to wean the country of dependence on oil. The military dictatorship of the era ordered the major manufacturers of cars to produce dedicated alcohol-fueled vehicles, and ordered sugar producers to shift away from table sugar to fuel production.

In a democracy, it would have taken years to get action on this front, but when the dictators said, "Read my lips—we want alcohol-fueled cars now," the corporations were forced to act. In 1980, less than six months after car companies told the government it was impossible to make a car run on alcohol, 60% of all cars coming off Brazilian assembly lines were specialized alcohol-only vehicles. They had high-compression engines (with 12.5 to 1 **compression ratios**), and they ran fine after automakers worked out the kinks. Very quickly, the production of both alcohol and the cars using it took off, reaching a peak in 1984, when 94.4% of all cars produced ran on ethanol.

Production was managed by the government to stay in close connection with demand. The national oil company, Petrobras, which had full control of the distribution of fuel, complained loudly of surplus gasoline that it had to get rid of on the open market internationally. The group of elites that controlled the national oil company were a different political faction than the military government.

Then, in the late 1980s, military rule came to an end in Brazil. In the first elections, heavily influenced by Washington and big money, a rightist, "free-market fundamentalist" government was elected. All subsidies and departments involved with alcohol fuel were essentially dismantled. Also, the sugar growers were released from having to supply the nation with alcohol, and they immediately began producing sugar for export, cutting the amount of alcohol roughly in half. Suddenly there was a huge shortage of fuel, which the producers exploited by raising prices. The public was the victim of these changes.

It's important to note that many in the United States allege that alcohol fuel in Brazil "failed" due to removal of government subsidies. But the reality is that there was a sea change in the way elites ran Brazil. The new bosses included the large sugarcane plantation owners, who wanted to make more profit by selling table sugar.

In 1989, following this debacle, sales of alcohol vehicles dropped to 10% of the new auto market there. During the 1990s (a global era of artificially cheap oil), and until oil prices rose at the end of 2001, alcohol-fueled vehicle manufacture stayed at about 1% of the total number of Brazilian vehicles produced per year. Everyone thought the fuel alcohol movement would die.

But it didn't die. It changed and expanded. Brazil's auto fleet continued to dramatically increase, and gas-powered vehicles needed alcohol for the 25% blending with gasoline. Also, many people kept their old alcohol cars going, and they made up a stable market for the wet alcohol (96% alcohol/4% water) sold at more than 31,000 locations all over the country.

FARMING EFFICIENCY IN BRAZIL

When I went to Brazil to investigate alcohol fuel production, I expected to see lots and lots of sugarcane. After all, it is the largest alcohol crop in the world. I was also prepared for environmental destruction, soil erosion, a mega-monoculture doomed to collapse, and lots of water and air pollution—what the opponents of alcohol have been

FUEL ALCOHOL HAS BEEN USED AROUND THE WORLD

The world is no stranger to fuel alcohol. China used alcohol as a farm fuel after its revolution, with rice and marine algae as some of its feedstocks. When other countries, for political reasons, refused to sell diesel fuel to China, the Chinese used soybean oil in their tractors.

Before there was any widely developed oil tanker system in operation, petroleum was hardly available in the Philippines or New Zealand, and those countries were almost entirely alcohol-powered early in the 20th century. The Philippines made alcohol from nipa palms and sugarcane; New Zealanders used beets and other feedstocks. Neither country had an automobile industry, but their alcohol fuel was used to run imports from Studebaker and Chrysler—whose automobiles were specifically designed for alcohol fuel.

In the early 1900s, France had a well-developed alcohol fuel system and did everything possible to forestall oil dependence and trade deficits. French fuels were a blend of anything that could be produced within French borders. Benzol/alcohol, benzol/ether, benzol/ether/alcohol, and benzol/alcohol/gasoline were common.

Today the European Union is moving to renewables far more quickly than the United States. Sweden already has a national network of **E-85** (85% ethanol, 15% gasoline) pumps at service stations.

moralizing about for 30 years. I have seen all that I can stand of cornfields and grape vineyards laid out with the rows running up and down hills, swiftly eroding the soil with each rainfall. So I braced myself for what might be a gruesome sight.

I really enjoyed being wrong here. What especially impressed me when I first saw cane country in Brazil was the obvious influence of permaculturists. The fields were all tilled to **keyline** (close to contour) with periodic swales (on-contour, dead-level ditches that hold water, letting it gradually sink in) made by bulldozed berm walls of about three feet. This was done on hills that were sloped about 15 degrees! We watched the results of a downpour just pool up behind the swales and soak in. No runnels took soil downhill with each rain. Each sugarcane row was also a contour berm that soaked the water in evenly. This water collection technique is very important later in the season when the canes form, since they shoot up during the dry season and need to draw upon water stored underground.

This keyline layout went on for scores of miles, on a massive industrial scale. I've never seen modern swales done like this in the U.S. The last time was in the 1940s (before my time) by the Civilian Conservation Corps, to stop soil erosion in the Southwest and the South.

Not only does the new Brazilian layout design significantly charge the aquifers with surplus rain, it also conserves the soil. The swales also prevent nutrient and chemical runoff into surrounding streams.

I spoke with Brazilian agronomists who told me that this system of field layout started in the early 1990s and has spread throughout the country. They explained also that the shading of the soil by the closed canopy of the sugarcane went a long way toward preventing water evaporation from the soil. The Brazilians could teach a few things to our Midwestern agribusinesses, whose farming methods have resulted in the Ogallala Aquifer dropping many feet per year and our topsoil going down the Mississippi.

Some plantations in Brazil are using beneficial insects to control cane pests. Octavio Lage, a large grower I visited, told us his costs were maybe 30% higher with organic practices, but the higher price brought by organic sugar more than made up for the increased costs.[1] Organic acreage there is increasing rapidly, but is still considered to be quite small. Lage told me that he had "only" 4600 hectares dedicated to organic production. That's as much land as the largest organic farm in California.

COGENERATION

With the continuing solid demand for alcohol in Brazil, mid-sized distilleries consolidated to form bigger companies, and the planting of cane, with its dual markets of sugar and alcohol, continued to grow.

Due to slim profit margins, it was uneconomical for smaller distilleries to compete with the bigger operations, so many of them converted to beverage production. This was sad news for our team, since we had hoped to visit them.

The deciding issue was process energy. The bigger plants could afford to invest in cogeneration equipment—which turns the bagasse (the fibrous byproduct left over after crushing cane to extract the juice used in making sugar or alcohol) into steam and electricity to run the plant.

The larger plants' ability to invest in cogeneration gave them an edge over the smaller operations that were common at the start of the alcohol movement, which had to buy natural gas and electricity to run

Fig. 5-2