June 2008

Impact of Biofuels on Forestland in Central America

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May 2008

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Abstract. Although biofuels are thought to be one of the solutions for reducing carbon dioxide in the atmosphere, the net effects might be ambiguous when indirect land use effects are incorporated. Along with the increasing price of biofuel crops, forest lands might be destroyed throughout the world. In this study, the net effect of the increases in U.S. production of corn due to ethanol demand is explored in terms of additional land impacts and deforestation in Central America. I present data from FAO and Searchinger et al, where it is suggested that the Central American region has been in the process of deforestation and convertion of forest lands for agricultural use. Consequence is contribution to higher concentration of carbon dioxide in the atmosphere due to deforestation.

[1] Paper prepared for seminar UHON395 "Carbonomics: Will Biofuels Save the World?" Spring 2008

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Executive Summary

One of the biggest concerns for us, humans, today is increasing amount of carbon in the atmosphere and global climate change, which is thought to be the consequence of higher level of carbon. At one point, it seemed that we have found the solution called biofuel. However, there are some arguments that claim that the actual impacts of biofuel production cause increase of carbon in the atmosphere. It is because there are some factors that promote conversion of forest areas in order to produce more crops.

This study specifically focuses on the Central American nations, which have ratified a free trade agreement, CAFTA, Central American Free Trade Agreement, with the U.S. Because of the climate, this region is blessed with rich ecosystem represented by tropical forests. Tropical forests play a significant role in terms of human and earth's ecosystem well-beings (Tropical Forests Mesoamerican/Caribbean). Therefore, the U.S. producing corn ethanol could have unpredictable impacts on the entire world.

The main purpose of this study is to examine net effect on carbon emission because of the change in land allocation in the U.S. caused from the U.S. ethanol production. By the U.S. allocating its corn production to ethanol, it becomes necessary for the rest of the world to produce their own food sources if they have been dependent on import from the U.S.

In order to do so, data on proportion of land within each Central American nation used for agricultural purposes and kept as forest or woodland are collected to measure how much land allocation has been changed in the last four decades. According to FAO, Food and Agriculture Organization of the United Nations, there has been a slight increase in agricultural area while forest and wood lands have shown a decrease over time. Although the

amount of information does not allow us to specify that the cause of decreasing area of forest is the change in land allocation from forest to agricultural use, this result suggest that the loss in forest area might be able to be explained by agricultural practices.

Then, an article written by Searchinger et al in the Science magazine is referred to see whether or not production of corn ethanol in the U.S. is a net contributor to carbon emission. Searchinger et al has suggested that the U.S. production of corn ethanol is a contributor to higher level of greenhouse gases emission. They argue that the use of gasoline emits less greenhouse gases than corn ethanol when the land conversion throughout the world is taken into account.

Biofuel is thought to be clean energy and one of the solutions for increasing greenhouse gases in the atmosphere. However, there are some necessary trends to consider such as land allocation in other parts of the world. Countries such as the U.S. have significant impacts on the rest of the world. In other words, even if the net effect of greenhouse gases emission within the U.S. shows decreasing amount of greenhouse gases, we still need to consider and predict what the implication of the change in the U.S. would be in terms of the other countries in the whole world.

By the study done by Searchinger et al, it is suggested that production of corn ethanol actually triggers higher level of greenhouse gases emitted than gasoline. It is true that this study includes vast amount of uncertainties and assumption, which might make one wonder if the suggestions are valid. However, there is an implication of net greenhouse gases emission and we should not forget the possibility. This complex relationship between nations needs to be

revisited in the future to examine the real impacts of the U.S. corn ethanol production on the environment.

I. Introduction

A. Global Climate Change and Biofuel Production

One of the hottest topics today is global climate change and its solution. The global climate is thought to have happened due to the human activity of burning fossil fuels (Greenhouse Gases, Climate Change, and Energy). The more important it becomes, the more biofuel production and its environmental impacts are discussed. Biofuels are expected to reduce the amount of greenhouse gases emitted due to the use of fossil fuels by producing fuels from crops such as corn and sugarcane (Biofuels: The Growing Solution to Energy Dependence and Global Warming). However, the benefit of biofuel production is ambiguous. Some argue that the production of biofuels creates more problems than we have now.

Among the arguments that criticize biofuel production, what is focused here is deforestation caused from converting forests into agricultural lands. As the price of the energy crops have gone up, forest lands have been converted to agricultural lands for the sake of farmers' profit. This practice makes the overall effect of biofuel production uncertain; net loss or net gain of carbon in the atmosphere. It has been reported that many of the countries where tropical forests are located have converted their tropical forests to crop land and been producing palm, sugarcane and so on for biofuels. Time's magazine has discussed deforestation in Brazil because of the increasing price of energy crops such as soybeans (Leahy, 2007). The energy

source of biofuel, which was thought to be environmentally friendly, might not be as clean as we think.

B. The Significance of Tropical Forests

Tropical forests are significant for not only the countries that own the forests areas but also any creature on earth since they are strongly connected to the earth’s ecosystem and creatures in a various ways (Tropical Forests Mesoamerican/Caribbean).

Although all the other type of ecosystem is unique and important, tropical forests tend to be paid more attention than the others because they hold much richer biodiversity and therefore, the inter-relationship between different species is very complex. When this vulnerable balance of tropical ecosystem crumbles, it is very difficult to recover the original ones. For example, a loss of one species may result in destroying another species in the topical forest, whose well-being is entirely dependent on the creature lost (Hart, 2007).

Tropical forests are also thought to be beneficial for humans’ health. One of the most common arguments made in favor of tropical forest conservation is that there are more plant and animal species that have not yet been discovered by humans. Thus, there is possibility of inventing new pharmaceuticals that might cure cancer and other type of disease by discovering new species (D. E. Bierer, T. J. Carlson, S. R. King).

Tropical forests conserve not only the diversity of species but also cultural diversity such as indigenous populations. As there are numerous tribes in the Brazilian Amazon, Central America is also one of the most important origins of indigenous cultures in the world. In

Costa Rica, for instance, there is an indigenous tribe called Bribri in the south and they have developed their genuine culture by utilizing the natural resources available in tropical forests (Maura, 2007).

C. The Role of Tropical Forests in terms of Carbon Emission

In terms of climate change, tropical forests also play an inevitable role. Here, three characteristics are discussed; tropical forests' role in carbon absorption, their usage as agricultural lands, and carbon sequestration.

Tropical forests are sometimes described as "earth's air conditioner" (Institution, 2007). Plants conduct photosynthesis and in the process they capture carbon dioxide from the air and convert it to what we would be able to consume as food source. Oxygen is, in fact, just a byproduct of photosynthesis (Beder). Tropical forests generate significant amount of oxygen by converting carbon dioxide in the air. Global climate change is said to happen because of the high concentration of greenhouse gases such as carbon dioxide and forests are thought to be one of the most significant outlets of carbon dioxide. Tropical forests are particularly important because they absorb more carbon dioxide than other types of forests.

