in Brazil's social and environmental health has increasingly impacted the sector's practices and future directions. Examining "ecoinnovation" in a comparison between the US and Brazilian biofuels industries, Gee and McMeekin (2011) conducted secondary research as well as semi-structured interviews with 19 stakeholders in Rio de Janeiro, and in Campinas and Piracicaba in SP. They concluded that attention paid to environmental issues has played a significant role in shaping the biofuels industries as they exist today in both countries. Bolwig and Gibbon (2009) found that Brazilian cane-energy sector participants in a Swedish conference investigating the sustainability and potential importation of Brazilian ethanol perceived benefits from their participation. These benefits included greater transparency and communication can reduce doubts consumers may hold about the industry's practices, specifically the firms for which participants work, and set them apart in the minds of these consumers from those producers not participating in such efforts. Others wonder if the sector's efforts in such sustainability areas are sufficiently substantive to solve for the harms they create, or if they are merely "greenwashing" what in reality is an environmentally destructive and socially exploitative industry (Mendonca, 2011). Clearly, there is a host of potentially competing priorities, including protection of natural resources, the potential impacts of dislocating food production, and related socio-economic issues, respectively.

3.1.2. Protection of Natural Resources

A major question is the use of finite arable land, even in a country as expansive as Brazil, and how to accommodate increasing demand for energy as well as food and fiber, while also protecting the country's forests, the world's largest stocks of fresh water and biodiversity, and other aspects of environmental health. The Brazilian government has been working with cane producers and their largest association, UNICA (Sugarcane Industry Association), to determine acceptable land allocation rules. These discussions have resulted in the recently released Zoneamento Agroecologico de Cana (Agro-Ecological Zoning for Sugarcane), a national program describing which areas may be used for cane production, and which are off limits (ZAE, 2010). There is still concern, however, regarding impacts of sugarcane production in permitted areas on valuable resources. Water use and quality is one central concern despite the fact that very little sugarcane production utilizes irrigation. Ethanol production requires $1.83m^3$ of water per ton of cane (tc^{-1}), though this had decreased, down from $5m^3\ tc^{-1}$ in the 1990s (Duffey et al., 2007). Gunkel et al. (2007) found that cane plantations that did not maintain vegetated buffer zones along waterways posed serious problems to water quality from agri-chemical runoff in Northeastern Brazil. Hartemink (2008) and Moreira (2007) found similar problems posed by cane production in SP. A major problem has been the disposal of *vinasse* and the runoff from ethanol refineries. *Vinasse* is a byproduct from cane refining, a liquid effluent high in potassium that had caused significant problems with water (Smeets et al., 2008). At lower concentrations it is actually an excellent fertilizer, but refineries often lack the infrastructure to distribute the *vinasse* effectively.

Soil quality is another issue of concern, although the erosion rates for cane, 12.4 tons of soil per hectare per year ($ts\ ha^{-1}\ yr^{-1}$), are about half the rates of erosion for grain production in Brazil, at 24.5 $ts\ ha^{-1}\ yr^{-1}$ (Duffey et al., 2007). Sparovek and Schnug

(2001) found an erosion rate of approximately 15 ts ha^{-1} yr^{-1}, which they extrapolated to mean that in approximately 361 years, intensive cane production in Southeastern Brazil could decline to one-half of its current productivity.

The threat posed to biodiversity by monoculture has also been a global concern (Myers et al., 2000), and is of particular importance in Brazil due to the high biodiversity areas of the Atlantic and Amazon Rainforests (Rodrigues et al., 2008). Displacing higher diversity areas such as rainforest or savannah in the Brazilian *Cerrado*, located in the center of the country and a likely area for cane expansion (Sparovek et al., 2007), could be an economic concern if the functioning of the ecosystem is hampered. Further, displacing natural areas with cropland or pasture is also a pressing concern in terms of greenhouse gas emissions (GHGs) from deforestation (Nepstad et al., 2008). Using spatial analysis, Lapola et al. (2010) conclude that direct land use changes from increased production of ethanol from sugarcane and biodiesel from soy will be minimal, but that the indirect effects of displacing rangeland into previously forested areas of the Amazon Rainforest will create a carbon debt that could take as long as 250 years to repay.

3.1.3. Protection Against Displacement of Food Production

These socio-economic and land use concerns also include the often-discussed issue of food security and the potential for a decreased supply to raise food prices, threatening poorer people's ability to purchase food. A World Bank study (Timilsina et al., 2009) finds that current biofuels targets pursued by governments such as those in the US, Brazil, and Europe would not affect food supplies on the global level and would induce minimal (1-8%) increases in the price of the main biofuels feedstocks of sugar, corn, and oilseeds. However, these policies could have the most pronounced negative effects in countries in Southern Asia and Sub-Saharan Africa. Naylor et al. (2008) discuss the linkages between biofuels production and food prices and wages paid to agricultural producers, pointing out that while there may be rises in food prices due to biofuels production, there may also be a corresponding rise in agricultural wages that offsets the negative impacts of increasingly expensive food. Compounding the complexity, they also point out that many agricultural producers are actually net consumers of food, consuming more food than they produce, meaning that price rises could have more negative effects than positives for people in rural areas. Rathmann et al. (2010) seem to pick up where Naylor et al. leave off, arguing that the potential increases in food commodity prices in the short-term will begin to fall when cellulosic biofuels begin wider production in the next ten years, thereby reducing the competition between food and fuel. They also contend that increases in food prices caused by biofuels production have so far been minimal, and that at least some of these price increases are caused by dedicating land to low-energy biofuels feedstocks such as corn for ethanol and soybeans for biodiesel. In addition, restricting biofuels to those feedstocks with the highest energy content, namely Brazilian sugarcane, is the most efficient option until technology is developed that can extract the lower energy levels found in oilseeds, starchy crops, and eventually cellulose.

The rise in food prices experienced in 2008 was examined in detail by Abbot et al. (2008, updated in 2009), where they find that 17% of that rise could be attributed to biofuels production. Four other factors also combined to create a sort of perfect storm: the rise in petroleum prices; changing food consumption practices, particularly increased meat consumption in developing countries such as China and India; the depreciation of the US dollar; and a series of poor harvests in countries such as Australia and the USSR.

If there is a significant rise in food prices, which biofuels may or may not induce, the impacts on the poor, for whom food represents a larger proportion of expenditures, will be the most pronounced. These issues lead to examination of related factors such as land rights and job creation since poorer people are those losing jobs as the sector moves towards greater mechanization (Azanha, 2007). Due to these interrelations, it is essential to consider these issues together in the larger context of the biofuels debate.

3.1.4. Job Creation, Infrastructure, Institutions, and Related Socio-Economic Issues

The issue of land use, whether for food, fuel, or protection of natural resources, is becoming increasingly intertwined with social and economic issues, as illustrated in the Brazilian Federal Constitution, where Article 184 mandates that all land serve "a social function." There is, however, disagreement as to which priorities should be privileged under this directive, with tension often existing between job creation versus preservation of environmental health. In the interview with Marcia Azanha, professor of economics at ESALQ and author of articles about the labor market for sugarcane (Azanha, 2007), she defined the “social function” as producing energy, sugar, profits, and jobs, in that order. Later in the same interview, however, she said that job creation was more important for the Northeast of Brazil, while environmental protection should be a higher priority in São Paulo and the Center-South Region. It seems that how to interpret “social function,” and where the priorities lay, exactly, is not clear. Therefore, land use issues cannot be examined in isolation, but must be addressed simultaneously to learn the tensions and possible resolutions between land use and environmental health, job creation, and other socio-economic considerations.

Some contend that growth in Brazil’s cane-energy sector will increase the country’s GDP, generate tax revenues and quality employment opportunities for those with less education, and also encourage infrastructure and other industrial development in separate but related areas (Fava Neves et al., 2010). Several capacity building programs are discussed in Dufey et al. (2007), mainly programs dedicated to technical assistance in areas such as increasing cane yields and increasing yields of ethanol per unit of sugarcane. These may help indirectly with job creation, but, as the author themselves point out, no program is explicitly directed towards enhancement of employment opportunities or worker training.

Brazil has made significant strides in addressing food insecurity (Chmielewska and Souza, 2011), with more than sufficient food production to feed its population (FAO, 2006). It is listed as “Low Hunger” by the International Food Policy Research Institute[1], with remaining food insecurity issues due more to income inequality than lack of food (FAO, 2006). Therefore, quantitative data have shown that the welfare gains from biofuels production can be considerable. Ewing and Msangi (2009) provide these data and point out that benefits to the poor are greater if small holders continue to function as part of the supply chain that allows refineries not only to produce their own sugarcane, but also to purchase cane from smaller, independent producers. Smeets et al. (2008) point to higher wages in sugarcane production than those paid to agricultural workers producing other crops. In addition, there are higher wages paid to workers in ethanol refineries than those paid to workers in similar industries, meaning that not only is there

[1] http://www.foodsecurityportal.org/brazil

potential for increased revenues to landowners of different sizes, but also potential for increased incomes among workers with different levels and types of training.

Martinelli et al. (2011) find great potential for cane and ethanol production to further Brazil's rural development, pointing out that agriculture and agribusiness account for 25% of Brazil's GDP. Admitting that the Brazilian agricultural system has at times been guilty of greater concentrations of wealth and land into the hands of fewer people, as well as producing dangerous working conditions and ecological damage in the form of deforestation and decreased water and soil health, they also point to the many positive externalities. In their spatial analysis of Sao Paulo's municipalities, they identified the municipalities with ethanol mills, and evaluated these along with area of land dedicated to cane production and number of cattle, finding that two different human development indicators (HDI)—the Sustainable Development Index (SDI) and the Municipal Development Index (MDI)—were considerably higher in those municipalities with mills. They caution, however, that correlation is not causation, meaning that there is still a need for continued examination of the relationship between cane and ethanol production and rural development. Furthermore, their article does not examine the external environmental costs of cane production, but points out that these may indeed be sufficient to outweigh the positive economic impacts. There is potential for the cane-ethanol sector to diminish income inequality in Brazil and increase equitable development so long as those directing the sector view this as a priority in the coming years. The objective of this chapter is not to prioritize job creation as more or less important than protection of natural resources or other priorities, but to acknowledge that there are different viewpoints on these issues and to assess the prioritization of these issues by a sample of stakeholders in SP's cane-energy sector.

Though they are optimistic about the potential for cane and ethanol production to aid in Brazil's development as it is defined by SDI or MDI, Martinelli et al. (2010) also present data on increasing inequality in Brazil and poor working conditions for agricultural workers, environmental degradation associated with reduced rainfall due to deforestation, and human illnesses caused by runoff from pesticides and fertilizers. Specifically, land concentration from 1996 to 2007 was most pronounced in Sao Paulo municipalities that experienced major increases in land dedicated to sugarcane (Olivette et al., 2009). Taken together, these conditions represent significant disadvantages to those most vulnerable to losing incomes due to sickness or forfeiture of land. Still, Martinelli et al. (2010) are cautiously optimistic about the potential for reducing inequality, provided the government continues to pursue this objective, particularly by improving the systems of land titles and education, as well as strengthening laws protecting natural resources. Problems associated with lack of property rights to land are also discussed by Chaddad and Jank (2006) who lament decreasing government efforts in this and other areas such as government investment in infrastructure. That article also calls for a careful balance between continuing to support inclusion of small and family farms, with the need to foster an agri-business system that is competitive on the global stage.

The increasingly capital-intensive nature of the cane and ethanol supply chains may prove difficult for smaller producers. Peskett et al. (2007) found that investments such as ferti-irrigation systems on land immediately surrounding some refineries and improved varieties of cane mostly benefitted the larger plantations. In addition, pressure on producers to increase labor productivity while keeping wages low will also likely be detrimental to poorer segments of the population. Mendonça (2011) goes even further by contending that the industrialization of the cane-energy sector, and greater influence by international corporations and bodies such as the WTO, are concurrent with a marked rise in monoculture as well as exploitation of Brazil's natural and human resources and an increasingly difficult environment for smaller producers. Coming from a different perspective, Zylbersztain (2010) credits the internationalization of the Brazilian agricultural sector and the bioenergy industry in particular as increasing product quality through more rigid production practices necessitated by this global integration. This also includes greater attention paid to environmental and social sustainability that demands care for natural resources and higher living standards for agricultural workers. Hall and Matos (2010) finds that the emerging biodiesel industry in Brazil provides greater opportunity for those at the "bottom of the pyramid." However, there are considerable barriers to increased inclusion due to higher costs and the lack of business knowledge as well as trust in industry officials on the part of those who have been excluded from the bioenergy sectors.

As is the case with the present study, several other articles have discussed jointly the various economic, environmental, and social issues as they pertain to Brazilian cane and ethanol production. Borrero et al. (2003) develop a matrix to evaluate all three aspects in the performance of three different sugarcane mills in Sao Paulo, scoring these mills over a period of ten years, from 1987-1997. They establish scoring for each of the three areas, but they did not attempt to rank or prioritize any of the three areas, and instead recommended that these improvements should be made in future assessments. Acosta-Michlik et al. (2011) propose a model to evaluate potential trade-offs between food versus fuel, welfare, and equity in terms of all three, commonly used pillars of sustainability—social, economic, and ecological—using large amounts of time-series data and GIS maps, as well as surveys. They admit that sufficient amounts of such a wide range of data are rarely available and are often costly to assemble in terms of both time and money. However, their model is an effort to identify exactly which strata of the human population and which aspects of the natural environment may gain or lose, and in what amounts, given specific decisions regarding biofuels feedstock production. They do not arrive at definitive results in their study, but apply results from various previous studies to the potential for conversion of land dedicated to food crops to biomass production in India, Portugal, and Russia. Their study evaluates various quantitative approaches and parameters, suggesting further refinement for future studies. The present study therefore contributes to the literature by offering a similarly broad assessment of a single state by gathering and analyzing the viewpoints of over 130 stakeholders in Sao Paulo's sugarcane-energy sector.

3.1.5. Certification

In reviewing the literature and during the interview process, there has been much discussion of certification regimes in order to accomplish some of the objectives outlined in the priorities. Two different organizations have taken on the task of producing voluntary criteria, or principles, which evaluate the sustainability of biofuels and their feedstocks. Bonsucro, formerly known as the Better Sugarcane Initiative, is a completely voluntary set of criteria for sugarcane production (Figure 3.4), providing this description of the organization on its website: "Bonsucro is global multi-stakeholder non-profit initiative dedicated to reducing the environmental and social impacts of sugar cane production. It aims to achieve this with a Standard that measures these impacts accurately, and with the development of a system to certify that sustainable practices are being adhered to" (www.bonsucro.com). This body was initiated by the World Wildlife Fund (Dufey et al., 2007), and includes members such as Coca Cola, Cargill, UNICA, Shell, and BP (www.bonsucro.com).

Another organization, the Roundtable for Sustainable Biofuels (RSB), attempts to certify biofuels production in general, and has established a tool producers can use to assess their risk level based on production processes. Producers can then apply for official certification by the RSB (Figure 3.5). The RSB provides this description: "The RSB is an international initiative coordinated by the Energy Center at EPFL [Ecole Polytechnique Federale Lausanne] that brings together farmers, companies, non-governmental organizations, experts, governments, and inter-governmental agencies concerned with ensuring the sustainability of biofuels production and processing. Participation in the RSB is open to any organization working in a field relevant to biofuels sustainability" (http://rsb.epfl.ch/).

PRINCIPLE 1. Obey the law.
PRINCIPLE 2. Respect human rights and labour standards.
PRINCIPLE 3. Manage input, production and processing efficiencies to enhance sustainability.
PRINCIPLE 4. Actively manage biodiversity and ecosystem services.
PRINCIPLE 5. Continuously improve key areas of the business.

Figure 3.4. Principles of the Better Sugarcane Initiative. EU Production Standard. (BSI, 2011).

The criteria from both of these studies were used to formulate the five main priority areas as well as the questions for surveys and interviews. For example, Principal 2 from the BSI and Principals 4 and 5 from the RSB were integrated into the sub-questions on employment regarding prioritization of increased total number of jobs versus safer jobs. Principals 7-10 from the RSB were used to formulate the questions and priorities regarding protection of natural resources.

Principle 1: Biofuel operations shall follow all applicable laws and regulations.
Principle 2: Sustainable biofuel operations shall be planned, implemented, and continuously improved through an open, transparent, and consultative impact assessment and management process and an economic viability analysis.
Principle 3: Biofuels shall contribute to climate change mitigation by significantly reducing lifecycle GHG emissions as compared to fossil fuels.
Principle 4: Biofuel operations shall not violate human rights or labor rights, and shall promote decent work and the well-being of workers.
Principle 5: In regions of poverty, biofuel operations shall contribute to the social and economic development of local, rural and indigenous people and communities.
Principle 6: Biofuel operations shall ensure the human right to adequate food and improve food security in food insecure regions.
Principle 7: Biofuel operations shall avoid negative impacts on biodiversity, ecosystems, and conservation values.
Principle 8: Biofuel operations shall implement practices that seek to reverse soil degradation and/or maintain soil health.
Principle 9: Biofuel operations shall maintain or enhance the quality and quantity of surface and ground water resources, and respect prior formal or customary water rights.
Principle 10: Air pollution from biofuel operations shall be minimized along the supply chain
Principle 11: The use of technologies in biofuel operations shall seek to maximize production efficiency and social and environmental performance, and minimize the risk of damages to the environment and people.
Principle 12: Biofuel operations shall respect land rights and land use rights.

Figure 3.5. "Principles and Criteria for Sustainable Biofuel Production," Rountable for Sustainable Biofuels (RSB, 2010).

3.2. Methods

A combination of surveys and interviews was chosen in order to facilitate quantifiable responses from as many stakeholders as possible (surveys), while also allowing for more in-depth and open-ended responses (interviews). This combination has previously been used in related areas, such as social perspectives on the ecological impacts of agriculture (Salazar-Ordonez and Sayadi, 2011) and on other issues such as physical health in Brazil (Galduróz and Carlini, 2007). With the population of stakeholders being those directly involved with and most impacted by cane and ethanol production in Sao Paulo (stakeholders), the ideal sample was a diverse group of these stakeholders who would also have knowledge of some of the broader context of pertinent issues in biofuels. Therefore, efforts were made to contact groups and individuals working at different stages of the supply chain; as well as industry groups; academic researchers engaged in areas such as business, economics, ecology, sociology, and other relevant disciplines; and government officials.[2] The objective was to collect the viewpoints of a variety of stakeholders, older and younger, who would likely hold divergent priorities for the sector. Most of the academics involved in the research were from ESALQ, the Escola Superior de Agricultura "Luiz de Queiroz" (Luiz de Queiroz College of Agriculture), the agricultural college for the University of São Paulo (USP), considered Brazil's premiere university and located in Piracicaba, in the heart of São Paulo's sugarcane producing region. Students were involved because it was important to consider not only today's decision makers, those already working within the industry, but also the people who will be running the cane-energy sector in the next generation. The central research questions addressed by these surveys and interviews are presented again in Figure 3.6.

Surveys were deemed the most proficient tool for gathering responses from a diverse array of stakeholders to answer these questions, so the questions were broken into more detailed questions and administered to 119 stakeholders. Semi-structured interviews have previously been effective to solicit perspectives from 19 stakeholders in Brazil's cane-energy sector (Gee and McMeekin, 2011) to obtain more in-depth responses on issues similar to those addressed in this chapter. Therefore, as the survey results for the present study were obtained, they were complemented with even more detailed responses from 36 stakeholders in semi-structured interviews.

For a variety of reasons, it was essential to discuss the various environmental and socio-economic issues related to cane and ethanol production together in a single study. First, economic questions continued to arise within the environmental context: Who would pay when environmental protection caused increased costs? As one stated intention of the move to mechanized harvest is decreasing air pollution, are not the jobs lost and created also important aspects to be examined? Second, as

Figure 3.6. Central research questions.

- What are the socio-economic and environmental priorities for the sector's future growth among stakeholders in Sao Paulo (SP), Brazil's main sugarcane- and ethanol-producing state?

- In which methods and administrative bodies—private, public, NGOs, or others—do stakeholders have the most confidence to encourage their priorities?

[2] Unfortunately, speaking with cane cutters in ways that allowed them to speak freely and comfortably proved quite difficult. At times when I spoke with them not in the presence of management they were suspicious of my motives and unwilling to talk with me, likely fearing that I would report any of their grievances to their supervisors. As much as I wanted to try to earn their confidence and press them for information, it seemed inappropriate to do so as it could, at least in their perception whether true or not, if others learned they were speaking with me, jeopardize their job security if not their personal safety.

was discussed in the previous chapter of this dissertation, protecting land to preserve environmental health can often come at the expense of job creation as land is set aside, eliminating jobs that could be created through timber collection, agriculture, or other extractivist activities. During the literature review and preliminary visits, a consistent response has been that Brazil's economic development needs to be considered at least along with, if not before, environmental protection. This opinion was confirmed in early interviews when questions of forest protection and riparian health were posed. O'Lear and Gray (2006), in their study of environmental conflict in Azerbaijan, emphasize the tendency for researchers to focus on environmental issues, even though these are often not the priority of the people involved in the research, and that environmental issues "may be precluded if other day-to-day concerns eclipse environmental concerns" (p.394).

3.2.1. Surveys

The main objective of the surveys was to rank the five main priorities and the sub-priorities within these five main areas (Figure 3.1, above). Questions were also asked regarding what methods respondents believed would best encourage the priorities, and which kinds of administrative bodies should oversee these efforts. Surveys were designed according to the guidelines suggested in Fowler (1995) and in Tourangeau, et al. (2000). The complete survey, with English translations included (these translations were not included in the actual hardcopy surveys given to respondents), is in Appendix 6.

3.2.1.1. Survey Sample Selection

The majority of surveys (84%, or 100 surveys) were administered to classes at USP, where it was possible to reach a combination of professionals enrolled in MBA and other programs that took place during evenings and weekends, as well as undergraduate and graduate students. Instructors were given the surveys and then administered them themselves in my absence so that I would not bias the responses by providing information to some groups and not others. The response rate was much higher for the undergraduate courses than for the professional courses, though instructors were unable to report exact response rates since they were not counting students in the room at the time of the survey, and not all students attended every class. Instructors were uncertain if the lower response rates in older groups were due to lack of interest by the professionals or simply the atmosphere being less structured in those professional courses than in the undergraduate classes.

3.2.1.2. Survey Tools

The entire survey was designed to take approximately 15-20 minutes for complete and careful responses. Surveys began with a brief explanation of the research project and the purpose of the survey as well as my program and contact information. The three portions of the survey were also outlined in this introduction: 1) Priorities; 2) How those priorities should be encouraged and who should administer them; and 3) Basic information about the respondent, including age (Table 3.4) and experience with or knowledge of the cane-energy sector (Table 3.5).

Table 3.4. Survey respondents' experience in cane-energy sector. n=119

Have worked in or studied sector directly	75
Have read about sector beyond direct work or study	44

Table 3.5. Age division of survey respondents. n=119, two respondents did not report their age.

Under 27 years of age	78
27 years of age or older	39

Based on the literature review, initial interviews, and preliminary surveys (not included in the results), five main priority areas were identified and respondents were asked to rank them in the first question on the survey. As a private sector in what is basically a free market economy, surveys and interviews began with the statement that, as businesses, generating profits is their primary concern. But because this sector is also an important aspect of Brazil's development, posing significant environmental and socio-economic impacts, both positive and negative, it is important to gauge stakeholders' priorities. The surveys requested numerical responses, asking participants to rank their preferences, as was suggested by Fowler (1995), to allow statistical examination of correlations between priorities, importance of those priorities, experience with and knowledge of the sector, and other responses. For these ranking questions, respondents were asked to mark the most important option as "1," the second as "2," etc., and any option respondents did not think was relevant to the cane-energy sector should be marked with a “9.” When applicable, questions included an “other” option, asking respondents who marked this option to provide a brief explanation of what they meant with “other.” This was important to provide, though in the end was not used often enough to be useful, possibly indicating that material included was sufficiently comprehensive. In the event that a respondent marked “Other” without giving an explanation of what that “Other” should be, the number provided was not recorded.

To test the survey for clarity and to ensure all relevant aspects were included, 20 preliminary surveys were given in four rounds of five surveys each to people from the sample population, with revisions made after each round. These 20 respondents were professors and students at ESALQ with direct experience with the cane sector and/or experience with survey design. This was done, as recommended by Fowler (1995), to ensure clarity of questions, as well as to determine if there was other material or other questions or response options that should be included, or aspects that should not be included. For example, the initial draft of the survey included only four main priorities: ‘infrastructure,’ ‘job creation,’ ‘protection against displacement of food production,’ and ‘protection of natural resources.’ The fifth priority, ‘institutions,’ was added because preliminary respondents suggested that infrastructure, as it would likely be understood, referred more to the quality of aspects such as schools, hospitals, and roads, while ‘institutions’ would cover areas such as combating crime and corruption, research, strengthening of democracy, and the legal system. The other major changes were to revise ‘food production’ to ‘protection against displacement of food production,’ and to add brief explanations in parentheses beside the main priorities of ‘infrastructure’ (education, heath, physical infrastructure, etc.), and ‘institutions’ (rights, security, research, etc.). These were made in the first and second round of five surveys each, and the ten respondents in the next two rounds did not make suggestions for further revisions, indicating that the survey was ready for distribution.

An early concern was to guard against haphazard reading of preliminary surveys if people were simply too busy or not sufficiently interested to want to go further. Therefore, preliminary surveys were administered in such a fashion to ensure that respondents had ample time, usually about an hour even though the actual survey took only 15-20 minutes to complete, to read the survey carefully and respond with me there in their presence, having already been instructed on the purpose of the project as well as the purpose of these preliminary test rounds. Furthermore, the reactions to the survey were overwhelmingly positive. Similar to the sector's participants in the Swedish forum (Bolwig and Gibbon, 2009), respondents stated that they were happy to know that foreign audiences may be presented with the results of their reactions. They also stated that the cane sector is an important aspect of Brazilian development, with the material covered in the survey sufficiently addressing issues pertinent to cane and ethanol production.

