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LAND USE GREENHOUSE GAS EMISSIONS FOR CONVENTIONAL AND UNCONVENTIONAL OIL PRODUCTION

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Overview

The purpose of this paper is to explore direct land use greenhouse gas (GHG) emissions associated with fossil fuel production, including conventional oil production in California, and oil sands production in Alberta. The scope of the analysis covers direct land disturbance that results from the upstream production of two key transportation fuels: conventional oil and synthetic crude oil from oil sands development.

There has been significant attention paid to the land use impacts of biofuels. Many have argued that biofuels, if produced from carbon-rich land (such as tropical forest), will have small or negative GHG benefits since the emissions of carbon from stocks in soil and underground and above-ground biomass can outweigh the avoided fossil fuel emissions from biofuels as opposed to gasoline or diesel (Fargione et al. 2008; Gibbs et al. 2008; Hill et al. 2006). Even though unconventional fuels have high "upstream emissions" (Bergerson and Keith 2006; Brandt and Farrell 2007; Charpentier, Bergerson, and MacLean 2009), we know very little about the land use GHG impacts of conventional and unconventional fossil fuels. The land use GHG emissions have not being incorporated in any standard lifecycle analysis models, such as the GREET model, GHGenius, or independent studies (Brandt and Farrell 2007; Charpentier, Bergerson, and MacLean 2009). However, recent studies examining the land use impacts of oil and gas development on habitat loss, fragmentation, and ecological and environmental impacts (Jager, Carr, and Efroymson 2006; Jordaan, Keith, and Stelfox 2008; Weller et al. 2002; Griffiths, Taylor, and Woynillowicz 2006) suggest that the land use impacts of conventional and unconventional oil production can be non-trivial. Our study intends to quantify the upstream direct land use GHG emissions of conventional and unconventional fossil fuel production. Sensitivity analysis of peatland emissions and accounting for the temporal patterns of GHG fluxes are conducted.

Methods

Data for California conventional oil production is obtained from the California Department of Oil Gas, and Geothermal Resources (California Department of Conservation 2006). Our dataset contains 308 oil fields covering 3×109 m2 (1180 square miles), and a total of 9,775 wells. The cumulative crude oil produced to date is 25.1 billion bbl. Given that nearly all California oil fields are in the southern half of the state, we assume that the land above the California fields is 25% chaparral and 75% grassland. These land types have carbon stocks in soil and above ground biomass of 8 and 4 g C/m2 (80 and 40 Mg C/ha), respectively, for chaparral and 8 and 1 g C/m2 (80 and 10 Mg C/ha), respectively, for grassland (Searchinger et al. 2008).

To estimate the fraction of land in California oil fields that is disturbed, we used an image analysis program to convert the images of three oil fields into binary files (black and white). Black being the vegetation, which is typically much darker than the dirt roads and areas around wells. The percentages without vegetation (white) range from 25-35% for the 3 fields analyzed, with a few images having as low as 10% cleared.

We use Jordaan and Keith (2008, submitted to ERL) study to estimate the average land use for open pit mining and in situ production. The land use impacts of mining include clearing of vegetation, removal of overburden, mining, and transport of oil sand for processing and refining. Bitumen upgrading to SCO uses natural gas, which is used to heat water to extract the bitumen, and to generate heat and produce hydrogen for upgrading and refining. The land use impacts of extraction and transport of natural gas are also included. For each step in the life of an oil sands project, we estimate the fate of carbon held in the ecological region that are disturbed due to the extraction processes and allocate the total quantity of carbon in grams of CO2 equivalents (CO2e) to the quantity of synthetic crude oil produced. Figure 1 shows the sequence of extraction steps that have a land-related GHG release to the atmosphere over the life of mining operations for (a) surface mining and (b) in-situ production. In both cases our goal is to estimate the fate of the C stored in different landscapes, including peatlands, whether it is oxidized to CO2 and released to the atmosphere or decays anaerobically to form CH_4, which then diffuses to the surface from the catotelm layers of peat.

Results

Our *preliminary* analysis suggest that the GHG emissions associated with land use conversion are in the range of 0.025–1.40 gCO2e/MJ for conventional oil production, 1.5–3.1 gCO2e/MJ SCO for oil sands surface mining and 0.5-4.0 gCO2e/MJ SCO for in situ productions of oil sands, a range much smaller than the values for biofuels. These values are 0.02–1.3% of those from conventional oil, and 0.41-3.3% of those of SCO. Significant uncertainty exists in estimating CO2 emissions from land use, especially in Alberta region where peat and tailing pond oxidation in the form of methane can be significant sources for greenhouse gas emissions in some special undisturbed cases and in the disturbed cases in general. Our work focus on greenhouse gas emissions associated with land use disturbance. However, the land-based activities for each of these fuels pose other significant sustainability risks other than changes in greenhouse gas fluxes through the transformation of landscapes and loss of biodiversity that should be considered in policies associated with the development of unconventional fuels.

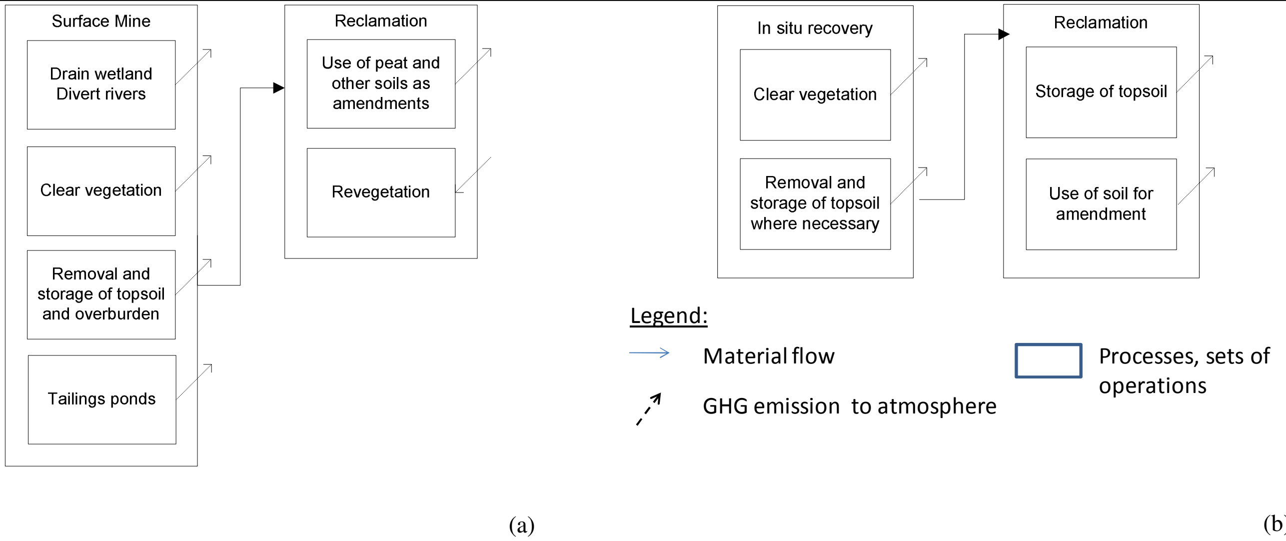

Figure 1. Emission of GHGs to atmosphere resulting from land disturbance from oil sands mining using (a) surface mining; and (b) in-situ extraction.

Conclusions

There is a need for research in the area of land use change and greenhouse gas emissions for the energy sector, particularly in determining the changes in global carbon flux caused by land use change. This research provides first-order estimates for greenhouse gas emissions from land use, but we highlight the importance of key uncertainties for characterizing land use GHG emissions for conventional and unconventional oils, especially for Alberta oil sands. Our study only characterizes GHG emissions, but the impacts on ecosystems are much more significant, as illustrated in many other studies (Dyer 2006; Griffiths, Taylor, and Woynillowicz 2006; Jordaan, Keith, and Stelfox 2008; Price 2008).

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