POP Diesel Report on Carbon Balance
of Growing Jatropha and Castor in Savannah Grassland

1. As documented in 100 photographs that they took, accompanying this report, which are accessible by **clicking here**, POP Diesel's representatives gathered data to measure the carbon stock lost by cutting down switch-grass measuring 8 feet tall to a height of approximately 6 inches and then gained by inter-planting jatropha and castor plants to grow amongst the low-lying, remaining switch-grass (except that, as explained below, they did not actually uproot any jatropha trees and therefore, did not provide data on the carbon stock of jatropha trees).

2. The method they followed for measuring the mass of the carbon stock lost from the cut-down switch-grass was to start in an area of savannah and stake out a square area that measured 3 meters by 3 meters, to cut down all the switch-grass within that area to a height of 6 inches tall,[1] to gather the cut switch-grass into bundles, and to weigh each bundle on a scale. The total weight of these bundles would be twice the mass of the carbon stock lost by this method. Skutsch, M., E. de los Rios, S. Solis, E.;Riegelhaupt, D. Hinojosa, S. Gerfert, Y. Gao, and O. Masera. 2011, Jatropha in Mexico: Environmental and Social Impacts of an Incipient Biofuel Program. *Ecology and Society* 16(4): 11 ("Skutsch, et al.") (half of plant mass consists is carbon). As described below and depicted in the photographs referenced herein, this weight came to 24.7 kilograms. Half this weight would be the mass of the carbon lost from the switchgrass, or 12.35 kilograms.

3. POP Diesel's representatives uprooted a mature castor plant and weighed it, to determine the weight that each castor plant planted within the 3 meter square would contribute,

[1]At that point, an organic herbicide may be applied to eliminate the stubble of switch-grass and its competition with the jatropha and castor saplings for soil nutrients.

upon the plant's growing to maturity. As described below and as depicted in the photographs referenced herein, this mass came to 13 kilograms per mature castor plant. Since half of this weight would be attributed to carbon, Skutsch, et al., each mature castor plant would contribute 6.5 kg of carbon stock in its plant mass alone.

4. Jatropha trees in this particular scheme are planted such that on each of the corners of a 3 meter square, ordinarily there would be one jatropha seedling planted. Once grown to maturity after five years or so, each of these four jatropha trees would contribute one-quarter of its mass to the area within the square, for a total of the mass with the 3 meter square of on one full, jatropha tree. According to Skutsch, et al., at page 10 (citing a study in India, as well as their own in Mexico), the carbon mass of a jatropha tree at 3.5 years old is 2.8 kilograms, based on a weight that is twice that mass. Such a jatropha tree is not nearly mature.

5. It is feasible to plant one castor tree in the middle of a 3 meter square with jatropha trees on each corner.

6. Thus, summarizing the numbers above, the weight lost from trimming the switch-grass in a square measuring 3 meters on each side down to a height of 6 inches is 24.7 kilograms, containing carbon mass of 12.35 kilograms, and the carbon stock gained from the plant mass of planting one jatropha tree and one castor tree within this area is 2.8 kilograms plus 6.5 kilograms, for a total of 9.3 kilograms when the jatropha plant is 3.5 years old, and still growing.

7. The foregoing analysis of carbon stocks in this switch-grass savannah habitat leaves a carbon deficit in the 3 meter by 3 meter square of land of 12.35 kilograms of carbon in the switch-grass plant mass that is cut down, minus 9.3 kilograms restored by the plant mass growth of one jatropha tree and one castor plant within this square plot of land, equaling a net loss of 3.05 kilograms of carbon from plant mass after 3.5 years. This carbon stock deficit in

plant mass will disappear as the jatropha tree grows to maturity and gains in plant mass over the ensuing several years.