In order to evaluate statistical significance and verify the results of respondents' rankings, a rank order logit was used. As rankings are ordinal measures, they do not lend themselves to parametric analysis. For the rank order logit, one of the priorities is established as a base and then compared to the coefficients to each of the other priorities. The "other" category is used for the main priority, but as so few respondents marked "other" in the sub-priorities, "jobs requiring higher education" was used under the "jobs" category, and "preservation of the Atlantic Rainforest" was used in the "natural resources" category as these were the least favored options in their respective categories, and t-tests are then performed to verify significance. These methods, described by Layton and Lee (1998), and Hausman and Rudd (1987), were used for the analysis described in the Results section below.

3.2.2. Interviews

Preliminary interviews were conducted before the surveys to formulate the research process. Formal, semi-structured interviews were then conducted after as survey results were being collected to gain further insights on survey results. The analysis performed on the interviews was not a full-scale qualitative analysis as these were used to add anecdotal evidence and to provide further elaboration and greater detail than is possible in the surveys. Interviews were also conducted to learn from people in industry some of the programs that have been and are being implemented to combat the problems already known regarding land use issues such as deforestation (Searchinger et al., 2008; Tillman et al., Fargione et al., 2008), water quality (Moreira, 2007), and treatment of workers (Azanha, 2007; Novaes, 2007). This approach was not intended as a means to let the industry dictate the course of the research but to provide a realistic framework to assess their activities beyond their focus on cane and ethanol production. People within the industry have become hesitant to speak with people outside of the industry, especially foreigners, due to the amount of negative press they have received on issues such as poor working conditions and accusations that cane-energy sector producers are causing deforestation (NewsOne, 2009; Philbott, 2008). To be objective it was important to have knowledge early in the interview process of these concerns as well as planned programs and those already in place that are meant to ameliorate these problems (i.e., Renovação and Compromisso Nacional, discussed in detail in Results section). Interviewees were also encouraged to learn that I was equally interested in discussing positive (along with negative) aspects of the industry and were thus that much more willing to share information with me. These methods have been important to other interview processes found in the literature review (Stephens, 2007; Hunter, 1995; Ostrander, 1993).

3.2.2.1. Interview Sample Selection

Interviews were conducted with 34 individuals during the months of March, April, and May, 2010. All of these interviews were performed with people who had worked directly with the cane-energy sector, either as agricultural producers, with the refineries, or on practical or research projects such as reforestation on cane land, determining costs of cane and ethanol production, the sector's impacts on workers and employment, and other similar activities. All participants were given the option to remain anonymous with their responses. All who did so have had their names changed here (those names appear in *italics*) and their associations obscured. Because some of the participants are prominent figures in cane-energy sector, such as Marcos Jank, President of UNICA; Marcia Azanha, a professor at ESALQ; and Marcos Buckeridge, a leading researcher at CTBE (Bioethanol Science and Technology Center), it was preferable to use their names if they allowed this, as most of them did. The sample was also chosen based on those who are clearly in favor of increased cane and ethanol production, such as Jank, and those who may be more reluctant based on the potential negatives the sector's growth could bring with it, such as Valdemar Chaves of the MST, living and farming in a settlement in Pontol, in the western end of Sao Paulo. Again, divergent perspectives were viewed as beneficial to generate a more balanced discussion representing contrary viewpoints among stakeholders.

Another possible tension concerned a perceived opposition between smaller producers and larger companies, with land and refinery acquisitions by larger companies possibly squeezing out smaller firms and independent producers (Piketty et al., 2008). Interviews with Marcos Croce, Joao Neto, and others were valuable in presenting the perspectives of these smaller, independent producers, balanced against the conversations with individuals representing three of the largest cane and ethanol-producing firms. It was also important to explore the possibly opposing viewpoints between people working on the social and environmental sides, defending workers and ecological health, and those within the sector as they worked to minimize labor costs while also fighting against potentially higher costs incurred by enforcement of forest and other environmental legislation. Stephens (2007) used such oppositional methods in interviewing economists regarding how their political opinions affected their academic research to produce usable results.

The approach used to identify interview participants was to begin with existing contacts involved with the cane-energy sector, and to solicit names of other people within the sector with whom I should speak. This “snowball” approach has been used by other researchers pursuing interviews in somewhat closed networks (Stephens, 2007; Hunter, 1995; Ostrander, 1993). Initial contacts were made during several years living in São Paulo and subsequent trips for work and research on the sector. ESALQ was an excellent starting point as it has many rich connections with people in the sector through programs such as several professional, agricultural MBA programs that people currently employed or who had been employed in the sector attended on Friday evenings and Saturdays. I was also fortunate to benefit from the help of people such as Prof. Carlos Bacha, head of the economics department at ESALQ, who introduced me to, among others, Marcos Jank, the president of UNICA, the Brazilian sugarcane industry association, whose associates account for 60% of Brazilian cane production. Mr. Jank has often been published and quoted in both the Brazilian and English-speaking media and the interview with him was very helpful due to his perspective on and impressive knowledge of the sector’s activities. Professor Ricardo Rodrigues was also an excellent and generous contact as his reforestation laboratory within the Biological Sciences Department at ESALQ is doing substantial work with cane producers, including one project with Cosan, Brazil's largest cane and ethanol refinery company, rehabilitating riparian corridors on the cane producing land they own. These contacts provided diverse insight into stakeholder priorities and how they perceived the industry to be succeeding or failing with implementation of these various priorities.

3.2.2.2. Interview Methods

Semi-structured interviews were conducted according to the guidelines laid out in Rubin and Rubin (1995). The interviews began with me explaining that I was writing for a North American audience about Brazilian cane and ethanol production, specifically the priorities of stakeholders in São Paulo as production is projected to increase. I explained that it was especially important now as the US considers importing more Brazilian ethanol due to the EPA's recent RFS2 decision[3] on advanced biofuels (See Figure 3.7). Many of the respondents were already well aware of this decision, which in itself was interesting to learn, but for those who were not aware I explained what it meant and its possible implications, including that it increased the possibility that the US would import more Brazilian ethanol. I also explained there had been some news in the North American media, both positive and negative, about biofuels in general and the Brazilian sector in particular, but that it was important to learn more first-hand from Brazilians working on and studying these issues in São Paulo. This was at times followed by explanations of Brazil's tariff recently being lowered, estimates of yields of liters per hectare of both Brazilian sugarcane ethanol and US corn ethanol, and other relevant issues. These issues were explained in part to provide context for the discussion, in part to give myself a bit of credibility with interviewees, showing that I was knowledgeable and up to date with the important issues, and in part to keep interviewees from feeling the need to take valuable and limited interview time to explain to me basic details already known, as this happened in a few of the early interviews.

[3] This decision, announced by the U.S. EPA in February, 2010, qualified Brazilian ethanol as an "advanced biofuel," since it reduces GHG emissions by 61% compared to gasoline. This is important as the requirements for advanced biofuels, which must reduce GHGs by at least 50%, have just begun in 2010, with their proportions of the U.S. Renewable Fuel Standards increasing until the end of the program in 2022, with Brazilian ethanol the only commercially available biofuel that meets these standards.

Interview questions followed the same general content as the surveys and covered the five main priority areas of natural resource protection, employment, building of institutions and infrastructure, and food production. Interviews were placed in the broad context of the research questions for this chapter, and then were focused on those subjects with which interviewees had specific knowledge of relevant policies and practices. Questions were also posed about any existing or planned programs addressing the areas of the main priorities and the interviewees' expertise so as to learn of programs not available in published literature. For example, in cases such as interviews at UNICA, they had published reports about their involvement in programs such as Protocolo Agroambiental and the aforementioned agro-ecological zoning (UNICA, 2009), and so I sought elaboration regarding the ongoing implementation of these programs.

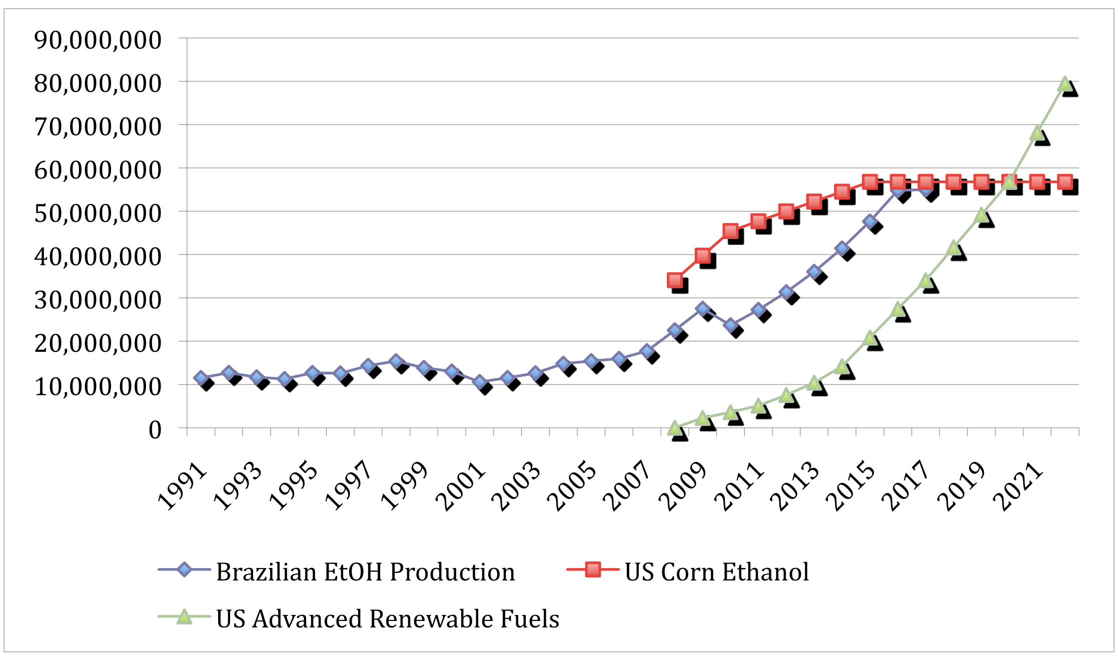

Figure 3.7. Brazilian ethanol production and the U.S. renewable fuel standards**.** Listed in thousands of liters. The year 1991 refers to the 1990/'91 Brazilian harvest, 1992 to 1991/'92, etc. Source: UNICA. The U.S. Renewable Fuel Standards include mandates to cap corn ethanol at 15 B gals in 2015, with increasing amounts of '"advanced renewable fuels,' defined as fuels that reduce GHG emissions by at least 50% compared to gasoline. As of the US EPA's RFS2 decision (2010), Brazilian ethanol meets this standard. Data on Brazilian ethanol production to the year 2010 come from UNICA. Future projections are based on the possibility of doubling 2009's production by 2017, with approximately 15% growth per year.

In terms of sugarcane workers and worker organizations, interviewees were asked about changes underway in the sector's labor and employment areas, including estimates of timeframes for the move to mechanization in the state and country as a whole, or, where applicable, for the individual refineries and cane producers. They were also asked about the futures for the people who would lose jobs as the sector cut its roles of manual laborers, and what programs were in place to retrain these people. Again using UNICA as a reference, they had published their efforts in programs such as RenovAção (combining the Portuguese words for Renovation and Action), which aims to retrain '7000 cane workers per year,' and the Compromisso Nacional (National Commitment), which shares best labor practices between UNICA's affiliated producers (UNICA, 2009). Interviewees were asked to comment on the success and potential difficulties of these recently-implemented initiatives.

3.3. Results

The results from these surveys and interviews show the divergent opinions of many of the stakeholders in São Paulo, but with a predominant feeling that the priorities outlined here can be met with self-discipline by industry motivated by continued guidance from government and citizens. The presentation of results continues with an overview of survey results, then moves through the main priority areas:

1. Protection of natural resources;
2. Job creation;
3. Infrastructure, institutions, and education are discussed jointly for reasons explained at the outset of that section; and
4. Protection against displacement of food production.

Survey results are then presented for administration and enforcement of priorities. An overview of the results from interviews is presented next. Discussion of results follows with interviews and surveys discussed jointly as the results from each often helps to shed light on the other, providing more depth and insight as well as some viewpoints opposing the survey results. Finally the discussion is broadened to certification regimes and market forces, as these two subjects were frequently addressed by interviewees.

3.3.1. Survey Results

The first hypothesis to be tested by the surveys —that job creation would be the most important priority, followed by protection against displacement of food production with protection of natural resources the lowest ranked priority, was not supported. The results in Table 3.4 illustrate the importance of natural resources as the primary concern, with 44 respondents indicating that as the most important priority, in a statistical tie with infrastructure as 32 people marked it as most important, 28 for job creation, and 12 and 10 for institutions and food production, respectively.

Table 3.6. Summary of respondents' priorities. More detailed results are listed in Appendix 4. n=119 for all except "Other," where n=8. The rank ordered logit indicates Natural Resources is not statistically significantly different from Infrastructure, but is significantly different from Job Creation at a 90% confidence interval, and from the other two options at a 99% confidence interval. The Other category was used as the "base".

	Infrastructure	Job Creation	Food	Natural Resources	Institutions
Coefficient	-1.188	-1.105	-0.132	-1.399	-0.285
Std. Error	0.515	0.512	0.511	0.515	0.512
Most Import. (%)	26.9%	23.5%	8.4%	37.0%	10.1%
Most Import. (#)	32	28	1	44	12
Least Import. (%)	8.4%	6.7%	47.9%	2.5%	33.6%
Least Import. (#)	10	8	57	3	40

3.3.1.1. Protection of Natural Resources

As seen in Table 3.5, protection of Water was listed as the highest priority under Natural Resources for survey respondents, statistically significantly different from each of the other priorities except the Other category, which was not marked enough times to be significantly different from any of the other priorities. Water is followed by Air, Soil, and Biodiversity. Biodiversity is statistically tied with soil, but ranked as slightly less important than air at an 85% confidence interval. Survey respondents placed protection of the Atlantic and Amazon Rainforests specifically as the least important priorities.

Table 3.7. Natural resources sub-priorities.

	Air	Soil	Water	Atlantic RF	Amazon RF	Biodiversity
Coefficient	-1.1909	-0.9431	-1.7307	0	0.0390	-0.9383
Std. Error	0.1707	0.1664	0.1805	na	0.1563	0.1670
Most Import. (%)	26.9%	23.5%	8.4%	37.0%	10.1%	10.1%
Most Import. (#)	32	28	1	44	12	12
Least Import. (%)	8.4%	6.7%	47.9%	2.5%	33.6%	33.6%
Least Import. (#)	10	8	57	3	40	40

3.3.1.2. Job Creation

Survey results for 'Job Creation,' were fairly tightly grouped in their sub-priorities, with Safer, Healthier Jobs being the preferred ranking, followed by More Jobs, and Higher Paying Jobs. Jobs Requiring Higher Education is the least preferred option. Other was not marked a sufficient number of times to make statistically significantly different from any of the other options. This result is paradoxical in light of the previous paragraph as well as the fact that 'education' was by far the most common comment inserted into surveys, being marked eleven times under the Other category in ways to combat Brazil's widening disparity in wealth, ten of those times ranked as the number one best way to combat disparity. These eleven responses were not grouped in one time or place at which the survey was administered, but came from six different groups.

Table 3.8. Job creation sub-priorities.

	More	Safer	Higher Pay	Higher Educ	Other
Coefficient	-0.5957	-0.8933	-0.3560	0	0.1766
Std. Error	0.1764	0.1745	0.1646	0.9306	0.9306
Most Import. (%)	26.9%	23.5%	8.4%	37.0%	10.1%
Most Import. (#)	32	28	1	44	12
Least Import. (%)	8.4%	6.7%	47.9%	2.5%	33.6%
Least Import. (#)	10	8	57	3	40

3.3.1.3. Infrastructure, Institutions, and Education

These three aspects are grouped here because infrastructure and institutions were both in the middle of the priorities, and because educational issues were the highest sub-priority for each. The highest sub-priority in both Institutions and Infrastructure was that which related to education, these being Research in Institutions, and Education under Infrastructure. In Institutions, the Legal System was ranked second, Democracy third, and Anti-Corruption and Anti-Crime the last two.

3.3.1.4. Protection Against Displacement of Food Production

Protection against displacement of food production was the lowest priority among survey respondents (Table 3.1), giving important local insight to an existing debate between those who contend that biofuels production poses serious risks to food security (Runge and Seanauer, 2007; Samuelson, 2007), and those who maintain it is entirely possible to increase production of both with little or no risk to either one (Azevedo et al., 2010; Naylor et al., 2008; Daschle, 2007).

3.3.1.5. Administration and Enforcement of Priorities

Nearly 80% of survey respondents indicated that their 1st priority should be obligatory, not voluntary (Table 3.9). Of course, implementing measures that will ensure that these priorities are addressed, and deciding who should administer these programs, is an entirely different question. The government's role has been discussed at length earlier in this chapter, from the agro-ecological zoning, to the need for improved education at all age levels. The Brazilian government's involvement, according to survey results, is of the utmost importance, as the government was ranked first in answer to the question of who should administer priorities, at 56% (Table 3.9). The Brazilian private sector was second at 38%, with "Brazilian other" ranked third at 33%.

Table 3.9. Importance of priorities. Percentage of survey respondents who marked priorities as obligatory, or more important than profit, or as important as profit.

	Top Ranked Priority	**Lowest Ranked Priority**
Should be obligatory	79.8%	55.7%
More important than profit	40.3%	11.5%
As important as profit	52.9%	31.0%

Table 3.10. Administration of priorities**.** Respondents were asked who would be best to administer the main priorities they marked as most important in the first question on the survey.

	% as 1st Choice	% as 2nd Choice	% as Last Choice
BR Private	38.0	36.8	3.7
BR Gov	56.4	14.0	3.6
BR NGO	4.9	28.6	21.4
Foreign Private	3.0	8.2	35.4
Foreign Gov	1.0	7.1	49.5
Foreign NGO	1.0	1.0	63.0
BR Other	33.3	0.0	25.0
Foreign Other	25.0	0.0	50.0

Of the people who marked "Brazilian other" as their first choice of who should administer their first priority, only five wrote in an actual suggestion: 'society through the public ministry,' 'social movements' (twice), and 'universities' (twice). The fourth ranked option for who should administer was 'Foreign other', at 25%, with three suggestions written besides those eight entries: 'universities,' "WTO" (World Trade Organization), and "FAO" (Food and Agriculture Organization). Non-governmental organizations (NGOs) were not favored by respondents, as domestic NGO's were the first choice of just under 5% of respondents and foreign NGOs only 1%, tied with foreign governments. Foreign private institutions were only slightly more favored at 3%.

The methods for ensuring compliance with priorities were much more tightly grouped (Table 3.11). The most highly ranked method was certification for producers that achieve respondents' highest ranked priorities, being ranked first by 37% of respondents. Reducing taxes or tariffs for firms that comply with priorities was second, as 25.9% ranked it #1, punishments for failure to achieve the priority was third (21.3%), and direct payments fourth at 20%. The 'other' option was marked only three times, each time ranked first, with two respondents suggesting that cane producers and refineries pay taxes to the government to administer their priorities. The third respondent's comment was illegible.

Table 3.11. Methods of ensuring compliance**.** Respondents were asked to rank their preferences for methods to encourage compliance with the main priority they ranked as #1 on the survey's first question. The full phrasing of these options can be found with the survey in Appendix 6.

	1st Choice Method		4th Choice Method	
Methods	n	% of total	n	% of total
Direct Payments	22	20.2	16	14.7
Punishments	23	21.3	10	9.3
Certification on Free Market	40	37.0	3	2.8
Reduce Tax/Tariff	28	25.9	12	11.1
Other	3	100.0	0	0.0

Perhaps more telling are the results examining these methods according to which priority the respondent marked as #1 (Table 3.12). Certification on the free market ranked highest among those prioritizing protection of natural resources, marked 18 times, followed by punishments, ranked first 14 times by those favoring natural resource protection.

Table 3.12. Implementation of priorities by priority. Percentage of respondents who marked a given priority as #1 and this method as #1.The one respondent who marked 'Other' as #1 wrote in 'Profits' and marked 'Direct Payments' as the preferred methods

Method:		Dir. Payments	Punishments	Certification	Reduce Tax/Tariff
<u>Priority</u>	Tot. #1				
Infrastructure	32	9	2	9	11
%		28.1%	6.3%	28.1%	34.4%
Jobs	28	3	5	9	11
%		10.7%	17.9%	32.1%	39.3%
Food	10	1	1	4	3
%		0.1	0.1	0.4	0.3
Nat. Resources	44	6	14	18	3
%		13.6%	31.8%	40.9%	6.8%
Institutions	12	3	3	4	2
%		25.0%	25.0%	33.3%	16.7%
Total		22	25	44	30

Another standout was reduction of tariffs and taxes for contributions to infrastructure, each marked 11 times. Direct payments to producers was the least favored option, marked only 22 times total, the highest instances coming with infrastructure and, again, protection of natural resources. Because certification was ranked highest, and was a prominent topic in interviews, that is discussed below at greater length, followed by a discussion of the market forces that bear on producers and how those can be effective at motivating compliance with these priorities.

3.3.2. Interview Results

Interview results show that while there is disagreement in some details regarding which priorities are most important and exactly how they should be achieved, 32 of the 36 respondents believed priorities could be met within the framework provided by the status quo, and that increased industrialization and mechanization are positive aspects of this process. Again, it needs to be noted that interviews were used to provide deeper, anecdotal evidence, shedding further light on survey results. As such, full-scale qualitative analysis was not performed on interview results. For the first hypothesis regarding ability of independent producers to compete as well as to contribute positively to the main priorities, the hypothesis was largely rejected as only four of the independent producers, two of whom hail from the same farm, viewed increasing industrialization and mechanization negatively, as did one official representing refinery workers, though for slightly different reasons. All of the other 36 respondents, including representatives from other independent firms, an independent producer co-op, workers' organizations, and interviewees from academia rejected the first hypothesis. These respondents also stated their belief that independent firms would be able to compete in an increasingly industrialized market, and that larger firms could also help to fulfill priorities identified in this research. These representatives, including Arnaldo Bortoletto of Coplacana, the cooperative of independent cane producers, believed small producers would be able to continue as positive participants in the cane-energy sector, but they would need to adapt and adopt mechanization. Only one interviewee, Edson dias Bicalho of Fequimfar (Federation of Workers in the Chemical and Pharmaceutical Industries of Sao Paulo, which includes ethanol refinery workers), supported the third hypothesis—that those outside the private sector would oppose increased cane production and intensification due to negative environmental and socio-economic impacts—while all other interviewees rejected it. Bicalho's support of this hypothesis stemmed from a fear that cane cutters may indeed receive training through new programs, and would then threaten jobs held by people in ethanol refineries and others working in industrial occupations represented by Fequimfar.

Table 3.13. Interviewees**.** In the case that an interviewee has elected to remain anonymous, the name has been changed and italicized and the employer obscured. Interviewees mentioned in the text are referred to by the names listed here.

Name	Workplace	Occupation
Mateus	Independent Refinery	Cane Prod. Mgr
Camilo	Independent Refinery	Industrial Mgr
Milvia	Independent Cane Producer	Farm Owner
Werner Baer	U of Illinois	Economics Professor
Carlos Azzoni	USP	Vice-Director of Econ, Bus. Admin, Acct., Dep't, USP
Arnaldo Bortoletto	Coplacana	Director
Marcos Jank	UNICA	President
Evandro	Cane-Ethanol Consulting Firm	President
Joao Neto	Independent Cane Producer	Farm Owner
Maria Luisa Pereira Neto	Independent Cane Producer	Farm Manager
Jaime	Independent Refinery	President
Mauricio	Independent Refinery	Management
Roberto	Independent Refinery	Director
Jose	Independent Refinery	Cane Cutter
Ricardo Ribeiro Rodrigues	LERF, ESALQ	Director
Marcos Buckeridge	USP, CTBE	Prof.,USP; Co-Director, CTBE
Marcos Croce	Faz. Ambiental Fortaleza	Farm Owner
Marcia Azanha	ESALQ	Economics Professor
Thiago Romanelli	ESALQ	Engineering Professor
Wilson	University Professor	Business Administration
Joao Martines	ESALQ	Economics Professor
Peter Zuurbier	ESALQ/Wageningen	Economics and Business Professor
Beatriz Secaf	UNICA	Environmental Analyst
Luiz Fernando do Amaral	UNICA	Environmental Advisor
Eugenio	Large Cane-Ethanol Prod. Firm	Commerical Manager
Adriana Silva	CTC	Agricultural Engineer
Jose Tome	CTC	2nd Generation EtOH Researcher
David	Large Cane-Ethanol Prod. Firm	Environmental Analyst
Paulo Kageyama	ESALQ	Forestry
Valmir (Bill) Rodrigues Chaves	MST	Landowner
Gerd Sparovek	ESALQ	Soil Science
Geraldo	Large Cane-Ethanol Prod. Firm	Ethanol Trading
Carolina	Large Cane-Ethanol Prod. Firm	Ethanol Trading
Edson dias Bicalho	Fequimfar	Sec. General
Artur B. de Camargo	Conf. Nac. .../Fetiasp	Pres, Vice Pres
Sergio Torquato	SP State Gov., Instituto de Economia Agrícola	Researcher

3.4. Discussion of Results

Some of the anticipated tensions did not seem to be as important as expected. For example, interviews with several indpendent refinery company representatives (*Mateus, Camilo, João*) were not hesitant toward mechanization and larger firms having more of a share in the market. Arnaldo Bortoletto, the Director of Copracana, a cooperative for smaller independent producers, who could be presumed fearful of increasing competition and capital costs due to a perceived lack of their ability to compete, was quite frank: 'Those who can adapt to the increased environmental regulations, mechanization, and other changes occurring will succeed.' When asked if he thought they could, he was optimistic and not at all fearful. This was a surprise coming from someone who acts as an agent for these small producers, someone who works for a cooperative who lists as their very first value, "Tradition," as some, including sources discussed earlier (Pikkety et al., 2007; Mendonca, 2011), had said that these small producers could be swallowed up by the bigger companies operating on larger scales. There was no reason to believe Arnaldo was not being sincere as the existence of his job depends on the success of these small farmers. If there are no independent producers, there is no need for a cooperative, nor its director. He has a vested interest in their continued prosperity, so his optimism was quite convincing.

