

ETHANOL'S ROOTS: HOW BRAZILIAN LEGISLATION CREATED THE INTERNATIONAL ETHANOL BOOM

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INTRODUCTION

On March 9, 2007, President Bush, in conjunction with Brazil's President, Lula da Silva, announced the formation of a new partnership between the two countries.¹ Capitalizing on the strength of the ethanol industry in both countries, the partnership was aimed at broad goals of developing new ethanol production technologies, sharing resources and promoting the use of ethanol as an alternative to fossil fuel.² Brazil is currently the world's leading producer and exporter of ethanol and the United States follows close behind.³ While the announcement of the deal received international press coverage, the media focused mostly on the fierce protests by Brazilian citizens against President Bush's policies in Iraq.⁴

This ethanol partnership merits a far greater examination, however, as its effects could be extraordinarily far-reaching. An increase in the already large-scale ethanol industry in the U.S. and Brazil could portend a similar increase in harmful environmental effects on a national and international level. For example, there is evidence to suggest that an expansion of ethanol production in any country necessarily demands an expansion of land area used to grow the crops from which ethanol is produced—primarily corn in the U.S. and sugar cane in Brazil. If crop

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¹ Peter Baker, *U.S., Brazil Team Up To Promote Ethanol*, WASH. POST, Mar. 10, 2007, at A12, available at <http://www.washingtonpost.com/wp-dyn/content/article/2007/03/09/AR2007030902102.html>.

² *Id.*

³ USDA, THE ECONOMIC FEASIBILITY OF ETHANOL PRODUCTION FROM SUGAR IN THE UNITED STATES 3 (July 2006), <http://www.usda.gov/oce/EthanolSugarFeasibilityReport3.pdf>.

⁴ Peter Baker, *Bush Continues on Latin America Tour*, WASH. POST, Mar. 10, 2007, available at <http://www.washingtonpost.com/wp-dyn/content/article/2007/03/10/AR2007031000504.html>.

production for ethanol use proves to be economically viable for farmers and large industries, such expansion could push crops used for food to marginal or protected land, or largely eliminate land currently used for food production.⁵ Additionally, questions still surround the level of harmful emissions created both from the mobile sources that use ethanol as well as emissions from ethanol plants themselves. Debate over the efficiency of ethanol production remains unresolved. Critics point to data that questions the overall net energy used to produce ethanol in comparison to production of fossil fuels. Additionally, large monocultures of corn or sugar cane could be disastrous to the surrounding ecosystems.

The litany of questions and controversies surrounding ethanol are especially relevant in light of the current ethanol production boom in the United States. However, this is not the first time an industrial nation has attempted to create and promote a massive ethanol production industry. Starting in 1975, Brazil began a national program to promote ethanol production, setting a goal to produce 3.5 billion liters of ethanol by the year 1980.⁶ The program has met and vastly exceeded that goal, becoming the largest producer of ethanol for domestic and international use.⁷ Before the U.S. embarks on a full-scale national promotion of the ethanol industry, it would do well to look to Brazil's program, noting both the successes and missteps the country has made along the way.

This paper will examine, in detail, the history of Brazil's ethanol industry, looking closely to legal incentives used by the government over the past three decades to spur the industry's remarkable growth. Brazil's dominance in the international ethanol market is due, largely, to government involvement in the sugar cane industry, but has been shaped by international politics as well as market forces. In addition, this paper will look to possible creative alternatives to mainstream ethanol production systems in both the U.S. and Brazil. The current ethanol boom in the United States has the strong support of the Presidential administration as well as many very vocal interest groups. By looking to Brazil's history, this paper will examine whether a similar program in the U.S. would be in the best interests of the nation and the environment.

⁵ Andrew Martin, *Farmers Head to Fields to Plant Corn, Lots of It*, N.Y. TIMES, Mar. 31, 2007, at C1, available at <http://www.nytimes.com/2007/03/31/business/31corn.html>.

⁶ F. JOSEPH DEMETRIUS, BRAZIL'S NATIONAL ALCOHOL PROGRAM: TECHNOLOGY AND DEVELOPMENT IN AN AUTHORITARIAN REGIME 47 (1990).

⁷ In 2007, Brazil produced 17.47 billion liters of ethanol. Editorial, *Produção nacional de cana-de-açúcar deve crescer 15,2% neste ano*, O DIA ONLINE (Braz.), Aug. 30, 2007, http://odia.terra.com.br/economia/htm/geral_120564.asp.

I. HISTORY OF BRAZILIAN ETHANOL PRODUCTION

Brazil is currently the world's leading producer and exporter of ethanol for fuel.⁸ The ethanol industry in the country is based, almost exclusively, on the use of sugar cane. Sugar cane production has historically been concentrated in two main areas in the country, the Northeast, in the states of Alagoas and Pernambuco and the Center South, in the state of Sao Paulo.⁹ The ethanol industry has expanded enormously in the past three decades, due largely to strong governmental incentives and pro-ethanol legislation.

A. *Before the Ethanol Boom*

Brazil has historically had a robust sugar cane production industry, and in the years before the national ethanol program was initiated, a great number of sugar cane plantations were owned and operated by smaller, independent growers.¹⁰ Without additional processing, such as milling sugar, producing ethanol or producing derivatives, sugar cane in and of itself possesses little economic value.¹¹ As a result, those individuals who are in control of the sugar mills have essentially controlled the industry.

Though sugar cane production has its origins in the colonial era in Brazil, it only became a direct part of the Brazilian government's economic plan in 1933 with the creation of the national agency, the Institute of Sugar and Alcohol (IAA).¹² Speaking to an international symposium of sugar manufacturers in 1985, the President of the IAA at the time looked to the history of the sugar cane industry in Brazil and traced direct state intervention to the reign of Dom Manoel I, the King of Portugal from 1495 to 1521.¹³

[R]egarding State intervention in Brazil's sugar cane agro-industry, this intervention started when the first sugar cane mill was built in 1516. Ordered by Dom Manoel, the King of Portugal, a search was made to find and elect a

⁸ USDA, *supra* note 3, at 27.

⁹ CHRISTINE BOLLING & NYDIA R. SUAREZ, THE BRAZILIAN SUGAR INDUSTRY: RECENT DEVELOPMENTS, Sugar and Sweetener Situation & Outlook/SSS-232 (Sept. 2001) (Economic Research Service/USDA), <http://www.ers.usda.gov/Briefing/Brazil/braziliansugar.pdf>.

¹⁰ DEMETRIUS, *supra* note 6, at 147.

¹¹ *Id.* at 35.

¹² JOSE APRIGIO BRANDAO VILELA, *The Brazilian Model*, in COPERSUCAR INTERNATIONAL SYMPOSIUM ON SUGAR AND ALCOHOL: Sao Paulo 41 (1985).

¹³ *Id.* at 42.

practical and capable man who was to go to Brazil and start a sugar cane mill. He was to receive all the money necessary, as well as the copper, iron, and everything else needed in order to set up the mill.¹⁴

In his remarks to Copersucar (the international sugar manufacturers symposium), the IAA President argued that this “interventionist attitude” has prevailed since 1516, finding its modern foothold in 1933 with the creation of the IAA and in 1939 with a governmental decree declaring that the export and external marketing of sugar was a State monopoly.¹⁵

In 1941, the Sugar Cane Agriculture Statute was enacted and created a quota system for sugar cane production.¹⁶ The IAA was charged with determining the production level for all growers, large or small, independent or mill owners.¹⁷ In an effort to protect smaller, independent farmers, the act created a guarantee that at least 60 percent of all sugar cane would be provided by independent farmers.¹⁸ The quota system, though, had an opposite effect.