Although tropical forests are called "carbon sink" meaning that they store carbon in the ground, they are not suitable for agricultural practices. One may think the rich nutrient in their soils would help and enhance agricultural activities. However, a vast portion of the nutrients are stored at the surface of land, which makes it easier to exploit all the nutrients in the soil in a relatively short period of time. Because of the poor-nutrient soil, the production site needs to be migratory and consequently such an agricultural performance is likely to wipe out all the forest

areas quickly. What is more, one of the most common practice made in order to clear the forest is burning, whose impacts on the earth climate are also significant. In short, agriculture in tropical forest regions not only harms the rich biodiversity and effective carbon sink but also contributes to global climate change by being reduced and burnt (J. L. Mastrantonio, J. K. Francis, 1997)).

According to the Science magazine, net gain in greenhouse gases emission is caused because of the significant amount of carbon stored in the ground besides the actual action of converting forests into croplands (T. Searchinger). Forests, in general sequestrate carbon, which implies that the carbon stored thanks to forests would be released into the air when they are converted to produce biofuels. The Science magazine discussed how deforestation's contribution to higher level of carbon emission could be measured. In this study, the same procedure will be taken in order to calculate what the net effect of biofuel production would be. The methods of calculation applied are discussed later in Section Ⅱ E.

For aforementioned reasons, tropical forests hold the key to carbon emission in the atmosphere. In this study, the Central American regions are focused. The regions are the house of numerous species since they possess vast area of tropical forests. Countries such as Costa Rica earn most of its income from tourism or ecotourism attracted to its rich natural resources including the tropical forests. Countries observed were Guatemala, Honduras, El Salvador, Dominican Republic, Nicaragua, and Costa Rica, which are all in CAFTA; Central American Free Trade Agreement. We hope to examine how the land use has been changed over the last four decades particularly from forest lands to crop lands.

D. Central American Free Trade Agreement; CAFTA

The history of CAFTA is relatively short. It is a free trade agreement between these Central American countries discussed and the United States, which eventually eliminates tariffs on exchanged goods between these two regions in the Americas. CAFTA had been ratified by all the countries in the agreement except Costa Rica until October 7th, 2007. The people in Costa Rica were given the opportunity to choose whether or not they would allow the implementation of CAFTA and their choice was in favor of the trade agreement (Delacour, 2007).

The average GDP per capita of the six CAFTA countries is $6,1667 in 2006 with the highest being $12,500 of Costa Rica and the lowest being $3,100 of Honduras and Nicaragua (The World Factbook). The economies of most of the countries are highly dependent on their income from the agricultural sector. In Table 1 and Table 2, the data collected from CIA; the World Fact Book, are shown. Table 1 includes each country's population, GDP per capita in 2006, the percentage of workforce in agriculture, and the percentage of agricultural share in GDP, while Table 2 contains mean, maximum and minimum of each category.

II. Biofuel Production and Central America

A. Current Trends of Biofuel Production in Central America

In terms of biofuel production, are Central American countries discussed above making any significant decisions? One December 14th, 2006, Grist; Environmental News and Commentary has reported that Brazil has conducted a study and it showed that the Central American regions would have potential of producing ethanol. As the countries in Central America have developed economically, they consume more energy. Due to the rising price of

gasoline, Central American nations need to develop alternative energy sources that are cheaper. Therefore, it is not surprising that they have become interested in biofuel production as some other countries in the Americas (Barclay, 2006).

Among the countries in Central and South America, they have named a few that have a fairly tangible plan of adopting energy crops; Argentina, Costa Rica, Colombia, El Salvador, Jamaica, Mexico, Nicaragua, Paraguay, Peru and Venezuela. Besides these ten countries listed above, they discussed the potential of some CAFTA nations, which are Honduras, El Salvador, Guatemala, and Costa Rica.

The first to be discussed is Honduras. Its foreseen energy crops are sugar and African palm. The government of Honduras has promoted sugar production by claiming that biofuel production from sugarcane would decrease Honduras' energy dependency on foreign countries, create more jobs for the locals, and therefore stimulate its economic growth. Environmental News and Commentary stated that farmers in Honduras have already responded by converting additional 27,200 acres for two ethanol refineries and its agricultural ministry sees another 494,000 acres for African palm production by transforming abandoned farmland (Barclay, 2006).

Secondly, we would like to emphasize on El Salvador. According to RUTA, Regional Unit for Technical Assistance; a project of the Ministries of Agriculture of Central America, El Salvador built its first biodiesel plant in 2006, which is expected to produce 400 liters of biodiesel per day from physic nut. Physic nut are generally known as template and higuerillo while their more scientific names are Jatropha curcas and Ricinus comunis. These

crops are native to the land of El Salvador, contain large amount of oil in their seeds, and can be produced under any severe environment such as salty and rocky lands (El Salvador).

The third country is Guatemala. IDB, Inter-American Development Bank, has published an article called “A Blueprint for Green Energy in the Americas”. According to this article, despite that its sugar production accounts for the large portion of its agricultural sector, Guatemala produces its biodiesel from crops such as jatropha, which was discussed in El Salvador as well, palm oil, and avocados. It added that Guatemala is one of the largest producers of palm kernel equivalents in the world (Constance).

Finally, Costa Rica is focused. One might consider Costa Rica has established the most stable access to the international market for ethanol. The IDB article discussed above says that Costa Rica both produces and exports about 40-42 million liters of ethanol per year between 2003 and 2006. Early in 2006, one Costa Rican national oil company called RECOPE has agreed on cooperating with a Brazilian counterpart, Petrobras, to conduct studies on blending ethanol with gasoline and its feasibility. Although 64 gas stations throughout Costa Rica have already been offering E5 and E10, biodiesel has not gained enough consumer confidence yet. The project signed by RECOPE and Petrobras is expected to alter the consumer beliefs (G.Rothkopf, 2007).

As discussed above, there seem to be some countries in CAFTA, where the movement toward promoting biofuel production is worth notifying. Even though the biofuel market in Central America has not been fully established, many see the potential of expanding. Now that we have discussed the trends, the questions to be addressed are the following three; Have Central American forest and wood lands been converted to agricultural

land use due to higher demand of biofuels? If they have been reallocated for agriculture, how fast is the change occurring? What the net effect in terms of carbon emission by decreasing forest lands?

B. Have the Central American Forest and Wood Lands been Converted?

In order to answer the first question, the data available at the Food and Agriculture Organization of the United Nations were collected so that the rate of change in land use can be measured if there is any (FAOSTAT). The data collected are on various types of land use; Agricultural Area, Forest and Woodland, Arable Land, Permanent Pasture, Permanent Crops Land, and Arable and Permanent Crops Land. The data on these different types of land are presented in Table 3-8 and Figure 1-6. Due to the data availability, forest and wood lands are examined only between 1961 and 1994.

For the sake of study simplification, we would focus mostly on Figure 1a and Figure 2a, which show the rate of forest and wood land disappearing and agricultural land increased. From Figure 2a, we could suggest that the overall trend is decrease in forest and wood land even though Guatemala has increased forest areas between late 80's and early 90's and countries such as Honduras, the Dominican Republic, and El Salvador have not had significant changes. Costa Rica and Nicaragua have shown a significant decrease.

These countries have increased the land areas for agricultural use. As in the data on forest and wood land, there are some outliers that conflict with the overall trend. Honduras has decreased its land area for agricultural use particularly in the last ten years. When the

developed graphs are compared with each other based on different types of agricultural land use, it becomes clearer which type of land use is likely to have caused an increase in overall agricultural land areas. It is examined more in details in the next section.