Another tension I had anticipated was from researchers and others who seek to defend workers and natural resources, and who might be resistant to mechanization or increased cane production. This was also much less of a concern than I had anticipated. Ricardo Rodrigues, who directs the reforestation program at ESALQ, was confident that increased cane production could coincide with increasing reforestation efforts, and Marcia Azanha, a professor in economics at ESALQ, said she believes that increased cane production and mechanization will be generally positive for the employment sector. Somewhat ironically, one person who did express concern about the U.S. and other countries opening their markets to Brazilian ethanol, Marcos Buckeridge, is one of the country's leading researchers on developing higher yields of crops as well as crops for second generation, cellulosic ethanol. He was unconcerned with the amount of land used, but did fear that a sudden opening of foreign markets could create a lack of ethanol for domestic consumption.

3.4.1. Protection of Natural Resources

Deforestation may be a very important issue to stakeholders surveyed, but interviewees explained that survey respondents may have marked forest protection lower because of a belief that cane cultivation has little to do with deforestation, a point that flies in the face of much of the current concerns regarding biofuels and indirect land use changes (ILUCs). Egeskog et al. (2011) conducted a case study in the Western region of Sao Paulo, where small farmers had been converting pastureland for dairy cows to sugarcane production, often with negative economic effects. Some farmers then attempted production of sugarcane integrated with dairy cow production, using the *bagasse* from the cane refining as cattle feed. This practice was found able to triple farmer income while also reducing the potential for indirect land use changes since pasture was not displaced by the cane production, thus mitigating the potential for increased GHG emissions due to biofuels feedstock production. The low priority given to forest protection could reflect confidence in the recently released agro-ecological zoning (ZAE, 2010). Alternatively, with so much land in Brazil that people either do not use, or use inefficiently, and the very small amount of land used for cane (Figure 3.2, as well as interviews with Evandro, Marcos Jank, Gerd Sparovek, Ricardo Rodrigues, others discussed below) there is no reason why cane production should have any impact on forests. These and other efforts (Sparovek et al., 2007) indicate that there are concerns by some stakeholders in SP that the status quo of cane and ethanol production may present problems to Brazil's people and ecosystems, and solutions are being sought.

When asked if the Forest Code could be of more help than agro-ecological zoning if Legal Reserves and APPs were better enforced, Joao Neto, an independent producer who moved from cane production to organic coffee in 2005 and one of the respondents expressing the greatest concern for the fate of Brazil's forests, said this would not be sufficient since it still allowed excessive tracts of monoculture with heavy external environmental costs. A problem, he explained, is that profits are earned from the same aspects, such as increased chemical fertilizer and pesticide application, that create the external costs. He gave the example of the macauva tree, whose fruit can be used for oil for biodiesel and is at least as productive per hectare as soy, and, unlike soy or sugarcane, can be grown in a polycultural system that does not require chemical applications and can be conducted while conserving forests.

Another independent producer, Marcos Croce, also saw a dire need for increased polyculture, but saw increased enforcement of Forest Codes as likely being sufficient to ensure ecological health. His farm of about 800 ha is midsize for Brazil, with approximately 150 ha dedicated to sugarcane, and the rest an organic polyculture of coffee, bananas, and other fruits and vegetables, all interspersed with native forests. When I asked him of the increased producer costs incurred when leaving 25-30% of each parcel of land fallow or as forest, he was candid: 'The things you are saying are so unethical I have a tough time responding. […] No one is measuring the costs of scarcity [of water, soil, food, or forests]. If you cut a little forest it will come back, but if you cut a lot of forest, it will never be healthy again.' He went on to explain that these big companies have more than enough money to leave aside the LRs and APPs and still turn a very healthy profit. Though Croce's and Joao Neto's voices are minorities among respondents, theirs and others like theirs will be essential to ensure that the monitoring and enforcement so many respondents saw as necessary if the priorities discussed here are to be fulfilled.

David, an environmental analyst with the investment group that owns land in partnership with one of Brazil's largest cane and ethanol producers, saw it somewhat differently, saying that there is no evidence that cane monocultures, so long as APPs are properly implemented, cause any problems at all to soil or water quality. His company, which is owned 80% by an American investment fund and 20% by a Brazilian cane and ethanol producing company, will not participate in any land owning activity unless it is clearly established to have '0% environmental risk.' For this reason, not only are they ensuring that APPs are left fallow, as is required by Forest Code law, but they are going above and beyond this by replanting native forests on the land where they operate, whether or not the land is owned by his firm. He explained that with projects underway, 32,000 ha will be reforested by 2017, all of this voluntary. *David* is one of several interviewees (Marcos Jank, *Eugenio*, Arnaldo Bortoletto, others) who explained that if these APPs were allowed under law to be considered as Legal Reserves (LRs), they would create forest corridors along waterways, rather than fragments currently produced under the LR system[4]. With LRs mandated at 20% of each parcel of land, and APPs occupying another 5-10%, *David* contended that the Forest Code is prohibitive, especially for small producers. Marcos Jank explained in our interview as well as in an article published in one of São Paulo's two major daily newspapers (2009), having forests on productive agricultural land is economically and environmentally inefficient, as it forces refineries to draw their cane from longer distances, and creates forest fragments that do not necessarily support biodiversity. Bringing APPs under LRs, Jank argued, would provide better environmental health, and allow for more cane producing land in the most productive regions.

Evandro, the president of a small cane and ethanol consulting firm in São Paulo, suggested that perhaps LRs did not even need to be in the state, but could be in other parts of the country, where land is much less expensive and productive. When asked about the possibility of moving LRs to other states, *David* said he believed this would become very difficult to monitor, and both he and Professor Rodrigues pointed out that it is important to have substantial forests in São Paulo, and that the integrity of these connected ecosystems within each basin be conserved, though this should not inhibit greatly increased cane production. Evandro's is another dissenting voice, moving in the opposite direction from Marcos Croce's and Joao Neto's, with almost all the other interviewees seeing the existing legislative framework as satisfactory, albeit with some proposing minor adjustments.

Another important facet of deforestation on the minds of researchers (Fargione et al., 2008; Nepstad et al., 2008; Searchinger et al., 2008) and policy makers (Al Riffai et al., 2010) is indirect land use changes, with deforestation in tropical countries potentially being driven by renewable fuels policies in the US and Europe. Two environmental analysts from UNICA explained that there is no way to certify individual producers regarding this concern. If, for example, a cattle farmer in São Paulo decides to sell the cattle herd and plant sugarcane to sell to a new refinery in the area, she cannot control whether or not, or where, another person may decide to buy virgin forest to clear for soy, pasture, or other agricultural activities, whether for food, fuel, furniture, or anything else.

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[4] This issue of forest fragmentation is discussed at greater length in the previous chapter of this dissertation.

Even if we see these as intrinsically linked on a macro level, the individual cane producers, or even their industry association or the state government, are not responsible for these changes. Because the whole system must be addressed, they explained that UNICA is working with Aliança Brasileira pelo Clima (Brazilian Climate Alliance) to stop deforestation, adding credence to the predominant view that the existing framework, especially with pressure coming from so many public and private sources, is already addressing these concerns. Whether or not one agrees cane producers cannot be held to account for indirect deforestation, the reasoning these industry officials employed makes sense. Hence, if protection of forests or food production is the aim, federal governments or other institutions need to be involved to enforce these objectives. The Brazilian government appears to be recognizing this demand with recent adoption of the AEZ (2010). Sergio Torquato (interview), with the São Paulo state government, was confident that the state government could monitor and enforce its own, more stringent zoning policies for sugarcane, but was not so certain that the federal government could be as successful in protecting forests or food production. It will be up to all parties involved to continue monitoring and enforcement of the priorities discussed here to ensure the successful fulfillment of priorities in the years and decades to come.

Currently, perhaps the most efficient potential for increasing production while protecting forests and biodiversity as well as water and soil, lies in adopting best practices using existing technology. This dispersion of these best practices is the job of Adriana Silva, an agricultural engineer with CTC, who visits cane producers throughout Brazil, working with them to adopt the methods developed within CTC as well as in the field by producers themselves. She explained that, especially with the sector industrializing, there are necessary changes in every aspect of production: using higher producing yields suited for specific locations with their different soil and climate types, and changing cropping patterns to protect against erosion and for more efficient use of machinery and fuel. She proudly provided a long list of ongoing improvements being adopted by producers of all sizes throughout the Center-South Region. Spraying less cane ripener on the fields prior to harvest saves money while also reducing potential harmful effects from runoff; improved distribution of *vinasse* reduces the need for chemical fertilizers and decreases potential for water pollution; improved cane and *bagasse* (sugarcane straw) collection boosts yields for both cane production and the electricity cogeneration created by burning *bagasse*. Changing cropping patterns by reducing the number of cane rows while increasing their length reduces the number of times a tractor needs to turn around, saving time and fuel. This simple alteration can save tens of thousands of *reais* per year on just a few hundred hectares. Using slightly more sophisticated but still currently existing maps and technology, cane rows can be planted in patterns better suited for the contours of the land, reducing erosion while also increasing yields. Added up across the hundreds of thousands of hectares of land where these practices have not yet been adopted, she saw tremendous potential for increased production with far fewer negative environmental problems. This is exactly the work that CTC does for its members, who represent 60% of the cane produced in Brazil. Jose Tome, another researcher a CTC, believes that these are the areas that can help smaller producers compete in the coming decades, as, even on a smaller scale, these changes are simple to make.

Several interview respondents (Luiz and Beatriz of UNICA; Adriana from CTC; Mateus, agricultural manager for an independent refinery) were eager to talk about the improvements that have been made with the problem of *vinasse* disposal (Smeets et al., 2008). Now, interviewees explained, refineries have irrigation canals that spread this potassium-rich byproduct of the cane refining process out over a larger radius, more efficient trucking systems, and newer refineries are built on higher ground to enable gravity-fed ferti-irrigation. This improved infrastructure leads to lowered chemical fertilizer use and improved soil and water quality. For the second highest sub-priority, air quality, the move to mechanization is eliminating its largest threat, burning fields prior to harvest (Arbex et al., 2007). In addition, some maintain (Buckeridge interview) that air quality in the cities is improved by replacing petroleum gasoline with the more highly-oxygenated ethanol.

3.4.2. Job Creation, Infrastructure, Institutions, and Education

These four are grouped here because they were addressed together so consistently in interviewees' responses. For example, education was a constant subject in interviews addressing employment issues, with respondents arguing, quite logically, that the private sector will depend on government at all levels to improve Brazil's educational system and research institutions to ensure a workforce that is prepared to compete in a highly technical, global bioenergy industry. At times interviewees defended the move to mechanization because of the jobs it would create that require more education and training. Others, such as Marcos Croce and *Evandro*, agreed that cane cutting jobs and others, such as workers attending to cattle pasture, are best eliminated through mechanization as they require very little education and do not lead to healthy economic development for Brazil. Interview respondents broke education into three areas that would improve the employment sector: basic schooling for children, better technical training for workers, and increased research and sharing of research by organizations such as EMBRAPA, Brazil's powerful and well respected agricultural research service. Hence, even though 'Jobs Requiring Increased Education' did not come through as a priority in the survey results under the 'Job Creation' heading, in the Institutions and Infrastructure portions of the surveys, as well as in many interviews, this was a clear and pressing need for the cane sector in particular as they make the move to mechanization and need a more skilled workforce.

Many different programs were also often discussed as encouraging greater education, in part through government incentives such as *Bolsa Familia* (Family Grant) and in part by private industry out of the necessity for more skilled workers. *Jaime*, the president of a small refinery, when asked about workers who would be laid off in the move to mechanization, said *Bolsa Familia* was essential in helping these workers make ends meet back home in places such as the Northeast of Brazil where jobs are much more scarce. This program, a conditional cash transfer program (CCT) tied to school attendance by children and visits to healthcare facilities, has been shown to have mixed results, offering short term relief to many of those most at risk of persistent poverty (Hall, 2008). If *Bolsa Famlia* comes at the expense of school budgets or is not efficiently and effectively administered, however, as it often is not, it can trap recipients into being dependent on government handouts (de Janvry et al, 2005).

An important and complex change currently underway in the sector is the move to mechanized harvest and the ban on cane burning, which is necessary only prior to manual harvesting. After years of attempting to ban cane burning necessary for manual harvest, implementation of this ban is finally succeeding (Macedo et al., 2008). The end of burning and concurrent move to mechanization is in fact due less to the ban on burning and more to three other factors: increasing value of *bagasse*, cane tops and leaves, which is now increasingly burned in the refinery for electricity generation; increasing costs of labor, due in part to improved certification of labor; and decreasing costs of mechanization stemming from a stronger local currency, the *Real* (R$). Burning, and manual harvesting, are now on track to end by 2017 in São Paulo state, and nationwide within a decade after that (Macedo, 2008). Azanha (2007) explains that the number of workers in the cane-energy sector has fallen 23%, from 670,099 workers in 1992, to 519,197 in 2005, this despite a 54.6% increase in cane production during the same period. Her article further explains that workers in the agricultural as well as industrial side of the cane-energy sector receive better pay than their counterparts in other agricultural sectors in Brazil. With the move to mechanization, this will change in two directions at once: the most poorly paid employees of the sector, the *cortadores*, or cane cutters (cutters), who also have the most difficult and unsafe jobs (Novaes, 2007), will be all but eliminated; but this move will also bring with it an increase in the number of skilled, better paying and much safer jobs. It remains to be seen whether there will be enough effective training programs to help a significant portion of the thousands of cutters who are at risk of losing their jobs achieve gainful employment in new occupations inside and beyond the cane-energy sector.

Some respondents highlighted programs to retrain cutters to do other, better jobs. The president of UNICA, Marcos Jank, showed clear concern for the people losing jobs, but also pointed optimistically to programs such as the Compromisso Nacional[5], a voluntary program already involving over 300 refineries, and RenovAção (the literal translation is 'renovation,' with the capital "A" starting the word "Action"), with the objective to provide training and education to 7000 cane workers per year to transition to other occupations both inside and beyond the cane-energy sector (UNICA, 2009). Joao Neto and the representatives from the Movimento dos Trabalhadores Rurais Sem Terra (Landless Rural Workers Movement or MST) would like to see some of this support

[5] Compromisso Nacional para Aperfeiçoar as Condições de Trabalho na Cana-de-Açucar (National Commitment to Improve Cane Worker Conditions), UNICA, 2010

going towards family agriculture and training people in methods other than monoculture, such as polycultures and low input agriculture. Joao Neto contended that when people from the MST are granted land, they often do not have the knowledge or experience to work the land successfully. While people such as Valmir “Bill” Chaves, another interviewee, and others farming on an MST settlement in Pontal, in the western end of the state, may not agree, they do see a need for greater research and support from the government to help people learn how to produce more food from the land using ecologically sensitive methods. Chaves explained that almost all of the research done by EMBRAPA goes toward helping large land owners and agribusinesses improve their yields and their profits, which does not help small farmers nor does it necessarily help to create much needed jobs. This is supported by the study by Dufey et al. (2007) which points to government support for programs striving for improved varieties of cane and increasing refinery efficiency, but found far too few government programs aimed at creating jobsor directly helping small and family farms.

The aforementioned president of the small refineries, *Jaime*, was visibly distressed when I asked him what 60-70% of his cane cutters would do as his operations moved from manual to mechanized harvest to comply with the laws banning the cane burning necessary for manual harvest. ‘We think a lot about these people and what they will do. There are no easy answers. We very much want to help them, but just do not know what to do. It’s a very difficult situation.’ Clearly, helping those workers transition to other employment is an important priority to many of the stakeholders, even if solutions are not yet clear.

Edson Dias Bicalho, the Secretary General of FEQUIMFAR (National Federation of Workers in Chemicals and Pharmaceuticals Industry), which represents 30,000 people who work within the refineries, worried about the pressure exerted in various directions as more and more refineries mechanize. With so many programs claiming to retrain workers for jobs in other areas within the sector, some of FEQUIMFAR’s associates are wondering if their jobs are at risk. Many of these cane cutters will return to their homes in the Northeast of Brazil, where job prospects are even more bleak, and Edson worries about issues such as crime, drugs, and prostitution. Along these lines, several interviewees (*Evandro*, Marcia Azanha, *Roberto*) said that job creation is a much more pressing matter for the Northeast, independent of but now possibly being added to by the developments in the cane-energy sector.

Another alternative employment for cane cutters returning to the Northeast was offered by *Roberto*, the director of a small refinery in São Paulo. 'The Brazilian government should promote tourism,' especially in the Northeast, and train people to be tour guides, work in hotels, 'make and sell trinkets that tourists buy.' This initially struck me as an idea that had not been very well thought out, and while I still do not see how it would create the 100,000 jobs that would be needed to take up the slack from the mechanizing cane-energy sector, it probably is not a terrible option, as Northeast Brazil boasts amazing cultural and natural resources already enjoyed by travelers from around the world. An essential question in this or any option regarding what these workers will be doing in the coming decades, is what they would like to do and feel capable of doing.

In an interview with Werner Baer, an economist from the University of Illinois and author of the well known book, *The Brazilian Economy* (1995), he maintained that increasing capital intensification in the Brazilian cane-energy sector will likely provide incentive for more skilled laborers. This will happen naturally, so much so that environmental protection and education should be prioritized, in that order, with human health concerns and job creation the next two most important concerns in Brazilian development, respectively. He warned, however, that excessive environmental regulation in the form of certification could result in another form of trade barrier, unwisely distorting markets.

3.4.3. Protection Against Displacement of Food Production

As was the case for protection of forests, interview respondents explained that the low priority given to protection against displacement of food production should not be taken as saying that food production is not important. Interviewees simply did not see any mutual exclusivity between increased cane production and continued food production, be it for export or domestic consumption. Paulo Kageyama, a professor of forestry at ESALQ who works with family agriculture on MST settlements in Western São Paulo, as well as Valmir "Bill" Chaves, the farmer who lives on one of these MST settlements in Pontal, SP, did not see increased cane production as a threat to food production or even to family agriculture. This was also a surprise as the expansion of industrialized agriculture has at times been seen as antithetical to movements such as the MST (Martinelli et al., 2011; Hall et al., 2009). Bill would like to see Agroecological zoning expanded to include provisions for crops other than sugarcane, as well as land set aside for family agriculture, but believes there is plenty of land in Brazil for all of these uses, as well as forests. The Egeskog et al. (2011) and Sparovek et al. (2008) studies cited above are examples of how integrating different productive activities, rather than relying solely on monoculture, can increase food production while protecting natural resources while encouraging participation of independent family farms. Marcos Croce's farm—with its shade-grown coffee plants interspersed among banana trees, stands of forest, and other food-producing species—is another example of how this can be done on a larger scale. Prof. Kageyama explained that MST settlements also illustrate how producers of even a few hectares can accomplish the same productivity on forested polycultures. These responses give light to survey results placing protection against displacement of food production as a very low priority, as interviewees explained that there should be room for both, and with smaller, family agriculture providing a potential means to address the second highest priority from survey results, job creation.

3.4.4. Administration and Enforcement of Priorities

Interview responses regarding questions of administration and enforcement of priorities often turned to discussions regarding certification systems such as Better Sugarcane Initiative and Roundtable on Sustainable Biofuels as having the most potential to be effective in ensuring that production is as socially and environmentally positive as possible. The problem with such regimes, according to Marcos Jank and others inside the industry, is that there is not one, unified, enforceable system in existence today. Indeed, there was widespread agreement amongst interview respondents that the number of certification systems for sugarcane and biofuels needs to be reduced and parameters harmonized if they are to have any impact on production processes. Rather than resisting foreign efforts to provide guidelines for the production processes that would make Brazilian ethanol more attractive to countries that might import it, an article published by UNICA regarding the EU's recently released sustainability criteria asked for clearer definitions regarding exactly what those guidelines mean (UNICA, 2010d). In separate interviews, *Eugenio* and *David*, executives for two of the five largest producers of sugarcane and ethanol; Marcos Jank, the president of UNICA; *Camilo*, a manager of a small ethanol refinery in São Paulo, and others pointed out that having so many different certification systems, so few of them with any official governmental authority, is simply prohibitive for producers. Jank and *Eugenio* explained that producers in São Paulo had been encouraged by the Roundtable on Sustainable Biofuels (RSB) as they understood this was to be an umbrella organization for others such as the Roundtable on Sustainable Sugarcane, the Roundtable on Sustainable Soy, and others. Jank said he believed they had lost this focus and were now over-generalizing in their certification systems, and UNICA was consequently no longer looking to the RSB for guidance, and has instead become more interested in the Better Sugarcane Initiative. Though the BSI has no official status, he explained, it is helpful in guiding and encouraging cane producers to adopt practices specific to their crops that might help to open foreign markets to increased importation of Brazilian ethanol under the BSI or another official certification system that may be implemented later.

3.4.5. Market Forces

I asked *Carolina*, a representative of one of Brazil's big three cane and ethanol producers, why there is so much pressure now on cane and ethanol environmental regulations, but not for 200 years on sugar exports. She had the same answer to that question as to why firms such as hers believe it is important to comply with these regulations: market forces. This, she believes, is a combination of factors. First, competing firms in the US and EU are trying to protect nascent bioenergy markets in which they can now compete, while they could not compete on sugar and so were dependent on imports, regardless of deforestation or treatment of workers. Second, consumer demand is far more responsive in the age of information. The study of Brazilian cane producers participating in the sustainability conference in Sweden, mentioned above in section 3.1.1, is an example of how firms understand that consumers pay attention to firms' practices, and will make buying decisions based on their perceptions of those practices.

Not everyone, however, agrees that consumer use of this information is positive. In our interview, Peter Zuurbier, the editor of a prominent book on sugarcane ethanol's environmental impacts, responded to a question about the impacts of increased cane production on indirect land use changes: 'It's a shame we have to talk about this. No one ever asked these questions about sugar. When people in Europe decide to refill a previously drained wetland for lakes for recreation, displacing the food production that had been occurring there with parks, no one is asking if this is going to cause deforestation in Africa or the Amazon. Why do we ask these questions now?' Zuurbier is not alone in wondering if these certification systems are truly being pushed because of concern for forests and workers, or if it is a form of market protectionism by the US and EU. Elbesen et al. (2008) also question if these policies are actually intended to protect domestic biofuels production, rather than their stated intentions or protecting forests or biodiversity. In an age of information when we have far more access to the knowledge of activities in the far corners of the globe, the market signals we consumers send can have powerful and at times uninformed, or at least unintended consequences. *Carolina* and Zuurbier echoed other respondents who said that much of the bad news about firm behavior *applies* to only a few producers, but *is applied* to the entire sector. Consumers send clear market signals indicating they want no part in contributing to socially or environmentally irresponsible behavior. As Marcia Azanha explained, 'Watch what happens when news comes out about one of Cosan's producers mistreating their workers or violating environmental regulations or polluting water: their stocks fall by 15% the next day.' There is a valuable role to be played by the public and the media, but we get a different sense of these issues interviewing and surveying stakeholders on the ground in SP than by reading about them in the popular media, or even, at times, the academic literature.

Such a scenario brings us back to Joao Neto's concern that Brazil make such investments, the land conversion and refinery construction they entail, and then 20 years down the road, once contracts have been fulfilled and new technology is more efficient, what then? Will the development of this infrastructure have occurred in such a fashion that the land can be used for other purposes, whether cultivation of other crops or another purpose all together? Will workers have reaped long term benefits from their employment, such as training that is relevant to other industries, if there is no continued demand for cane-energy sector workers? The answers to these questions will come from the long-term planning that Brazilian firms, citizens, and governments are capable of producing in the near-term to ensure the long term health of the people and lands affected by cane and ethanol production.

3.5. Conclusions

Based on the results from surveys with stakeholders in Sao Paulo's cane and energy sector, the highest priority that ought to be considered as the sector continues to increase production is protection of natural resources. This represents a rejection of the first hypothesis stating that job creation would be the highest ranked priority, followed by protection against displacement of food production, with protection of natural resources the least important priority. Specifically, stakeholders ranked water, air, soil, and biodiversity, respectively, as the most important to protect, with conservation of the Amazon and Atlantic Rainforests the lowest ranked priorities. The other hypothesis tested and supported by the surveys was that the Brazilian government and domestic private sector would be the preferred administrative bodies to oversee the pursuit of these priorities.

Three hypotheses were tested by interviewing stakeholders in Sao Paulo's cane-energy sector. The first was that smaller producers would view increasing industrialization and mechanization negatively, arguing that the environmental and socio-economic priorities should be placed before lowered costs potentially offered by larger firms and economies of scale, and that smaller operations are better able to fulfill those priorities. This hypothesis was largely rejected as most interviewees, including people representing small, independent cane growers and ethanol refineries welcomed the industrialization and mechanization of the industry, while only five of 36 responded as was hypothesized, that smaller producers will be better able to create jobs and protect natural resources. The second hypothesis tested, that larger firms would either disagree outright with the need to place the other priorities above lowered costs, or would argue that they are better positioned to accomplish these other priorities as well as generate produce at lower costs than independent producers was basically supported.

Representatives from larger firms saw their companies as completely capable of generating jobs for less educated Brazilian workers as well as protecting natural resources, and viewed each of these as highly important while pointing to several recently enacted programs that would allow them to fulfill environmental and socio-economic priorities. They did, however, see a place for independent producers in the sector's future, and did not see their continued growth and coexistence as mutually exclusive. The third hypothesis, that interviewees outside the private sector would be opposed to increased cane production and particularly intensification due to potential negative environmental and socio-economic consequences of the sector's growth, was rejected as academics and all but one of the stakeholders outside the private sector saw great potential for the cane-energy sector to contribute positively to the five main priority areas. Their caveat, as has been discussed throughout this chapter, was that there needs to be continued monitoring of the sector's practices not only by government, but also by consumers, academics, and people within the sector as well.

The intention of combining interviews with stakeholders was achieved quite well, as interviewees were able to comment in greater detail on survey results. For example, interviewees proposed that low rankings for forest protection were not because respondents did not see the forests as important, but because they did not see the cane-energy sector and its growth as having anything to do with forests. There seems to be the belief that there is more than enough land for increased cane production as well as healthy forests. This explanation was also applied to protection against displacement of food production, which received the lowest ranking of the five main priorities, since, again, there is the belief that there is more than enough arable land in Brazil for food, forests, fiber, and fuel. Job creation was the second highest priority, with safer, healthier jobs ranked as most important, followed by more jobs, higher paying jobs, and jobs requiring higher education, respectively.