Although ostensibly strengthening the bargaining position of the independent producers, quotas actually served to weaken their position. A failure to meet their quota meant a reduction in the quota itself, an administrative penalty for which there was no recourse. As a result, the quota system, the most important tool in the IAA's regulatory arsenal, offered only nominal protection to *fornecedores*¹⁹ from the power of mill owners.²⁰

Including the 1941 Statute, there have been around 20 Federal Directives and Resolutions addressing the sugar cane industry in the years before 1975—a pivotal year as shall be explored later in this paper. Resolution n° 109/45 of June 27, 1945 set forth a subsidy program for lower-producing sugar mills as well as establishing a base price for sugar.²¹

¹⁴ *Id.*

¹⁵ *Id.*

¹⁶ Decreto No. 3.855, de 21 de novembro de 1941, D.O.U. de 21.11.1941 (Braz.) available at www.planalto.gov.br/ccivil_03/Decreto-Lei/Del3855.htm.

¹⁷ *Id.* at Título I, Capítulo IV, art. 11.

¹⁸ *Id.* at Título III, Capítulo I, art. 48.

¹⁹ *Fornecedores*—independent growers.

²⁰ DEMETRIUS, *supra* note 6, at 36.

²¹ 21 Decreto No. 6.969, de 19 de Outubro de 1944, Dispõe sobre os fornecedores de cana que lavram terra alheia e dá outras providências available at <http://www2.camara.gov.br/>

In Directive n° 308 of February 28, 1967, the government guaranteed a base price of 1.57 Cruzeiros (the national currency at the time) for every 60 kilo bag of sugar which was destined for domestic consumption and guaranteed a base price of .01 Cruzeiros per liter of alcohol which was destined for domestic consumption.²² The Brazilian government continued to modify its pricing and subsidy plans for the sugar industry through various statutes.

Apart from the 1941 Statute and sundry other statutes and resolutions, other economic and social factors contributed to the steady decline of smaller, independent sugar cane farmers in Brazil. During the international sugar boom of the early 1970s, the Brazilian government temporarily suspended the quota system of the 1941 Statute to allow farmers to take advantage of higher sugar prices.²³ By relaxing its constraints on the amount of sugar a single farmer could produce, the government spurred a dramatic increase in the amount of sugar cane grown by large-scale producers.²⁴ This led to the rapid expansion of large-scale mills as they were better equipped to produce sugar more efficiently than smaller, independent mills.²⁵ Additionally, there was no legal restraint on the amount of land a sugar producer could buy, leading to larger producers assimilating smaller, struggling farmers.²⁶

Since Article 51 of the Sugar Cane Cultivation Statute of 1941 allowed mill owners to surpass their legal limit of 40 percent when the production of cane by independents was deemed insufficient, mill owners often purchased all or most of the lands close to the refinery, thereby reducing the output of the *forneceadores*. As the percentage of cane grown by independents declined, the *usineiro*²⁷ could then request the IAA to raise its production quota.²⁸

internet/legislacao/legin.html/textos/visualizarTexto.html?ideNorma=458339&seqTexto=1&PalavrasDestaque=.

²² Decreto No. 308, de 28 de fevereiro de 1967, D.O.U. de 28.02.1967 *available at* www.planalto.gov.br/ccivil_03/Decreto-Lei/Del0308.htm.

²³ DEMETRIUS, *supra* note 6, at 36.

²⁴ *Id.*

²⁵ *Id.*

²⁶ *See id.* at 36-37.

²⁷ LAROUSSE CONCISE DICTIONARY: PORTUGUESE—INGLES, INGLES—PORTUGUESE, 389 (2003) (defining *usineiro* as a mill owner).

²⁸ DEMETRIUS, *supra* note 6, at 37.

With greater and greater economic incentive to produce ethanol from the sugar cane crop, large-scale growers slowly co-opted the traditionally smaller, individual farmers in Brazil.

This long-term movement toward greater concentration of land and production in fewer and fewer hands has been accompanied by a growing predominance of sugar cane monoculture as the standard form of cane cultivation. The elimination of a large number of small policulture producers and the frequent incorporation of their lands into larger units has resulted in a seemingly unstoppable rise of sugar cane monoculture. The concentration of cane production, more often than not, came at the direct expense of small producers and their basket of agricultural goods.²⁹

Contributing to the decrease in smaller, independent growers and the increase in larger, industrial growers who also controlled sugar mills, was the nature of transporting the sugar cane itself. As sugar cane is a bulky and difficult-to-transport crop, independent growers became beholden to a single buyer—the sugar mill in closest proximity to their farm—if they wished to minimize their transportation costs.³⁰

Even for large-scale farmers, mechanized harvesting of sugar cane has not yet become economically viable. Around 80 percent of the sugar cane crop is still harvested manually, requiring the use of seasonal laborers.³¹ The traditional practice of harvesting sugar cane in Brazil involves burning the crop at the end of the growing season.³² The entire field is set on fire, a process that may seem paradoxical to the goal of harvesting the cane.³³ Burning, however, serves two purposes. First, the fire burns off the sharp outer leaves of the sugar cane plant and allows laborers to more easily navigate the field and harvest the cane.³⁴ Second, the fire is used as a precautionary measure benefitting laborers as it kills off or drives away venomous snakes that may be in the field.³⁵ The fire does not harm the

²⁹ *Id.* at 35.

³⁰ *Id.* at 35-36.

³¹ *Id.* at 41 n.16.

³² Erika Engelhaupt, *Burning Sugarcane Releases Ozone-Producing Nitrogen*, ENVIRONMENTAL SCIENCE AND TECHNOLOGY, Dec. 5, 2007, http://pubs.acs.org/subscribe/journals/esthag-w/2007/dec/science/ee_Brazil_biofuels.html.

³³ *Id.*

³⁴ *Id.*

³⁵ *Id.*

crop itself as the water-rich and extremely hardy stalks are left unharmed by the burning process. Though there are laws that expressly prohibit burning of crops, they are not often enforced.³⁶

By 1975, the sugar cane industry in Brazil was dominated by a small, elite group of large-scale farms who controlled over 60 percent of sugar cane production.³⁷

In the half century before [1975], the *usineiro* elites had expanded and solidified their influence over the industry, over the IAA that nominally regulated it, and over independent growers. They had successfully voided the quota system of the 1941 Statute of Sugar Cane Cultivation; they had achieved production and productivity levels usually unmatched by smaller growers.³⁸

The emergence of the large-scale farmers as a political and economic powerhouse in the sugar cane industry had a disastrous effect on the independence of smaller-scale farmers.³⁹ The total number of sugar mills declined substantially in the twenty-five years before 1975.⁴⁰ Fewer mills, combined with increased total land area of larger farms meant that the distance between independent growers' farms and the end destination of the crop, the sugar mill, often increased.⁴¹

Since the transportation of cane is very costly and since the official price paid for cane is uniform, *forneceadores* often incur higher expenses without the benefit of higher revenue. Relative to the mill owner, the productivity of the independents often fell as uncompensated transportation costs rose. Other factors being equal, the cost per ton of sugar cane is considerably higher for independents simply because of their geographical disadvantage: their fields are located farther from the sugar mills than those of mill owners.⁴²

³⁶ One such law is Decreto No. 97.635, de 10 de abril de 1989, Regula o art. 27 do Código Florestal e dispõe sobre a prevenção e combate a incêndio florestal, e dá outras providências.

³⁷ DEMETRIUS, *supra* note 6, at 39.

³⁸ *Id.*

³⁹ *See id.* at 38.

⁴⁰ *Id.* at 38.