C. What is the Rate of Conversion?

Now that the change in land allocation in Central America is supported, the second question can be addressed; what the rate of the conversion would be. The data on FAO website were revisited and the trend over time was examined. The percentage change in a ten-year period was taken over Agricultural Land and Forest and Woodland and shown in Table9 and Table11. Table10 and Table12 show the mean, maximum and minimum number of each period. As seen in these tables, on average, deforestation has happened in each era observed more or less while agricultural area has been expanded. The highest deforestation rate is noted between 1971 and 1980 when the agricultural area has increased most significantly as well.

When individual countries are taken a closer look, the main causes of land conversion could be explained. With Arable and Permanent Crop use being relatively stable, Costa Rica’s main cause for decreasing forests is likely to be the slight increase in Permanent Crops and larger increase in Permanent Pasture. Nicaragua might have deforested due to an increase in Arable and Permanent Crop and Permanent Pasture. Since the rate of increase of Permanent Crops is relatively smaller than Arable Land, Permanent Crop’s contribution might be slightly less significant than Arable Land’s. In order to specify when the biggest change has

happened in the land use, annual percentage change was calculated over Forest and Wood Land and Agricultural Land data and presented in Table 13, 14 and Figure 1b, 2b.

Since each country has quite different trend, it is hard to make a general comment on the overall change over time. However, Table 12 suggests some useful results for this study. According to Table 12, the biggest increase in Agricultural Area was seen in the 1970's. During the years, none of the countries showed a negative number, suggesting that every Central American country increased their agricultural land use during the time period. In terms of Forest and Wood Land, the biggest loss of forest areas also occurred in the 1970's, correlating with the increased agricultural areas discussed above. Although it is dangerous to conclude that forests in Central America were transformed to agricultural land since this set of data is not strong enough, the similar percentage changes, 12.9% increase in Agricultural Area and 13.2% decrease in Forest and Wood Land, suggest that these two consequences might have some correlation.

D. What the Environmental Impacts of this Change in Land Allocation?

This third question addressed in this study is the most important yet most complex question to answer. Carbon sequestered by the presence of forests could be calculated from the following three different points of view; direct loss of carbon stored in vegetation such as trees and grasses, the carbon opportunity cost (the same forest could have sequestered more carbon if it is left as a forest), and the international impacts (in order to secure the same amount of crops for food source, other parts of the world may convert their forests to cropland).

The Science article visited here focuses mainly on the third point, increased greenhouse gases due to the U.S. allocating its crop production for biofuel. For example, when

corn produced in the U.S. starts to be used for biofuel production, other countries might need to convert their original forest lands to cropland in order to supply the same amount of corn consumers need. In such cases, there would be some impacts on the total carbon emission throughout the world and we would like to estimate what the net effects on carbon emission would be.

This estimation made in the Science article by Searchinger explains the current situation in Central America as well. As discussed in Section Ⅱ A, there are some Central American countries that have already started producing biofuels while others have not had major changes in terms of biodiesel production yet. As we have discussed earlier on page six, it is unlikely that all of the six CAFTA countries have made some adjustment in their agricultural sector by producing more biofuel crops. However, it is possible that the Central American nations have already responded to the change in the U.S. market and converted lands where there used to be no agricultural practice.

Methods Used

Searchinger conducted his research on different regions of the world during the period of 1990 and 1999. The analysis methods used by Searchinger involve three major steps.

- First of all, they have estimated what the changes in cropland in other countries throughout the world caused from increasing corn-based ethanol production in the U.S. They have estimated how each country and region would adjust to the new market outlook by the U.S. producing 55.92 billion liters of corn ethanol.

- Secondly, they calculated the average amount of CO2 emitted in a hectare-area by each country increasing the proportion of croplands within the country. Different types of land in each major region are collected to estimate the different level of carbon emission since different ecosystem holds and releases different amount of carbon. Then carbon losses in vegetation were estimated depending upon each type of ecosystem.
- Finally, they converted the result from the previous parts into carbon emission in terms of ethanol.

In the Science article, Searchinger assumed that 25% of the top meters of soil have lost carbon as the land is converted to cropland. Since there should not be any increase in carbon emission by producing crops as food source, we ignore the carbon emission from applying fertilizer, pesticides, tractors and so on. In addition, we define carbon emission due to land use change as the change caused from converting forest and wood lands to agricultural land for any reason. In other words, we do not differentiate deforestation caused from producing biofuel crops and food sources.

Study Results

What is suggested in the research done by Searchinger is that substituting ethanol for gasoline contributes to net gain in carbon emission when land conversion is taken into account. Table 1A in the Science article suggests that production of ethanol for energy source would lead to greenhouse gas emission of 536g/km compared to 221g/km when gasoline is used. Without considering land conversion, use of ethanol would result in 20% reduction in total greenhouse gases emission.

Another suggestion by the result has to do with the future outlook. Most of the land conversion predicted here is likely to occur within the next few years and all is expected to occur in the next 30 years. When we consider the land conversion in 30-year long span, the amount of greenhouse gases that are additionally emitted would be reconciled in 167 years, according to Searchinger. In other words, production of ethanol will keep contributing to larger amount of greenhouse gases emitted for 167 years (T. Searchinger).

III. Conclusion

Some once thought that the production of biofuel would solve the problems we face today: energy independence, greenhouse gases emission, living standard of locals, hunger, poverty, and so on. The Central American nations focused here perhaps are not exceptions. By stimulating their agricultural sector, the people would expect the economy to create more wealth from more agricultural products, which can be not only consumed by the locals but also exported to outside of the countries. However, the outcome of deforestation in Central America impacts the entire world since the tropical forests areas are lost from the earth's ecosystem, which would generate more carbon emission into the atmosphere.

From the observations made in this study, one may question if production of biofuel is the answer to global climate change. This study has supported that the forest areas in Central America have gradually shrunk and the U.S. production of corn ethanol would have negative impacts on carbon emission when the rate of land conversion in other parts of the world is considered. However, the uncertainties and assumptions made are so significant that it is dangerous to conclude that the production of ethanol, in reality, causes more carbon emission.

Such questions that address on the effects of one country's policy or activity need to be investigated more in the future considering these studies might not reflect the actual circumstances well.

What we may learn from this study is that a change in countries such as the U.S. could have uncertain however significant impacts on the other countries in the world. Biofuel production might have reduced the U.S. carbon emission but increased the overall emission throughout the world. It is important for influential countries as well as small nations such as those in Central America to investigate possible outcomes that may be seen in the rest of the world and act responsively.