The hypothesis that job creation would be the highest priority for stakeholders was, on the face of it, inaccurate, as that was ranked second, and the prediction that protection of natural resources would not be important was completely upended, as that was the highest ranked priority. This may be especially interesting to note in light of the Green Party's surprisingly successful campaign in the 2010 election, where candidate

Marina Silva, Lula's former minister of the environment, garnered 19% of the vote, forcing a runoff election between Jose Serra, the former governor of Sao Paulo, and Lula's eventual successor, Dilma Roussef (Souza, 2011). No one in Brazil predicted such a strong performance by Silva and the Greens (Shifter, 2011), and based on my own experience (leading to my hypotheses) it was a surprising change to see Brazilian voters throw this much support toward their environmental party.

Previous to conducting the interviews, based on extensive reading as well as time spent talking informally with people in Sao Paulo's cane-energy sector, I had been looking at land availability and employment as the major issues that would determine the future of the Brazilian cane-energy sector. These are not, however, the main concerns of people inside the sector. Brazil has the land and the work force to deliver much more ethanol, but only if there is sufficient demand. According to interviews with two executives from one of Brazil's three largest cane and ethanol producers, *Geraldo* and *Carolina*, the demand presently coming from outside of Brazil is based merely on policy, not natural market demand, and is therefore much too tenuous to drive substantial increases in production. For the most part, this demand, driven by transitory government policies such as the U.S. Renewable Fuel Standards (Figure 3.7, above) and California's Low Carbon Fuel Standards, does not merit substantial increases in investment and infrastructure. Rather, these major players are content with moderate increases in capacity, confident that Brazil's expanding flex-fuel vehicle fleet and only slightly increasing external demand will make these investments pay off.

Based on these results, this chapter can serve as a benchmark: What are the priorities amongst stakeholders and what are those in the industry saying they will do to attend to those priorities? Since efforts such as RenovAção, with its objective of retraining 7000 cane workers per year, or David's firm's aim to reforest 32,000 ha of APP by 2017, are only inchoate projections for future intentions, it will be important to continue revisiting these priorities in the coming years, putting pressure from various directions to ensure that these priorities are realized.

4. The Brazilian Sugarcane-Energy Sector: Possible Future Market Scenarios

4.1. Introduction

The potential for the biorefinery of the future continues to be debated in industry and the academic literature. The concept is that sugar and biomass could be refined to produce replacements for fuel and the multitude of other products currently made from petroleum. The objective for these biorefineries would be to diminish demand for and eventually possibly replace fossil fuels with renewable inputs that are more environmentally friendly while providing much needed jobs for rural economies. Meanwhile, Brazil, a pioneer in biofuels production, is benefitting economically from a growing bioenergy sector, but one that is limited by several factors. First, though they are still the world's largest exporter of ethanol, barriers in the US and Europe inhibit the sector's expansion onto the international market. Second, technological barriers and the precipitous fall of oil prices in 2008 have dampened enthusiasm for bio-based products such as ethylene or propanediol (PDO), which could be transformed into a suite of goods and materials currently made from petroleum. Today, the sector is increasing value with its dominant products—sugar, ethanol—by increasing efficiencies in the field and in the refinery, exploiting what Prahalad calls "the performance gap": "improving performance across a wide variety of dimensions such as quality, cost, cycle time, productivity, and profitability" (1993, p. 41). In the case of the Brazilian cane-energy sector and the present chapter, this can refer to increasing cane yields per hectare, yields of ethanol per ton of cane, and improving other efficiencies within existing products in current markets. Excessive reliance on this gap, Prahalad (1993) contends, could inhibit the sector from much greater growth and prosperity in "the opportunity gap," "profitably deploying resources to create new markets, new businesses, and a sense of broad strategic direction" (1993, p.41). For our purposes, this refers to expanding the suite of products the cane-energy sector offers as well as the number of markets to which these products are sold. A framework for analyzing if and how the Brazilian cane-energy sector might move from one gap to the other was provided in two articles: "The Competitive Advantages of Nations" (Porter, 1990), and later "The Determinants of National Innovative Capacity"

(Furman, Porter, and Stern, 2002). This chapter asks what are the constraints that could hold the Brazilian cane-energy sector in its current space, and what drivers could move it into potentially more lucrative foreign markets and diverse products? Then, based on these factors, what are the most likely future scenarios?

The objective of this chapter is to draw upon primary research with individuals inside the Brazilian cane-energy sector as well as research of existing data and literature to evaluate its status quo according to the framework provided by Porter (1990; and Furman, Porter, and Stern, 2002) so as to identify what barriers may hold it to Prahalad's "performance gap," as well as what opportunities could propel it in to the more lucrative "opportunity gap (1990). The results are presented in two sections: 4.3., Future Drivers of Change; and 4.4., Potential Scenarios. The three main drivers are 1. Supply and demand of existing energy resources, especially petroleum but also sugarcane and ethanol; 2. Development of technology; and 3. Access to markets, especially in the US and Europe, but also China, India, and others as they continue to develop. The results then indicate four, potentially overlapping scenarios for the cane-energy sector, and the discussion below outlines the factors that will determine towards which of these scenarios the sector may move in the coming decades. These four scenarios are

~ Domestic Focused: Sugar remains on the international market, but ethanol, the sole other dominant product from the sector, remains largely on the domestic market (more fully in the "performance gap").

~ Domestic Diversified: The cane energy sector moves into production of ethylene and other, high-value products previously limited to the petroleum refinery ("opportunity gap"), but, other than sugar, sales are largely limited to the domestic market ("performance gap").

~ Export Focused: The cane-energy sector continues its focus on sugar and ethanol production ("performance gap"), but gains entrance to international markets and exports substantial portions of its ethanol ("opportunity gap").

~ Export Diversified: In addition to sugar and ethanol, other high-value products such as ethylene are exported to various international markets (more fully in the "opportunity gap").

This chapter continues with a review of existing related literature, further discussion of the problem statement, elaboration of research questions and hypotheses, followed by the theoretical framework. Status quo conditions are then analyzed according to the framework laid out in Porter (1990). Based on the analysis of the status quo, drivers of future change—namely market conditions, technology, domestic and foreign policy, and corporate governance—are then discussed. This leads to a description of the four potential scenarios envisioned for the Brazilian cane-energy sector, and finally conclusions.

4.1.1. Review of Existing Literature

Several works by other authors provide information and guidance on various aspects of this chapter, or parallel assessments on the future of bioenergy crop production, the markets, or policy. In testing the ability of Porter's framework to provide an accurate assessment of Brazil's ability to compete, Stone and Ranchhod (2006) used data from over 20 economic, demographic, and geographic indicators to quantify Porter's framework and assess the competitiveness of the US, UK, and BRIC countries (Brazil, Russia, India, China). Brazil tied China for the highest rating in "Related and Supporting Industries," ranked second behind the UK in "Factor Conditions," and came in third for both "Country Strategy, Structure, and Rivalry" and "Demand Conditions." In terms of strategy and structure, some of the areas where Brazil is listed as lagging behind have changed since the article's publication in 2006. For example, Brazil earns a low score for foreign reserves, yet figure 4.1 shows the tremendous growth in Brazil's foreign reserves since 2000. Curiously, the study states that Brazil is not a member of the WTO, and so deducts points for lack of a voice in global trade, but Brazil is and has been a member of the WTO since 1995[1]. Recently Brazil been using its voice to argue against the US dumping cotton on world markets (Hoekman and Waters, 2011), and is threatening to pursue action against the US tariff on imported ethanol (Sapp, 2011b). This strong position in 2006 according to Porter's (1990) framework provides understanding for how Brazil managed to be among the least affected by the Great Recession of 2008-09,

[1] World Trade Organization, http://www.wto.org/english/thewto_e/countries_e/brazil_e.htm

posting one of the most positive changes in real GDP of all G20 countries both during and after the collapse (Crowley and Luo, 2011). This also lends credence to the ability of Porter's (1990) diamond to assess the competitiveness of nations.

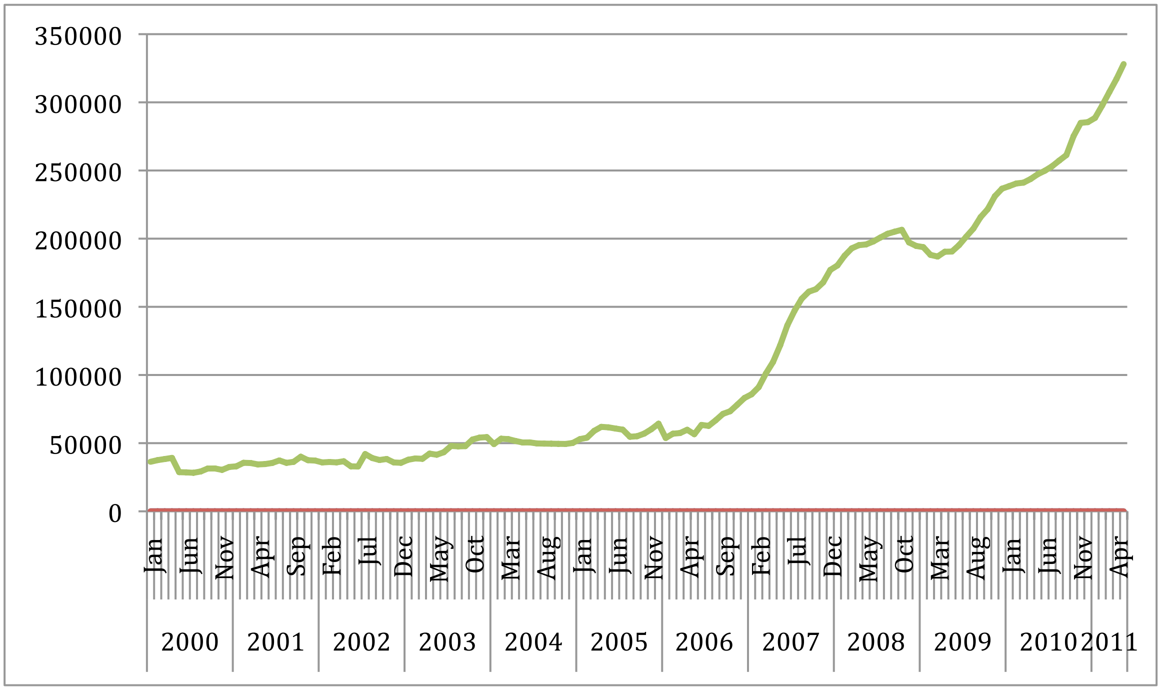

Figure 4.1. Brazil's Foreign Reserves. Source: Banco Central do Brasil. (Millions of US$)

A framework for examining the potential pathways for bioenergy and various tradeoffs between social, economic, and environmental benefits and consequences is provided by Acosta-Michlik et al. (2011). That article points out the difficulty of establishing definitive positives or negatives in these three areas of sustainability due to their interconnectedness, as well as the different impacts of, for example, policy in one region on the ecosystems, food availability, or wages in another region. They write,

> "Assessing the potentials of bio-energy production is not straightforward because '[b]io-energy is quite an [atypical] energy supply option due to its diversity and inter-linkages with many other technological (thermo-chemical conversion options, biotechnology, agronomic, etc.) and policy areas (climate, energy, agriculture and waste policy)" (Faaij, 2006, qtd in Acosta-Michlik et al., 2011).

They conclude that it is important to continue developing the framework for analysis they began in order to understand more clearly the multiple and widespread impacts of continued bioenergy crop production, and that it is important to focus studies on specific regions due to the difficulty of arriving at accurate conclusions on global scales. That article provides a solid starting point on how to assess the future sustainability of biofuels production and policy. It does not attempt to assess the future of bioenergy markets.

Macedo et al. (2008) examine current technology and technological development to project efficiency improvements in cane and ethanol production as well as future reductions in GHG emissions based on these projections. There is not an evaluation of the potential for diversifying towards cellulosic feedstocks nor other finished products from refineries. Goldemberg proposes that cane and ethanol production could increase by factor of 10 worldwide, to 30 million ha to replace 10% of global petroleum use, but does not propose barriers or justifications for these figures (2007). A similar study is performed by Luo et al. (2009), in which they project the increases in ethanol yields per unit of sugarcane, as well as ethanol production costs. Their future scenarios assume the ability to produce ethanol from *bagasse* (cellulose) and therefore project decreased costs and GHG emissions along with increased yields of fuel per unit of land. Due to the volatility in petroleum prices their model uses static petroleum prices, admitting that both these prices as well as tariffs and subsidies will have pronounced impacts on ethanol prices.

Other articles examine the technical feasibility of diversification of feedstocks and products made from biomass feedstocks in Brazil. Commercial scale plants capable of fermenting the diverse sugars in cellulose could be operational as soon as the next five years, and, though at least initially less profitable than using the bagasse for electricity co-generation , the biochemical conversion to ethanol would allow greater reductions in GHG emissions (Seabra and Macedo, 2011). Bremer and Sanders propose a list of products for which cane could be refined, specifically PDO, from which a variety of other products can be produced such as plastics and resins, hinging the success of these products and processes on petroleum prices and the pace of technological development. They do not, however, evaluate the marketplace to assess the sector’s ability to innovate nor the global marketplace for petroleum nor overall energy demand. The competiveness of second generation, lingo-cellulosic ethanol from sugarcane bagasse is compared to its common current use in electricity co-generation by Dias et al. (2011). There, it is determined that once technological improvements allow cost effective and energetically efficient production of second generation ethanol, it will also be cost effective compared to electricity generation.

The impacts of trade barriers and other market distortions imposed by governments are discussed by Elobeid and Tokgoz (2008), who find that removing the US tariff on imported ethanol would decrease price volatility for ethanol, corn, and related agricultural products such as livestock as the US market is opened to world trade. They also find a positive effect on producer surplus in the Brazilian ethanol and, to a lesser extent, sugarcane markets. Consumer surplus is affected negatively due to increased international demand and a corresponding rise in prices. This negative effect on consumer surplus is less than the positive effect on producer surplus, however, creating a net increase in welfare of US$181.92 Million for the ethanol market and US$ 42.92 Million (both 1995 dollars). Crago et al. (2010) examine the competitiveness of US corn ethanol compared to Brazilian cane ethanol, finding that fluctuations in exchange rates and prices of feedstocks determine which is more cost effective in the US market. They find that under current (2010) conditions, the US tariff is non-binding, and that exchange rates would have to increase by at least 77% to US$1 = R$3.8, or corn prices would have to increase by 78% in order for Brazilian cane ethanol to be less expensive in the US than domestic corn ethanol. They also find, however, that capacity constraints in the US corn supply and variations in price during the growing seasons may create windows of opportunity when Brazilian cane is a more attractive option in the US market. Add to this Brazilian cane ethanol's official status as being able to meet the RFS Advanced Biofuel mandate of decreasing GHGs by over 50% compared to gasoline (EPA, 2010), and there is considerable potential for increased US importation.

The objective of this chapter is to contribute to existing literature by combining academic and industry literature with interviews of industry and government officials as well as academic and private researchers. This synthesis will assess the sector's potential to play a substantial role in overcoming the problems described above, while also providing domestic contributions to Brazil's economic, environmental, and social health.

The contribution also includes documenting current objectives and nascent efforts to achieve them as a means to benchmark the status quo for future evaluation.

4.1.2. Problem Statement, Research Questions and Objectives

Companies must innovate to remain competitive in today's markets. The Brazilian sugarcane-energy sector has recently benefitted from considerable innovation, foreign and domestic investment, and changes in relationships between firms. Having diversified in the 1970s from sugar and cachaça, a sugar-based alcoholic drink similar to rum, to ethanol and, more recently, to electricity co-generation, the sector's firms appear content to remain in this space. Value will be increased by improving production efficiencies in the field and the refinery, partially though technological innovation, but mostly through dispersing best practices of existing technology. There may be more lucrative opportunities if firms can diversify their products to include substitutes for other fuels, plastics, resins, and more of the goods currently made from petroleum, and second, if refineries can add cellulosic feedstocks to the current simple sugars that form the basis of the industry. Increasing exports to foreign markets would also add greater volume to sales, either of current products or the diversified suite listed above.

More dire problems of finite petroleum resources, global climate change, and other environmental, economic, and security concerns are also driving governments and firms to devise new methods of meeting their energy demands. The Shell Global Scenarios for 2011 point out that current rates of growth in supply will boost available energy in 2050 by about 50%, which would still leave a gap in projected demand of 400 EJ per year, the output of the entire energy industry in the year 2000 (Shell, 2011). Seen in this light, the problem transcends matters of profitability and illustrates the need for cooperation between industry, government, and civil society to develop methods sooner, even when these alternatives are not as profitable, to overcome this looming dilemma.

Three main barriers stand between the Brazilian cane-energy sector and the solutions it may realize: Technology, low or volatile petroleum prices, and trade barriers to the US and Europe that limit export markets that could lead to greater profit and further incentivize innovation. On the first point, the technology is not currently available for cost effective production of a wider variety of bioproducts from cellulose or even sugarcane. Although, as is discussed later in the chapter, several firms and government and private research agencies are aggressively pursuing these opportunities. The motivation to pursue cellulosic ethanol leads us to the second factor: petroleum prices. These prices create a barrier when they are low, as they were in the second half of 2008, or simply when they are too volatile to provide confidence to firms that investments will pay off over a longer timeframe. Figure 4.1 shows weekly prices for petroleum since 2007, and illustrates the low prices that significantly reduced ethanol demand in 2008, the more recent rise in prices that are becoming less of a barrier and more of a driver, and also the rapid fluctuations that have characterized markets over the last several years and dampened investor confidence.

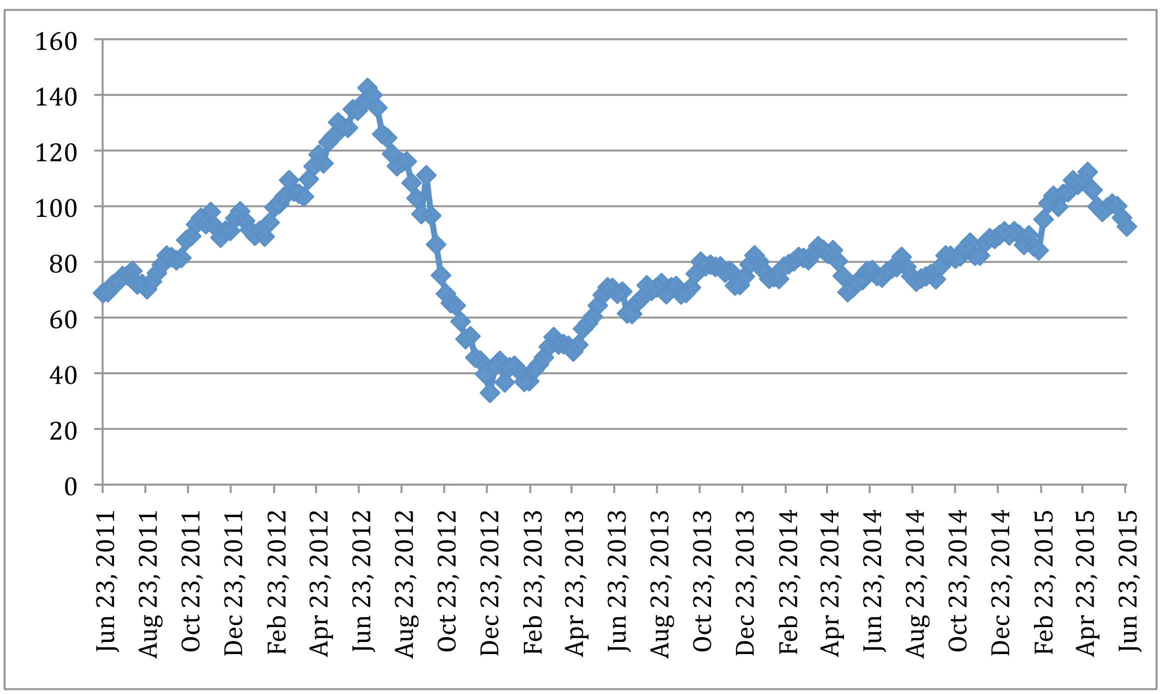

Figure 4.2. Weekly Cushing, OK WTI Spot Price FOB (US$ per Barrel). Source: US Energy Information Administration, http://tonto.eia.doe.gov/dnav/pet/hist/rwtcm.htm.

The third major barrier to the sector's diversification lies in the tariffs and other policies that limit access to large markets in the US, Europe, and other places. Currently, the US has a tariff of $0.54 per gallon on imported ethanol, as well as an ad valorem tax of 2.5% (US Congress, 2008). In 2009 the EU adopted the Renewable Energy Directive

(RED), which mandates 10% renewable fuels for road transportation, but also comes with caveats. Renewable fuels must be achieving 35% reduction in GHGs in 2009, rising to 50% in 2017, though imported fuels are subject to a tariff between €0.102 and €0.192 per liter, as well as other strict quality and environmental standards (Al Riffai et al., 2010).

The question arises, then, what sector(s) could produce most or all of the products coming from today's petroleum refineries that we rely upon so heavily, while also meeting these strict standards? Could the Brazilian cane-energy sector produce not only replacements for petroleum fuels, but also diversify into products such as ethylene and others from sugarcane and second generation, cellulosic feedstocks envisioned for the biorefinery of the future? Furthermore, will the sector move from its current position with only sugar having a substantial presence in international markets, to greater exportation of current and potential future products? What are the factors that could constrain the sector in its current space, or drive it towards greater diversification and greater export-orientation?

Based on evaluation of existing evidence, whether or not obstacles can be overcome and opportunities realized will be determined by 1) petroleum prices; 2) the speed of the sector's technological innovation; 3) cooperation between private firms, government, and civil society; and 4) the sector's ability to increase transparency, particularly around environmental and social issues, to give importing countries the confidence they are currently seeking to open their markets. As it is difficult to test hypotheses for future scenarios, particularly given the volatility of the past two to three decades and even the past two to three years, rather than propose hypotheses to be tested, this chapter has the objective, described in greater detail above and in the theoretical framework below, of contributing to existing literature by providing a detailed assessment of the Brazilian cane-energy sector's status quo, and then employing that assessment to propose potential future scenarios for the sector as well as what factors may drive the sector towards these four, potentially overlapping scenarios.

4.1.3. Theoretical Framework

The theoretical framework for this study rests on three main aspects: 1) assessment of the macro-level economic conditions affecting the competitiveness of the

Brazilian cane-energy sector—availability of land and labor, as well as government influence on the sector—based on Porter (1990, 2002) (see Figure 4.1); 2) assessment of micro-level conditions for the sector—firm structures, strategies, and rivalries, related and supporting industries, and the demand conditions that drive these—employing the framework established by Prahalad (1993) with some elaboration provided by Leonard-Barton (1992) and Williamson (2008); and 3) the future scenarios for the sector and the drivers that will lead towards those scenarios. Porter's Determinants of National Competitiveness assesses four areas of a macro-economy: 1) factor conditions, especially how a nation creates and develops, rather than simply inherits, aspects such as skilled labor, land, and a policy environment that further upgrades these factors; 2) firm strategy, structure, and rivalries that allow and even force firms to innovate, rather than remaining stagnant due to comfortable market positions; 3) related and supporting industries that create synergies in important sectors; and 4) demand conditions in which buyers, particularly firms, industries, and other institutions, put pressure on firms towards continual innovation.

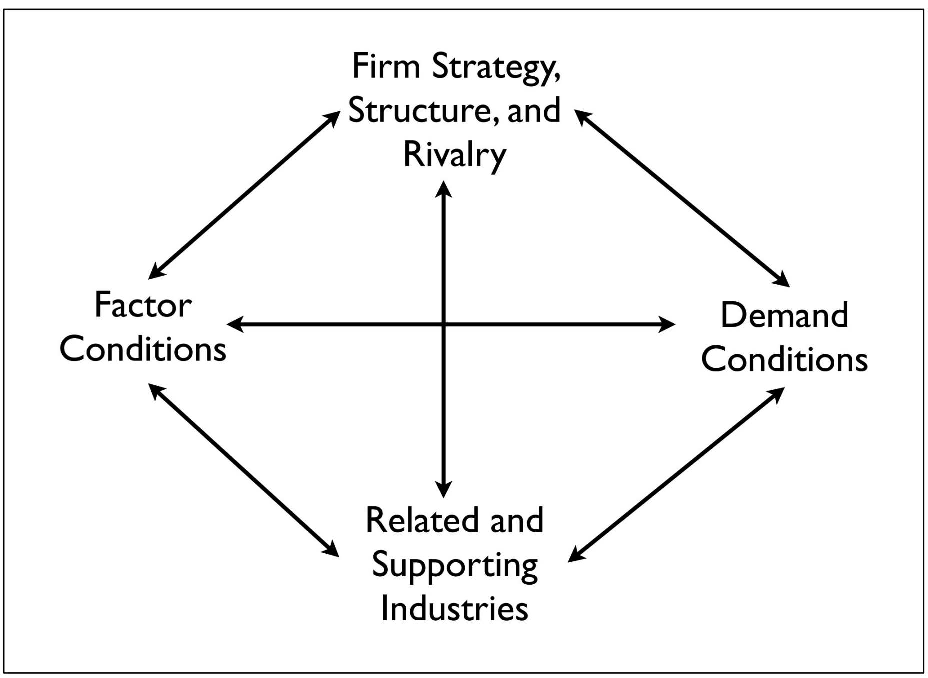

Figure 4.3. Determinants of national competitive advantage. From Porter (1990), " The Competitive Advantage of Nations."

The potential growth and diversification of the Brazilian cane-energy sector will be evaluated according to these parameters, as well as to the relationships between them. Porter's perspective is not that a country must contain advantages in each of the four areas, but that often disadvantages in one area can lead to even greater innovation in the others. This is complicated by the fact that firms develop their core competencies, and then remain focused on these areas, becoming resistant to change. The tension between investing in a firm's strengths while retaining flexibility brings the analysis to the microeconomic level and the assessments of how firms can capitalize on both existent competitive advantages while also branching out into new areas as markets change.