⁴¹ *Id.*

⁴² *Id.*

By 1975, the large-scale producers had effectively amassed the bulk of the sugar cane industry in the country. "In 1975, . . . the *usineiro* elites, and especially the Paulista element, had become industrial and agricultural powers unto themselves. Their hegemony over the sector had become virtually complete. The mill owners were the undisputed rulers of the world's largest sugar industry."⁴³

B. The Creation of Proalcool

Established on November 14, 1975 by presidential decree, Proalcool (*Programa Nacional do Álcool*) was created at a time of great flux in the international sugar industry. The oil crisis of 1973 had sent gasoline prices soaring internationally, and the Brazilian government decided to look to possible domestic sources of fuel production in order to insulate itself from the chaotic market.⁴⁴ The program was aimed at bolstering Brazil's national sugar economy by safeguarding the privately owned sugar industry.⁴⁵ "Proalcool sought to stabilize the industry prices by mandating that excess sugar be turned into anhydrous ethanol which would be blended with gasoline."⁴⁶

The specific text of the Presidential Decree creating the program, Decree n° 76.593 of November 14, 1975, established a baseline of governmental involvement in the ethanol industry in Brazil.⁴⁷ Article 2 of the Proalcool decree specifically named the feedstock crops the government had in mind to supply the ethanol plants—sugar cane and manioc root and any other raw material that would be particularly suited to the increase in ethanol production.⁴⁸ This increase, the decree noted, would necessarily include the increase of agricultural production of the feedstock, modernization, and modification of existing sugar distilleries.⁴⁹

Article 3(b) of the decree defined the principle goals of the program: (i) reduce regional disparities in production of ethanol, (ii) increase the availability of necessary implements of production, both in the agriculture setting and in sugar distilleries; and (iii) help assuage the cost of

⁴³ DEMETRIUS, *supra* note 6, at 39.

⁴⁴ Environmental News Network, *Sugarcane Ethanol: Brazil's Biofuel Success*, Jan. 3, 2008, <http://www.enn.com/ecosystems/article/28580#>.

⁴⁵ DEMETRIUS, *supra* note 6, at 43.

⁴⁶ *Id.*

⁴⁷ Decreto No. 76.593, de 14 de novembro do 1975, D.O.U. de 20.02.1976. (Braz.).

⁴⁸ *Id.* at Article 2.

⁴⁹ *Id.*

transportation of the product.⁵⁰ Article 4 speaks directly to financial incentives used to bolster production, stating that the investments and expenses related to the Program would be financed by the national system of banks.⁵¹

Article 5(a) stated that investments used for installation, modernization or expansion of distilleries would be provided by the *Banco Nacional do Desenvolvimento Economico*, by the *Banco do Brasil*, by the *Banco do Nordeste do Brasil*, and by the *Banco da Amazonia*.⁵² Investments aimed at increasing raw material production would be handled by *Sistema Nacional de Credito Rural*. Section (b)§1 mandated that the National Monetary Council would assist regions where the feedstock production was not traditionally cultivated, or regions of low cultivation or conditions of special interest.⁵³

Article 7 stated that in order to guarantee the commercialization of anhydrous alcohol, of whatever origin, the National Petroleum Council would establish a program of distributing ethanol between existing petroleum companies at a fixed price to be decided by the Council.⁵⁴

The Proalcool mandate was simple enough to implement as alcohol plants already in operation required only simple modifications to produce ethanol. "These modernized facilities, known as adjacent distilleries or *anexas* were, as their name implies, attached or annexed to working sugar mills."⁵⁵ Proalcool's specific mandate was to produce 3.5 billion liters of ethanol from sugar cane by 1980.⁵⁶ For comparison's sake: in the year before Proalcool was initiated, 1974, the nation had 130 ethanol distilleries which produced 625 million liters of ethanol from sugar cane.⁵⁷ In addition to this production goal, the program hoped to achieve broader socio-economic goals as well. These included: "foreign exchange savings, the reduction of regional and personal income disparities, the fuller utilization of idle land and labor resources, and the expansion of the production of capital goods made in Brazil."⁵⁸

⁵⁰ *Id.* at Article 3(b)(I)-(III).

⁵¹ *Id.* at Article 4.

⁵² *Id.* at Article 5(a).

⁵³ Decreto No. 76.593, *supra* note 47, at Article 5(b) §1.

⁵⁴ *Id.* at Article 7.

⁵⁵ DEMETRIUS, *supra* note 6, at 43.

⁵⁶ *Id.* at 11.

⁵⁷ Felix Andrade Silva, *The Logistics Behind Proalcool in COPERSUCAR INTERNATIONAL SYMPOSIUM ON SUGAR AND ALCOHOL* 521 (1985).

⁵⁸ DEMETRIUS, *supra* note 6, at 43.

In the first years after the creation of Proalcool, many of the goals of the program were achieved.⁵⁹ Sugar prices were stabilized as many existing sugar plants expanded or constructed alcohol fermentation and distillation processes, turning millions of tons of surplus sugar into ethanol.⁶⁰ "These new facilities, known as annexed or adjacent plants (*anexas*), were located near or directly attached to existing sugar or sugar-ethanol mills [*A*]*nexas* then sold ethanol at pre-established prices to Petrobras, the national petroleum company that mixed the ethanol into gasoline and then distributed it on a nation-wide basis."⁶¹ Even though at the inception of Proalcool the Brazilian sugar industry was the largest in the world, the continued mandate to increase production of ethanol required substantial subsidies for farmers and producers.⁶²

In order to boost the domestic market for ethanol, the government instituted an ever-changing mandate of blending ethanol with gasoline to be sold to consumers.⁶³ The blending percentages were in great flux in the first years as the government adapted to consumer interest in the product and transporting the product across the country.⁶⁴ In the beginning, only the state of Sao Paulo and the Northeast region of the country were required to sell blended gasoline to consumers.⁶⁵ Slowly, that mandate expanded to the rest of the country.⁶⁶ For example, in 1976, the government required the state of Sao Paulo and the Northeast to mix 10 to 15% of alcohol with gasoline.⁶⁷ In addition to these two major zones of production, the government required the states of Rio de Janeiro and the northern part of the state of Parana to blend its gasoline at a 10 to 15% mixture of ethanol.⁶⁸ The states of Rio de Janeiro and Parana border the state of Sao Paulo, making the transportation of ethanol efficient.

In 1977, the government increased the required blend to 20% for the city of Sao Paulo, capital of the state of Sao Paulo, while the interior of the state, Rio de Janeiro, Parana and the Northeast were mandated to use a 12% blend.⁶⁹ At the time, the government stated that the increase

⁵⁹ *Id.* at 10-11.

⁶⁰ *Id.* at 11.

⁶¹ *Id.*

⁶² *Id.*

⁶³ Silva, *supra* note 57, at 521-22.

⁶⁴ *See id.*

⁶⁵ *See id.*; Bolling & Suarez, *supra* note 9, at 15.

⁶⁶ *See* Silva, *supra* note 57, at 521-22.

⁶⁷ *Id.* at 521.

⁶⁸ *Id.*

⁶⁹ *Id.*

to 20% of blended gasoline in the city of Sao Paulo was an attempt to reduce harmful pollution caused by lead-based gasoline emissions from mobile sources.⁷⁰ By 1979, the government mandated the ethanol blend to be set at 20% for the entire country.⁷¹ The supply of ethanol to the country as a whole, however, proceeded in fits and starts. Priority in distributing the blended fuel was given to the primary areas of production and then slowly expanded out from those nexus points.⁷² The first chosen areas of expansion were the cities of Rio de Janeiro, Sao Paulo, Brazilia, Belo Horizonte, Maceio, Recife, Joao Pessoa and Natal.⁷³

The year 1979 also saw the first pumps, 300 to begin with, for pure hydrated alcohol installed at gas stations across the country.⁷⁴ As for transportation, the government initially installed storage tanks for the ethanol between the centers of production and the centers of consumption and then slowly adapted the transportation structure already in place for gasoline to accommodate ethanol as well.⁷⁵ A striking example of this was in the state of Sao Paulo.⁷⁶ At the time, the state had a pipeline that was used by Petrobras, the governmentally-backed national oil company, which had six branches that extended 320 kilometers within the state and jutted into the bordering state of Parana for an additional 100 kilometers.⁷⁷ At the time, Petrobras was able to alternate the transportation of ethanol through the pipeline with the transportation of oil.⁷⁸

In the early years after Proalcool, ethanol was produced nearly exclusively by existing sugar mills that had expanded their distillation capacity.⁷⁹ While this allowed the existing sugar cane industry to minimize their initial investments, it eventually led to several long-term consequences for the industry as a whole.⁸⁰

[I]t forged an indissoluble link among sugar cane cultivation, the sugar industry, and alcohol production. Second, rather than develop a technology distinct from that of the

⁷⁰ *Id.* at 522.

