Biofuels: Environmental Consequences and Interactions with Changing Land Use.[1]

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Assessment of report by Peter Baker

We draw attention here to a SCOPE report on an international biofuels rapid assessment, entitled Environmental Consequences and Interactions with Changing Land Use. The report is the result of a 2008 workshop that has recently become available on the Internet.

The report covers too many aspects to report here, so we concentrate on what it says about one important aspect – marginal lands, which are a crucial issue for biofuels.

The case for marginal land

The argument is simple: significant quantities of biofuels cannot be produced from current agricultural land because this rapidly leads to food shortages. Neither should it come from forested land or other land rich in carbon and biodiversity such as savannahs, since conversion may often make emissions worse rather than better and are also needed for other ecosystem services, especially hydrological services. As Searchinger (SCOPE Chapter 2) puts it: 'The basic question now confronting the world involves the trade-offs in using land to meet energy needs rather than other needs.'

So biofuels, if they are to become a significant and sustainable industry, must be grown on so-called marginal land, i.e. land that is currently unproductive or unused for a variety of reasons. As Ojima *et al.* (Chapter 17) point out, abandoned, under-exploited, and degraded "marginal" lands appear to provide good opportunities for conversion to biofuel crops, but unfortunately they are poorly defined, so there are widely varying estimates of their extent and the viability of exploiting them. Given their importance, it is vital to reach agreement on their potential for biofuel production.

The confusion over terms

Bustamente *et al.* (Chapter 16) point out that the amount of land needed to produce large quantities of energy may be as large as the amount of land currently farmed. Like Ojima, he alludes to the confusion of the term "marginal lands", since it means different things to different people. Bustamente prefers the term "lands of low competition" – these are lands that currently produce little food and are undesirable and ill-suited for enhanced food production. They store little carbon today and stand to sequester little carbon in the future and they have a low biological diversity.

Connor & Hernandez (Chapter 4) also point to the major problem with terminology – the descriptors 'abandoned', 'waste', and 'marginal' land are commonly used without qualification and contribute to confusion. An agronomic assessment of productivity is needed that requires a description of topography, soil, climate and the availability of resources that could be applied to improve and sustain productivity. Once assessed, Connor & Hernandez claim, it is inescapable that as demand for food increases, any land that can be made productive will also be sought for food crops.

The problem of irrigation

In theory, dry lands could be irrigated and used for growing biofuels, but Bustamente *et al.* claim that the impacts of water diversions on biodiversity and fishery resources, coupled with demands for more irrigation to meet food supplies, suggest that irrigation for biofuel production should rarely be acceptable. The best candidates for biofuel production are therefore lands wet enough to support substantial production but that are not serving other valuable needs.

[1] http://cip.cornell.edu/DPubS?service=UI&version=1.0&verb=Display&handle=scope

Degraded land
Most of the lands that qualify for biofuels, Bustamente *et al*. therefore suggest, will be lands that are for some reason degraded. But here again there is room for confusion: some degraded lands simply lack chemical inputs, and are good targets for enhanced food production. But others face other obstacles: lands that have suffered great soil degradation, but that might respond to perennial grasses or trees; lands that are overrun by invasive species; or tropical grazing lands that are currently degraded and relatively unproductive.

Particularly if coupled with efforts to boost the productivity of adjacent lands, such lands might be suitable for biofuel production. One appropriate policy would seek to map and evaluate the productivity of these areas, and thereby outline areas of appropriate use for biofuels.

Unacknowledged uses of marginal land
Crucially, Bustamente *et al*. point to the often overlooked uses of what some believe to be marginal lands: most traditional rural African communities are reliant on their environment to supply services ranging from fuelwood, construction wood, thatch grass, fruit, bush meat, medicines, grazing, water etc. Even in areas where there is no evidence of habitation or use of resources, they may still be significant to rural livelihoods. An example of this is in south east Botswana where in November the larvae of the Emperor moth (*Imbrasia belina)* from *Colophospermum mopane* trees are harvested. They smoke them and then sell them as far a field as cities in neighbouring countries. Per kg they sell for more than the cost of prime beef. Botswana's Central Statistics Office (2000) claims trade in mopane worms or phane as they are known locally, is second to agriculture as a source of livelihood and that the cash income it provides is particularly important to women.

The inputs problem
Connor & Hernandez (Chapter 4) are even more suspicious of marginal lands for biofuels. They write that claims that energy crops can be grown with less intensive production methods, on land unsuitable for food crops, are largely untrue.

Further, under all circumstances, efficient and continuing production will require substantial inputs of fertilizer, and irrigation if available, to justify effort and investment. Dedicated energy crops therefore are always fated to compete with food crops for land, nutrients, and/or water.

Unfortunately, attention to the inputs required to show adequate and sustainable productivity are absent from most studies. For example they question the concept promoted by Tilman *et al.* (2006[2]) that unfertilized, low-input, high diversity prairie grassland on 'degraded' land produces more net energy than fertilized corn grain ethanol systems while sequestering significant amounts of carbon in soil organic matter. Their estimates were based on removal of less than 3% of standing biomass, whereas in a real-world biomass system, all above-ground biomass, and thus nutrients, would be harvested. It is improbable, Connor & Hernandez suggest, that the net productivity of the system could be maintained at an industrial scale. The same applies to short-term rotation crops. Yields of trees and shrubs are relatively small on a per year basis (4–8 t ha^{-1}) and the nutrient requirements for continuing productivity are undefined.

The pollution problem
Simpson *et al*. (Chapter 9) are concerned about the increased extent and intensity of high nutrient input crops, largely in response to demand for ethanol, that has major implications on nutrient cycles throughout the world. The expansion of intensive, annual crop production onto marginal lands and lands in perennial grasses will, they suggest, result in large increases in nutrient losses to lakes, rivers, and coastal marine ecosystems around the world.

The 2007 expansion of corn acreage in the Mississippi river basin (MRB) for example, is calculated to increase annual loads to surface waters by 117 million kg N and 9 million kg P. But this conflicts with national goals to decrease N and P loads from the MRB by 40% or

[2] Tilman, P., J. Hill, and C, Lehman. 2006. Carbon negative biofuels from low-input high diversity grassland biomass. Science 314: 1598-1600.

more to reduce the size of the area of the “Dead Zone” in the northern Gulf of Mexico caused by nutrient rich hypoxia.

Conclusions
The SCOPE report concludes that biofuel crops offer their greatest promise for greenhouse gas benefits if grown on abandoned, degraded, or marginal lands. But it acknowledges that if the lands have the potential to revert to forests, conversion to biofuels represents a lost opportunity for carbon storage.

In short there is increasing realization of the many factors that need to be taken into account if biofuel expansion is to be beneficial to human societies. Some salient ones are that:

1. Expansion should not be on good agricultural land.
2. Expansion should not replace high carbon or high biodiverse lands.
3. Expansion can only come from marginal lands, but the term itself requires categorization, and by definition includes those lands are where marginal people eke out marginal lives.
4. The most likely source of land for biofuels is degraded agricultural land that is effectively abandoned. This will have to be land with adequate rainfall, since laying on irrigation will be too expensive.
5. But if such land could be brought back to production for biofuels, it could also be used to regrow forests and store carbon, or be used to produce the food that we will be needed to supply a growing world population and to replace land that is becoming marginal because of the effects of climate change.
6. Many of the problems about biofuel land-use involve indirect effects, and point to a deficiency in many early life cycle assessments, since they tended to ignore or under-estimate these effects.

All this implies, to this reviewer at least, that some major quantifiable guidelines are now urgently required before any new large scale programmes start, especially those financed by governments and international donors. Any scheme surely needs to pass a series of rigorous tests about fundamentals such as economics (e.g. the jatropha yield debacle), thermodynamics (the exaggerated energy capture claims for microbials) and land use (the environmental and societal impacts that are so often poorly evaluated).

We suggest that this can only come from concerned scientists from the public sector, such as those who prepared the SCOPE report that we have reviewed above. We are now in such peril that we surely cannot afford to see either the public or the private sector expend valuable time and funds on schemes that are, in practical terms, economically unviable, socially unjust or environmentally damaging.