Prahalad's (1993) first distinction is between the "performance gap" and "opportunity gap." Though his assessment involves aspects of corporate culture that become difficult to assess from outside of firms, it is possible to evaluate the sector's ability as a whole to accomplish the proposed objectives. To move from the "performance gap" to the "opportunity gap" firms, must develop aspirations to innovate that stretch from engineers and machinists on factory floors, through the executive suites where larger strategic decisions are made. The risk that both Prahalad (1993) and Leonard-Barton (1992) identify is that not all innovative ideas will succeed, meaning executives and other employees who take the initiative to pressure change will not always be rewarded, and may at times even be punished, creating an environment in which it is safer simply to stay the course. Especially in industries in flux and times of change, as is the case in the Brazilian cane-energy sector, this stasis will lead to stagnation and loss of market share. It is the job of management to instill firm-wide aspirations, and then leverage corporate resources towards innovation that creates new competitive space and business development in the industry. Though such characteristics cannot be assessed in detail from outside of the firms, basic analysis can be performed with recent industry movements, firm literature, and interviews with executives. This is an important aspect of the present study, but it is also understood that executives will be unwilling or even unable to discuss or identify characteristics such as a firm's strategy or culture. This is also true of the aspects that Williamson (2000, 2008) has made a career of analyzing, transaction costs and the 'make or buy decisions' that firms must make regarding when to perform services or produce goods in-house, and when to outsource those processes to other firms. Again, this is the objective as well as the challenge of scenario building. Brazilian cane and ethanol producers are seen entering a multitude of joint ventures and other strategic partnerships as the sector changes. Representative examples will be discussed and analyzed, with the emphasis of the study not on predicting the future, but on looking at the main factors, or drivers, that will move these firms and the relationships between them in different directions over the next three decades.

The scenario building aspect relies on several academic, government, and industry studies to determine likely production levels for the Brazilian cane-energy sector in the next 30 years, specifically the impact that product diversification and an orientation more towards the domestic market or towards export could have on the sector. Academic studies examining various specific impacts of biofuels production, such as on European and US policy (Banse et al., 2007; Harvey and McMeekin, 2010), food prices and consumption (Rosegrant et al., 2010), on food security and water use (Msangi et al., 2007), provide evaluations of the likelihood that the US and/or Europe will open their economies to importation of bioenergy products. The US Energy Information Administration's "Energy Outlook 2010" examines energy production and consumption up to 2035 by source under five scenarios: reference case, high and low economic growth, and high and low oil prices. For the business aspects of this study, and a framework assessing similar ends, scenarios published by Shell Oil Company every three years (2002, 2005, 2008, 2011) provide appropriate frameworks due to their stature as an energy and transportation fuel leader, as well as Shell's participation in the bioenergy sector in general, and the Brazilian cane-energy sector in particular (Jelmayer, 2011; Winterstein, 2011).

4.2. Status Quo Conditions and Recent Developments

This section explores the four areas discussed above according to the framework laid out in Porter (1990), including the conditions of land and labor, and how the Brazilian private and public sectors are developing these for long term market capitalization. Firm strategies, structures, and rivalries are then assessed based on recent market developments. This is followed by a brief discussion of related and supportive industries, including petroleum and refining, automobiles, and aviation. Finally, based on these aspects, demand conditions are assessed for the historical roots of ethanol production in Brazil and the PROALCOOL program in the 1970's.

Brazil is possibly the country best positioned for increasing bioenergy production to meet both domestic and global needs. The US surpassed Brazil in terms of volume of production in 2005, making it the second highest global producer (Table 4.1), but, unlike the US, Brazil has land available for expanded production (Cequeira et al., 2009) and is much more efficient in terms of volume per unit of land, producing approximately 6100 L ha^{-1} while the US produces approximately 4200 L ha^{-1} (Crago et al., 2011).

Table 4.1. Top 10 Ethanol Producing Countries by Volume.

Country	**Production**		
	Million Liters	Million Gallons	% of the total
United States	34,070	9000	52
Brazil	24,500	6472.2	37
China	1900	501.9	3
France	1000	264.2	2
Canada	900	237.7	1
Germany	568	150	1
Thailand	340	89.8	1
Spain	317	83.7	-
Colombia	256	67.6	-
India	250	66	-

From Mussatto et al. (2010).

4.2.1. Factor Conditions

4.2.1.1. Land Use and Availability

Several academic and government studies have assessed the amount of land available and suitable for the expansion of cane production in Brazil. Fischer et al. (2008) posit that with 6.7 million hectares (M ha) of Brazilian land cultivated for sugarcane in 2007, the vast majority of this rain-fed, another 17.9 Mha of currently cultivated land are either suitable or very suitable for cane, which does not include another 18 Mha of moderately suitable, rain-fed land. There is still the risk discussed by Cequeira et al. (2009) and others that cane expansion into those cultivated lands could replace food production, either reducing it outright, or displacing it to more ecologically sensitive areas such as the Amazon Rainforest or the Cerrado in the center of the country. This does not have to be the case, however, as a closer look at the data show vast potential for sugarcane without incurring these risks.

Many assessments of land available for sugarcane cultivation in Brazil point to the areas such as cattle pasture and uncultivated grasslands that others have seen in the expansion of cane production, With intensification of cattle, increasing the number of head per hectare so that they are closer to worldwide averages, means that this cane expansion could occur without displacing any agricultural activity or causing deforestation (Sparovek et al., 2009; Goldemberg, 2009). In scenarios presented by Cequiera et al. (2009), land for expanded cane production comes from pasture as intensification and other improvements allow for beef production levels to be maintained thereby allowing cane production to increase without infringing on food production or forests. Their expansion scenario is based largely on a study by NIPE (Interdisciplinary Center for Energy Planning) at UNICAMP (University of Campinas, SP) which evaluated the potential for Brazil to fulfill 5% of global gasoline demand by 2025, projected at 1.7 trillion L by the EIA. Ethanol, assumed to be 102 BL, would account for differences in energy density and innovation in engine efficiency. The scenario also assumed producers would be compliant with the BFC mandate to set aside 20% of each parcel of land for forest. Intensification of cattle production from the current 1.0 head ha^{-1} to 1.3-1.5 head ha^{-1} would make 50-70 Mha available, much more than the 17 Mha needed for production plus 4 million for forest set asides. Though not all of this is suitable for cane production, if cattle intensification were increased to 1.4 head ha^{-1} the newly available pasture alone, they contend, would provide more than enough land adequate for the 17 Mha of cane production. These land needs could be reduced by between 29% and 38% if cellulosic technologies allowed for the use of the cane leaves, or bagasse, as a source of sugar for fermentation into ethanol. No other uses of sugarcane, such as for PDO or ethylene to replace other petroleum uses, are discussed in the article. Fischer et al. (2008) identify 7.7 Mha of unprotected grass, scrub, or woodland as very suitable for rain-fed cane production, and another 26.5 Mhaof suitable land, which is in addition to the already-cultivated land discussed above. Using the range of 95 tc ha^{-1} for 2020 projected by Macedo et al. (2008), and 125 tc ha^{-1} projected by Brehmer and Sanders (2009), this land could provide an additional 731.5-962.5 Mt of cane from the very suitable land. In addition, if we take 80% of those projected yields for the land deemed only suitable, 2517.5-3312.5 Mt of cane production each year, would provide more than enough for the doubling from the 569 Mt of cane crushed in 2009.

Recently implemented Agro-Ecological Zoning on both the national level and in the state of São Paulo was designed to reduce the risks to food security and biodiversity and ecological health. The numbers these sources present for suitability are slightly different from those above, but still project an additional 6.7 Mhafor cane production in 2017 (Figure 4.2). However, adding together the high and medium suitability lands currently used for agriculture and agriculture with livestock, EMBRAPA arrives at 36.7 Mhaof land for sugarcane, which is slightly higher than Fischer et al's. 34.2 Mha(Figure 4.3). Clearly there is some disagreement among these academic researchers and those identified by government studies, but between them we arrive at a range of between 26.5 and 34.2 Mha of land available and suitable for expanded sugarcane production. Together with yield increases and refining improvements these sources agree that ethanol production could more than double without displacing food production or valuable forests.

TERRITORY OR ESTIMATED AREA	MILLION (ha)	PERCENTAGE IN RELATION TO THE NATIONAL TERRITORY
National territory (IBGE)[1]	851.5	100%
Agricultural lands	553.5	65%
Land in use 2002 (Probio Estimate)[2]	235.5	27.70%
Environmentally restricted areas (including the Amazon and Pantanal biomes, and Paraguay River Basin)	694.1	81.50%
Suitable areas that are currently being used for agricultural and livestock production	64.7	7.5%
Suitable areas that are currently being used for pasture (high and average suitability)	34.2	4.02%
Area currently cultivated with sugarcane 2008/2009 harvest[3]	7.8	0.90%
Expansion of sugarcane production foreseen for 2017[4] (EPE)	6.7	0.80%

Figure 4.4. Land use, zoning, and cane expansion possibilities in Brazil. Figure comes from "Sugarcane Agroecological Zoning: To expand production, preserve life, and ensure a future." EMBRAPA, 2009.
1 – IBGE - Brazilian Institute of Geography and Statistics
2 – PROBIO – Activity of the Program for Conservation and Sustainable Use of the Brazilian Biological Diversity
3 – Source: Conab, 2009.
4 – Adapted from the Energy Research Company (EPE) estimate, 2008.

It is important to remember that according to Porter's (1990) framework, for countries to be successful, they must develop, and not simply inherit factors such as land and labor, making the efforts discussed here and in the next section that much more essential. If the government and industry can be successful in monitoring and enforcing the many policies and programs they have recently put in place, such as Projeto Agora (Now Project) and the Protocolo Agroambiental do Setor Sucroenergetico (AgroEnvironmental Protocol of the Cane-energy Sector), they will be making the long term investments that Porter (1990) asserts are essential to keep a nation competitive. As Sergio Torquato, an economist from the São Paulo Ministry of Agriculture, pointed out in an interview, these are big ifs, but market pressures in the age of information are proving effective, as evidenced by the publicity of these programs.

BRAZIL	CLASSES OF SUITABILITY	SUITABLE AREAS GIVEN TYPE OF LAND USE BY CLASS OF SUITABILITY (ha)				
		Al	Ag	Ac	Al + Ag	Al + Ag + Ac
TOTAL AREAS FOR BRAZIL	High (H)	11.3 million	600 thousand	7.3 million	11.9 million	19.2 million
	Medium (M)	22.8 million	2.01 million	16.3 million	24.8 million	41.2 million
	Low (L)	3.04 million	483 thousand	731 thousand	3.5 million	4.2 million
	H + M	34.1 million	2.6 million	23.7 million	36.7 million	60.4 million
	H + M + L	37.2 million	3.09 million	24.4 million	40.3 million	64.7 million

Figure 4.5. Land use and suitability for sugarcane production**.** Figure comes from "Sugarcane Agroecological Zoning: To expand production, preserve life, and ensure a future." EMBRAPA, 2009.
Al: Areas used with livestock;
Ag: Areas used with agriculture and livestock;
Ac: Areas used with Agriculture.

Projeto Agora recently brought together all three major Brazilian presidential candidates to discuss the environmental protection necessary for the continued success of ethanol production (Agora, 2010). The Protocolo is a voluntary initiative between the government and industry which includes efforts to maintain riparian corridors, first by removing cane that had previously been allowed to stretch right up to river and stream banks, and then by reforesting those banks with buffer zones composed of native species. One recent initiative promoted by UNICA is the replanting of 260,000 ha of riparian corridor since 2007 at a cost of R$75 million (UNICA, 2010c). Not only do these practices maintain soil and water quality essential to cane production and human health, they also serve to bolster UNICA's frequent claims that, contrary to detractors who decry environmental damage done by cane production, sugarcane ethanol is an environmentally friendly energy source. It is healthy for local environments while also promoting global health through decreased GHG emissions and demand for petroleum. Efforts in these areas may help to ensure continued land availability through the physical ability of the land itself to produce in a sustainable manner, as well as transparency that encourages public acceptance of and support for the sector's activities.

4.2.1.2. Labor Markets

Brazilian labor markets have shown mixed results over the last decade in terms of their ability to provide educated workers, ability to reduce poverty, and the ease with which employers can legally hire and certify new employees. Earnst (2008) evaluated the employment market during highly volatile years of privatization and market liberalization from the 1980's until 2004, when markets began to stabilize slightly. He points to longstanding problems that have plagued Brazil for decades, yet have recently been showing improvement. Past problems include rising unemployment and informal employment, especially in urban areas as people leave the countryside, and lack of education to increase productivity and perform more highly skilled jobs. Both of these are pertinent to the cane-energy sector as labor certification has been an ongoing problem. One independent cane producer exclaimed in an interview, 'I don't want to hire anybody! Each of those people requires a mountain of paperwork and represents a huge potential liability.' He went on to explain that it's important for him to help his community and to provide jobs, but the government is not helping the situation with prohibitive labor regulations, which partly explains the informal labor Earnst (2008) found to be common and counterproductive for the overall development of the economy. Kakwani et al. (2010) focused on the outcomes of these deficiencies, specifically the high rate of inequality in Brazil, though that too was found to be diminishing thanks to policies targeted at low-skilled workers and their education, minimum wages, and general well being such as health care. Recently, the government has been working with UNICA and cane- and ethanol-producers to transition workers from low-skilled and low-paying jobs such as cane harvesting, into more technical positions running tractors and working in the refineries. *Compromisso Nacional*[2] is one such program, involving over 300 refineries, and another, *RenovAção* (the literal translation is 'renovation,' with the capital "A" starting the word "Action"), has the objective to provide training and education to 7000 cane workers per year to transition to other occupations (UNICA, 2009). It is difficult to assess the success of these programs as they are too new to verify results, hence the importance of documenting these aims and watching as the sector moves forward to see whether or not their objectives are fulfilled.

4.2.1.3. Related Policy

Brazil has created a fairly business-friendly environment for agribusiness in general, and for the cane-energy sector in particular. The labor policy difficulties notwithstanding, the federal government has increased the availability of rural credit 400% since 2003 (Reuters, 2010b). They have also made substantial investments in research and development for improving existing sugarcane and biofuels production as well as innovating towards next generation technologies. This includes US$540 million invested over the next three to four years by the Brazilian Innovation Agency (FINEP) and the Brazilian National Development Bank (BNDES), and tax exemptions for technology firms that invest at least 4% of their revenues in research and development (Ethanol Producer Magazine, 2010). Combine this with policy changes such as lowering the tariff on imported ethanol in an effort to pressure the US and other markets to do the same (Bloomberg, 2010), and the recent raising of the ethanol blending mandate from 20

[2] Compromisso Nacional para Aperfeiçoar as Condições de Trabalho na Cana-de-Açucar (National Commitment to Improve Cane Worker Conditions), UNICA, 2010

to 25% (Cortes, 2010). Consequently, there is a policy environment that is already conducive to the sector's move from Prahalad's (1993) "performance gap" into the "opportunity gap" that could add far more value to an already burgeoning business sector. As discussed in the previous chapter of this dissertation, according to Dufey et al. (2007), government investments often go towards technological innovation and other areas that may indirectly benefit those people who are in the lower levels of the socio-economic strata, but there are fewer direct efforts to help these people. This contention lends credence to the disparity found in the Kakwani et al. (2010) study mentioned above, but the recent progress found in that article provides evidence that programs such as Agora and Renovacao are making tangible progress.

4.2.2. Firm Strategy, Structure, and Rivalries

The Brazilian cane-energy sector in the last few years has been marked by both growth and volatility. Investments continue from private and public domestic entities, as well as foreign firms. As can be seen from the examples below from the sector's largest producers, the sector continues to move downstream towards more retail outlets, working with the possibility, as yet uncertain, of opening new markets. Brazilian cane-energy firms are tightly interlinked, from equipment for refineries produced almost exclusively by a single São Paulo-based company called Dedini (Furtado et al., 2008), shared research performed by the Centro Tecnologia Canveira (CTC), and the industry's voice provided by UNICA, the distinction between rivalry and dependency becomes blurred. Consider an analogous situation with Ford Motor Company benefitting from the bailouts of GM and Chrysler due to their shared supply chains, shared reliance on the United Auto Workers, and other commonalities (Dolan, 2008). The contradictions in the Brazilian cane-energy sector are not limited to supply chains, or even research and advocacy, but also extend to relationships with the petroleum industry, another would-be competitor with vested interests in cane and ethanol. Given this complexity and the high velocity changes in the sector, firms are having to consider carefully when to enter into joint ventures and other partnerships, when to outsource completely to separate firms, or when to work to develop competencies internally. Williamson (2008) quotes a Deloitte survey that found “many companies learned that unexpected complexity, lack of flexibility among outsource providers, and other unforeseen problems added costs as well as friction.” In keeping with assessing the sector according to Porter’s (1990) framework, this section describes some of the major investments, relationships between firms, and movements along supply chains for the sector’s biggest players.

Dow Chemicals and Crystalzev, one of Brazil’s largest ethanol producers, had entered into a joint venture to build the world’s first facility to produce polyethylene from sugarcane (Dow, 2007). The facility was scheduled to open in 2011 and would have the capacity to produce 350,000 tonnes of polyethylene per year. According to Dow’s announcement, “The venture will combine Dow's leading position in polyethylene with Crystalsev's know-how and experience in ethanol to meet the needs of Dow's customers in Brazil and what will likely be international interest.” As quoted:

> "We are excited to partner with a great company like Crystalsev to build the first world-scale polyethylene facility that will use a renewable feedstock," said Andrew Liveris, chairman and CEO of Dow. "This project is a prime example of how Dow's innovation and industry leadership are creating outstanding opportunities to drive forward our strategic growth agenda in a way that fully supports our 2015 Sustainability Goals commitments."

The state of this venture is now in question, however, as Santelisa Vale, the majority owner of Crystalsev, has since been bought out by LDC Commodities to form LDC Bioenergia, which provides no information on the status of the venture, nor is there updated information from Dow Chemicals or elsewhere. Crystalsev also had a joint venture (JV) with California-based Amyris, which describes itself as a “renewable products company” (Amyris, 2010), to produce biodiesel from sugarcane (Bevill, 2008). That project may still go forward, but not with Crystalsev, as Amyris bought out Crystalsev’s share of the JV. Said an Amyris executive, "We would like to buy a mill to produce ethanol at first and then, next year, convert it to our product (diesel), which has more added value" (Reuters, 2009). These fluctuations in the market have been common in the last few years as the global economic crisis and volatility in petroleum prices, combined with technological uncertainty, have fostered a high-velocity market with a bright yet uncertain future.

Another major example of investment and movements in the Brazilian cane-energy sector comes from Cosan, the sector's largest cane crusher. They have expanded further into Brazil's Center region, opening an R$1 Billion mill in the state of Goias, drawing approximately 60% of the funding for the project from Brazil's National development bank (UNICA, 2010). In 2009, Cosan moved downstream by purchasing the retail outlets belonging to Esso, Exxon's gas station brand in Brazil. Finally, in another move with a foreign firm, Cosan has engaged in a JV with Royal Dutch Shell valued at approximately US$21 Billion to further enable their movement downstream into retail markets, especially foreign, export markets. But, as one analyst, Julio Maria Borges, director of Job Economia and an often cited expert in the cane-energy sector, pointed out in an article entitled, "Brazil Hopes Shell-Cosan Can Boost Ethanol Exports," "The deal itself does not raise or reduce the economic viability of blending anhydrous ethanol in gasoline. This will be determined by the oil market" (Reuters, 2010).

The relationships and rivalries between ethanol and petroleum become further complicated with the Cosan example because the firm is an active participant in petroleum throughout the supply chain. Their businesses include not only Esso gas stations, but also production of Mobil's petroleum-based lubricants (Cosan, 2010). Perhaps an even clearer example of this seemingly contradictory relationship is the strategic partnership between Brazil's national petroleum company, Petrobras, and Açúcar Guarani, the fourth largest sugarcane producer, which is owned by another French firm, Tereos International. The two have entered into the US$1.2 Billion agreement in which the petroleum company and the French maker of sugar and starch products will "develop opportunities" in Brazilian cane ethanol (Wheatley, 2010). Marcos Jank, President of UNICA, took the opportunity to explain that, contrary to "veiled criticism […] that the industry is being 'sold to foreign capital,' this solidifies Brazil's leadership in transportation fuels and electricity cogeneration" (UNICA, 2010b). Clearly the Brazilian cane-energy sector, which is dominated by firms such as these, but still involves many smaller cane producers and independently owned sugar and ethanol refineries, is undergoing substantial change.

In an interview with this author, Jank explained that during the economic crises, with its low petroleum prices and negative impacts on biofuels markets, many multinational corporations purchased refineries, including the so-called ABCD companies of ADM, Bunge, Cargill, and (Louis) Dreyfus Commodities. The entrance of these MNCs into Brazil's domestic market may increase the likelihood of the US and Europe opening their markets as these companies have considerable clout in their home countries, and may see substantial benefit to increasing the size of their markets. Other interviewees disagreed, pointing out that companies such as ADM and Cargill have a far greater interest in maintaining their dominance in the US corn markets, and thus would not want to jeopardize their interests at home. Domestic firms have developed cane production, sugar and ethanol refining, and electricity cogeneration as central core competencies. However, the industry is changing, and those competencies will have to be broadened, balancing between foreign involvement and maintaining revenues that benefit domestic stakeholders, if the sector is not to succumb to the fears of losing its benefits to the domestic Brazilian economy that Marcos Jank addressed.

4.2.3. Related and Supportive Industries: Automobile Manufactures, Petroleum Refining, Aviation

While petroleum can be seen as the main competitor to ethanol, the refining industry in Brazil may also provide the infrastructure and the know-how to help transition to the biorefinery of the future. A large presence of automobile manufacturers, especially in the main cane-producing state of São Paulo, has been beneficial to the ethanol industry, particularly with the recent advent of flex-fuel vehicles, and the airplane manufacturer Embraer could also be an important future partner.

Flex fuel vehicles (FFVs) have been important in moving ethanol beyond a government supported industry and onto the free market, providing consumers true choice in transportation fuels, with ethanol helping to reduce petroleum price volatility (Ferreira et al., 2010). Previous to FFVs being launched on the Brazilian market in 2003, drivers chose between cars that ran on gasoline, with ethanol blended in at rates from 5-20%, or cars that ran on pure hydrous ethanol, leaving car owners vulnerable to price fluctuations as they were bound to one type of fuel for the life of the car. Innovation by automakers, encouraged by the federal government, has allowed drivers to choose their fuel at the pump based on market prices, helping to increase ethanol's share in transportation fuels to 50% by volume as FFVs accounted for 77% of all cars in Brazil in 2008 (Batian-Pinto et al., 2009).

Moving from the "performance gap" improvements enabled by automobile manufacturers to the "opportunity gap" presented with product diversification, Braskem, long a leader in petroleum refining in Latin America and worldwide, may build the first example of the biorefinery of the future in Brazil. In a project funded in part by the state of São Paulo, the two have invested R$ 8.25 million in research on polymers from ethanol (Braskem, 2010). This comes on the heels of last year's announcement that the company has invested R$500 million to build a polyethylene plant that will have the capacity to produce 200,000 tons per year. Public Private Partnerships such as this one, loans to Cosan from Brazil's Development Bank, and others mentioned above illustrate Brazil's desire and capacity to move towards product differentiation, even if only on a smaller scale for the time being.

Finally, the next generation of biofuels will likely include aviation fuels, making Brazil's EMBRAER, founded as a government enterprise in 1969 and privatized in 1994, an important player in the future of the cane-energy sector. In addition to drop-in replacements for gasoline with higher energy content than ethanol, jet fuels are envisioned as the next step (Regalbuto, 2009). EMBRAER was testing a form of biokerosene in turbo-prop airplanes in the 1980s, and Virgin Atlantic and Air New Zealand have recently tested "Biojet Fuel" blends in their 747 airplanes (Dinjust et al., 2010). If demand conditions can induce EMBRAER to encourage innovation of these bio-based aviation fuels it will drive the innovation Porter (1990) contends is essential for a sector to remain competitive over the long term.

4.2.4. Demand Conditions: Products, Substitutes, Complements

The growth of ethanol production grew from the oil crises of the 1970's, when rising oil prices and a highly unfavorable balance of trade induced the government to institute PROALCOOL and the birth of the cane-energy sector (Goldemberg, 2006). Similar crises in the future, whether because of political insecurity in places like the Middle East, or oil spills that gush for months on end into the Gulf of Mexico, are similar examples of negative demand that would encourage further expansion of ethanol production, and perhaps move firms to invest in different kinds of products. The US state of California, through its Environmental Protection Agency's Air Resources Board, has been evaluating the energy use and GHG emissions of both US corn- and Brazilian sugarcane-ethanol, finding more favorable results for Brazil's ethanol, possibly indicating their intention of importing the biofuel (CARB, 2009a ; CARB, 2009b).

4.3. Results: Future Drivers of Change

Based on a review of the literature and the analysis above, three main drivers were identified that would have the greatest impact on the future of the sector: 1) market conditions, particularly supply and demand of petroleum prices, but also sugar and sugarcane; 2) technology development, including agriculture, biorefining, petroleum extraction, and vehicle fleets; and 3) policy, both domestic encouragement or inhibition of cane and ethanol production and consumption, and international barriers or incentives to importation of biofuels. To a slightly lesser extent, corporate governance of individual firms in the sector, and the sector as a whole in shared institutions such as UNICA and CTC, will also play an important role in the sector's future. These drivers are based on firsthand experience surveying and interviewing representatives from within the cane and ethanol industry, as well as reviews of the literature regarding the future of biofuels in general, and the Brazilian sector in particular. The USDA Economic Research Service published a study entitled "The Future of Biofuels" (Coyle, 2007), which identified five drivers, with petroleum prices listed as the most important factor. Low cost feedstocks are also included, along with government policy, technological development, and competition from "unconventional fossil fuel alternatives," such as oil sands, heavy crude oil, and the conversion of coal to oil. Here we will draw upon this and other studies as well as the analysis above to discuss briefly each of the four drivers.