⁷¹ *Id.*

⁷² See Silva, *supra* note 57, at 521; Bolling & Suarez, *supra* note 9, at 15.

⁷³ See Silva, *supra* note 57, at 522-23.

⁷⁴ *Id.* at 523.

⁷⁵ *Id.*

⁷⁶ *Id.* at 527.

⁷⁷ *Id.*

⁷⁸ *Id.*

⁷⁹ DEMETRIUS, *supra* note 6, at 76.

⁸⁰ *Id.*

sugar sector, the program adopted the technology of the sugar industry as it existed in 1975. The Program thereby limited itself to an agro-industrial structure based largely in a single state and under the control of an elite that had consolidated itself and its privileges during the past half century.⁸¹

However, this system of simply modifying existing plants allowed for a degree of flexibility in the industry.⁸² If the price of sugar rose in comparison to the price of ethanol, plants could easily return to sugar production.⁸³ "Proalcool's initial 'marriage' to the sugar industry . . . had a triple justification. It was quick, cheap, and reversible As sugar industry spokesmen frequently pointed out, Brazil could not have reached such high production levels so quickly and at so reasonable a cost without the resources of the sugar sector."⁸⁴

One of the most innovative governmental programs to emerge from the late 1970s in Brazil was the agreement brokered between the Brazilian government and large automobile manufacturers to produce cars that ran on ethanol alone, rather than simply a blend of ethanol and gasoline.⁸⁵ On September 19, 1979, major automobile manufacturers signed an agreement with the federal Brazilian government that created a protocol that defined aims of mass production ethanol-only vehicles.⁸⁶

Those were years of fighting without respite against the reluctance of the consumer market, accustomed to using a fuel acclaimed for over 80 years.

A great part of the Brazilian public expressed their disbelief regarding the new product, mainly during the initial stages of introduction.

This attitude was perfectly understandable when we consider the following aspects:

⁸¹ *Id.*

⁸² *Id.*

⁸³ *Id.*

⁸⁴ *Id.* at 76-77.

⁸⁵ See Aldebert de Queiroz, *The Role of the Brazilian Automotive Industry*, in COPERSUCAR INTERNATIONAL SYMPOSIUM ON SUGAR AND ALCOHOL 497 (1985).

⁸⁶ *Id.*

1st—there was an enormous technological distance between the gasoline powered vehicles and those using the new product.

2nd—enormous difficulties and a long delay were foreseen for establishing a distribution network for the fuel.

3rd—above all, there was a great mistrust as to the future availability of this fuel, considering the sugar-manufacturing tradition of Brazilian producers.⁸⁷

The 1979 protocol was extremely ambitious in its scope. The aim was to produce 250,000 ethanol-only vehicles by 1980; 300,000 by 1981 and 350,000 by 1982.⁸⁸ The first ethanol-only vehicles appeared on the streets in 1978.⁸⁹ In order to help raise awareness of the new vehicle, priority for these vehicles was given to governmental fleets.⁹⁰ The government also mounted a comprehensive information campaign about the vehicles.⁹¹

C. *Innovations in the 1980s*

Following the initial years after the creation of Proalcool, several factors contributed to the continued growth of the ethanol industry in Brazil. First, international raw sugar prices continued to falter, and second, the oil crisis in 1979 gave further support to the promotion of alternative fuels.⁹²

Following the outbreak of the Iran-Iraq war in 1979 and the second OPEC oil shock, the Brazilian government, under the leadership of President Joao Figueiredo, opted to transform the sugar stabilization plan into a full-fledged commitment to alcohol as a substitute for gasoline. Alcohol would now be used not only as an additive to gasoline (anhydrous ethanol), but gradually would replace all gasoline in the nation's auto fleet (hydrous ethanol).⁹³

⁸⁷ *Id.*

⁸⁸ Silva, *supra* note 57, at 522.

⁸⁹ *Id.*

⁹⁰ *Id.*

⁹¹ Queiroz, *supra* note 85, at 497.

⁹² DEMETRIUS, *supra* note 6, at 11.

⁹³ *Id.* at 77.

Thus, the goal of Proalcool became more far-reaching. Rather than acting as simply a short-term bolster of the sugar industry, it became, "a full-fledged energy program."⁹⁴ The ethanol production mandate was raised to 10.7 billion liters by 1985 and following a government-sponsored protocol issued in 1979, all major auto makers in Brazil were required to phase in ethanol-consuming cars and phase out gasoline cars.⁹⁵ This increase in production was achieved by constructing new distilleries rather than simply modifying existing plants.⁹⁶ By 1985, 85-90% of Brazil's new cars were alcohol powered.⁹⁷ Two million of the total of ten million cars were fueled completely by ethanol, the rest were fueled by gasohol.⁹⁸

Liberal governmental incentives and generous subsidies drew major new private investment into the production of ethanol in autonomous distilleries (*autonomas*), that is, ethanol plants unattached to sugar production facilities. By the end of Proalcool's first decade, autonomous plants accounted for over half of all ethanol output . . . Proalcool created an alcohol industry distinct from the sugar sector. In a sense, ethanol had 'outgrown' even Brazil's massive sugar industry.⁹⁹

In explaining the "Brazilian Model" of government intervention in the sugar industry during the Copersucar International Symposium on Sugar and Alcohol, the president of the IAA at the time explained the basic structure of the domestic market for sugar.¹⁰⁰

[R]egarding sugar for the internal market, the State intervenes in its marketing by fixing the total quantities to be sold therein and the division of that total into monthly quotas. Not only this, but our internal market is legally subdivided into two separate regions, and the producers of one region are prohibited from selling to outlets in the other region. This is not a restriction of free trade, it is out-and-out prohibition.¹⁰¹

⁹⁴ *Id.* at 11.

⁹⁵ *Id.* at 11, 77.

⁹⁶ *Id.* at 77.

⁹⁷ *Id.* at 12.

⁹⁸ DEMETRIUS, *supra* note 6, at 12.

⁹⁹ *Id.*

¹⁰⁰ See Vilela, *supra* note 12, at 39, 41.

¹⁰¹ *Id.* at 41.

The President elaborated on the role of the government in the realm of alcohol. Under the guidance of the Ministry of Mines and Energy, the National Petroleum Council was the governmental organ most closely linked to supervising alcohol production.¹⁰² It fell to the National Petroleum Council to determine the quantity of alcohol to be purchased domestically by fuel companies from alcohol manufacturers.¹⁰³ The National Petroleum Council also established the amount of alcohol to be allocated to the chemical industry, creating a quota system for allocation.¹⁰⁴ It was the duty of the Ministry of Finance, through the Central Bank and the Bank of Brazil to intervene in the financing of the sugar cane economy, either acting independently or conjointly with the IAA, creating export subsidies and providing capital to the sector.¹⁰⁵ The relationship between the Bank of Brazil and the IAA was extremely close, and “for many years the Bank had a near monopoly of the supply of credit to the national sugar cane system.”¹⁰⁶ Additionally, the government attempted to control labor relationships in the sugar cane sector.

Besides enjoying all the rights guaranteed to every worker, sugar and alcohol industry workers receive an additional benefit in the form of contributions of 1% of the value of sugar, 1% of the value of sugar cane and 2% of the value of alcohol produced each year in Brazil. These resources are transferred to the sugar cane workers through their associations and companies, all subject to inspection by the IAA, which analyzes and approves the application of these funds.¹⁰⁷

In addition to incentives and subsidies, governmental involvement in setting prices for alcohol continued in the 1980s. In 1980, the government decreed that the price of hydrated alcohol, as sold to the consumer, would be at most 65% higher than that of simply gasoline.¹⁰⁸ This price cap was set in the hopes of reigning in the price of ethanol so that it would be a viable choice for drivers in the country.¹⁰⁹

¹⁰² *Id.*

¹⁰³ *Id.*

¹⁰⁴ *Id.*

¹⁰⁵ *Id.*

¹⁰⁶ Vilela, *supra* note 12, at 41.