Tables

Table 1. Countries' General Information

	Population	GDP per capita (2006)	% workforce in Agriculture	% Ag share in GDP
Costa Rica	4,133,884	12,500	20	8.7
DR	9,365,818	8,400	17	11.6
El Salvador	6,948,073	4,900	17.1	10.1
Guatemala	12,728,111	5,000	50	22.2
Honduras	7,483,763	3,100	34	13.8
Nicaragua	5,675,356	3,100	29	17.2

Table 2. Mean, Maximum and Minimum of Table 1

	Population	GDP per capita (2006)	% workforce in Agriculture	%Ag share in GDP
Mean	7,722,501	6,167	27.85	13.93333333
Maximum	12,728,111	12,500	50	22.2
Minimum	4,133,884	3,100	17	8.7

Table 3. Agricultural Area

	Costa Rica	DR	El Salvador	Guatemala	Honduras	Nicaragua
1961	1395	3082	1252	2646	2980	5080
1962	1410	3097	1252	2658	2990	5130
1963	1420	3112	1258	2670	2995	5188
1964	1485	3127	1258	2682	3000	5238
1965	1555	3142	1260	2694	3005	5288
1966	1635	3157	1250	2706	3015	5350
1967	1636	3172	1241	2728	3025	5400
1968	1716	3182	1239	2740	3030	5450
1969	1790	3222	1237	2742	3030	5505
1970	1856	3227	1235	2755	3040	5555
1971	1887	3236	1278	2767	3045	5605
1972	1887	3262	1281	2800	3080	5660
1973	2048	3297	1288	2843	3090	5720
1974	2048	3317	1298	2875	3096	5780
1975	2122	3347	1308	2888	3135	5830
1976	2205	3402	1300	2930	3170	5880
1977	2287	3432	1309	2993	3245	5930
1978	2360	3457	1350	3005	3257	5985
1979	2443	3482	1400	3016	3257	6055
1980	2516	3512	1410	3050	3257	6060
1981	2599	3517	1370	3067	3264	6142
1982	2679	3522	1341	3104	3269	6144
1983	2682	3522	1337	3119	3270	6145
1984	2748	3522	1347	3785	3277	6198
1985	2803	3522	1377	3785	3278	6220
1986	2826	3529	1397	3785	3285	6222
1987	2826	3529	1397	3785	3285	6254
1988	2833	3529	1417	4285	3285	6285
1989	2830	3542	1437	4285	3371	6308
1990	2840	3590	1450	4285	3320	6310
1991	2845	3610	1468	4285	3342	6315
1992	2850	3640	1501	4285	3355	6340
1993	2840	3640	1531	4482	3548	6375
1994	2860	3640	1564	4512	3520	6380
1995	2855	3609	1605	4512	3480	6685
1996	2850	3589	1610	4512	3480	6694

1997	2845	3589	1610	4522	3395	6795
1998	2845	3639	1644	4532	3395	6846
1999	2865	3671	1675	4542	3337	6897
2000	2865	3696	1684	4567	2935	6966
2001	2865	3696	1704	4597	2936	6970
2002	2865	3696	1704	4627	2936	6976
2003	2865	3696	1704	4652	2936	6976

Table 4. Forest and Woodland

	Costa Rica	DR	El Salvador	Guatemala	Honduras	Nicaragua
1961	3240	673	208	5370	6000	6650
1962	3165	671	206	5340	6000	6535
1963	3090	669	204	5310	6000	6420
1964	3015	667	202	5280	6000	6305
1965	2940	665	200	5250	6000	6190
1966	2865	663	188	5220	6000	6070
1967	2790	661	186	5190	6000	5960
1968	2720	659	184	5160	6000	5850
1969	2640	657	182	5130	6000	5730
1970	2570	655	180	5100	6000	5620
1971	2490	653	178	5070	6000	5510
1972	2420	651	176	5040	6000	5390
1973	2350	649	174	5010	6000	5280
1974	2270	647	172	4980	6000	5160
1975	2200	645	170	4950	6000	5050
1976	2130	643	164	4870	6000	4940
1977	2050	641	158	4790	6000	4820
1978	1980	639	152	4710	6000	4710
1979	1900	637	146	4630	6000	4590
1980	1830	635	140	4550	6000	4508
1981	1730	633	134	4470	6000	4370
1982	1638	631	128	4500	6000	4260
1983	1598	629	122	4500	6000	4150
1984	1638	627	116	4500	6000	4040
1985	1550	625	110	4500	6000	3930
1986	1550	623	105	4500	6000	3820
1987	1550	621	105	4500	6000	3710
1988	1550	619	105	5000	6000	3600
1989	1550	617	105	5000	6000	3490
1990	1569	615	105	5212	6054	3380
1991	1570	613	105	5212	6000	3270
1992	1570	610	105	5212	6000	3200
1993	1570	600	105	5212	6000	3200
1994	1570	600	105	5212	6000	3200

Table 5. **Arable Land**

	Costa Rica	DR	El Salvador	Guatemala	Honduras	Nicaragua
1961	285	720	488	1100	1295	1030
1962	285	730	488	1100	1305	1030
1963	285	740	488	1100	1310	1030
1964	285	750	485	1100	1313	1030
1965	285	760	480	1100	1318	1030
1966	285	770	470	1100	1324	1040
1967	285	780	460	1110	1330	1040
1968	285	780	458	1110	1332	1040
1969	285	815	455	1100	1328	1040
1970	285	820	450	1100	1330	1040
1971	285	826	488	1100	1333	1040
1972	285	850	488	1120	1368	1040
1973	283	865	488	1150	1378	1050
1974	283	885	488	1170	1384	1060
1975	283	915	488	1170	1413	1060
1976	283	960	475	1200	1438	1060
1977	283	990	475	1250	1503	1060
1978	283	1015	515	1250	1504	1065
1979	283	1040	560	1249	1494	1069
1980	283	1070	558	1270	1484	1070
1981	283	1075	516	1275	1481	1150
1982	283	1075	479	1300	1476	1150
1983	283	1075	470	1300	1467	1150
1984	283	1075	480	1300	1464	1200
1985	285	1075	500	1300	1455	1220
1986	285	1075	520	1300	1451	1220
1987	285	991	520	1300	1441	1250
1988	280	991	540	1300	1431	1280
1989	260	1004	540	1300	1446	1300
1990	260	1050	550	1300	1462	1300
1991	260	1050	565	1300	1492	1300
1992	250	1050	588	1300	1515	1320
1993	230	1050	586	1324	1683	1350
1994	230	1050	584	1354	1650	1350
1995	225	1020	582	1355	1600	1650
1996	225	1020	565	1361	1600	1650
1997	225	1020	565	1370	1520	1750
1998	225	1070	600	1380	1520	1800
1999	225	1071	631	1390	1468	1850
2000	225	1096	640	1395	1068	1917

2001	225	1096	660	1405	1068	1920
2002	225	1096	660	1425	1068	1925
2003	225	1096	660	1440	1068	1925