8. Moreover, aside from the carbon stored in the plant mass of the growing jatropha trees and castor plants, the oil stored in the jatropha seeds that grow anew every year is a hydrocarbon oil that also stores carbon that the leaves of the jatropha tree extracted via photosynthesis from the atmosphere. If POP Diesel extracts 350 gallons (1,325 liters) per hectare at 3.5 years, that makes 0.22 gallons of jatropha oil per 3.5 year-old jatropha tree and, conservatively, 0.25 gallons per mature tree. Since 0.22 gallons of jatropha oil displace 0.2 gallons of petroleum diesel,[2] and since each gallon of petroleum diesel emits 22.38 pounds,[3] or 10.17 kilograms, of carbon dioxide, into the atmosphere, each 3.5 year-old jatropha tree will displace the equivalent of 2.0 kilograms of fossilized carbon from entering into the atmosphere each year and each mature tree, conservatively, 2.32 kilograms per year of fossilized petroleum carbon. Counting a modest amount of jatropha fruit harvested and oil yielded in the first two years, by the third year, the carbon balance on the square 3 meter by 3 meter test plot containing one jatropha tree and one castor plant will be net positive. When future annual yields of jatropha oil over the thirty year life-span of the jatropha tree are added to the carbon stock restored by the jatropha trees and castor plants, this displacement of fossil fuel carbon emissions far surpasses the 12.35 kilograms of carbon depleted on a one-time basis by cutting down the switch-grass.

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[2]Since the jatropha has around 10% lower energy content than petroleum diesel, 10% more of it is needed in volume for the diesel engine to perform the same amount of work.

[3]U.S. Energy Information Administration, FAQ's, found at http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=11 (Jan. 25, 2014).

9. The foregoing does not count the carbon extracted from the atmosphere and stored in the hydrocarbon oil in the seeds of the castor plant, which may also be useful as a biofuel feedstock that is harvested several times per year. The foregoing is a very simplified analysis that does not take into account the remainder of a life cycle comparison between jatropha oil and petroleum diesel, including in the case of the jatropha oil, the more modest energy cost required to plant, fertilize, apply herbicides and pesticides, press the oil from the seeds, and transport the jatropha oil to market, versus the energy cost to extract the crude petroleum from the earth, transport it to a refinery, and refine it into petroleum diesel for distribution to the market.

10. The remainder of this report describes the depictions in the photographs that POP Diesel's representatives took to demonstrate the switch-grass and jatropha/castor carbon balance. (They did not conduct any weighing of jatropha trees.). **TO GAIN ACCESS TO THE PHOTOS LISTED IN THE PARAGRAPHS FOLLOWING THIS ONE, CLICK HERE TO GET TO THE FOLDER, AND THEN OPEN THE FOLDER TO FIND THE PHOTO BY ITS FILE NUMBER STATED BELOW.**

Savannah Switch-grass Prior to Cutting Down to a Height of 6 Inches

11. Photos SAM 0001 to SAM 0006 portray typical savannah switch-grass prior to any cutting or mowing down.

Establishment of a Square Test Cutting Area Measuring 3 Meters on Each Side

12. Photos SAM 0007 to SAM 0009 portray the making of the wooden corner marker stakes for use in measuring a square plot of switch-grass that is 3 meters by 3 meters a side.

13. Photos SAM 0010 to SAM 0013 portray the measuring, using a measuring tape, of this square plot of switch-grass.

14. Photos SAM 0014 to SAM 0016 and also SAM 0024 to SAM 0025 show the placement of the tape measure at 300 and then 0 centimeters, or 3 meters apart, on, respectively, two of the corner wooden marking stakes.

15. Photos SAM 0017 to SAM 0023 and also SAM 0026 to SAM 0042 show the cutting down, using a machete and garden shears, and the bundling, of the switch-grass that lies within the measured 3 meter by 3 meter square.

16. Photos SAM 0043 to SAM 0046 and SAM 0048 to SAM 0054 show the blue twine used to mark the 3-meter sides of the square of switch-grass being cut to measure the carbon stock lost by planting jatropha within switch-grass that is cut down to a height of 6 inches.

Weight of the Cut Switch-grass

17. Photos SAM 0047, SAM 0056, and SAM 0061 show bundles of cut switch-grass prior to weighing and in transport to the weighing scale.

18. Photos SAM 0058 to SAM 0060 show the weighing scale without anything on it and the indicator needle reading “0 kilograms” on the outside and “0 pounds” on the inside of the circular dial.

19. Photos SAM 0062 show the placing of a bundle of cut switch-grass onto the scale.

20. Photos SAM 0063 and SAM 0065 show the weighing of a squat bundle of cut switch-grass, tied with a red ribbon, on the scale, with, in Photo SAM 0064, a close-up of the indicator needle showing that this bundle weighed 6.0 kg.