¹⁰⁷ *Id.* at 42.

¹⁰⁸ Silva, *supra* note 57, at 523.

¹⁰⁹ *Id.*

1981 saw some hiccups in the rapid expansion of the Proalcohol program. To begin, consumers were not yet fully convinced that ethanol blends and ethanol-powered vehicles were sound options.¹¹⁰ The higher price of ethanol as well as irregular use by consumers furthered suspicion of the fuel.¹¹¹ Even those consumers that were using ethanol had severe misgivings. At the time, gasoline engines were being converted to burn purely ethanol by auto repairers who would not observe the technical standards for the conversion and were not authorized by the government to make these conversions.¹¹² The government decided to reduce the ethanol-gasoline blend to 12% country-wide in order to prepare for what they expected would be an enormous increase in ethanol-powered vehicles.¹¹³ But, due to suspicion and mistrust of the fuel, this vast increase never manifested itself, and producers were left with a surplus of ethanol.¹¹⁴ In 1981, the federal government made it "mandatory to equip ethanol pumps at filling stations with direct-reading, temperature-corrected hydrometers to allow the consumer himself to verify the quality of the product."¹¹⁵

Reacting to the setbacks, the Proalcohol program suffered in 1981. Thus, in 1982, the government took steps to fortify the program. The government worked with auto manufacturers to improve the performance of ethanol-powered engines.¹¹⁶ Additionally, the government set a price cap on ethanol for a two-year period, requiring that it could be sold only at a 59% maximum of the price of gasoline.¹¹⁷ In spurring the automobile industry, the government set an objective to manufacture 500,000 ethanol-powered vehicles within the year.¹¹⁸ This increase in ethanol-powered vehicles was paralleled with an aim to expand alcohol production to meet the expected demand.¹¹⁹ The government also created programs to spur sales of ethanol-powered vehicles by reducing the taxes to be paid when consumers purchased the cars.¹²⁰ Further, the ethanol-gasoline blend was set once more at 20% for the entire country.¹²¹

¹¹⁰ *Id.*

¹¹¹ *Id.*

¹¹² *Id.*

¹¹³ *Id.*

¹¹⁴ Silva, *supra* note 57, at 523.

¹¹⁵ *Id.*

¹¹⁶ *Id.*

¹¹⁷ *Id.*

¹¹⁸ *Id.*

¹¹⁹ Silva, *supra* note 57, at 523-24.

¹²⁰ *Id.* at 523.

¹²¹ *Id.*

These governmental incentives, programs, and goals were successful in catapulting the use of ethanol and the purchasing of ethanol-powered vehicles. By 1983, the sale of ethanol-powered vehicles outnumbered that of gasoline-only vehicles.¹²² By 1984, the sale of ethanol-powered cars had reached 84% of total vehicle sales in Brazil.¹²³ Though the Proalcool program suffered some setbacks initially, the government propelled ethanol use in the country by using a wide variety of methods. Some of these methods could work best, or perhaps exclusively, in an authoritarian state, but many may be copied or modified for more market-based economies.

D. Why Sugar Cane?

The use of sugar cane as the crop of choice for ethanol production in Brazil is the result of several historical factors. The Proalcool decree allowed for the use of either sugar cane or manioc root for the production of ethanol.¹²⁴ Manioc (*mandioca*, in Portuguese), native to South America, is easily cultivated in the region and has traditionally been grown as a subsistence crop.¹²⁵ While Proalcool offered subsidies to both manioc-based plants and sugar cane-based plants, the de facto standard in the alcohol industry was the 120,000 to 240,000 liter per day facility, a scale that far exceeded the typically smaller manioc plants.¹²⁶

While ethanol-producing sugar cane plants have increased their efficiency over the years and have been able to minimize the net energy used to create ethanol, there is evidence to suggest that manioc could be a more energy efficient alternative to sugar cane as a ton of manioc yields much more alcohol than a ton of cane.¹²⁷ Additionally, manioc is grown very easily in all areas of the country, not just the major sugar cane strongholds that exist in three Brazilian states.¹²⁸ In *Brazil's National Alcohol Program: Technology and Development in an Authoritarian Regime*, Demetrius argues that low agricultural productivity and production led most investors to choose sugar cane as the preferred raw material for alcohol production.¹²⁹ He maintains that “[a] manioc-to-alcohol Proalcool [program]

¹²² *Id.*

¹²³ *Id.*

¹²⁴ DEMETRIUS, *supra* note 6, at 48.

¹²⁵ *Id.* at 48.

¹²⁶ *Id.* at 51.

¹²⁷ *Id.*

¹²⁸ *Id.* at 48.

¹²⁹ *Id.* at 51.

would have benefitted some of Brazil's most impoverished peoples and areas and avoided" placing sugar cane crops in already highly developed regions.¹³⁰

Brazil's sugar cane-based alcohol production system, like the sugar production technology Proalcool inherited, resembles a solar system as a handful of lesser bodies gravitate around a powerful celestial center. A manioc or even a manioc-and-cane system, however, would have distributed production much more evenly throughout the federation. For example, were alcohol production based on the share of manioc production of each state in 1975, Sao Paulo's enormous share would have been diminished greatly and the northeastern states, where millions rely on manioc as a staple, would have accounted for almost 50 percent of national output.¹³¹

The choice of sugar cane over manioc as the preferred ethanol crop was not directly mandated by the government, but by the existing sugar cane farmers and producers who made sugar cane appear a more viable alternative. While the Proalcool program mandated a vast increase in ethanol production and while it also offered government-backed subsidies and incentives to reach that goal, it was ultimately the responsibility of private investors and companies to achieve the end result. As such, sugar cane naturally appeared a more amenable crop as a means to reach that end.

The infrastructure of a massive sugar cane industry had already been established in the country and well-financed farmers and plant owners were able to convince additional investors that sugar cane ethanol production made more economic sense than alternatives such as manioc.¹³²

Because Proalcool ultimately depends on private initiative, it can generate wealth-creating investment only where and when private capital is able and willing to participate. Proalcool cannot, within its limited jurisdiction, help to resolve the regional balance of income until the major technical problems thwarting the use of manioc or other crops

¹³⁰ DEMETRIUS, *supra* note 6, at 50.

¹³¹ *Id.*

¹³² *Id.*

are eliminated or until the northeast's sugar industry can overcome the resistance of the very elites that dominate it.¹³³

Though a manioc-to-alcohol industry would have many benefits to farmers outside of the realm of the sugar cane industry, it certainly was not a complete solution to the dominance of sugar cane in Brazil. The country would perhaps be best served by following the language of the initial Proalcool decree—to use sugar cane, manioc or any other suitable crops to achieve ethanol production goals. Manioc happened to be a likely alternative simply because it was already widely grown throughout the country and is suitable to alcohol production. However, a diverse selection of alternative crops would have best served environmental and economic goals.

E. Land Use Concerns

Though sugar cane production is concentrated mainly in two geographic regions of Brazil, the Northeast and the Center South, dramatic land use changes are evident in both those regions since the inception of Proalcool. Less than 1% of Brazil's total territory would be needed to reach production of 30 billion liters of alcohol per year.¹³⁴ However, the area in which sugar cane production is most concentrated has experienced the negative effects of a large monoculture crop. As explained above, most sugar cane is currently grown in massive, interconnected areas.¹³⁵ A monoculture is the growing of only one species of crop, grown densely over a large land area. As such, monocultures require increased use of pesticides, since the area would be an ideal location for crop pests and diseases to grow. Monocultures require vast areas of land, and therefore can lead to the destruction of natural habitats. "In terms of the nation's total land mass, the area required for the production of 10.7 billion liters of alcohol seems absurdly small. A single square with sides measuring between 130 and 150 miles long can sustain this production."¹³⁶

By allowing very fertile agriculture production areas, such as Sao Paulo, to be devoted to sugar cane necessarily drove other crops out of the area, driving up the price of traditional food crops.¹³⁷ Demetrius argues

¹³³ *Id.* at 52.