Table 6. Permanent Pasture

	Costa Rica	DR	El Salvador	Guatemala	Honduras	Nicaragua
1961	915	2092	604	1110	1500	3900
1962	925	2092	604	1120	1500	3950
1963	935	2092	605	1130	1500	4000
1964	1000	2092	605	1140	1500	4050
1965	1070	2092	610	1150	1500	4100
1966	1150	2092	610	1160	1500	4150
1967	1150	2092	610	1170	1500	4200
1968	1230	2092	610	1180	1500	4250
1969	1300	2092	610	1190	1500	4300
1970	1363	2092	610	1200	1500	4350
1971	1390	2092	610	1210	1500	4400
1972	1390	2092	610	1220	1500	4450
1973	1558	2092	610	1230	1500	4500
1974	1558	2092	610	1240	1500	4550
1975	1630	2092	610	1250	1500	4600
1976	1710	2092	610	1260	1500	4650
1977	1790	2092	610	1270	1500	4700
1978	1860	2092	610	1280	1500	4750
1979	1940	2092	610	1290	1500	4815
1980	2010	2092	610	1300	1500	4815
1981	2090	2092	610	1310	1500	4815
1982	2167	2092	610	1320	1500	4815
1983	2167	2092	610	1334	1500	4815
1984	2230	2092	610	2000	1500	4815
1985	2280	2092	620	2000	1500	4815
1986	2300	2092	620	2000	1500	4815
1987	2300	2092	620	2000	1500	4815
1988	2310	2092	620	2500	1500	4815
1989	2320	2092	640	2500	1561	4815
1990	2330	2090	640	2500	1500	4815
1991	2330	2090	640	2500	1500	4815
1992	2340	2090	650	2500	1500	4815
1993	2340	2090	680	2602	1533	4815
1994	2340	2090	710	2602	1530	4815
1995	2340	2089	750	2602	1530	4815
1996	2340	2089	794	2602	1530	4815
1997	2340	2089	794	2602	1520	4815
1998	2340	2089	794	2602	1520	4815
1999	2340	2100	794	2602	1510	4815
2000	2340	2100	794	2602	1508	4815

2001	2340	2100	794	2602	1508	4815
2002	2340	2100	794	2602	1508	4815
2003	2340	2100	794	2602	1508	4815

Table 7. Permanent Crops

	Costa Rica	DR	El Salvador	Guatemala	Honduras	Nicaragua
1961	195	270	160	436	185	150
1962	200	275	160	438	185	150
1963	200	280	165	440	185	158
1964	200	285	168	442	187	158
1965	200	290	170	444	187	158
1966	200	295	170	446	191	160
1967	201	300	171	448	195	160
1968	201	310	171	450	198	160
1969	205	315	172	452	202	165
1970	208	315	175	455	210	165
1971	212	318	180	457	212	165
1972	212	320	183	460	212	170
1973	207	340	190	463	212	170
1974	207	340	200	465	212	170
1975	209	340	210	468	222	170
1976	212	350	215	470	232	170
1977	214	350	224	473	242	170
1978	217	350	225	475	253	170
1979	220	350	230	477	263	171
1980	223	350	242	480	273	175
1981	226	350	244	482	283	177
1982	229	355	252	484	293	179
1983	232	355	257	485	303	180
1984	235	355	257	485	313	183
1985	238	355	257	485	323	185
1986	241	362	257	485	334	187
1987	241	446	257	485	344	189
1988	243	446	257	485	354	190
1989	250	446	257	485	364	193
1990	250	450	260	485	358	195
1991	255	470	263	485	350	200
1992	260	500	263	485	340	205
1993	270	500	265	556	332	210
1994	290	500	270	556	340	215
1995	290	500	273	555	350	220
1996	285	480	251	549	350	229
1997	280	480	251	550	355	230
1998	280	480	250	550	355	231
1999	300	500	250	550	359	232
2000	300	500	250	570	359	234

2001	300	500	250	590	360	235
2002	300	500	250	600	360	236
2003	300	500	250	610	360	236

Table 8. Arable and Permanent Crops

	Costa Rica	DR	El Salvador	Guatemala	Honduras	Nicaragua
1961	480	990	648	1536	1480	1180
1962	485	1005	648	1538	1490	1180
1963	485	1020	653	1540	1495	1188
1964	485	1035	653	1542	1500	1188
1965	485	1050	650	1544	1505	1188
1966	485	1065	640	1546	1515	1200
1967	486	1080	631	1558	1525	1200
1968	486	1090	629	1560	1530	1200
1969	490	1130	627	1552	1530	1205
1970	493	1135	625	1555	1540	1205
1971	497	1144	668	1557	1545	1205
1972	497	1170	671	1580	1580	1210
1973	490	1205	678	1613	1590	1220
1974	490	1225	688	1635	1596	1230
1975	492	1255	698	1638	1635	1230
1976	495	1310	690	1670	1670	1230
1977	497	1340	699	1723	1745	1230
1978	500	1365	740	1725	1757	1235
1979	503	1390	790	1726	1757	1240
1980	506	1420	800	1750	1757	1245
1981	509	1425	760	1757	1764	1327
1982	512	1430	731	1784	1769	1329
1983	515	1430	727	1785	1770	1330
1984	518	1430	737	1785	1777	1383
1985	523	1430	757	1785	1778	1405
1986	526	1437	777	1785	1785	1407
1987	526	1437	777	1785	1785	1439
1988	523	1437	797	1785	1785	1470
1989	510	1450	797	1785	1810	1493
1990	510	1500	810	1785	1820	1495
1991	515	1520	828	1785	1842	1500
1992	510	1550	851	1785	1855	1525
1993	500	1550	851	1880	2015	1560
1994	520	1550	854	1910	1990	1565
1995	515	1520	855	1910	1950	1870
1996	510	1500	816	1910	1950	1879
1997	505	1500	816	1920	1875	1980
1998	505	1550	850	1930	1875	2031
1999	525	1571	881	1940	1827	2082
2000	525	1596	890	1965	1427	2151

2001	525	1596	910	1995	1428	2155
2002	525	1596	910	2025	1428	2161
2003	525	1596	910	2050	1428	2161

Table 9. % Change in Agricultural Area

	Costa Rica	DR	El Salvador	Guatemala	Honduras	Nicaragua
1961-1970	33.0	4.7	-1.4	4.1	2.0	9.4
1971-1980	33.3	8.5	10.3	10.2	7.0	8.1
1981-1990	9.3	2.1	5.8	39.7	1.7	2.7
1991-2000	0.7	2.4	14.7	6.6	-12.2	10.3

Table 10. Mean, Maximum, and Minimum of Table 9

	Mean	Max	Min
61-70	8.6	33.0	-1.4
71-80	12.9	33.3	7.0
81-90	10.2	39.7	1.7
91-00	3.8	14.7	-12.2

Table 11. % Change in Forest and Woodland

	Costa Rica	DR	El Salvador	Guatemala	Honduras	Nicaragua
1961-1970	-20.7	-2.7	-13.5	-5.0	0.0	-15.5
1971-1980	-26.5	-2.8	-21.3	-10.3	0.0	-18.2
1981-1990	-9.3	-2.8	-21.6	16.6	0.9	-22.7