21. Photo SAM 0066 shows the weighing of a taller, thinner bundle of cut switch-grass, tied by a red ribbon, on the scale, with, in Photo SAM 0067, a close-up of the indicator needle showing that this bundle weighed 4.0 kg.

22. Photo SAM 0068 shows the squat bundle with the red ribbon lying on the ground next to the taller, thinner bundle with the red ribbon, to show that they are two separate bundles, and not re-arrangements of the same bundle.

23. Photos SAM 0069 to SAM 0071 show the weighing of a tall bundle of cut switch-grass with leafy profusion, tied by yellow and red ribbons, on the scale, with, in Photo SAM 0072, a close-up of the indicator needle showing that this bundle weighed 6.0 kg.

24. Photo SAM 0073 shows the tall bundle of switch-grass with leafy profusion, tied by yellow and red ribbons, lying on the ground next to the squat bundle with the red ribbon and the taller, thinner bundle with the red ribbon, to show that they are three separate bundles, and not re-arrangements of the same bundle.

25. Photo SAM 0074 shows the weighing of a tall, thinner bundle of cut switch-grass with leafy profusion, tied by a yellow ribbon, on the scale, with, in Photo SAM 0075, a close-up of the indicator needle showing that this bundle weighed 4.2 kg.

26. Photo SAM 0076 shows the tall, thinner bundle of switch-grass with leafy profusion, tied by a yellow ribbon, lying on the ground next to the three other bundles of switch-grass, to show that they are four separate bundles, and not re-arrangements of the same bundle.

27. Photo SAM 0078 shows the weighing of a tall, leafy, bedraggled bundle of cut switch-grass, tied by a yellow ribbon, on the scale, with, in Photo SAM 0079, a close-up of the indicator needle showing that this bundle weighed 4.5 kg.

28. Photos SAM 0077, SAM 0080, and SAM 0081 show the tall, leafy, bedraggled bundle of switch-grass, tied by a yellow ribbon, lying on the ground next to the four other bundles of switch-grass, to show that they are five separate bundles, and not re-arrangements of the same bundle.

Weight of a Mature Castor Plant

29. Photos SAM 0082 and SAM 0083 show a mature castor plant, prior to its being cut down.

30. Photos SAM 0084 to SAM 0087 show the same mature castor plant, in the process of being cut down by a man with a machete, and Photos SAM 0088 to SAM 0091 show the man carrying the mature castor plant, without any roots, after he has cut it down.

31. Photo SAM 0092 shows the man laying the mature castor plant that he has cut down, the second one, on top of another mature castor plant that is already lying in the bed of a pick-up truck, the first mature castor plant. Photo SAM 0093 shows the branches and leaves of the two castor plants extending over the side of the bed of the pick-up truck.

32. Photos SAM 0094 and SAM 0095 show the man placing the first mature castor plant inside the bottom of the bed of the pick-up truck, on which he laid the second mature castor plant.

33. Photo SAM 0097 shows castor plant branches with castor nuts that are lying on the ground.

34. Photos SAM 0098 and SAM 0100 show the weighing of the second of the mature castor plant, which was cut off above the roots, with Photo SAM 0099 showing a close-up reading of the scale's needle indicator, pointing to 13 kg.

35. Photos 100 3583 and 100 3589 to 100 3591 show the weighing on a scale of the first mature castor plant, including its roots. It is not possible to read the weight on the scale because it is not a close-up picture. Nonetheless, these photos show that this castor plant does not have extensive roots. Therefore, the omission of the roots from the 13 kg weight of the second mature castor plant is immaterial, in terms of the weight of the overall castor plant and its

carbon stock.

Summary Weights of the Cut Switch-grass and the Mature Castor Plant

36. The text document titled, “carbon,” shows the weights of the individual bundles of switch-grass described above, being 6.0, 4.0, 6.0, 4.2, and 4.5 kg, respectively. This totals

24.7 kg of switch-grass cut down in a 3 meter by 3 meter square of wild switch-grass. The text document titled, “carbon,” also identifies the weight of the mature castor plant as being 13 kg.