¹³⁴ *Id.* at 55.

¹³⁵ *Id.* at 80.

¹³⁶ DEMETRIUS, *supra* note 6, at 55.

¹³⁷ *Id.* at 62-63.

that the Proalcool program did not encourage sugar cane producers to incorporate new land into the agricultural system, but extended the traditional sugar cane zones by expanding sugar cane monoculture into adjacent lands that had traditionally been used by small policulture producers.¹³⁸

Under the aegis of Proalcool, sugar cane cultivation spread by devouring lands adjacent to existing sugar cane zones. This process of 'phagocytosis' clearly indicates that, on the whole, Proalcool has yet to live up to its promise to bring new lands into production. Indeed, while fallow cane lands stand idle, cane continues its advance into food crop lands.¹³⁹

Not only are traditional food crops forced to move to other areas, the price of land surrounding sugar cane plantations has seen a dramatic increase since the creation of Proalcool.¹⁴⁰ Additionally, the practice of subsidizing one primary crop for ethanol production, especially a crop that is dominated by a relatively few large-scale farmers, implies the denial of similar subsidies to other crops or producers.

II. WHAT THE UNITED STATES CAN LEARN FROM BRAZIL

A dramatic recent development in U.S. energy legislation indicates that the U.S. is poised to accept corn as the dominant ethanol crop in the country. The "Energy Independence and Security Act of 2007" (2007 Act), passed in December of 2007,¹⁴¹ and has as its cornerstone a mandate for the increased production of renewable fuels.¹⁴² The 2007 Act creates a new subset of renewable fuels, labeled advanced biofuels and is further divided into three parts: cellulosic biofuel, biomass-based diesel and other.¹⁴³ The mandates for the increased Renewable Fuel Standard (RFS) described in the 2007 Act requires the amount of renewable fuel and advanced biofuel blended into gasoline to be increased over the next 4 to 14 years in each category of renewable fuel.¹⁴⁴ The mandate's passage

¹³⁸ *Id.* at 59.

¹³⁹ *Id.*

¹⁴⁰ *Id.* at 81.

¹⁴¹ Energy Independence and Security Act of 2007, Pub. L. No. 110-140, 121 Stat. 1492 (2007).

¹⁴² *Id.* at 1521-22.

¹⁴³ *Id.* at 1519-20.

¹⁴⁴ *Id.* at 1522-23.

generated criticism from many political and environmental corners, the most vocal being the Governor of Texas, Rick Perry, who requested a waiver from the mandate for the state of Texas.¹⁴⁵ Arguing that the mandate would only further increase the price of corn, Governor Perry voiced concern for increased costs that would be passed to both livestock owners and consumers.¹⁴⁶ The U.S. EPA received over 15,000 public comments on the mandate during the rulemaking period.¹⁴⁷ On August 7, 2008, the U.S. EPA denied Texas's request for a waiver, setting the stage for the rapid increase in renewable fuel production, as laid out in the following tables.¹⁴⁸

**Applicable Volume of Renewable Fuel
Calendar Year: (in billions of gallons):¹⁴⁹**

2006	4.0
2007	4.7
2008	9.0
2009	11.1
2010	12.95
2011	13.95
2012	15.2
2013	16.55
2014	18.15
2015	20.5
2016	22.25
2017	24.0
2018	26.0
2019	28.0
2020	30.0
2021	33.0
2022	36.0

¹⁴⁵ Ayesha Rascoe, *Texas Governor Urges EPA to Grant Ethanol Waiver*, REUTERS, June 24, 2008.

¹⁴⁶ *Id.*

¹⁴⁷ Environmental News Service, *EPA Puts Off Renewable Fuels Waiver Decision to August*, July 23, 2008, <http://www.ens-newswire.com/ens/jul2008/2008-07-23-093.asp>.

¹⁴⁸ DieselNet, *US EPA denies Texas biofuel waiver request*, Aug. 11, 2008, <http://www.dieselnet.com/news/2008/08epa.php>.

¹⁴⁹ Energy Independence and Security Act of 2007, Pub. L. No. 110-140, 121 Stat. 1492, 1522 (2007).

**Applicable Volume of Advanced Biofuel
Calendar Year: (in billions of gallons):¹⁵⁰**

2009	0.6
2010	0.95
2011	1.35
2012	2.0
2013	2.75
2014	3.75
2015	5.5
2016	7.25
2017	9.0
2018	11.0
2019	13.0
2020	15.0
2021	18.0
2022	21.0

**Applicable Volume of Cellulosic Biofuel
Calendar Year: (in billions of gallons):¹⁵¹**

2010	0.1
2011	0.25
2012	0.5
2013	1.0
2014	1.75
2015	3.0
2016	4.25
2017	5.5
2018	7.0
2019	8.5
2020	10.5
2021	13.5
2022	16.0

¹⁵⁰ *Id.*

¹⁵¹ *Id.* at 1523.

**Applicable Volume of Biomass-based Diesel
Calendar Year: (in billions of gallons):¹⁵²**

2009	0.5
2010	0.65
2011	0.80
2012	1.0

Though the 2007 Act will primarily motivate a large-scale increase in the amount of corn-based ethanol that is produced and used in the U.S., the Act also carves out provisions for alternatives to corn.¹⁵³ The U.S. could learn much from the historical development of sugar cane use in Brazil and perhaps look to incorporate many other alternative crops in ethanol production. While sugar cane and corn remain the world's two most-used crops for the ethanol industry, a great number of creative alternatives could potentially be used, including: fast-growing trees and grasses, wood chips, wheat straw, paper pulp, seaweed, municipal garbage and agricultural waste products, to name a few.¹⁵⁴

A. Current Ethanol Production in the U.S.

In the United States, there are currently 134 corn-based ethanol plants in operation compared with 95 in January 2006.¹⁵⁵ There are currently 77 more plants under construction and many more in various stages of planning.¹⁵⁶ Ethanol production has vastly increased in the U.S. in the past three decades. According to the Renewable Fuels Association, in 1980, the U.S. produced 175 million gallons of ethanol.¹⁵⁷ In 2006, it produced 4,855 million gallons.¹⁵⁸ Currently, 26 states have ethanol plants, the vast majority of which use corn as their sole feedstock.¹⁵⁹ The boom in ethanol and ethanol plants has driven up the price of corn, which in turn, has

¹⁵² *Id.*

¹⁵³ *Id.* at 1519-20.

¹⁵⁴ U.S. International Trade Commission, Investigation No. 332-481, Industrial Biotechnology: Development and Adoption by the U.S. Chemical and Biofuel Industries, (2008).

¹⁵⁵ Renewable Fuels Association, *Industry Statistics*, <http://www.ethanolrfa.org/industry/statistics/> (last visited Aug. 26, 2008).

¹⁵⁶ *Id.*

¹⁵⁷ *Id.*

¹⁵⁸ *Id.*

¹⁵⁹ *Id.*

driven up the supply. In 2007, U.S. farmers planted more acres of corn than at any time since 1944—90.5 million acres, 15% more acres than in 2006.¹⁶⁰ Additionally, the acreage planted for soybeans, cotton and rice in the U.S. have all decreased this year.¹⁶¹

The parallels between the development of the sugar cane-based ethanol industry in Brazil and the current state of the corn-based ethanol industry in the U.S. should be informative to anyone who can envision room for improvement in the U.S. system. In the years before Proalcool was initiated, the sugar cane industry in Brazil had steadily amassed political support for a sugar cane-focused industry. By the time Proalcool was initiated in 1975, through a combination of market forces, government incentives and political will, the industry was controlled largely by a few elite producers. In 2006, in the U.S., there were 46 farmer-owned ethanol plants, nearly half of the total number of ethanol plants in the country.¹⁶² However, of the 134 plants currently operating, only 49 of those are farmer-owned.¹⁶³ Certainly, the U.S. ethanol industry seems to be heading in the direction of the Brazilian industry of the early 1970's—a decrease in smaller, independent ethanol plants and a corresponding increase in large industry operated plants.