Table 12. Mean, Maximum, and Minimum of Table 11

	Mean	Max	Min
61-70	-9.6	0.0	-20.7
71-80	-13.2	0.0	-26.5
81-90	-6.5	16.6	-22.7

Table 13. Annual Percentage Change in Agricultural Area

	Costa Rica	DR	El Salvador	Guatemala	Honduras	Nicaragua
1961-1962	1.08	0.49	0.00	0.45	0.34	0.98
1962-1963	0.71	0.48	0.48	0.45	0.17	1.13
1963-1964	4.58	0.48	0.00	0.45	0.17	0.96
1964-1965	4.71	0.48	0.16	0.45	0.17	0.95
1965-1966	5.14	0.48	-0.79	0.45	0.33	1.17
1966-1967	0.06	0.48	-0.72	0.81	0.33	0.93
1967-1968	4.89	0.32	-0.16	0.44	0.17	0.93
1968-1969	4.31	1.26	-0.16	0.07	0.00	1.01
1969-1970	3.69	0.16	-0.16	0.47	0.33	0.91
1970-1971	1.67	0.28	3.48	0.44	0.16	0.90
1971-1972	0.00	0.80	0.23	1.19	1.15	0.98
1972-1973	8.53	1.07	0.55	1.54	0.32	1.06
1973-1974	0.00	0.61	0.78	1.13	0.19	1.05
1974-1975	3.61	0.90	0.77	0.45	1.26	0.87
1975-1976	3.91	1.64	-0.61	1.45	1.12	0.86
1976-1977	3.72	0.88	0.69	2.15	2.37	0.85
1977-1978	3.19	0.73	3.13	0.40	0.37	0.93
1978-1979	3.52	0.72	3.70	0.37	0.00	1.17
1979-1980	2.99	0.86	0.71	1.13	0.00	0.08
1980-1981	3.30	0.14	-2.84	0.56	0.21	1.35
1981-1982	3.08	0.14	-2.12	1.21	0.15	0.03
1982-1983	0.11	0.00	-0.30	0.48	0.03	0.02
1983-1984	2.46	0.00	0.75	21.35	0.21	0.86
1984-1985	2.00	0.00	2.23	0.00	0.03	0.35
1985-1986	0.82	0.20	1.45	0.00	0.21	0.03
1986-1987	0.00	0.00	0.00	0.00	0.00	0.51
1987-1988	0.25	0.00	1.43	13.21	0.00	0.50
1988-1989	-0.11	0.37	1.41	0.00	2.62	0.37
1989-1990	0.35	1.36	0.90	0.00	-1.51	0.03
1990-1991	0.18	0.56	1.24	0.00	0.66	0.08
1991-1992	0.18	0.83	2.25	0.00	0.39	0.40
1992-1993	-0.35	0.00	2.00	4.60	5.75	0.55
1993-1994	0.70	0.00	2.16	0.67	-0.79	0.08
1994-1995	-0.17	-0.85	2.62	0.00	-1.14	4.78

1995-1996	-0.18	-0.55	0.31	0.00	0.00	0.13
1996-1997	-0.18	0.00	0.00	0.22	-2.44	1.51
1997-1998	0.00	1.39	2.11	0.22	0.00	0.75
1998-1999	0.70	0.88	1.89	0.22	-1.71	0.74
1999-2000	0.00	0.68	0.54	0.55	-12.05	1.00
2000-2001	0.00	0.00	1.19	0.66	0.03	0.06
2001-2002	0.00	0.00	0.00	0.65	0.00	0.09
2002-2003	0.00	0.00	0.00	0.54	0.00	0.00

Table 14. Annual Percentage Change in Forest and Woodland

	Costa Rica	DR	El Salvador	Guatemala	Honduras	Nicaragua
1961-1962	-2.31	-0.30	-0.96	-0.56	0.00	-1.73
1962-1963	-2.37	-0.30	-0.97	-0.56	0.00	-1.76
1963-1964	-2.43	-0.30	-0.98	-0.56	0.00	-1.79
1964-1965	-2.49	-0.30	-0.99	-0.57	0.00	-1.82
1965-1966	-2.55	-0.30	-6.00	-0.57	0.00	-1.94
1966-1967	-2.62	-0.30	-1.06	-0.57	0.00	-1.81
1967-1968	-2.51	-0.30	-1.08	-0.58	0.00	-1.85
1968-1969	-2.94	-0.30	-1.09	-0.58	0.00	-2.05
1969-1970	-2.65	-0.30	-1.10	-0.58	0.00	-1.92
1970-1971	-3.11	-0.31	-1.11	-0.59	0.00	-1.96
1971-1972	-2.81	-0.31	-1.12	-0.59	0.00	-2.18
1972-1973	-2.89	-0.31	-1.14	-0.60	0.00	-2.04
1973-1974	-3.40	-0.31	-1.15	-0.60	0.00	-2.27
1974-1975	-3.08	-0.31	-1.16	-0.60	0.00	-2.13
1975-1976	-3.18	-0.31	-3.53	-1.62	0.00	-2.18
1976-1977	-3.76	-0.31	-3.66	-1.64	0.00	-2.43
1977-1978	-3.41	-0.31	-3.80	-1.67	0.00	-2.28
1978-1979	-4.04	-0.31	-3.95	-1.70	0.00	-2.55
1979-1980	-3.68	-0.31	-4.11	-1.73	0.00	-1.79
1980-1981	-5.46	-0.31	-4.29	-1.76	0.00	-3.06
1981-1982	-5.32	-0.32	-4.48	0.67	0.00	-2.52
1982-1983	-2.44	-0.32	-4.69	0.00	0.00	-2.58
1983-1984	2.50	-0.32	-4.92	0.00	0.00	-2.65
1984-1985	-5.37	-0.32	-5.17	0.00	0.00	-2.72
1985-1986	0.00	-0.32	-4.55	0.00	0.00	-2.80
1986-1987	0.00	-0.32	0.00	0.00	0.00	-2.88
1987-1988	0.00	-0.32	0.00	11.11	0.00	-2.96
1988-1989	0.00	-0.32	0.00	0.00	0.00	-3.06
1989-1990	1.23	-0.32	0.00	4.24	0.90	-3.15
1990-1991	0.06	-0.33	0.00	0.00	-0.89	-3.25
1991-1992	0.00	-0.49	0.00	0.00	0.00	-2.14
1992-1993	0.00	-1.64	0.00	0.00	0.00	0.00
1993-1994	0.00	0.00	0.00	0.00	0.00	0.00