4.3.1. Market Conditions

Petroleum prices will likely have the greatest impact on the future of the cane-energy sector in Brazil, and biofuels worldwide. The US Energy Information

Administration's 2010 "International Energy Outlook" (EIA, 2010) projected petroleum prices for the year 2035 of $51, $133, and $210 for their low oil price, reference, and high oil price scenarios, respectively. In assessing the viability of various bio-products that could replace petroleum-based products, Hermann and Patel (2007) used petroleum prices of $25 and $50 when they found that many bio-based products such as PDO, which can be transformed into an array of finished goods such as adhesives, laminates, and solvents, would be cost-competitive with their petroleum-based counterparts after 20-30 years of research (Table 4.2). Clearly petroleum's price volatility (Figure 4.4 below and 4.1 above) inhibits accurate estimations for future oil prices, though the EIA projections indicate likely further adoption of bio-based products, provided sugar prices remain within their historical realm.

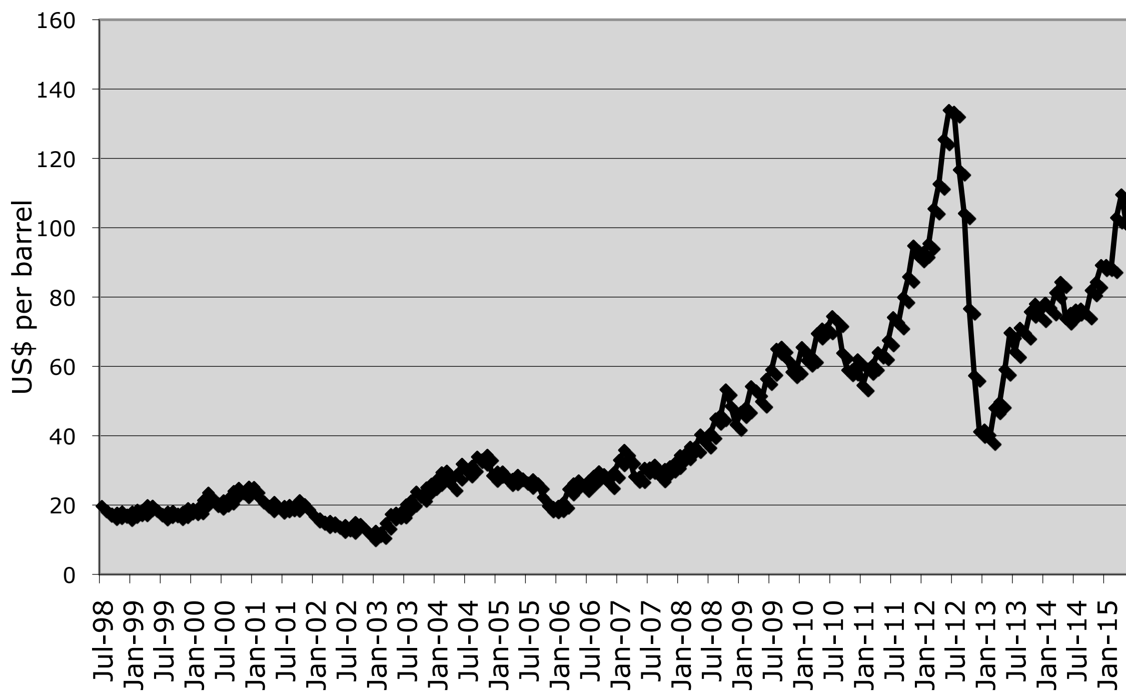

Figure 4.6. Petroleum prices in US$ per barrel. Cushing, OK, WTI Monthly Spot Price FOB (US$ per Barrel). Source: US Energy Information Administration, http://tonto.eia.doe.gov/dnav/pet/hist/rwtcm.htm.

4.3.1.1. Sugar Prices

Ethanol prices in Brazil rose towards the end of 2009, largely owing to dwindling supplies in the face of increasing international demand, due in large part to India cancelling sugar exports to the European Union, with Brazil's flexible *usinas* refining a larger proportion of cane into sugar to fill this demand (CommodityOnline, 2010). Most Brazilian refineries are capable of choosing whether to make sugar or ethanol on a day-to-day basis according to market prices for each, meaning that as sugar prices rose, producers met the demand, diminishing the domestic supply of ethanol (Holman, 2010). This illustrates the sensitivity of ethanol prices to sugar prices, meaning that incidents such as this could decrease the viability of next-generation products. Hermann and Patel (2007) took these fluctuations into account as they projected the profitability of a range of products traditionally produced from petroleum, projecting their viability to be made from fermentable sugar at four price levels based on New York Board of Trade and Brazilian sugarcane prices over the last decade. Their results (Table 4.2) indicate that at a low petroleum price of US$ 25.00/bbl, and a lower-mid sugar price of 135 Euros/tonne, eight of the 15 products they surveyed would be economically viable.

Table 4.2. Viability of white biotechnology (wb) chemicals for four price levels of fermentable sugar for current and future technology. From Hermann and Patel (2007). Assumes crude oil price of US$25/bbl.

Sugar price	Today	Future
400 e/t	PDO (possibly)	Lactic acid, PTT, lysine, PDO (possibly)
200 e/t	PDO, PTT, ethanol	Lactic acid, PTT, lysine, PDO, caprolactam, ethanol, succinic acid
135 e/t	PDO, PTT, ethanol	Lactic acid, PTT, lysine, PDO, caprolactam, ethanol, succinic acid, ABE
70 e/t	PDO, PTT, ethanol, succinic acid, PHA (possibly)	Lactic acid, PTT, lysine, PDO, caprolactam, ethanol, succinic acid, ABE, acrylic acid, adipic acid, ethyl lactate, PHA (possibly), PLA (possibly)

"Possibly" indicates that the production cost plus profits (PCPP) of the WB chemical is higher than the PCPP of its petrochemical equivalent, but lower than the current market price of the product. PDO, 1,3-propanediol; PTT, polytrimethylene terephthalate; PHA, polyhydroxyalkanoates; PLA, polylactic acid; ABE, acetone-butanol-ethanol.

4.3.2. Technology

There are four areas to consider in the technological innovation on the horizon that may impact the Brazilian cane-energy sector: Agriculture, biorefining, petroleum extraction, and vehicle fleets. Agriculture lies mostly within the "performance gap," improving efficiencies in the field. Biorefining can be seen in both the "performance" and "opportunity gaps," as innovation there can improve on existing technologies, but is also the greatest avenue for developing new products and markets. The second two are largely competitors to the biorefinery, especially vehicle fleets, namely plug-in hybrid vehicles (PHVs) that could diminish the demand for liquid transportation fuels.

4.3.2.1. Agriculture

Technological advancements in areas such as cane varieties, mechanization, and others have led to consistent yield increases for the past several decades, with yields averaging 72.3 tonnes of cane per hectare (tc ha^{-1}) and 88 tc ha^{-1} nationally and in São Paulo state, respectively, during the 2001-'05 period (Brehmer and Sanders, 2009). The continued improvements foreseen in the projections for future yields, discussed in the Problem Statement section above and presented in Table 4.3 are encouraging in terms of increasing yields of ethanol per hectare but do not help to move the sector into the "opportunity gap". That move would help achieve the lofty goals stated by former Minister of Agriculture Roberto Rodrigues for Brazil's agricultural and bioenergy sectors to move Brazil into the first world. These innovations will have to come in the areas of biorefining and product diversification, as well as vastly increased entrance into foreign markets.

Table 4.3. Historical Brazilian cane production**.** Harvest year 2000 refers to 1999/2000 harvest season, etc. Area harvested figures are in millions of hectares (M ha), production in M tons, and yield in tons per ha. Source: 2000-2008 data from IGBE, 2009; 2009-2010 data from CONAB, 2010.

Year	Area Harvested	% Change	Production	% Change	Yield	% Change
2000	4.82		325.33		67.51	
2001	4.96	2.90%	344.28	5.82%	69.44	2.86%
2002	5.1	2.82%	363.72	5.65%	71.31	2.69%
2003	5.37	5.29%	389.85	7.18%	72.58	1.78%
2004	5.63	4.84%	416.26	6.77%	73.88	1.79%
2005	5.76	2.31%	419.56	0.79%	72.83	-1.42%
2006	6.19	7.47%	457.98	9.16%	74.05	1.68%
2007	6.56	5.98%	489.96	6.98%	74.73	0.92%
2008	7.29	11.13%	558.14	13.92%	76.61	2.52%
2009	7.06	-3.16%	571.43	2.38%	80.97	5.69%
2010	7.53	6.66%	612.21	7.14%	81.29	0.40%

4.3.2.2. Biorefining

Studies from academic researchers such as Brehmer and Sanders (2009) have indicated that sugar fermentation is the best method for bioproducts, even into the foreseeable future. Whereas, Hermann and Patel (2007) and Goldemberg (2008) point to the tremendous increase in productivity per unit of land if cane and ethanol producers diversify into cellulosic fermentation and beyond current products. In interviews with executives from three of the top five sugar and ethanol producing firms, each of them told me that their firms were doing little or no research and development in these areas. These firms were instead wanting to see what innovation comes from other organizations such as the Centro Tecnologia Canaveira (CTC), the private research center that shares its findings with all ranges of cane and ethanol producers, who collectively represent 60% of Brazilian production. In interviews with researchers from CTC as well as public academic groups such as the Centro Tecnologia de Bioetanol (CTBE), there was far more enthusiasm for a wider array of bioproducts from both sugar and cellulose. But these are not the decision makers, and their results, even from the private CTC, are shared among the majority of firms, leaving the question open regarding who, how, and when these firms might operationalize these innovations.

Brehmer and Sanders (2009) cite substantial fossil fuel and GHG savings for both ethanol and ethylene by using sugarcane and biomass rather that petroleum. They do, however, find that fossil fuel energy savings are far greater when using traditional sucrose and glucose fermentation rather than the lingo-cellulosic biomass envisioned for second-generation technologies. Part of the tradeoff is due to the comparatively difficult process of fermenting the five-carbon sugars (or pentoses, such as arabinose and xylose) in the biomass. This process contrasts with the more straightforward fermentation of more homogenous feedstocks of six carbon sugars (or hexoses such as sucrose from sugarcane and glucose derived from corn) that has been performed for centuries. Either way, it is clear that renewable sugarcane shows tremendous potential to mitigate the need for petroleum. So if this is the case, why is the transition to the biorefinery of the future not occurring more rapidly? Brazil's petroleum industry provides answers as well as further questions, as we evaluate recent petroleum finds off Brazil's coasts that may diminish demand for the biorefinery, but also infrastructure and know-how that could aid in the biorefinery's innovation.

4.3.2.3. Petroleum Extraction

The vast oil reserves recently located off Brazil's southeastern coast have been touted as one of the largest new oil finds, but extracting that oil safely is far from certain. These recent finds, potentially 5-8 billion barrels (Bbl), reside in what's called the "pre-salt" or Tupi oil fields off the coast of Rio de Janeiro and São Paulo (Goodman, 2009). Technological improvements will be needed there as well, however, as much of the oil lies several thousand meters below the surface of the Atlantic (Beltrao et al., 2009). The depths of the oil fields, possibly over 5000 m and under approximately 2000 m of salt (Beltrao et al., 2009), are similar to the conditions under which the Deepwater Horizon rig was working, 5500 m deep, when it exploded on April 20, 2010 (Kerr et al., 2010). This accident, though, does not necessarily mean that oil at these depths is out of reach, as Maugeri (2009) describes technologies such as advanced imaging that allows prospectors to locate reserves at greater depths, and heat-based and gas injection methods that allow those reserves to be accessed and extracted. Assessing these technologies is certainly beyond the scope of this paper, but their improvements and further implementation will be very important determinants of the Brazilian cane-energy sector's future, as they will play a major part in petroleum prices. The company central to these efforts, Petrobras, began as a government agency, privatized in 1997[3]. It could be assumed that their efforts to innovate extraction technology would put them at odds with the cane-energy sector. As discussed above, however, these relationships are complex, and Petrobras has invested heavily in the ethanol industry, including working to build the country's largest ethanol refinery, capable of producing 700 ML (185 Mgals) per year (Bloomberg, 2011) as well as an investment of US$3.5 billion to double ethanol output over the next 4 years (Slater, 2011).

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[3] http://www.petrobras.com.br/en/about-us/our-history/

4.3.2.4. Vehicle Fleets

When an executive from one of the top three cane-ethanol producers said his firm was not making any moves toward second-generation, cellulosic ethanol or other bioproducts from cane or ethanol, I asked if there was any concern about potential competition from firms that do more towards these innovations. He said he believed his next and biggest competition was not coming from this direction, but from plug-in hybrid vehicles (PHVs). If this is true, the competition may be at least a decade or two away, if not more. Kromer et al. (2010) conclude that while PHVs emit only 34% the GHGs of current combustion engines and consume only 18% the petroleum per km traveled, they may account for only 5% of US vehicle sales as far off as 2025. Changes in infrastructure and attitude, they argue, will take at least that long in the US., which leads this researcher to conclude it will take at least that long in Brazil, as the hybrid vehicles becoming increasingly common in the US have yet to gain entrance in Brazil. This observation is corroborated by President Lula's recent decision not to launch a program intended to encourage domestic production of electric vehicles, a decision that came at least partially in response to petroleum and ethanol lobbies (Abranches, 2010).

Alfred Szwarc, UNICA's executive in charge of technology and emissions, had mixed reactions to the possibility of electric vehicles in Brazil, which he discussed in a recent article (Szwarc, 2010). He acknowledged that electric drive systems are very useful in applications such as forklifts, golf carts, and bicycles, but that expensive batteries with 5-7 year life spans translate into fully electric cars being at least 15 years away. Hybrid electric vehicles on the other hand, Szwarc (2010) points out, offer economic and environmental benefits over conventional internal combustion engines and UNICA welcomes the arrival in Brazil as well as government encouragement of their increased adoption. If, or when, PHVs do gain significant entrance into Brazil's transportation fleet, they will diminish demand for ethanol or petroleum or both, though this seems unlikely in the next 20 years. If they do arrive, this would likely be on a global scale, meaning decreased ethanol demand both domestically and in foreign markets. This event could push the most innovating firms toward diversification of products such as ethylene, PDO, and others, both on domestic and international markets, to continue valuation of abundant cane supplies in the face of decreasing ethanol demand.

4.3.3. Policy

Brazilian domestic policy has been described above as being very encouraging and accommodating to the Brazilian cane-energy sector, while also establishing guidelines on environmental issues and encouraging increased education for a more highly-skilled labor force that will aid the sector and Brazil in the long-term. Therefore, probably the biggest question for the expansion of the market, after petroleum prices, lies in what will be done in markets such as the US and Europe, where there is currently very little importation of biofuels, yet each has extensive policy objectives to encourage biofuel use. Without policy changes, the EIA Outlook (2010) predicts that fossil fuels will continue to account for 80% of global energy use in 2035, though renewable energy use is projected to grow by 111%. That growth figure is encouraging until we consider that biofuels account for only about 3% of transportation fuels worldwide (EIA, 2010).

In a presentation in March, 2010, at ESALQ, the agricultural school for the University of São Paulo (USP), Roberto Rodrigues, the former Brazilian Minister of Agriculture, said that agribusiness has the potential to move Brazil into the first world, stating confidently that ethanol exports would climb from 5.4 billion liters (BL) in 2010, to 15.1 BL by 2020. Isais Macedo, perhaps the foremost academic expert on the Brazilian cane-energy sector, has also projected a doubling of cane production from 2007 to 2017 (Macedo et al., 2008). However, tariffs and other barriers may remain in place and that would leave this increase in production without the market demand to create value for its products,.To be competitive for years to come, individual firms and the sector as a whole may need to move to Prahalad's (1993) other aspect of value creation: "the opportunity gap," where firms capitalize on opportunities in new products, markets, or areas of business development.

Both Europe and the US have put in place legislation that mandates increasing use of renewable fuels in the coming years. In Europe, the EU Renewable Energy Directive (RED) mandates that renewable fuels account for 10% of road transportation fuels by

2030, with 50% reduction in GHG emissions by 2017 (Al Riffai et al., 2010). Germany is the only significant biofuels producer in Europe, producing two-fifths and using about one-half the world's supply of biodiesel, predominantly from canola (rapeseed) as well as soy and other feedstocks, making it the largest on both counts (Bringezu et al, 2009). As even this largest producer is still a net importer, it is difficult to see how RED can be met without lowering existing barriers and importing ethanol or other biofuels. The US is in a similar position with its Renewable Fuel Standards (RFS), which mandate 36 billion gallons (B gals) of renewable fuels by 2022. These fuels are broken down by type, with corn ethanol capped at 15 B gals in 2015, and increasing amounts of cellulosic and advanced biofuels composing the remainder (EPA, 2010). The Brazilian cane-energy sector was recently given a glimmer of hope regarding entrance to the US market, as the EPA elaborated on the RFS by establishing Brazilian ethanol as an advanced biofuel, with its 61% reduction in GHG emissions compared to gasoline surpassing the 50% reduction required to qualify as an advanced biofuel. While this is encouraging, it does not remove the US$ 0.54 per gallon tariff on imported ethanol that currently blocks significant importation. For the Brazilian cane-energy sector to move into Prahalad's (1993) "opportunity gap," these policies will need to be revisited to allow entrance of Brazilian ethanol into these sizable markets and justify the expansion of cane production currently underway.

4.4. Results: Potential Scenarios

Future scenarios for the Brazilian cane-energy sector hinge upon two main questions: will the sector diversify its products to replace other goods usually made from petroleum; and will foreign governments open their economies to importation of ethanol and these other potential products? Using this reasoning, four scenarios are offered (Figure 4.5), though these are not mutually exclusive. It is certainly possible that some firms will diversify into a few initial new products, and that only limited foreign markets will be opened with only a few firms taking advantage and exporting to these foreign markets. That said, the four main scenarios are Domestic Focused, Domestic Diversified, Export Focused, and Export Diversified.

Figure 4.7. Possible future scenarios. These four are not envisioned as absolute or mutually exclusive, but as potential directions for the Brazilian cane-energy sector.

Figure 1. Scenarios. Possible Scenarios for the Brazilian Cane-Energy Sector.	
1. Domestic Focused: Sugar remains on the international market, but ethanol, the sole other dominant product from the sector, remains largely on the domestic market.	**2. Domestic Diversified:** The cane-energy sector moves into production of ethylene and other, high-value products previously limited to the petroleum refinery, but, other than sugar, sales are largely limited to the domestic market.
3. Export Focused: The cane-energy sector continues its focus on sugar and ethanol production, but gains entrance to international markets and exports substantial portions of its ethanol.	**4. Export Diversified:** In addition to sugar and ethanol, other high-value products such as ethylene are exported to various international markets.

The market is currently in the Domestic Focused scenarios, with only sugar maintaining a presence on international markets, and the other three main products, ethanol, cachaça, and electricity sold almost exclusively on the domestic market. To a very limited extent, the market is already moving into scenario 2, Domestic Diversified, with the recent boom in ethanol production as well as electricity generation and the biorefinery due to be opened by Braskem in 2011, discussed above. As it does not appear the products coming out of this biorefinery will be exported, the focus remains on the domestic market. In order to enter scenario 3, Export Focused, the sector would remain with its current suite of products, but would increase exports significantly, which can only happen if foreign markets drop their existing trade barriers. Both the private firms and Brazilian government have been working towards this goal, with UNICA consistently lobbying through their representatives in Washington D.C. and in Europe

UNICA, 2011, Amaral, 2011) and the Brazilian government dropping its own tariff on imported biofuels in February of 2010.

4.5. Conclusions

Once the macro-factors for the Brazilian cane-energy sector are taken into account, the most pressing drivers for its potential move into Prahalad's (1993) "opportunity gap" are rising petroleum prices, further development of technology, and policies in markets such as Europe and the US.. If petroleum prices fall once again, that potential driver becomes a barrier for this move. The same can be said about technology, in that its development is a driver while failing to develop technology becomes a barrier, and policies in foreign markets, which will either remain as they are and remain a barrier, or change to invite further importation of Brazilian ethanol. According to the EIA Outlook (2010) and the assessments of technology by Hermann and Patel (2007) and Brehmer and Sanders (2009), Brazilian bioenergy products beyond ethanol will be cost competitive with traditional petroleum-based products by the end of the present study's timeframe of 30 years. Perhaps the most important factor yet to be determined, then, is if executives and other employees of individual firms will be able to push their core competencies into those areas where demand is highest.

It is difficult to test hypotheses for what may happen in the coming years and decades, but the quantitative assessment provided by Stone and Ranchhod (2006), and the strong performance of the Brazilian economy through the economic crisis of 2008-09 (Crowley and Luo, 2011), indicate that the country as a whole is well positioned to compete in the global bioenergy sector. The substantial amounts of land available for cane production expansion, the biorefining infrastructure in place and planned in the near future, and the related and supported industries such as petroleum extraction and refining, automobile manufacturers, and aviation, indicate that the cane-energy sector has what is essential to a sector's competitiveness as it innovates in a changing world. Because future petroleum prices, government policy in foreign markets, and the speed of technological innovation, are impossible to predict, four scenarios were proposed for whether the Brazilian cane-energy sector will remain focused on its current products or will diversify.

In addition, whether or not it will be permitted to export ethanol and other possible future products to foreign markets, or if those will remain largely confined to domestic consumers.

Today, to a researcher who has been immersed in the bioenergy sector for several years, this future growth seems to be a given. But if public perception or technology or government policy change in the next decade, as they very well could do, and demand for biofuels collapses, given the time, money, and other resources necessary to convert sugarcane production to other land uses, Brazil and its landowners could be left holding a very heavy bag. It is important to remember that Henry Ford designed his first cars to run on ethanol, but the technology to extract and process petroleum put these plans on the shelf (Solomon et al., 2007). The biofuels buzz has only recently been reborn, and it could just as easily fade away again. Some stakeholders in São Paulo need greater assurance than fleeting government policy to feel comfortable with projections predicting a doubling of Brazilian cane land.

5. Conclusions

In April of 2010, demand for Brazilian cane and ethanol appeared poised to increase significantly. Brazil dropped its tariff on imported ethanol, in part an effort to pressure the United States to do the same, only two months after the U.S. E.P.A. affirmed that Brazilian ethanol is the only existing, industrial scale renewable fuel capable of meeting the U.S. "advanced biofuels" mandate in the Renewable Fuel Standard. At other times in the volatile energy environment, the opening lines of this article, "Algums vão ser deixados por atrás" ('Some will be left behind'), and, "É a realidade" ('It's the reality'), however, could just as easily refer to those investing heavily in fickle alternative energy markets, awash in Brazil's new found petroleum reserves and the world's increasing consciousness over workers' rights and environmental protection.

The changes addressed and continually underway for the sector have begun so recently that there is still very much a wait-and-see attitude expressed in all three studies contained here. The results of this dissertation, then, provide a baseline from which to assess the sector now and in the coming decades. Based on the results from the three studies, four main conclusions are drawn: 1. Conservation of natural resources, especially with increased enforcement of the Brazilian Forest Code (BFC); 2. Increased education at all levels, and by both public and private organizations, as the sector moves from one highly dependent on manual labor in sugarcane harvesting, to a mechanized system that will likely require fewer, but more highly trained workers and further technological innovation to keep pace with bioenergy developments; 3. Active and continued engagement by citizens, media, government, and other related organizations to ensure ecologically and socially responsible production of sugarcane and biomass feedstocks for the sector into the future; and, on a broader scale, 4. The need to address the finite nature of petroleum and other fossil fuels, in part through bioenergy, but especially with increased energy efficiency and greater regional independence as we work to meet the most basic necessities of food, water, and energy.

5.1. The Four Main Conclusions

5.1.1. Conservation of Natural Resources

The need for biodiversity is, it is hoped, well established in the second chapter of this dissertation, as is the threat posed to it by expansion of industrial agricultural that relies upon monocultural systems. The results of the second chapter also indicate that it is entirely possible for social benefits to be realized in ways that balance private and public costs so that producers don't bear these costs alone. Whether or not sugarcane production is extensified, taking up a greater proportion of Brazilian land, or intensified, benefitting from increasing yields with less need for expansion, Areas of Permanent Preservation and/or Legal Reserves will be essential on cane-producing lands in order to ensure the health of ecosystems and the people who live within them. In that second chapter, this need is addressed from all three perspectives of the three integrated aspects of economy, society, and ecology, and methods are identified and quantified to compensate producers for the private costs incurred to realize the environmental benefits offered by these forests.

Brazil is a very resource dependent country, and today's technology allows resources to be extracted or otherwise altered far more than has been the case in the past. There is a perception held by many stakeholders in Sao Paulo, revealed in the results of Chapter 3, that there is more than enough land for fuel, food, fiber, and forests. This may be true today, but inevitably there are limits. The US, too, began as an agrarian, resource dependent country, but the technology available in the 18th and 19th centuries didn't allow for the clear cutting and strip mining possible in the 21st century. Chemical inputs can also enable far more food or timber or fuel to be grown from a unit of soil. This is not to say, however, that there are no negative consequences to this increased extraction. Healthy soil and water are essential for the cane-energy sector to continue earning profitable yields from the land on which it operates, as well as to keep ecological systems there functioning in a cost effective manner. From the human perspective, soil, air, and water quality have been shown to be concerns associated with sugarcane production, and these clearly have direct impacts on human health and a functioning society. Best practices discussed in Chapter 3 illustrate the ability of cane production to mitigate past ills in these areas. These practices need to be disseminated, monitored, and improved.

5.1.2. Increased Education

Perhaps Brazil's greatest resource that needs careful cultivation in the coming years is its people. Moving beyond a resource-based economy into technology and services will continue to propel Brazil's economy to be one of the most innovative and robust in the world, one in which more of its people and its ecosystems are nurtured in healthy ways. As the move to mechanization continues, and as Brazil works within a global framework of increasingly rapid technological innovation, increased education from childhood through adult, professional levels will be essential to Brazil's development. As was discussed, particularly in Chapter 3, the hundreds of thousands of workers who have been or will be laid off from manual sugarcane harvesting will need to find employment elsewhere, either inside the cane-energy sector or beyond, in order to avoid the problems of poverty and crime associated with high rates of unemployment. Drawing on this issue and moving in to the future of the sector discussed in Chapter 4, a highly educated workforce will be needed in order for Brazil to remain competitive and achieve the objective of bringing Brazil into the "First World" that former Minister of Agriculture Roberto Rodrigues envisions for agriculture and bioenergy.