In order to weigh the viability of corn as a feedstock for ethanol, it is necessary to examine it in comparison to other potential feedstocks. In the U.S., there are two main methods of producing ethanol from corn; wet and dry milling.¹⁶⁴ Wet milling facilities can make a variety of corn-based products such as sweeteners and gluten feed, while dry milling facilities are dedicated solely to ethanol production.¹⁶⁵ The USDA states that,

approximately 2.65 gallons of ethanol can be produced from a bushel of corn in existing wet mill facilities [and] plants using the dry mill process can produce 2.75 gallons of ethanol per bushel of corn. Ethanol yield per bushel of corn in the United States has increased significantly since 1980.¹⁶⁶

¹⁶⁰ Philip Brasher, *What This Year's Corn Push Means to You*, DES MOINES REGISTER, Mar. 31, 2007, at 1A, available at <http://desmoinesregister.com/apps/pbcs.dll/article?AID=/20070330/NEWS/70330007/1056/NEWS09>.

¹⁶¹ *Id.*

¹⁶² Renewable Fuels Association, *supra* note 155.

¹⁶³ *Id.*

¹⁶⁴ USDA, *supra* note 3, at 11.

¹⁶⁵ *Id.*

¹⁶⁶ *Id.* at 17.

New ethanol plants utilize the latest technology to increase production.¹⁶⁷ When comparing the ethanol yield per ton of feedstock to viable alternative crops that are currently being used to produce ethanol, corn is by far the leader. According to the USDA, "a ton of U.S. corn can yield approximately 100 gallons of ethanol, compared with 25 gallons from a ton of French sugar beets and 20 gallons from a ton of Brazilian sugarcane."¹⁶⁸ This measure alone does not tell the whole story, however.

It is the cost of producing that feedstock which ultimately determines the relative economic feasibility of various feedstocks. In this regard, Brazil has a significant comparative advantage, with estimated gross feedstock costs of about 30 cents per gallon of ethanol produced, compared to 97 cent per gallon for sugar beets in France and 80-85 cents per gallon for corn in the U.S.¹⁶⁹

Additionally,

[t]he sugar and ethanol industry in Brazil has invested approximately \$40 million per year in research and development since 1979. This research has contributed to the dramatic increase in sugar and ethanol productivity in Brazil over the past thirty or so years. In 1975, sugarcane production in Brazil averaged 16 tons per acre. By 2004, sugarcane yields were averaging over 32 tons per acre. Ethanol production from sugarcane increased from 305 gallons per acre to about 590 gallons per acre over this same period.¹⁷⁰

B. Diversification of U.S. Feedstock

A major lesson the United States could learn from Brazil is the need to diversify feedstock used for ethanol production. As analyzed above, Brazil, through a mixture of government incentives, market forces and political maneuvering found itself with sugar cane as its main crop. This occurred in Brazil even though the initial statute mandating the creation

¹⁶⁷ *Id.*

¹⁶⁸ *Id.* at 29.

¹⁶⁹ *Id.*

¹⁷⁰ USDA, *supra* note 3, at 28-29.

of the national alcohol program, Proalcool, specifically mentioned not only sugar cane as a potential feedstock, but also manioc root.¹⁷¹ Manioc root is a perennial plant native to South America, easily grown on marginal land and also highly suitable for ethanol production.

A potential parallel to manioc root in the United States is switchgrass. Switchgrass is a rapid-growth perennial plant that can grow to around six feet in height and is native to North America.¹⁷² One of the great benefits of large-scale use of switchgrass for ethanol production would be that marginal land could be used rather than land currently used for food production. Switchgrass would fall in the category of cellulosic feedstocks used for ethanol production, which is quickly emerging as a very viable alternative to traditional ethanol feedstocks.

The U.S. Department of Energy (DOE) has designated switchgrass, a warm-season tall-grass prairie native, as a potential biomass energy crop, chosen because it produces more biomass than most other native grasses. In other parts of the country, the DOE has experimented with hybrids of poplar and willow trees, as they were better suited to differing climates.¹⁷³ Cellulosic crops such as switchgrass are preferred for several environmental reasons: they are able to hold the topsoil, capture carbon, aid in cleaning and purifying runoff and can provide habitats for indigenous wildlife.¹⁷⁴

Additionally, switchgrass can be harvested and baled with conventional farm equipment and a ton of switchgrass can produce approximately 80 gallons of ethanol.¹⁷⁵ Ethanol derived from switchgrass can produce about five times more energy than it takes to grow, harvest, and deliver it, according to studies by Oak Ridge National Laboratory.¹⁷⁶ If grown for biomass, switchgrass is cut once a year, in the fall after frost, leaving about a 6-inch stubble on the ground. During growth and after harvest, switchgrass can be home to pheasants, grouse, and grassland birds.¹⁷⁷ "Switchgrass grown on marginal lands would stabilize the soil, reduce soil erosion and siltation, and reduce nutrient runoff[, with] very little soil

¹⁷¹ Decreto No. 76.593, *supra* note 47, 53.

¹⁷² See, e.g., Don Comis, *Scientists Study Feasibility of Switchgrass for Energy Production*, USDA, Mar. 10, 2006, <http://www.ars.usda.gov/is/pr/2006/060310.htm>.

¹⁷³ See, e.g., *Bales of Opportunity*, 54 FARM AND HOME RES. 16, 18 (2003), available at <http://agbiopubs.sdstate.edu/articles/FHR54-2.pdf>.

¹⁷⁴ *Id.* at 16.

¹⁷⁵ *Id.* at 18.

¹⁷⁶ *Id.*

¹⁷⁷ *Id.*

compaction and soil disruption from machinery.”¹⁷⁸ “The people conducting this three-state research expect long-run total production costs of \$30 a ton. And about \$10 per ton to get the bales to the nearest plant.”¹⁷⁹

The DOE is currently operating several experimental cellulosic ethanol plants, designed to test whether switchgrass could be a viable ethanol feedstock in the U.S.¹⁸⁰ They have so far found that one of the first areas where switchgrass can be economically grown as an ethanol crop is the Northern Plains.¹⁸¹ Additionally, the DOE has estimated that switchgrass could yield 500 gallons of ethanol per acre.¹⁸² “Bio-oil yields greater than 60% by mass have been demonstrated for switchgrass, with energy conversion efficiencies ranging from 52 to 81%.”¹⁸³

The case of switchgrass is simply one of many possible feedstock alternatives to corn in the ethanol production industry. Ethanol can, has, and could be made from a variety of feedstocks. The use of cellulosic crops for ethanol production offers many environmental improvements over feedstocks such as corn or sugar cane. Though an improvement, certainly more research on a greater number of alternative crops will provide other possible feedstock solutions. The U.S. should, however, learn from Brazil's insistence on maintaining a monoculture of sugar cane for its ethanol industry, in that diversification of feedstocks could lead to both environmental and economic benefits.

Additionally, another very relevant lesson the U.S. could learn from Brazil is in the area of industrial initiatives. By working closely with major automobile manufacturers, the Brazilian government was able to set extraordinary goals for the production of flex fuel cars.¹⁸⁴ Perhaps even more extraordinary was the fact that these goals were met by the manufacturers.¹⁸⁵ Simply by looking at the Brazilian model, it is clear that such

¹⁷⁸ *Id.* at 19.

¹⁷⁹ *Bales of Opportunity*, *supra* note 137, at 18.

¹⁸⁰ U.S. Dep't of Energy, Bioenergy Research Centers an Overview of the Science, Feb. 2008 <http://genomicsgtl.energy.gov/centers/brcbrochure.pdf>.

