Bioenergy Development and Integrated Water-Energy Management

7 papers (2 hours)

Discussion of knowledge gaps and research plans (1 hr)

Co-Conveners:

David W. Watkins, Jr.[1] and Márcia M.G.A. Moraes[2]

[1]Dept. of Civil and Environmental Engineering, Michigan Technological University, Houghton, MI, USA

[2]Dept. of Economics, Universidade Federal de Pernambuco, Recife, BRA

Bioenergy Development and Integrated Water-Energy Management in Pan America

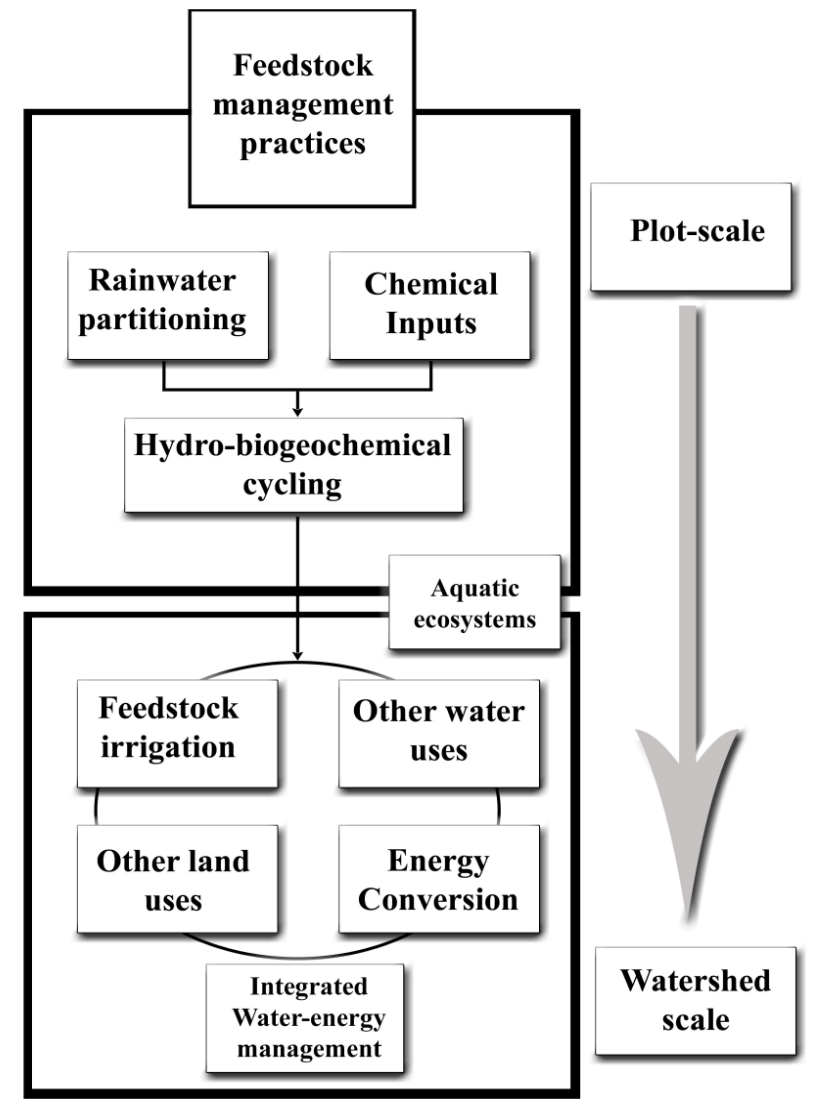
David W. Watkins, Jr.[1], Márcia M.G.A. Moraes[2], Heidi Asbjornsen[3], Alex S. Mayer[1], Julian Licata[4], Jose Gutierrez Lopez[3], Tom Pypker[5], Vivianna Gamez Molina[6], Guilherme Fernandes Marques[7], Ana Cristina Guimaraes Carneiro[2], Hector M. Nuñez[8], Hayri Önal[9], and Bruna da Nobrega Germano[2]