5.1.3. Continued Monitoring and Engagement

For both of the above objectives to be achieved, and especially for the fourth objective below, there will need to be continued, active engagement on the part of citizens, the media, government, and other organizations and institutions. As both Marcia Azanha and *Carolina* pointed out in their interviews, when a sugarcane producer, even a small, independent producer, is found to be in violation of environmental or labor policy, the larger firm that processes that cane may see their stocks drop, sometimes quite significantly, as this news hits the popular media. This does not happen on its own. Citizen engagement is necessary throughout the process, from the people who uncover the violations, to the media that report them, to the consumers and investors who care enough about these issues to send market signals back to the firms involved. This provides tangible, immediate, economic incentive for producers to remain within policy guidelines beyond simply being fined for violations. This active citizenry is also required to continue electing politicians who will draft the most responsible guidelines possible. The agri-environmental zoning the Lula administration passed, discussed in Chapter 3, is a great step in this direction. The lack of compliance with BFC regulations, however, illustrates that merely passing legislation does not guarantee that it will be followed.

5.1.4. Addressing Finite Energy Resources

Finally, and perhaps most importantly, solutions must be devised, within the next few decades, to account for dwindling supplies of petroleum and other fossil fuels. Much of the hope for the cane energy sector expressed by respondents in Chapter 3, and the uncertainty described in Chapter 4, both stem from the understanding that we will run out of petroleum and all fossil fuels, we just don't know exactly when. Europe's Energy Portal[1] (2010) predicts the exact moment when the world will run out of these nonrenewable resources, and it is not very far. Petroleum is projected to be exhausted in October, 2047; natural gas in September, 2068; coal in May of 2140; and even uranium, European Union government officials surmise, will be gone by November of 2144. If these projections are even close, many people alive today will live to see the end of the first two, and our grandchildren may survive to use the last of the latter. This is not meant as a scare tactic, but then again, as David Orr quoted Samuel Johnson, "The assurance of the gallows in a fortnight can concentrate the mind wonderfully" (2004).

5.2 Last Thoughts

Brazil's economy has almost limitless potential, and it will reach the greatest potential in the long term if it adopts those methods that ensure the health and availability of supply with which to meet global demand for its various products and the people who produce them. Some of these include sellable goods such as cane, timber and pulp, beef, and other agricultural products. But there are also other resources that are equally essential, but currently that value is not immediately economic. Healthy soil, water, air,

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[1] http://www.energy.eu/#depletion

and even biodiversity do not bring revenues to producers, but without these resources their revenues may decline, or costs will increase as producers, landowners, governments, and others find ways to counteract the deterioration of these resources.

Even with the vast potential for the Brazilian cane-energy sector outlined throughout this dissertation, and especially in Chapter 4, massive measures will need to be taken on a global scale to address these environmental concerns, which cross all three areas of economy, ecology, and society. Global biofuels production will almost certainly increase in many countries, hopefully keeping in mind the above limitations. With an increasing population, however, and the rapid advancement of economies such as China and India, with more people using more energy and consuming more meat, processed foods, and other energy-intensive edibles, biofuels will not likely be able to solve the problem on their own. As far as this researcher is concerned, the most cost- and energy-effective way to ensure the availability of energy resources for future generations is through increased energy efficiency and greater regional energy-independence. Every tanker of transport fuels coming from afar to U.S. ports requires energy and other resources to carry its cargo. When it transports ethanol it delivers only 70% the energy it would if it were carrying petroleum. Through redesigned urban centers, technological innovation, and small sacrifices, especially by those of us in the developed world who use far and away the most energy per person, we can use far less energy, and keep Orr and Johnson's gallows out of assurance.

Friends of mine have said there could be a string on my back, pulled to hear me utter a few very common phrases. One of them is that "This is absolutely the most fascinating time to be alive." I stand by that statement I say so often, even as I amend it to say that this is the most fascinating time to be working on energy issues. Some days that fascination tends towards terror, as we watched thousands of barrels of oil gushing into the Gulf of Mexico each day from the Deepwater Horizon oil well in the summer of 2010. But it is neither healthy nor productive to chart our course based on avoiding what we fear. Rather, I tend to seek a positive vision towards which we should strive, and then devise the means to achieve that vision.

Biofuels will indeed play a part in the positive vision for the future of our global energy matrix, but only in so far as they are responsibly produced, and only as a single aspect for an energy system built on the understanding that there are physical limits to our biosphere, which places physical limits on our energy systems as well as our economies. The second chapter of this dissertation discusses the physical limits to sugarcane production within an ecosystem, acknowledging the rates of soil erosion and replenishment, as well as air quality and water cycling. The results of the third chapter indicate that the people directing the Brazilian cane-energy sector, as well as those who will be directing the next generation, are aware of and addressing these physical limitations, as well as the needs of the laborers on whose backs the sector is carried. Together, they will work to care for Brazil's economy, ecosystems, and people in the coming decades, especially if citizens continue to watch closely and encourage them. The fourth chapter presents the important factors, as well as some unknown variables, to be considered for the sector's future: supply and demand of existing energy resources, technological innovation, and access to markets. These factors can also be extrapolated for other energy resources, and can be applied to all energy suppliers and consumers.

The positive vision towards which I believe we all need to strive is to establish the physical limits of our global ecosystem, and to devise ways in which to live within those limits. It can be done. Let's get to work.

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APPENDICES

Appendix 1. The Energy Independence and Security Act of 2007

“The Energy Independence and Security Act of 2007, signed into law on December 19th, boosts the requirements for renewable fuel use to 36 billion gallons by 2022. The act requires "advanced biofuels"—defined as fuels that cut greenhouse gas emissions by at least 50%—to provide 21 billion gallons of fuel by 2022, or about 60% of the total requirement. Such advanced biofuels could include ethanol derived from cellulosic biomass—such as wood waste, grasses, and agricultural wastes—as well as biodiesel, butanol, and other fuels. Previously, a national Renewable Fuels Standard (RFS) set by the Energy Policy Act of 2005 required 4.7 billion gallons of renewable fuels in 2007, which would have increased to 5.4 billion gallons in 2008 and to 7.5 billion gallons by 2012. […] A renewable fuel is defined in the Energy Policy Act as a motor vehicle fuel that is produced from plant or animal products or wastes, as opposed to fossil fuel sources. Renewable fuels would include ethanol, biodiesel and other motor vehicle fuels made from renewable sources.” (EPA RGS regs for 2007 and Beyond, p.2, from EERE News Network, available at http://www.eere.energy.gov/news/news_detail.cfm/news_id=11499).

Appendix 2. UNICA and Biodiversity

UNICA at Green Week: economic growth and environmental stewardship can and do go hand in hand

"Brazil´s experience in successfully expanding agribusiness without hampering the preservation of precious ecosystems was presented at the 2010 edition of Green Week as "An example for the European Union (EU) to follow." The suggestion came in a presentation by Emmanuel Desplechin, Chief Representative of the Brazilian Sugarcane Industry Association (UNICA) in the EU. Green Week (http://www.greenweek2010.eu/), the top event dedicated to environmental policies in the EU, was held between June 1 and 4 in Brussels, on the theme of 'Biodiversity – our lifeline'.

[…]

According to Desplechin, biodiversity conservation has already been integrated into operational practices in Brazil, to ensure the sustainable expansion of the industry. "It starts with monitoring, via satellite images, to ensure that production grows in appropriate areas. Best practices have already been instigated by UNICA associates."

http://english.unica.com.br/noticias/show.asp?nwsCode=6CC33DE2-B77C-43E4-902A-500CDB5E905A

Appendix 3. Further Data and Results from Chapter 2.

Table A3.1. Area dedicated to sugarcane, total production, and yields, Brazil and SP.
Source: Brazilian Ministry of Agriculture, available at http://www.agricultura.gov.br/. 2005-'10 SP figures are from IEA (http://ciagri.iea.sp.gov.br/bancoiea/subjetiva.aspx?cod_sis=1&idioma=1). 2006--'08 BR figs from BR Min of Ag Cane Stats Yearbook (2009) (http://www.agricultura.gov.br/desenvolvimento-sustentavel/agroenergia/estatistica). See Appendix for table of figures.

	Brasil			São Paulo		
Year	Production (th tons)	Area Harvested (th ha)	Yield (tn ha^{-1})	Production (th tons)	Area Harvested (th ha)	Yield (tn ha^{-1})
1990	262,674	4,273	61.5			
1991	260,888	4,211	62.0	136,200	1,852	73.5
1992	271,475	4,203	64.6	145,500	1,890	77.0
1993	244,531	3,864	63.3	148,647	1,896	78.4
1994	292,102	4,345	67.2	174,100	2,173	80.1
1995	303,699	4,559	66.6	174,960	2,259	77.5
1996	317,106	4,750	66.8	192,320	2,493	77.1
1997	331,613	4,814	68.9	194,025	2,446	79.3
1998	345,255	4,986	69.2	199,783	2,565	77.9
1999	333,848	4,899	68.1	197,144	2,555	77.2
2000	326,121	4,805	67.9	189,040	2,485	76.1
2001	344,293	4,958	69.4	198,932	2,567	77.5
2002	364,389	5,100	71.4	212,707	2,661	79.9
2003	396,012	5,371	73.7	227,981	2,818	80.9
2004	415,206	5,632	73.7	239,528	2,952	81.1
2005	455,272	6,172	73.8	254,810	3,121	81.7
2006	457,980	7,040	65.1	284,917	3,437	82.9
2007	515,820	7,890	65.4	327,684	3,907	83.9
2008	648,850	8,920	72.7	393,422	4,615	85.3
2009				423,087	4,938	85.7
2010				429,949	5,135	83.7

Table A3.2. Average annual costs of cane production. The cost of sugarcane for 1L of ethanol for refineries and independent producers ("Indep. Prod"). Data are from the results of this study.

	2007/08	2008/09	2009/10	2010/11
Farm 1				
Refinery	0.4106	0.4507	0.5934	0.5439
Indep Prod.	0.4215	0.4716	0.6365	0.5766
Farm 2A				
Refinery	0.4035	0.4430	0.5845	0.5361
Indep Prod.	0.4254	0.4134	0.5994	0.5524
Farm 2B				
Refinery	0.4182	0.4590	0.6029	0.5522
Indep Prod.	0.4405	0.4277	0.6169	0.5681
Farm 3A				
Refinery	0.4475	0.4430	0.5104	0.4810
Indep Prod.	0.3729	0.3975	0.5400	0.4838
Farm 3B				
Refinery	0.4626	0.4594	0.5265	0.4968
Indep Prod.	0.3870	0.4129	0.5568	0.4982

Table A3.3. Refinery sugarcane costs with labor cost variations. Production costs of sugarcane in 1L of ethanol. Labor costs are vaired 29% in each direction as this was the average variation in labor costs in Sao Paulo for the 2007/08 harvest season, which is the first year used for this study.

	Labor Cost		Machinery Cost	
	-29%	**29% +**	**-29%**	**29% +**
Farm 1				
Base	0.4946	0.4946	0.4946	0.4946
New	0.4769	0.5123	0.4395	0.5497
Difference	-0.0177	0.0177	-0.0551	0.0551
% Diff	-3.64%	3.52%	-11.79%	10.55%
Farm 2A				
Base	0.4868	0.4868	0.4868	0.4868
New	0.4769	0.5123	0.4395	0.5497
Difference	-0.0099	0.0255	-0.0473	0.0629
% Diff	-2.05%	5.10%	-10.21%	12.13%
Farm 2B				
Base	0.5030	0.5030	0.5030	0.5030
New	0.4853	0.5207	0.4479	0.5581
Difference	-0.0177	0.0177	-0.0551	0.0551
% Diff	-3.58%	3.46%	-11.59%	10.38%
Farm 3A				
Base	0.4703	0.4703	0.4703	0.4703
New	0.4502	0.4903	0.4287	0.5118
Difference	-0.0200	0.0200	-0.0415	0.0415
% Diff	-4.35%	4.17%	-9.24%	8.46%
Farm 3B				
Base	0.4861	0.4861	0.4861	0.4861
New	0.4661	0.5061	0.4446	0.5277
Difference	-0.0200	0.0200	-0.0415	0.0415
% Diff	2.82%	-2.67%	6.04%	-5.39%

Table A3.4. Independent producer ethanol costs. Production costs of sugarcane for 1L of ethanol. Production costs of sugarcane in 1L of ethanol. Labor costs are vaired 29% in each direction as this was the average variation in labor costs in Sao Paulo for the 2007/08 harvest season, which is the first year used for this study.

	Labor Cost		**Machinery Cost**	
	-29%	**29% +**	**-29%**	**29% +**
Farm 1				
Base	0.5206	0.5206	0.5206	0.5206
New	0.4980	0.5433	0.4699	0.5714
Difference	-0.0226	0.0226	-0.0508	0.0508
% Diff	-4.45%	4.26%	-10.25%	9.30%
Farm 2A				
Base	0.492	0.492	0.492	0.492
New	0.471	0.514	0.444	0.541
Difference	-0.022	0.022	-0.049	0.049
% Diff	-4.52%	4.32%	-10.42%	9.43%
Farm 2B				
Base	0.5079	0.5079	0.5079	0.5079
New	0.4861	0.5296	0.4591	0.5566
Difference	-0.0217	0.0217	-0.0487	0.0487
% Diff	-4.37%	4.19%	-10.08%	9.16%
Farm 3A				
Base	0.4457	0.4457	0.4457	0.4457
New	0.4275	0.4639	0.3962	0.4952
Difference	-0.0182	0.0182	-0.0495	0.0495
% Diff	-4.17%	4.01%	-11.76%	10.52%
Farm 3B				
Base	0.4608	0.4608	0.4608	0.4608
New	0.4426	0.4790	0.4113	0.5103
Difference	-0.0182	0.0182	-0.0495	0.0495
% Diff	2.71%	-2.57%	7.71%	-6.68%

Table A3.5. Elasticity of independent producer revenues and profits with respect to ATR price.

	2007/08	2008/09	2009/10	2010/11	Max-Min 2010/11-2008/09
ATR:	**0.259**	**0.257**	**0.310**	**0.361**	
Farm 1					
Cane Revs		-0.1375	-13.1749	0.5430	1.4360
PROFITS		-0.0097	-0.0596	-0.0823	0.2729
Disc. Profits		-0.0088	-0.0565	-0.0840	0.2589
FARM 2A					
Cane Revs		-0.1375	-13.1749	0.5430	1.4360
PROFITS		-0.0146	-0.0770	-0.0726	0.3524
Disc. Profits		-0.0146	-0.0770	-0.0726	0.3524
FARM 2B					
Cane Revs		-0.1375	-13.1749	0.5430	1.4360
PROFITS		-0.0044	-0.0409	-0.0927	0.1874
Disc. Profits		0.0053	-0.0063	-0.1120	0.0287
FARM 3A					
Cane Revs		0.0804	1.9051	0.4590	0.8016
PROFITS		0.0167	-0.1921	-0.0040	0.1813
Disc. Profits		0.0150	-0.1735	-0.0080	0.1443
Farm 3B					
Cane Revs		0.0804	1.9051	0.4590	0.8016
PROFITS		0.0135	-0.1283	-0.0204	0.1211
Disc. Profits		0.0088	-0.0377	-0.0402	0.0314

Table A3.6. Independent producer profit sensitivity analysis. Discount rate ranges from 2008 rate of 6%, the US rate of 4% (Crago et al., 2010), and the 2005 Brazilian rate of 9% (Banco do Brasil, 2011). ATR Price ranges from the four year average, the low, and the high for the same period (UNICA, 2011). Wages for agricultural laborers in SP varied by an average of 29% during the 2007/08 season (IEA, 2011), leading to the range of 29% above and below the labor costs presented in Marques et al. (2009). As detailed machinery costs were not available, that cost was allowed to vary by the range presented for wages.

	Discount Rate (0.06)		ATR Price (Avg 0.286)		Labor Cost		Machinery Cost	
	0.04	**0.095**	**L (0.242)**	**H (0.389)**	**-29%**	**29% +**	**-29%**	**29% +**
Farm 1								
Base	-588.83	-588.83	-588.83	-588.83	-588.83	-588.83	-588.83	-588.83
New	-716.29	-468.63	-7031.01	14364.61	1239.69	-2417.35	3511.01	-4688.67
Difference	-127.46	120.21	-6442.18	14953.45	1828.52	-1828.52	4099.84	-4099.84
% Change	21.6%	-20.4%	1094.1%	-2539.5%	-310.5%	310.5%	-696.3%	696.3%
Farm 2A								
Base	202.85	202.85	202.85	202.85	202.85	202.85	202.85	202.85
New	266.81	140.31	-8386.72	20140.78	2640.88	-2235.18	5669.30	-5263.60
Difference	63.96	-62.54	-8589.57	19937.93	2438.03	-2438.03	5466.45	-5466.45
% Change	31.5%	-30.8%	-4234.4%	9828.9%	1201.9%	-1201.9%	2694.8%	-2694.8%
Farm 2B								
Base	-2413.24	-2413.24	-2413.24	-2413.24	-2413.24	-2413.24	-2413.24	-2413.24
New	-2552.61	-2273.53	-8855.42	12540.20	-584.72	-4241.76	1686.60	-6513.08
Difference	-139.37	139.72	-6442.18	14953.45	1828.52	-1828.52	4099.84	-4099.84
% Change	5.8%	-5.8%	267.0%	-619.6%	-75.8%	75.8%	-169.9%	169.9%
Farm 3A								
Base	4961.24	4961.24	4961.24	4961.24	4961.24	4961.24	4961.24	4961.24
New	6834.29	3129.78	-3867.05	25453.30	6978.51	2943.98	10439.97	-517.48
Difference	1873.05	-1831.46	-8828.30	20492.06	2017.26	-2017.26	5478.73	-5478.73
% Change	37.8%	-36.9%	-177.9%	413.0%	40.7%	-40.7%	110.4%	-110.4%
Farm 3B								
Base	1155.55	1155.55	1155.55	1155.55	1155.55	1155.55	1155.55	1155.55
New	2373.00	-31.42	-5465.67	16524.59	2668.50	-357.39	5264.60	-2953.49
Difference	1217.44	-1186.98	-6621.22	15369.04	1512.95	-1512.95	4109.05	-4109.05
% Change	105.4%	-102.7%	-573.0%	1330.0%	130.9%	-130.9%	355.6%	-355.6%

Table A3.7. Elasticity of refinery revenues and profits with respect to cost of labor.

Cost of L ha^{-1}	2007/08 463.00	2008/09 468.06	2009/10 325.67	2010/11 347.43	Max-Min 2009/09-2009/10
Farm 1					
Cane Revs		-0.1256	-5.5675	0.2052	-8.4389
PROFITS		-0.0093	-0.0477	-0.0257	-0.5058
Disc. Profits		-0.0090	-0.0077	-0.1260	-0.1260
FARM 2A					
Cane Revs		-0.1256	-5.5675	0.2052	-8.4389
PROFITS		-0.0111	0.0065	-0.0218	-0.4279
Disc. Profits		-0.0111	0.0065	-0.0218	-0.4279
FARM 2B					
Cane Revs		-0.1256	-5.5675	0.2052	-8.4389
PROFITS		-0.0074	-0.1060	-0.0300	-0.5896
Disc. Profits		-0.0038	-0.2142	-0.0379	-0.7451
FARM 3A					
Cane Revs		3.5899	-0.4783	0.5270	-5.2971
PROFITS		0.0978	-0.0041	0.0203	-0.5866
Disc. Profits		-7.1842	0.0252	0.0171	-0.4637
Farm 3B					
Cane Revs		3.5899	-0.4783	0.5270	-5.2971
PROFITS		3.6018	0.0673	0.0076	-0.2177
Disc. Profits		-44.2914	0.1500	-0.0082	0.2240

Table A3.8. Elasticity of independent producer revenues and profits with respect to cost of labor.

Cost of L ha^{-1}	2007/08 479.000	2008/09 488.180	2009/10 468.100	2010/11 617.310	Max-Min 2010/11- 2008/09
Farm 1					
Cane Revs		0.3713	2.6123	1.0499	0.9787
PROFITS		0.0262	0.0118	-0.1591	-0.1591
Disc. Profits		0.0238	0.0112	-0.1624	-0.1624
FARM 2A					
Cane Revs		0.3713	2.6123	1.0499	1.0499
PROFITS		0.0394	0.0153	-0.1404	-0.1404
Disc. Profits		0.0394	0.0153	-0.1404	-0.1404
FARM 2B					
Cane Revs		0.0000	0.0000	0.0000	0.0000
PROFITS		0.0120	0.0081	-0.1792	-0.1792
Disc. Profits		-0.0144	0.0012	-0.2165	-0.2165
FARM 3A					
Cane Revs		3.0632	-2.7977	0.9754	-89.1075
PROFITS		0.6356	0.2821	-0.0084	-0.0427
Disc. Profits		0.5715	0.2547	-0.0171	-0.0909
Farm 3B					
Cane Revs		3.0632	-2.7977	0.9754	-89.1075
PROFITS		0.5143	0.1884	-0.0434	-0.2198
Disc. Profits		0.3359	0.0554	-0.0854	-0.4538

Table A3.9. Elasticity of refinery revenues and profits with respect to cost of machinery.

Cost of M ha^{-1}	2007/08 673.00	2008/09 1065.01	2009/10 1584.30	2010/11 1669.91	Max-Min 2010/11- 2007/08
Farm 1					
Cane Revs		-6.6941	8.9235	0.1659	5.3581
PROFITS		-0.4975	0.0765	-0.0208	1.4597
Disc. Profits		-0.4804	0.0918	-0.0214	1.4097
FARM 2A					
Cane Revs		-6.6941	8.9235	0.1659	5.3581
PROFITS		-0.5940	-0.0104	-0.0176	1.7432
Disc. Profits		-0.5940	-0.0104	-0.0176	1.7432
FARM 2B					
Cane Revs		-6.6941	8.9235	0.1659	5.3581
PROFITS		-0.3935	0.1699	-0.0242	1.1547
Disc. Profits		-0.2006	0.3434	-0.0306	0.5887
FARM 3A					
Cane Revs		-9.4638	-0.2007	0.3334	2.4289
PROFITS		-0.2577	-0.0017	0.0129	-0.0025
Disc. Profits		18.9389	0.0106	0.0108	-0.0336
Farm 3B					
Cane Revs		-9.4638	-0.2007	0.3334	2.4289
PROFITS		-9.4950	0.0282	0.0048	-0.0911
Disc. Profits		116.7603	0.0629	-0.0052	-0.2069

Table A3.10. Elasticity of independent producer revenues and profits with respect to cost of machinery.

	2007/08	2008/09	2009/10	2010/11	Max-Min
Cost of M ha^{-1}	**1276.410**	**1348.030**	**2010/11-2007/08**	**0.000**	**2010/11-2008/09**
Farm 1					
Cane Revs		2.8117	-13.2701	0.1848	1.3229
PROFITS		0.1981	-0.0600	-0.0280	0.1395
Disc. Profits		0.1804	-0.0570	-0.0286	0.1270
FARM 2A					
Cane Revs		2.8117	-13.2701	0.1848	1.3229
PROFITS		0.2980	-0.0775	-0.0247	0.2098
Disc. Profits		0.2980	-0.0775	-0.0247	0.2098
FARM 2B					
Cane Revs		2.8117	-13.2701	0.1848	1.3229
PROFITS		0.0905	-0.0412	-0.0315	0.0637
Disc. Profits		-0.1091	-0.0063	-0.0381	-0.0768
FARM 3A					
Cane Revs		-2.1837	0.4277	0.6533	1.4465
PROFITS		-0.4531	-0.0431	-0.0056	0.6268
Disc. Profits		-0.4074	-0.0389	-0.0115	0.5350
Farm 3B					
Cane Revs		-2.1837	0.4277	0.6533	1.4465
PROFITS		-0.3666	-0.0288	-0.0291	0.5072
Disc. Profits		-0.2394	-0.0085	-0.0572	0.3144

Table A3.11. Refinery profits on sugarcane with timber revenue details. Net present value of profits from sugarcane produced on land operated by a refinery when producer is compliant with BFC and sells selectively-harvested timber using methods allowed by BFC legislation.

	Timber Cons	Timber Avg	Timber Opt
Farm 1			
Base	-588.83	-588.83	-588.83
New	5833.38	8331.81	10830.25
Difference	6422.21	8920.64	11419.08
% Change	-1090.7%	-1515.0%	-1939.3%
Farm 2B			
Base	-2413.24	-2413.24	-2413.24
New	1965.72	3669.27	5372.82
Difference	4378.96	6082.51	7786.06
% Change	-181.5%	-252.0%	-322.6%
Farm 3B			
Base	-1971.91	-1971.91	-1971.91
New	5534.51	7238.06	8941.61
Difference	7506.42	9209.97	10913.52
% Change	-380.7%	-467.1%	-553.4%

Table A3.12. Average cost of refinery cane with timber revenue details. Average cost of sugarcane in 1L of ethanol produced on land operated by a refinery when producer is compliant with BFC and sells selectively-harvested timber using methods allowed by BFC legislation.

	Timber Cons	Timber Avg	Timber Opt
Farm 1			
Base	0.4946	0.4946	0.4946
New	0.4150	0.3841	0.3531
Difference	-0.0795	-0.1105	-0.1414
% Change	-19.2%	-28.8%	-40.0%
Farm 2B			
Base	0.5030	0.5030	0.5030
New	0.4340	0.4072	0.3804
Difference	-0.0689	-0.0958	-0.1226
% Change	-15.9%	-23.5%	-32.2%
Farm 3B			
Base	0.4861	0.4861	0.4861
New	0.4187	0.3924	0.3662
Difference	-0.0675	-0.0937	-0.1199
% Change	-13.9%	-19.3%	-24.7%

Table A3.13. Average cost of independent producer cane with timber revenue details. Average cost of sugarcane in 1L of ethanol produced on land operated by an independent producer when producer is compliant with BFC and sells selectively-harvested timber using methods allowed by BFC legislation.