¹⁸¹ USDA, *Improved Plants and Production Practices for Grasslands and Biomass Crops in the Mid-Continental USA*, AGRICULTURAL RESEARCH SERVICE, Sept. 15, 2008, http://www.ars.usda.gov/research/publications/publications.htm?seq_no_115=178898.

¹⁸² Ecotality Life, *Tennessee Bets \$70 Million on Switchgrass gas*, Oct. 22, 2007, <http://ecotality.com/life/2007/10/22/tennessee-bets-70-million-on-switchgrass-gas/>.

¹⁸³ USDA, *Economic Competitiveness of Renewable Fuels Derived from Grains and Related Biomass*, AGRICULTURAL RESEARCH SERVICE, Aug. 28, 2008, http://www.ars.usda.gov/research/publications/publications.htm?seq_no_115=202978.

¹⁸⁴ See Queiroz, *supra* note 85, at 497.

¹⁸⁵ *Id.*

initiatives are well within the grasp of the U.S. government should it decide to proceed down that path. Indeed, measures and agreements on not only ethanol additives, but fuel economy as well as a host of environmental initiatives are possible to foresee. The example of Brazil leaves little doubt as to the possible success of such programs. With governmental backing, industry support and informed consumers, such industrial initiatives could readily be adopted in the United States.

III. ENVIRONMENTAL CONCERNS

Many of the criticisms that can be leveled against the Proalcool program can find parallels in programs implemented in the United States to boost corn-based ethanol production. A state-supported national push to produce ethanol implicitly excludes many other environmentally beneficial energy-reducing alternatives. "In choosing to address its petroleum crisis by producing alcohol, Brazil underwrites the most energy-inefficient form of transport—the private automobile."¹⁸⁶ "The decision to produce ethanol for automobile carburetion places the interests of Brazil's usually affluent car owners over those of the majority of the populace, which must rely on buses for almost all of their transportation needs."¹⁸⁷

Certainly, that is a criticism that could be raised any time a government favors one system of alternative energy over another, but it is especially relevant in the U.S. where, for example, a great deal of improvement could be made in fuel economy of cars. The promotion of ethanol need not be at the exclusion of increased fuel economy, but by heavily promoting renewable fuels, the U.S. Administration seems to be able to deflect attention from other possible improvements in energy efficiency. Brazil chose to invest in ethanol. Whether that investment was a conscious decision to exclude other alternatives is left to debate.¹⁸⁸ However, Brazil lacks other environmentally-minded transportation systems, such as a national rail system.¹⁸⁹ "The allocation of resources to Proalcool limited or denied the possibilities of other methods of reducing petroleum imports. These rather substantial opportunity costs must be recognized, for Proalcool represents a heavy drain on the national treasury and non-investment in other critical sectors."¹⁹⁰ Ethanol use need not be a Faustian bargain between renewable

¹⁸⁶ DEMETRIUS, *supra* note 6, at 62.

¹⁸⁷ *Id.*

¹⁸⁸ *Id.* at 66.

¹⁸⁹ *Id.*

¹⁹⁰ *Id.*

energy and any other alternative plan or program, the United States can learn from Brazil that there is room for many complimentary programs.

As American farmers proceed to plant the largest corn crop since 1944, a bumper crop heavily influenced by a record number of corn-based ethanol plants under construction, the U.S. must seriously consider the long-range effects such a pattern will have on other staple crops in the country. "The rush to plant corn would come at the cost of other crops, particularly soybeans and cotton. The Agriculture Department said that if farmers followed through with their stated intentions, soybean acreage would be down 11 percent and cotton, 20 percent."¹⁹¹ A necessary ripple effect will occur if corn planting continues at this breakneck pace. Not only will other staple food crops be affected, but industries that depend on such crops will be competing directly with ethanol plants for the same raw materials. Chicken feed, for example, normally contains 70 percent corn, 20 percent soybean meal and 10 percent minerals and other ingredients.¹⁹² As the ethanol industry consumes a greater and greater share of the corn market, feed costs have increased 40 percent since last summer.¹⁹³ "When all of the current plants under construction are completed, probably in early 2009, ethanol plants will need about 4.3 billion bushels of corn a year to produce more than 12 billion gallons a year."¹⁹⁴ The effect of this profound boom in corn acreage will have on not only other staple food crops in the nation, but also on those industries that depend on corn is difficult to determine. Looking to Brazil as an example, the U.S. can learn much from the Brazilian model. Sugar cane monocultures in the states of Sao Paulo and in the Northeast region of the country drove out smaller, independent farmers as well as drastically increased the price of surrounding land. While the vast size of the country has allowed for the planting of ever more sugar cane acreage without significantly affecting the production of staple food crops, such a situation is not feasible in the U.S. The demand for corn for ethanol production has already taken a toll on corn prices as well as the acreage of other staple food crops. In order to combat this trend, the U.S. should think seriously about increasing the diversity of crops used for the production of ethanol.

¹⁹¹ Andrew Martin, *Farmers Head to Fields to Plant Corn, Lots of It*, N.Y. TIMES, Mar. 31, 2007, at C7.

¹⁹² *Id.*

¹⁹³ *Id.*

¹⁹⁴ *Id.*

CONCLUSION

The United States currently sits at a crossroads in the ethanol debate. The major players in the ethanol industry are heavily invested in corn-based plants and production, virtually to the exclusion of all other feedstocks.¹⁹⁵ Before the U.S. plunges ever further into an ethanol production system that depends on a single crop, it would do well to look at Brazil's ethanol history. Spanning over the past three decades, Brazil offers a rich and detailed case history of a government-backed push to rapidly and exponentially increase its ethanol production levels.¹⁹⁶ Set against the backdrop of the oil crises in the mid 1970's, the Brazilian Proalcool program offers many parallels to the current political and economic climate in the United States.¹⁹⁷ Certainly, the uniqueness of the Brazilian authoritarian political system at the time of Proalcool's inception sets it apart, but should the U.S. decide to follow Brazil's path, many of the governmental incentives, subsidies and regulations could be emulated and modified for the American political system.

One clear lesson that can be learned from Brazil's ethanol production strategy is the need for greater diversity in crops used to produce the fuel.¹⁹⁸ Though the Proalcool mandate listed sugar cane, manioc root and any other feasible crop as the types of feedstocks that should be used in producing ethanol, for the various reasons listed above, sugar cane became the dominant crop. By ignoring other potentially more energy efficient, environmentally sound crops, Brazil succumbed to an agro-industry that had gained deep economic and political footholds in the country by the mid 1970's.¹⁹⁹ A similar situation seems to be brewing in the United States. The political strength of groups such as the National Corn Growers Association as well as many state corn farmers' groups have been major supporters of a corn-based ethanol industry.²⁰⁰ This is a risky path to travel down. The U.S. would be best served by examining the Brazilian model and improving upon it in the realm of creating diversity in the feedstocks.

Through diversification of the ethanol feedstocks as well as forging agreements with large auto manufacturers to produce ethanol-friendly cars, the U.S. could both adopt the successes of the Brazilian model of

¹⁹⁵ *See supra* Part II.

¹⁹⁶ *See supra* Part I.A.

¹⁹⁷ *See id.*

¹⁹⁸ *See supra* Part I.D.

¹⁹⁹ *See id.*

²⁰⁰ *See supra* Part II.

ethanol production as well as avoid several environmental dangers.²⁰¹ The history of ethanol production in Brazil provides an interesting insight into how an authoritarian regime, dedicated to promoting an alternative renewable fuel, managed to achieve that goal. Brazil used a variety of governmental incentives, subsidies and mandates and was clearly affected by changes in the market since the inception of the Proalcool program.²⁰² The government, however, was able to adapt quickly to such changes and modified programs and mandates to match the economic reality. The debate over whether ethanol is truly the best solution to U.S. fuel concerns could easily be the subject of another paper of similar length. However, if the U.S. continues to careen towards exponential growth in the ethanol production sector, it would be wise to learn from the lessons Brazilian history can teach us.

²⁰¹ *See id.*

²⁰² *See supra* Parts I.A-D.