[1]Dept. of Civil and Environmental Engineering, Michigan Technological University, Houghton, MI, USA
[2]Dept. of Economics, Universidade Federal de Pernambuco, Recife, BRA
[3]Dept. of Natural Resources and Environment, University of New Hampshire, Durham, NH, USA
[4]Instituto Nacional de Tecnología Agropecuraria, Buenos Aires, ARG
[5]Dept. of Natural Resource Science, Thompson Rivers University, Kamloops, CAN
[6]Dept. of Civil and Environmental Engineering, University of Northern Arizona, Flagstaff, AZ, USA
[7]Dept. of Civil Engineering, Centro Federal de Educação Tecnológica de Minas Gerais, Belo Horizonte, BRA
[8]Dept. of Economics, Centro de Investigación y Docencia Económicas (CIDE), Aguascalientes, MEX
[9]Dept. of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, IL, USA

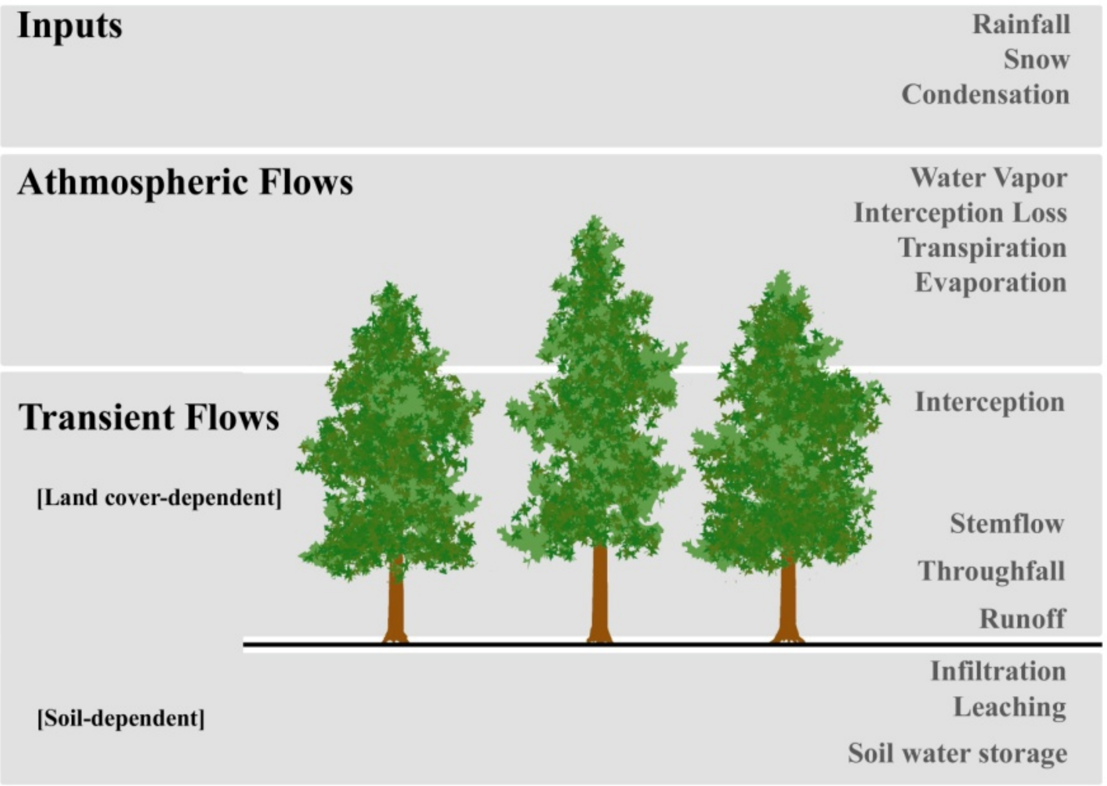
Research Goals

- Review research on water resource impacts of bioenergy production.
- Improve understanding of fundamental ways bioenergy production affects the hydrologic cycle.
- Through case studies in Pan America, illustrate:
  - Relevant spatial and temporal scales for impact assessment,
  - Unique aspects of biofuel production compared to other agroforestry systems.
- Identify primary gaps in knowledge that hinder policy development for integrated management of water-bioenergy systems.