	Timber Cons	Timber Avg	Timber Opt
Farm 1			
Base	0.5206	0.5206	0.5206
New	0.4411	0.4102	0.3792
Difference	-0.0795	-0.1105	-0.1414
% Change	-18.0%	-26.9%	-37.3%
Farm 2B			
Base	0.5079	0.5079	0.5079
New	0.4417	0.4159	0.3902
Difference	-0.0662	-0.0919	-0.1177
% Change	-15.0%	-22.1%	-30.2%
Farm 3B			
Base	0.4608	0.4608	0.4608
New	0.3964	0.3714	0.3463
Difference	-0.0644	-0.0894	-0.1145
% Change	-14.0%	-19.4%	-24.8%

Table A3.14. Refinery profits on cane with carbon payments. Net Present value of profits from sugarcane produced on land operated by a refinery when producer is compliant with BFC and receives payments for carbon sequestration.

	$R10 tC^{-1} Seq.	$R20 tC^{-1} Seq.	$R30 tC^{-1} Seq.	$R50 tC^{-1} Seq.	$R100 tC^{-1} Seq.
Farm 1					
Base	-147.50	-147.50	-147.50	-147.50	-147.50
New	23.67	194.84	366.01	708.35	1564.20
Difference	171.17	342.34	513.51	855.85	1711.70
% Change	-116.0%	-232.1%	-348.1%	-580.2%	-1160.5%
Farm 2B					
Base	-1971.91	-1971.91	-1971.91	-1971.91	-1971.91
New	-1800.74	-1629.57	-1458.40	-1116.06	-260.21
Difference	171.17	342.34	513.51	855.85	1711.70
% Change	-8.7%	-17.4%	-26.0%	-43.4%	-86.8%
Farm 3B					
Base	-1051.84	-1051.84	-1051.84	-1051.84	-1051.84
New	-880.67	-709.50	-538.33	-195.99	659.86
Difference	171.17	342.34	513.51	855.85	1711.70
% Change	16.3%	32.5%	48.8%	81.4%	162.7%

Table A3.15. Independent producer profits on cane with carbon payments. Net Present value of profits from sugarcane produced on land operated by an independent producer when producer is compliant with BFC and receives payments for carbon sequestration.

	\$R10 tC^{-1} Seq.	**\$R20 tC^{-1} Seq.**	**\$R30 tC^{-1} Seq.**	**\$R50 tC^{-1} Seq.**	**\$R100 tC^{-1} Seq.**
Farm 1					
Base	-588.83	-588.83	-588.83	-588.83	-588.83
New	-417.66	-246.49	-75.32	267.02	1122.86
Difference	171.17	342.34	513.51	855.85	1711.70
% Change	-29.1%	-58.1%	-87.2%	-145.3%	-290.7%
Farm 2B					
Base	-2413.24	-2413.24	-2413.24	-2413.24	-2413.24
New	-2242.07	-2070.90	-1899.73	-1557.39	-701.55
Difference	171.17	342.34	513.51	855.85	1711.70
% Change	-7.1%	-14.2%	-21.3%	-35.5%	-70.9%
Farm 3B					
Base	1155.55	1155.55	1155.55	1155.55	1155.55
New	1326.72	1497.89	1669.06	2011.40	2867.25
Difference	171.17	342.34	513.51	855.85	1711.70
% Change	14.8%	29.6%	44.4%	74.1%	148.1%

Table A3.16. Refinery cane costs with carbon payments. Cost of sugarcane in 1L of ethanol from sugarcane produced on land operated by a refinery when producer is compliant with BFC and receives payments for carbon sequestration.

	\$R10 tC^{-1} Seq.	**\$R20 tC^{-1} Seq.**	**\$R30 tC^{-1} Seq.**	**\$R50 tC^{-1} Seq.**	**\$R100 tC^{-1} Seq.**
Farm 1					
Base	0.4946	0.4946	0.4946	0.4946	0.4946
New	0.4925	0.4903	0.4882	0.4840	0.4734
Difference	-0.0021	-0.0042	-0.0064	-0.0106	-0.0212
% Change	-0.4%	-0.9%	-1.3%	-2.2%	-4.5%
Farm 2B					
Base	0.5030	0.5030	0.5030	0.5030	0.5030
New	0.5009	0.4987	0.4966	0.4924	0.4818
Difference	-0.0021	-0.0042	-0.0064	-0.0106	-0.0212
% Change	-0.4%	-0.9%	-1.3%	-2.2%	-4.4%
Farm 3B					
Base	0.4861	0.4861	0.4861	0.4861	0.4861
New	0.4840	0.4820	0.4799	0.4757	0.4654
Difference	-0.0021	-0.0041	-0.0062	-0.0104	-0.0207
% Change	-0.4%	-0.8%	-1.2%	-1.9%	-3.9%

Table A3.17. Independent producer cane costs with carbon payments. Cost of sugarcane in 1L of ethanol from sugarcane produced on land operated by an independent producer when producer is compliant with BFC and receives payments for carbon sequestration.

	\$R10 tC^{-1} Seq.	**\$R20 tC^{-1} Seq.**	**\$R30 tC^{-1} Seq.**	**\$R50 tC^{-1} Seq.**	**\$R100 tC^{-1} Seq.**
Farm 1					
Base	0.5206	0.5206	0.5206	0.5206	0.5206
New	0.5185	0.5164	0.5143	0.5100	0.4994
Difference	-0.0021	-0.0042	-0.0064	-0.0106	-0.0212
% Change	-0.4%	-0.8%	-1.2%	-2.1%	-4.2%
Farm 2B					
Base	0.5079	0.5079	0.5079	0.5079	0.5079
New	0.5058	0.5038	0.5018	0.4977	0.4875
Difference	-0.0020	-0.0041	-0.0061	-0.0102	-0.0204
% Change	-0.4%	-0.8%	-1.2%	-2.0%	-4.1%
Farm 3B					
Base	0.4608	0.4608	0.4608	0.4608	0.4608
New	0.4588	0.4568	0.4549	0.4509	0.4410
Difference	-0.0020	-0.0040	-0.0059	-0.0099	-0.0198
% Change	-0.3%	-0.6%	-0.9%	-1.5%	-2.9%

Appendix 4. Rank Order Logit Do File. This is the code and command file used in Stata to verify the order of the rankings and evaluate statistical significance.

Ranking do file

```
drop if infrastructre==.
gen option1=infrastructre
gen option2=jobs
gen option3=food
gen option4=nat_resources
gen option5=institutions
gen option6=other

gen job_opt1=more_jobs
gen job_opt2=high_pay
gen job_opt3=safe_healthy
gen job_opt4=high_educ
gen job_opt5=oth_jobs

gen res_opt1=air
gen res_opt2=soil
gen res_opt3=water
gen res_opt4=amazon_rf
gen res_opt5=atlantic_rf
gen res_opt6=biodiversity
gen res_opt7=oth_nat

reshape long option, i(surveyid) j(choice)
save "C:\Users\baylis\Documents\2009\Jason\rank_prioritylong.dta", replace
drop if option==.
rename option rank
gen onat=1 if choice==4
gen ojobs=1 if choice==2
gen oinf=1 if choice==1
gen oins=1 if choice==5
gen ooth=1 if choice==6
gen ofoo=1 if choice==3

recode onat ojobs oinf oins ooth ofoo (.=0)

rologit rank onat, group(surveyid)
rologit rank onat ojobs oinf oins ooth ofoo, group(surveyid)

save "C:\Users\baylis\Documents\2009\Jason\rank_prioritylong.dta", replace

**natural resource priorities
```

```
use "C:\Users\baylis\Documents\2009\Jason\rank.dta", clear

reshape long res_opt, i(surveyid) j(res_choice)
drop if res_opt==.
rename res_opt res_rank

tab res_rank res_choice
list surveyid res_rank res_choice air soil water amazon* atlant* biodiv* oth_nat_res

gen r_air=1 if res_choice==1
gen r_soil=1 if res_choice==2
gen r_water=1 if res_choice==3
gen r_amazon=1 if res_choice==4
gen r_atlantic=1 if res_choice==5
gen r_biod=1 if res_choice==6
gen r_oth=1 if res_choice==7


recode r_* (.=0)

rologit res_rank r_water r_air r_soil r_bio r_oth r_amazon, group(surveyid)
test r_water=r_oth
test r_water=r_soil
test r_water=r_air
test r_water=r_bio
test r_air=r_bio
test r_water=r_bio


save "C:\Users\baylis\Documents\2009\Jason\rank_res_long.dta", replace

**Job priorities
use "C:\Users\baylis\Documents\2009\Jason\rank.dta", clear

reshape long job_opt, i(surveyid) j(job_choice)
drop if job_opt==.
rename job_opt job_rank

tab job_rank job_choice
list surveyid job_rank job_choice more_jobs high_pay safe_healthy high_edu oth_jobs

gen j_more=1 if job_choice==1
gen j_highpay=1 if job_choice==2
gen j_safe=1 if job_choice==3
gen j_edu=1 if job_choice==4
gen j_oth=1 if job_choice==5
```

```
recode j_* (.=0)

rologit job_rank j_more j_safe j_high j_oth, group(surveyid)
test j_safe=j_more
test j_safe=j_high
test j_safe=j_oth
test j_more=j_high
save "C:\Users\baylis\Documents\2009\Jason\rank_jobs_long.dta", replace
```

Appendix 5. Rationale for Survey Sub-Priorities. These sources found during the literature review, along with some of the early interviews and preliminary drafts of the surveys, provided the framework to design the sub-priorities used in the surveys.

Main Priority / Sub-priority	Citation with rationale
Infrastructure	Chagas et al., 2010;
Education	
Health	
Roads and other physical infrastructure	
Other (brief explanation):	
Job creation	
More jobs	Azanha, 2007
Jobs that pay more	Piketty et al., 2008
Jobs that are healthier/safer	Novaes, 2007
Jobs that require greater education	
Other (brief explanation): "Mazza (2004) argues that labor markets can foment social exclusion by (a) not providing jobs; (b) providing only low paying ('poverty') jobs; or (c) preventing access to quality jobs that allow for mobility" (quoted in Hall et al., 2008).	
Dislocation of food crops	Searchinger et al., 2008; Martinelli and Filoso, 2008; Azevedo et al., 2009
Production for domestic consumption	
Production for exportation	Kenfield, 2007
Protection of natural resources	
Air quality	Arbex et al., 2007
Soil quality	Momoli, 2006
Water quality	Moreira, 2007
Amazon Rainforest	Nepstad et al., 2007; Sparovek et al., 2008
Atlantic Rainforest	Rodrigues et al., 2009
Biodiversity	Myers et al., 2000
Other (brief explanation):	
Institutions	Hunter and Sugiyama, 2009
Legal System	
Research	
Strengthen democracy	
Combat crime	
Combat corruption	
Other (br. expl.):	

Appendix 6. Full Survey. This is the survey with English translations. The English version was not included in the surveys distributed to respondents.

Levantamento sobre o setor sucroenergético e o papel das instituições

Muito obrigado por sua participação neste levantamento anônimo, que tem três partes e deve levar, no máximo, 20-25 minutos.

Thank you very much for your participation in this anonymous survey, which has three parts and should take, at most, 20-25 minutes.

Explicação do Projeto **Explanation of the Project**

As perspectivas são que o setor sucroenergético vai crescer, talvez o dobro, nos próximos 10-15 anos. Muita da demanda por esta expansão vem dos paises estrangeiros, e, hoje, os Estados Unidos são os maiores importadores do etanol (álcool) do Brasil, com mais potencial para aumentar a importação. Por isso, é muito importante para os estrangeiros entender as prioridades dos Brasileiros e seu pensamento deste área.

The perspectives are that the sugarcane-energy sector will grow, maybe as much as 100%, in the next 10-15 years. Much of the demand for this growth is coming from other countries, and, today, the U.S. is the largest importer of Brazilian ethanol, with still more potential to increase its importation. Therefore, it is very important for people in other countries to understand the priorities of Brazilian people and your thinking in this area.

As primeiras prioridades dos fornecedores e das usinas são para produzir e vender seus produtos. Mas também, depois disso, eles tem capacidade para afetar outros aspectos do desenvolvimento Brasileiro, especialmente com os incentivos de prioridades em determinadas áreas.

The first priority of cane producers and refineries is to produce and sell their products. But they also have, after this priority, the capacity to affect other aspects of Brazilian development, especially with incentives towards the priorities determined for certain areas.

Este levantamento faz parte de um projeto de doutorado sobre o setor sucroenergético em São Paulo, e o pensamento do povo Brasileiro neste assunto. Eu não trabalho por ninhuma empresa ou governo, Brasileiro ou estrangeiro.

This survey is part of a doctoral project regarding the sugarcane-energy sector in São Paulo, and the perspectives of Brazilian people on this subject. I do not work for any government or company, Brazilian or foreign.

As três partes, na ordem em que são apresentados a seguir, são

The three parts, in the order that they appear here, are

1. O que você acha que devem ser as prioridades do setor sucroenergético para o desenvolvimento do Brasil em geral e no estado de São Paulo em particular?

1. What do you think should be the priorities for the sugarcane-energy sector for Brazilian development in general, and for the state of São Paulo in particular?

2. Como e quais instituições você acha e/ou indica que deveriam administrar as prioridades do setor sucroenergético de forma mais eficaz e eficiente?

2. How and what institutions do you think would administer the priorities of the sugarcane-energy sector in the most effective and efficient manor?

3. Informação básica sobre você (por favor não inclua informações pessoais, além do que é solicitado pelas questões abaixo. O levantamento deve ser anônimo).

3. Basic information about you. Please do not include any personal information beyond what is solicited here. The survey should be kept anonymous.

Se você gostaria de participar numa entrevista de 30-60 minutos sobre estes assuntos, ou se você tiver qualquer duvida sobre o projeto, por favor entrar em contato comigo:
If you would like to participate in an interview of 30-60 minutes about these subjects, or if you have any questions about this project, please contact me:

Jason Barton
Instrutor, Centro das Pesquisas de Bioenergia Avançada, Universidade de Illinois, E.U.A.
Candidato por PhD, Economia e Ecologia da Produção de Etanol Brasileiro
Faculdade das Sistemas da Terra e Comida, Univ. de Columbia Britânica, Vancouver, Canadá

Parte 1: Prioridades **Part 1: Priorities**

Item A: As Prioridades Principais. Depois da produção e rendas, quais outros aspetos devem ser a primeira prioridade (**marca com 1**), a segunda (**com 2**), etc.? Caso entenda que exista alguma prioridade em que o setor sucroenergético não deva contribuir, **marque essa com 9**. Por favor marcar todas as opções, mas pode deixar em branco a opção "Outro aspeto", se você não tem ideas alem dos aqui. Você vai ter oportunidade elaborar nelas depois.

Item A: Principal Priorities. After production and income, what other aspects should be the first priority (mark with 1), the second (with 2), etc.? In the case that the sugarcane-energy sector should not contribute to an option, mark that option with 9. Please mark all options, though you may leave blank the "Other aspect" option if you do not have an idea other than those here. You will have the opportunity to elaborate later in the survey.

_______ **Infraestrutura (educação, saúde, infraestrutura física, etc.)**
Infrastructure (education, health, physical infrastrucure, etc.)

_______ **Criação dos empregos**
Job creation

_______ **Deslocamento de culturais alimentícias**
Dislocation of food crops

_______ **Proteção dos recursos naturais**
Protection of natural resources

_______ **Instituições (direitos, segurança, pesquisa etc.)**

Institutions (rights, security, research, etc.)

_______ **Outro aspeto (breve explicação):**

Other aspects (brief explanation):

Item B: Importância. Paras as duas questões próximas, marcar com "X" a melhor opção.

Item B: Importance. For the next two questions, mark the best option with an "X."

1.B.1 Quão importante é a prioridade principal que você marcou como **1 no Item A**?

How important is the principal priority that you marked as 1 in Item A?

______ Ela é mais importante do que os lucros dos fornecedores e das usinas.

It is more important that producer and refinery profits

______ Ela é tão importante quanto os lucros dos fornecedores e das usinas.

It is as important as producer and refinery profits

______ Ela é importante, mas não tão importante como os lucros dos produtores e das usinas.

It is important, but not as important as producer and refinery profits

______ Ela não é muito importante.

It is not very important.

______ Ela não é importante.

It is not important.

1.B.2 Quão importante é a prioridade principal que você marcou como **5 (ou 6** se você marcou) no **Item A**?

How important is the principal priority that you marked as 5 in Item A?

______ Ela é mais importante do que os lucros dos fornecedores e das usinas.

It is more important that producer and refinery profits

______ Ela é tão importante quanto os lucros dos fornecedores e das usinas.

It is as important as producer and refinery profits

______ Ela é importante, mas não tão importante como os lucros dos produtores e das usinas.

It is important, but not as important as producer and refinery profits

______ Ela não é muito importante.

It is not very important.

______ Ela não é importante.

It is not important.

Item C: Outras Prioridades. Embaixo da cada opção principal, por favor **marcar com 1, 2, etc.,** as prioridades dentro das prioridades principais. Caso entenda que exista alguma prioridade em que o setor sucroenergético não deva contribuir, **marque essa com 9**.
Item C: Other Priorities. Under each principal priority, please **mark with 1, 2, etc**., the priorities within each principal priority. In the case that the sugarcane-energy sector should not contribute, **mark this with 9.**

1.C.1. Infraestrutura Infrastructure _____ Educação Education _____ Saúde Health
_____ Estradas e outras infra-estruturas físicas _____ Outro (breve explicação):
Roads and other physical infrastructure Other (brief explanation):

1.C.2 Criação dos empregos Job creation _____ Mais empregos More jobs
_____ Empregos que pagam melhor Jobs that pay more
_____ Empregos mais saudáveis/seguros Jobs that are healthier/safer _____ Empregos que necessitam maior educação Jobs that require greater education
_____ Outro (breve explicação): Other (brief explanation):

1.C.3 Deslocamento de culturais alimentícias Dislocation of food crops
____ Produção para consumo doméstico ____ Produção deve ser para exportação
Production for domestic Consumption Production for exportation

1.C.4 Proteção dos recursos naturais Protection of natural resources
_____ Qualidade do ar Air quality _____ Qualidade do solo Soil quality
_____ Qualidade da água Water quality _____ Floresta Amazônica Amazon Rainforest
_____ Mata Atlântica Atlantic Rainforest _____ Biodiversidade Biodiversity
_____ Outro (breve explicação): Other (brief explanation):

1.C.5 Instituições Institutions ____ Sistema legal Legal System ____ Pesquisa Research ___ Fortalecimento da democracia Strengthen democracy ____ Combater crime Combat crime ___ Combater corrupção Combat corruption ___ Outro (breve explicação): Other (br. expl.):

1.C.6 Outro aspeto que você marcou no **Item A** na primeira pagina (breve explicação):
Other aspect that you marked in **Item A** on the first page (brief explanation)

Item D: O que você acha sobre a frase, “O setor sucroenergético concentra renda”? Marcar com “X” a melhor opção.

Item D: What do you think about the sentence, "The sugarcane-energy sector concentrates income? Mark the best option with "X."

____ Eu concordo muito ____ Eu concordo um pouco ____ Eu sou neutro
I strongly agree I agree a little I am neutral

____ Eu discordo um pouco ____ Eu discordo muito ____ Eu não tenho opinião formada
I disagree a little I strongly disagree I do not have an opinion

Parte 2: Como e quem? Part 2: How and whom?

2.A.1 Como deve ser a participação dos fornecedores e das usinas na prioridade **no Item A na Parte 1** que você marcou **como 1**? ____ Deve ser **voluntário** ____ Deve ser **obrigatório**

How should the producers and refineries participate in the priority in **Item in Part 1** that you marked **as 1**? _____ It should be **voluntary** _____ It should be **obligatory**

2.A.2 Como deve ser a participação dos fornecedores e das usinas na prioridade **no Item A na Parte 1** que você marcou **como 5**? ____ Deve ser **voluntário** ____ Deve ser **obrigatório**

How should the producers and refineries participate in the priority in **Item in Part** 1 that you marked **as 5**? _____ It should be **voluntary** _____ It should be **obligatory**

2.B De que forma os fornecedores e as usinas deverão cumprir com a prioridade principal **no Item A na Parte 1** que você marcou **com 1**? Marcar a melhor opção com 1, segunda com 2, etc. Caso entenda que exista alguma uma opção que você acha não deva ser usada, **marque essa com 9**.

How should producers and refineries comply with the principal priority **in Item A Part 1** that you marked **as #1**? Mark the best option with "1," the 2nd best with "2," etc. In the case that you believe one of the options should be used, **mark this with 9**.

_____ Pagamentos diretos aos fornecedores e às usinas para realizar a prioridade

Direct payments to cane producers and usinas.

_____ Punições para o fracasso para alcançar a prioridade

Punishments for failure to achieve the priority.

_____ Certificação pelos produtores quem encontrem um nível satisfatória, e deixe o mercado livre decidir os preços

Certification for producers that reach a satisfactory level, and let the free market decide the price.

_____ Reduzir os impostos (domésticos) e/ou as tarifas (dos estrangeiros quem importam) por os produtores quem encontrem um nível satisfatória

Reduce taxes (domestic) and/or tariffs (for foreign importation) for those producers that reach a satisfactory level.

_____ Outro (breve explicação) Other (brief explanation)

2.C.1 Quais instituições que você acha que seriam mais eficazes e eficientes para incentivar e administrar a prioridade principal que você marcou **com 1 no Item A na Parte 1**? Marcar a melhor opção com 1, segunda com 2, etc. Caso entenda que exista alguma uma opção que você acha não deva ser usada, **marque essa com 9**.

What institutions do you think would be most effective and efficient in motivating and administering the main priority that you marked as number **1 in Item A in Part 1**? Mark the best option with 1, the second with 2, etc. In the case that you think an option should not be used, **mark this with 9**.

____ Setor privado Brasileiro ____ O governo Brasileiro ____ ONGs Brasileiras

Brazilian private sector Brazilian government Brazilian NGOs

____ Setor privado estrangeiro ____ Os governos estrangeiros ____ ONGs estrangeiras

Foreign Private Sector Foreign Governments Foreign NGOs

_____ Outras instituições Brasileiras _____ Outras instituições estrangeiras

Other Brazilian Institutions Other foreign institutions

2.C.2 Quais instituições que você acha que seriam mais eficazes e eficientes para incentivar e administrar a prioridade principal que você marcou **com 5 no Item A na Parte 1**? Marcar a melhor opção com 1, segunda com 2, etc. Caso entenda que exista alguma prioridade em que o setor sucroenergético não deva contribuir, **marque essa com 9**.

What institutions do you think would be most effective and efficient in motivating and administering the main priority that you marked as number **5 in Item A in Part 1**? Mark the best option with 1, the second with 2, etc. In the case that you think an option should not be used, **mark this with 9**.

____ Setor privado Brasileiro ____ O governo Brasileiro ____ ONGs Brasileiras

Brazilian private sector Brazilian government Brazilian NGOs

____ Setor privado estrangeiro ____ Os governos estrangeiros ____ ONGs estrangeiras

Foreign Private Sector Foreign Governments Foreign NGOs

_____ Outras instituições Brasileiras _____ Outras instituições estrangeiras

Other Brazilian Institutions Other foreign institutions

2.D.1 Marcar a melhor resposta para seu pensamento sobre a frase, “Não necessariamente dentro do setor sucroenergético, mas em geral no Brasil, atenção deve ser prestada à disparidade entre os ricos e os pobres”? Marcar com “X” a melhor opção.

Mark the best option for your thinking regarding the sentence, “Not necessarily within the sugar-energy sector, but in general in Brazil, attention should be paid to the disparity between rich and poor”? Mark the best option with “X.”

____ Eu concordo muito ____ Eu concordo um pouco ____ Eu sou neutro

I strongly agree   I agree a little   I am neutral

____ Eu discordo um pouco   ____ Eu discordo muito   ____ Eu não tenho opinião formada

I disagree a little   I strongly disagree   I do not have an opinion

2.D.2 Quais áreas você acha seriam mais eficaz diminuir esta disparidade? Marcar a melhor opção com 1, segunda com 2, etc. Caso entenda que exista alguma prioridade em que o setor sucroenergético não deva contribuir, **marque essa com 9**.
What areas do you think would be most effective in diminishing this disparity? Mark the best option with 1, the second with 2, etc. In the case that you think an option should not be used, **mark this with 9**.

____ Infraestrutura   ____ Criação dos empregos   ____ Produção da comida

Infrastructure   Job creation   Food Production

____ Proteção dos recursos naturais   ____ Instituições (direitos, segurança, pesquisa etc.)

Protection of natural resources   Institutions

_____ Outros aspetos (breve explicação): Other aspects (brief explanation):

Parte 3: Informações Básicas   Basic Information

Qualquer resposta aqui não vai diminuir a importância das suas respostas em cima. É importante entender o pensamento das pessoas diferentes.

The responses here will not diminish the importance of your responses above. It is important to understand the thinking of different people.

3.A Idade em anos: Por favor circule a resposta que descreve sua idade hoje.

Age in years: Please circle the answer that describes your age today.

18-20   21-23   24-26   27-29   30-34   35-39   40-44   45-49   50-59   Mais de 60

3.B Marca a frase a baixo que melhor descreve seu conhecimento do setor sucroenergético.
Mark the sentence below that best describes your knowledge of the sugar-energy sector.

_____ Eu já trabalhei/estudei muito detalhamento o setor. Em qual área? ________________
I have worked in/studied the sector with great detail. In what area?
_____ Eu já trabalhei/estudei o setor em geral.
I have worked in/studied the sector in general.
_____ Eu já trabalhei/estudei um pouco sobre o setor.
I have worked/studied in the sector a little.
_____ Eu já vi/li muitas noticias sobre o setor.
I have seen/read a lot in the news about the sector.
_____ Eu já vi/li um pouco de noticias sobre o setor.
I have seen/read a little in the news about the sector.
_____ Eu só sei um pouco sobre o setor.
I know only a little about the sector.
_____ Eu não sei nada sobre o setor.
I don’t know anything about the sector.

3.C Área do trabalho/estudo: Area of work/study:

Economics/Finance	Industry	Environment	Sociology	
Biological Sciences	Soil Sciences	Agricultural Production		
Administration	Engineering	Forestry	Health	Other: