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A methodology to assess open pond, phototrophic, algae production potential: A Hawaii case study

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ABSTRACT

Geographic information system (GIS) analysis was used to identify lands suitable for open pond production of phototrophic microalgae in the state of Hawaii where rainfall is less than 1.0 m y^{-1}, solar insolation is at least 4.65 kWh m^{-2} d^{-1}, slope is ≤5%, zoning is non-residential, and contiguous area is at least 0.2 km^2 (*Base Case*). Eight sensitivity analyses were performed that varied these criteria and considered an added criterion stipulating a maximum distance from power plants that could serve as CO_2 sources. Results were overlaid with GIS layers for agricultural lands of importance to the State of Hawaii and land serviced by freshwater irrigation infrastructure. *Base Case* conditions were identified on 476 km^2, 2.9% of State land area. 60% of *Base Case* lands are important agricultural lands and of these, half are serviced by irrigation infrastructure. Assumed algae oil productivity of 1.87 dm^3 m^{-2} y^{-1} would yield 0.9 hm^3 y^{-1}, equivalent to 30% of the combined total consumption of distillate and jet fuel in the State in 2011.

1. Introduction

Hawaii is the most isolated island archipelago in the world and the most fossil fuel-dependent state in the U.S. In 2010, over 85% of Hawaii's electricity was generated from fossil fuels and petroleum accounted for 75% of the total [1]. Having no indigenous fossil fuel resources, Hawaii imports all of its fossil fuels. This geographic isolation and import dependence put Hawaii at risk from interruptions in supply and fluctuations in fuel prices. In recognition of this energy security dilemma, Hawaii's state lawmakers established a renewable energy goal which calls for 40% of the state's energy to be obtained from renewable resources by 2030.

Algae are deemed a superior crop for biofuel production because of their projected high productivity rates, their ability to grow in a wide range of water qualities, and their potential for cultivation on land unsuitable for food production [2].

Algae have long been researched as a potential source of renewable energy [2–5] in general and liquid fuels in particular, and algae research has long identified Hawaii as a prime location for algae production due to the state's sub-tropical climate and ample sunshine [2,6,7]. Proximity to marine waters also provides a cheap and abundant source of water for growing algae in Hawaii. These climatic factors coupled with the state's renewable energy portfolio standards have led to great interest in growing algae for biofuels in Hawaii.

The purpose of this study is to provide a logical methodology and objective information regarding land suitable for open pond, phototrophic, microalgae and biofuels production using Hawaii as a case study. This analysis will provide the biofuels community, both private and public,

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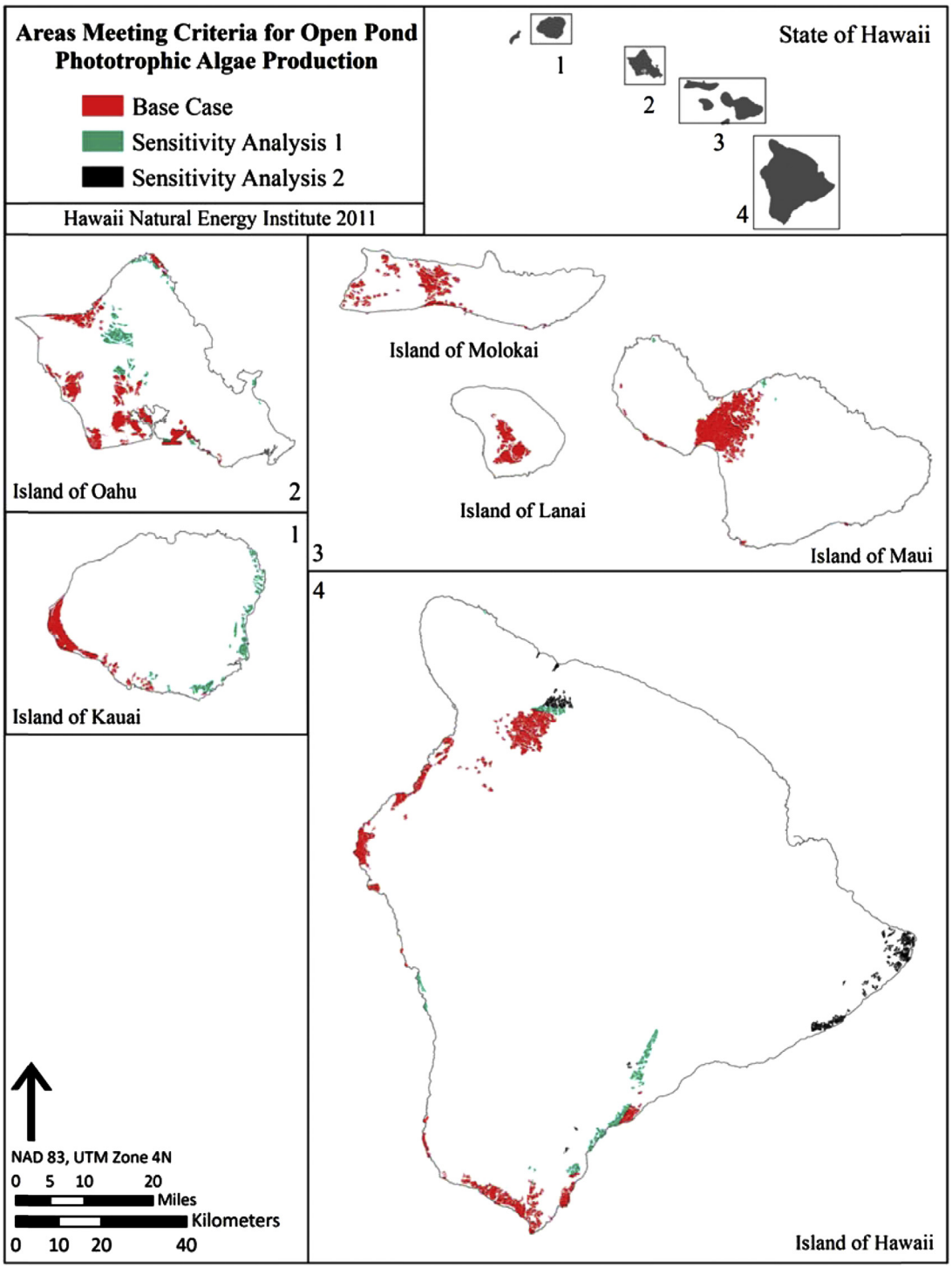

Fig. 1 – Areas meeting criteria for open pond phototrophic algae production in the State of Hawaii. *Sensitivity Analysis 1* areas shows land incremental to *Base Case* analysis. *Sensitivity Analysis 2* shows area incremental to *Base Case* and *Sensitivity Analysis 1* results.

information necessary in making sound land use decisions. The methodology utilized in the study provides a framework for analysis that can be used in, or adapted to, other locations. Relevant criteria include: slope, rainfall, solar insolation, contiguous land area, zoning, distance from production resources, and alternative land use options.

2. Methods

A set of *Base Case* criteria (solar insolation, rainfall, slope, and land use zoning) for growing phototrophic microalgae in open ponds was established as described below. ESRI's ArcGIS 9.3

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