Integrated Approach



Feedstock Water Budget



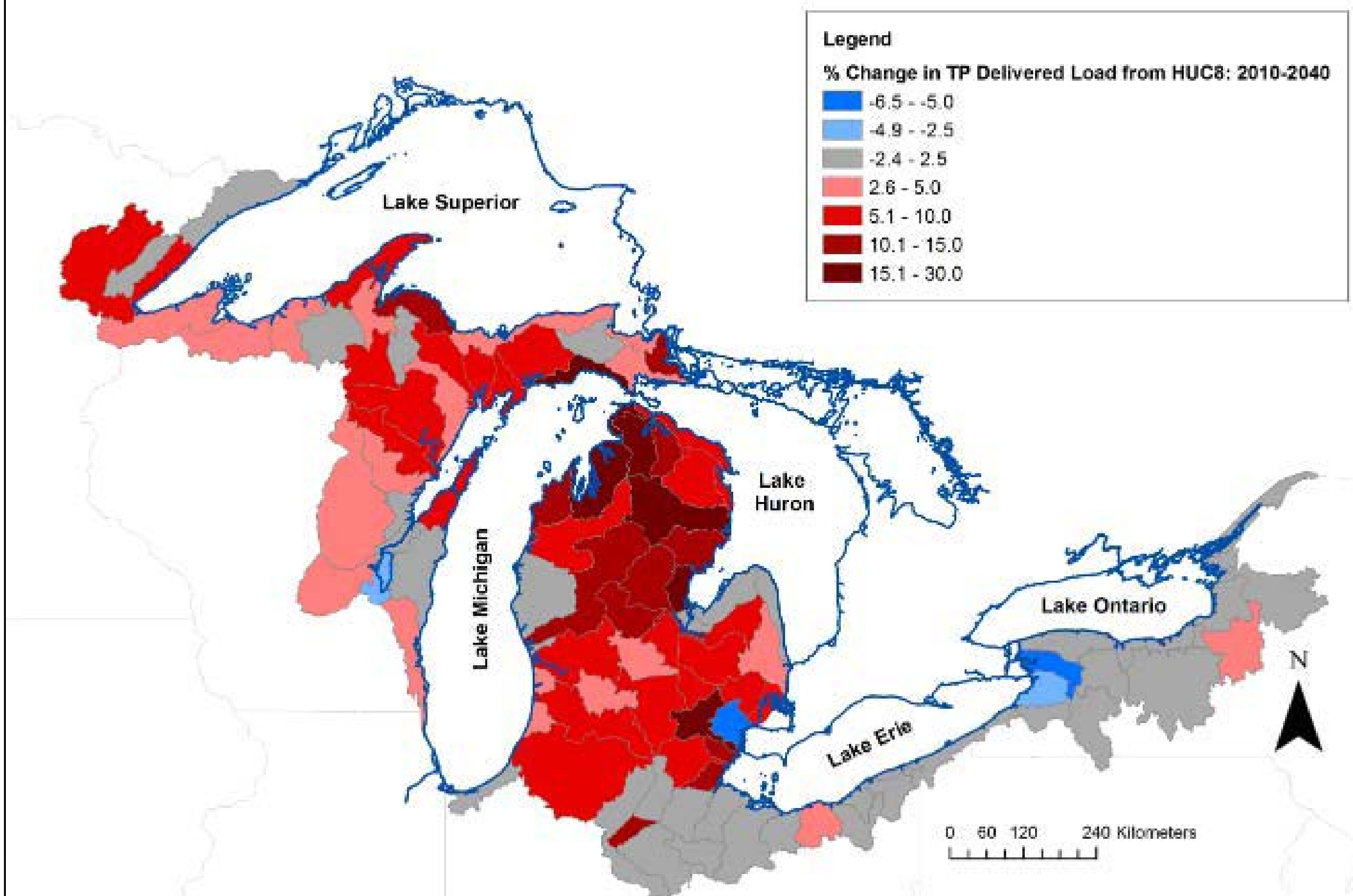
$$\mathrm{WY} = P - T - I - E + \Delta S$$

where WY = water yield, P = precipitation, T = plant transpiration, I = rainfall interception by the canopy, E = soil evaporation, and ΔS = change in soil water (considered to be negligible over longer time periods)