Figures

Figure 1a. Agricultural Area

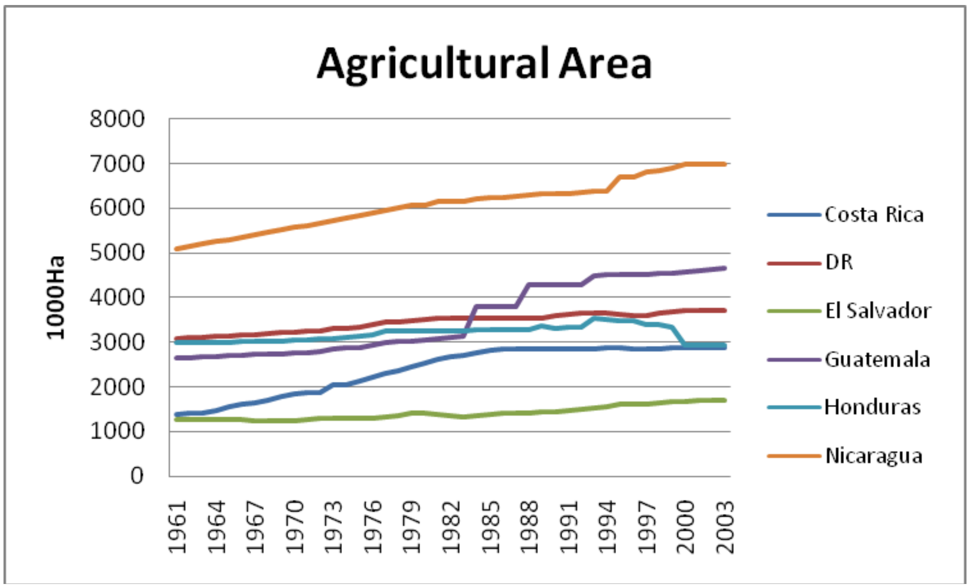


Figure 1b. Annual Percent Change in Agricultural Area

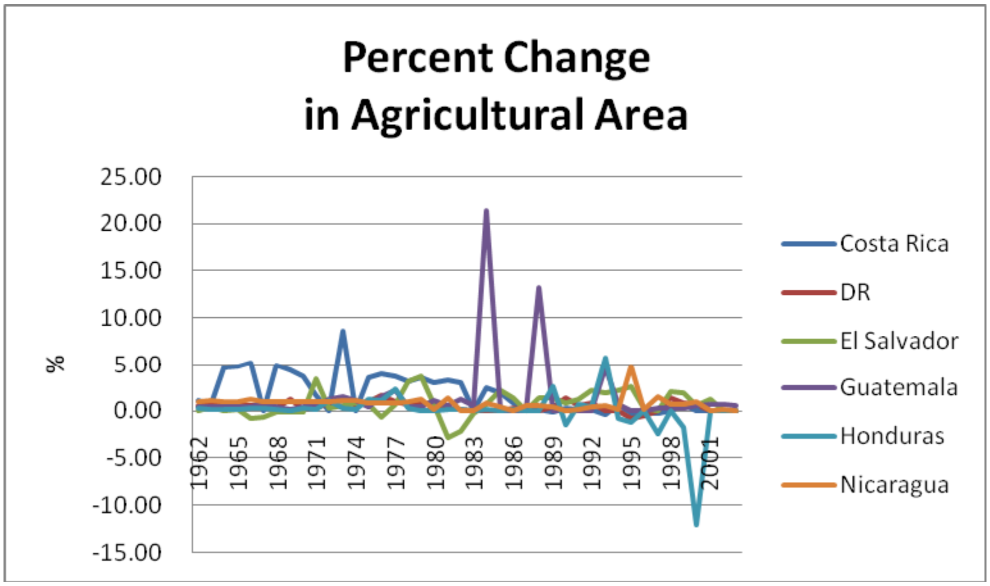


Figure 2a. Forest and Woodland

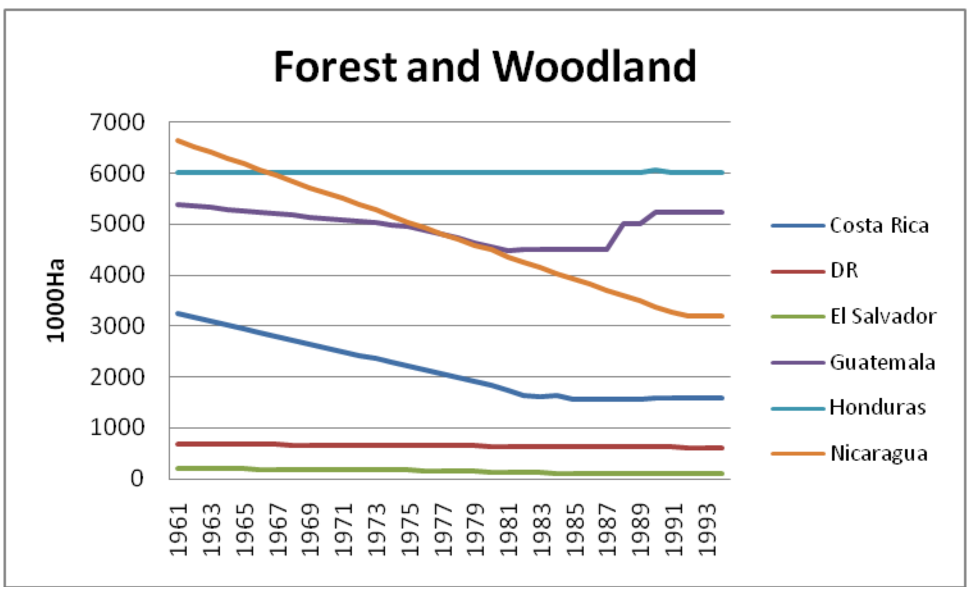


Figure 2b. Annual Percent Change in Forest and Woodland

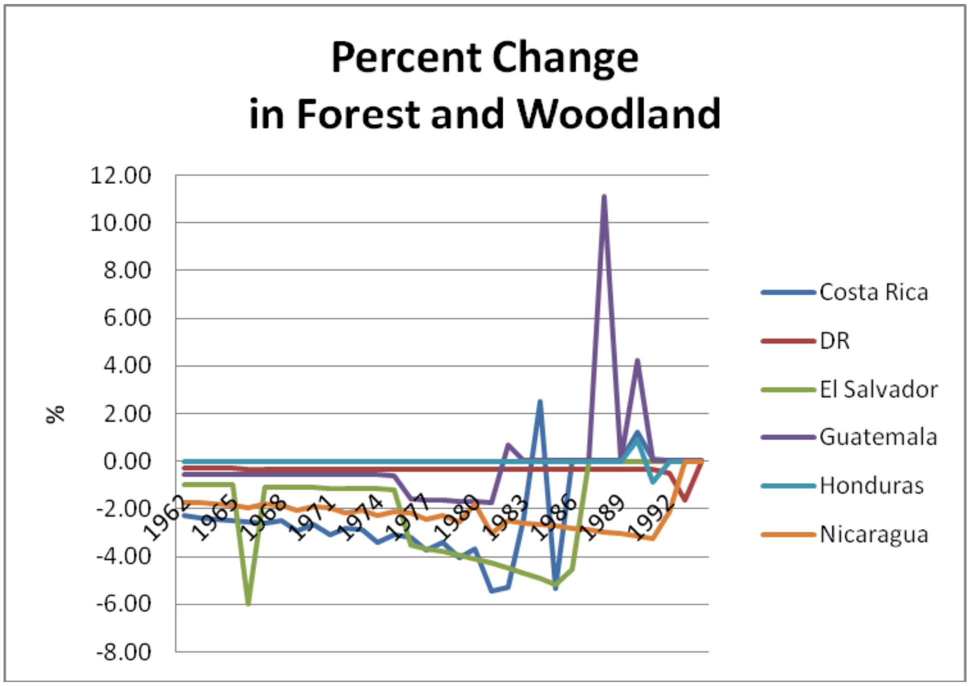


Figure 3. Arable Land

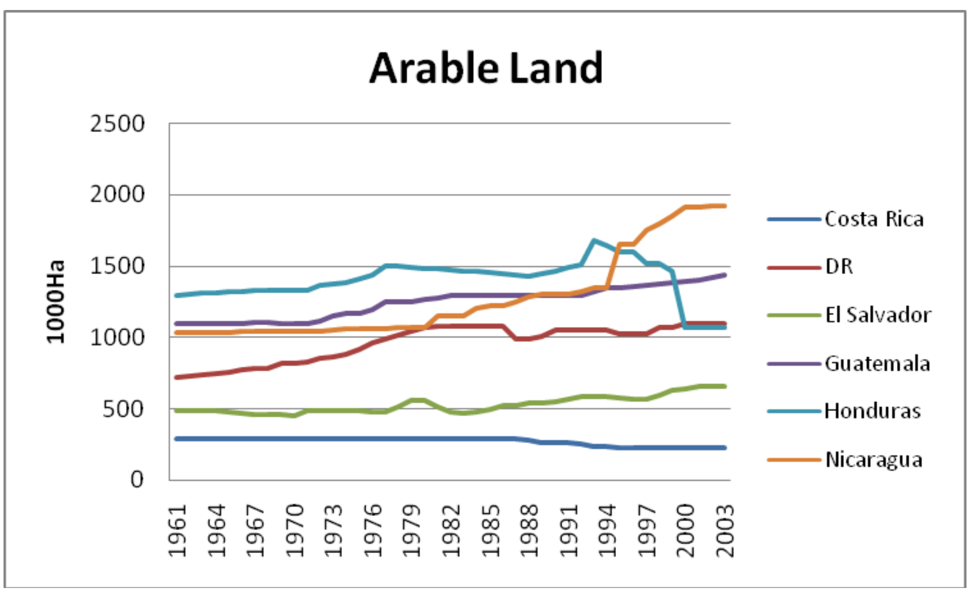


Figure 4. Permanent Pasture

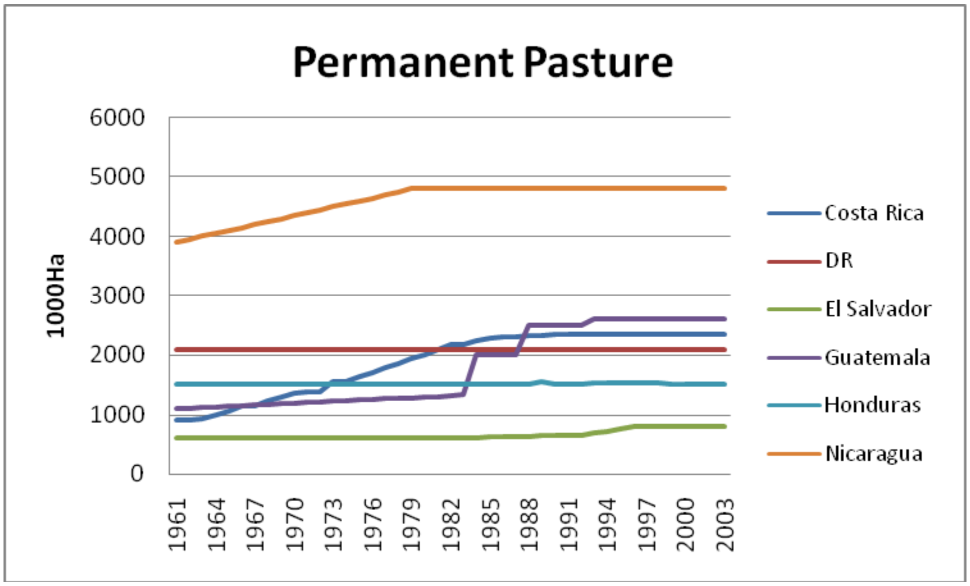


Figure 5. Permanent Crops

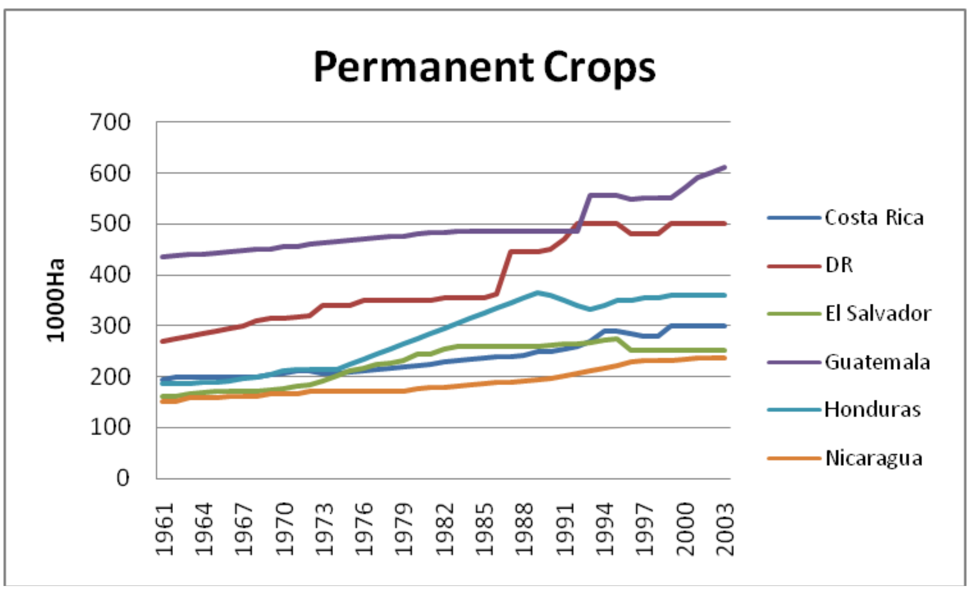
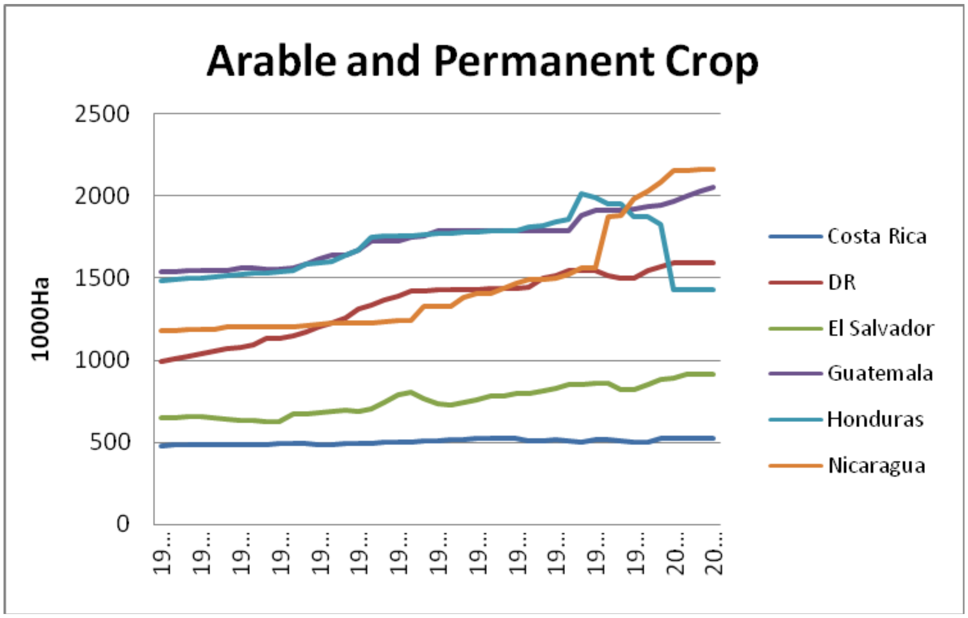


Figure 6. Arable and Permanent Crop



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