Key Findings

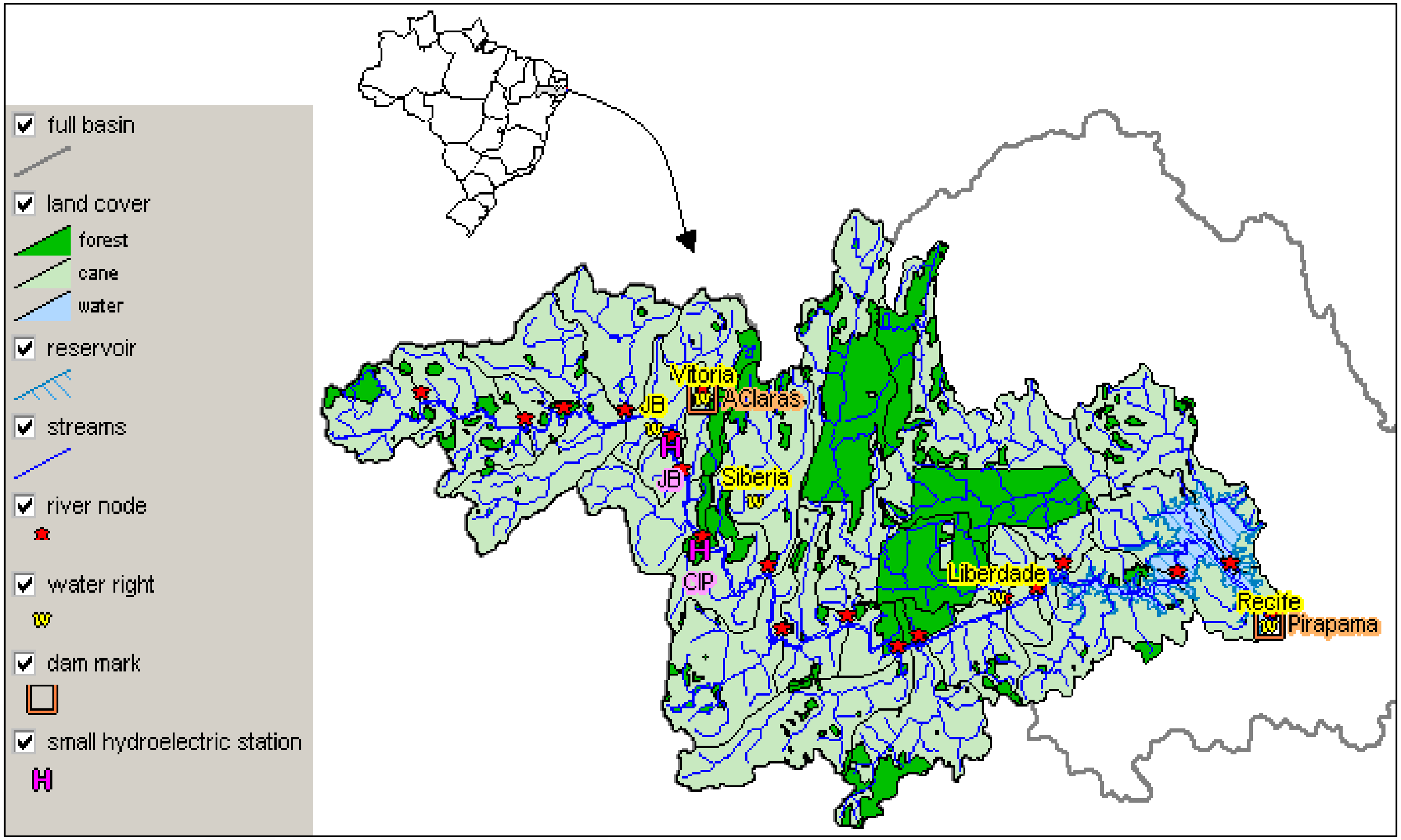
- More research is needed to understand how different bioenergy systems vary in their ecohydrologic functions and the implications at the stand to the watershed scale.
- There is a knowledge gap of how bioenergy-oriented forestry will impact water use at the tree and stand levels.
  - Studies of monoculture and mixed-species of short-rotation bioenergy production systems are lacking.
- Research should be intensified on water efficiency in the energy conversion side of second-generation technologies.

Great Lakes Basin, USA



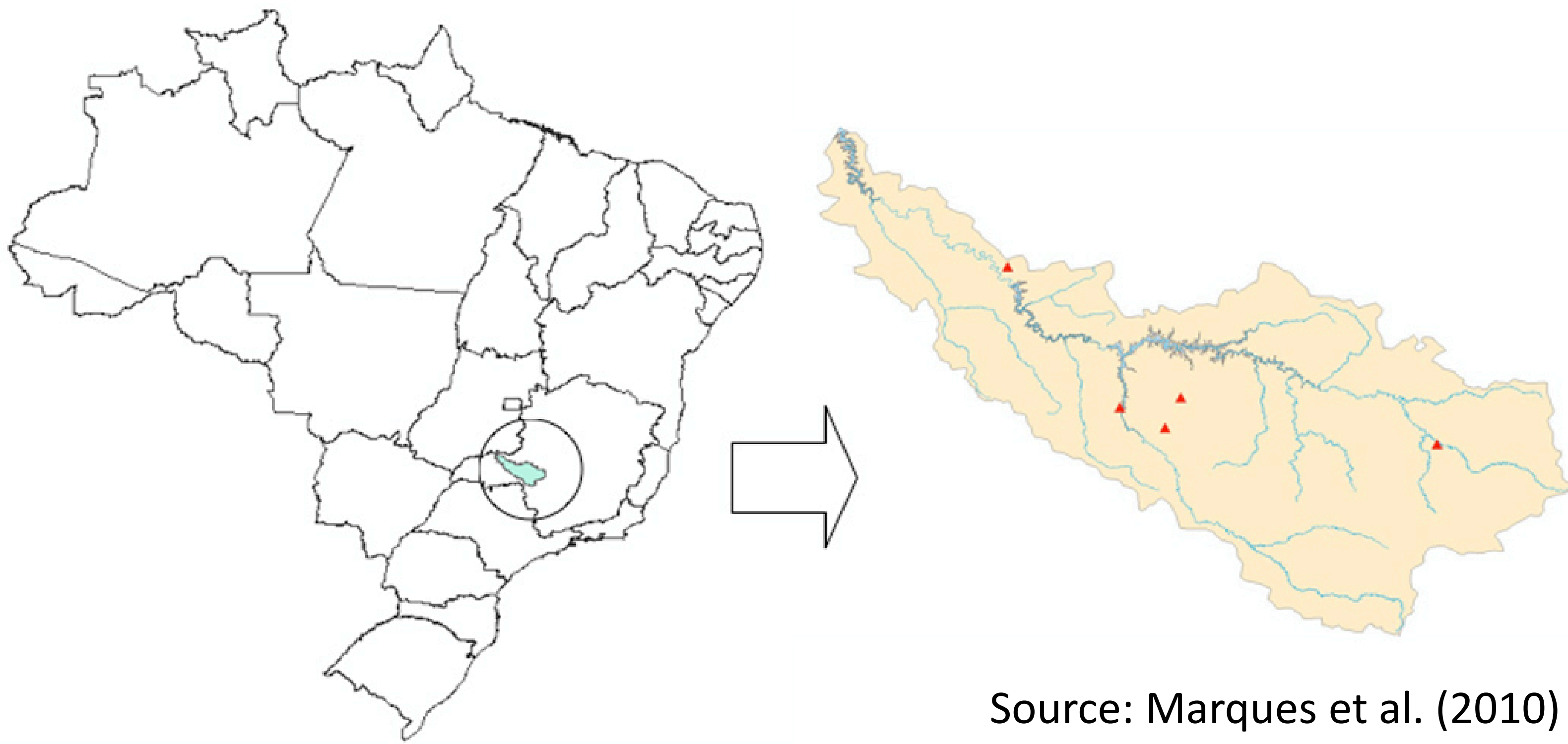
Biofuels Development Scenario (LeBeau, 2012)

Pirapama River Basin, Brazil



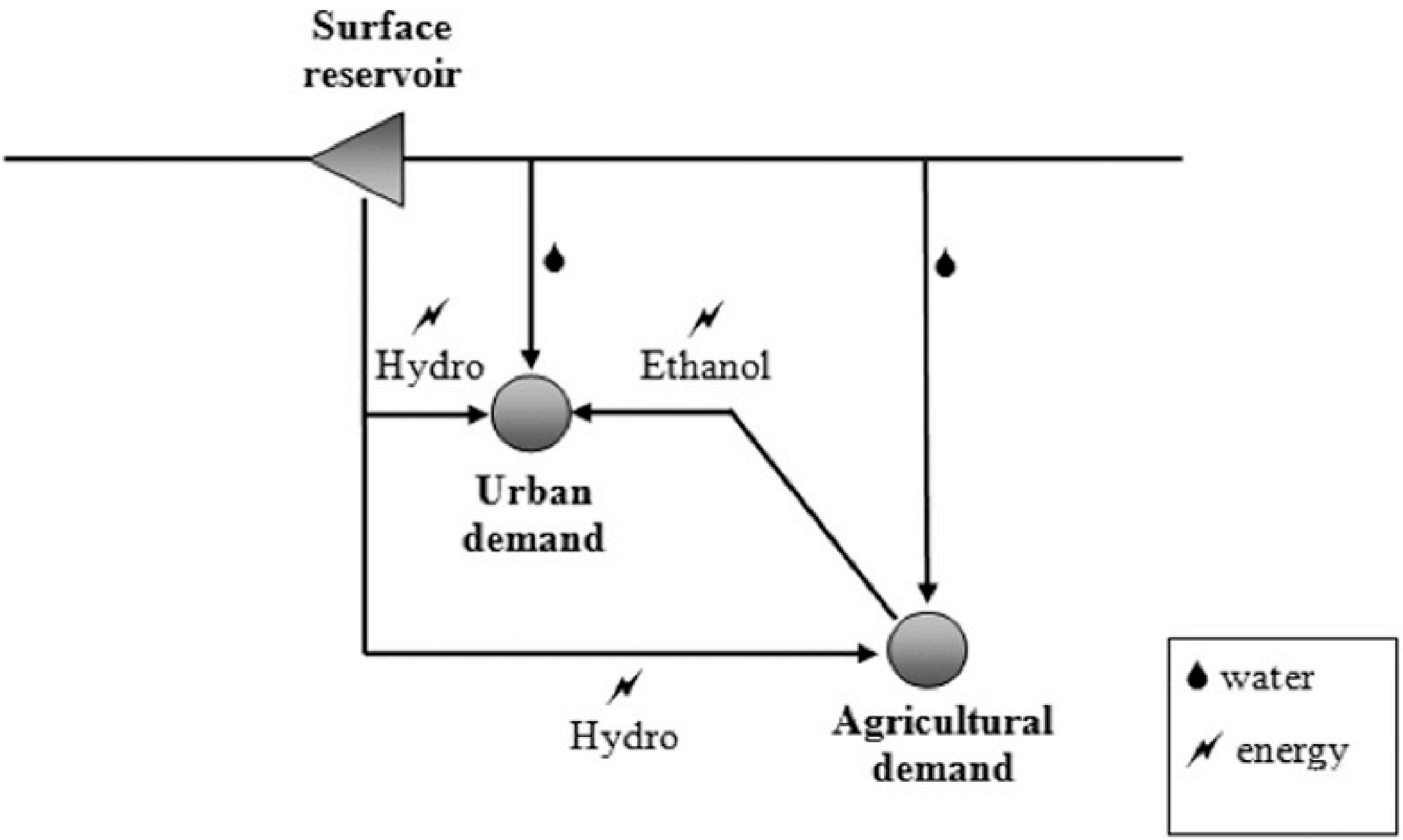
Source: Moraes et al. (2010).

Araguari River Basin, Brazil



Source: Marques et al. (2010)

Araguari River Water-Energy System

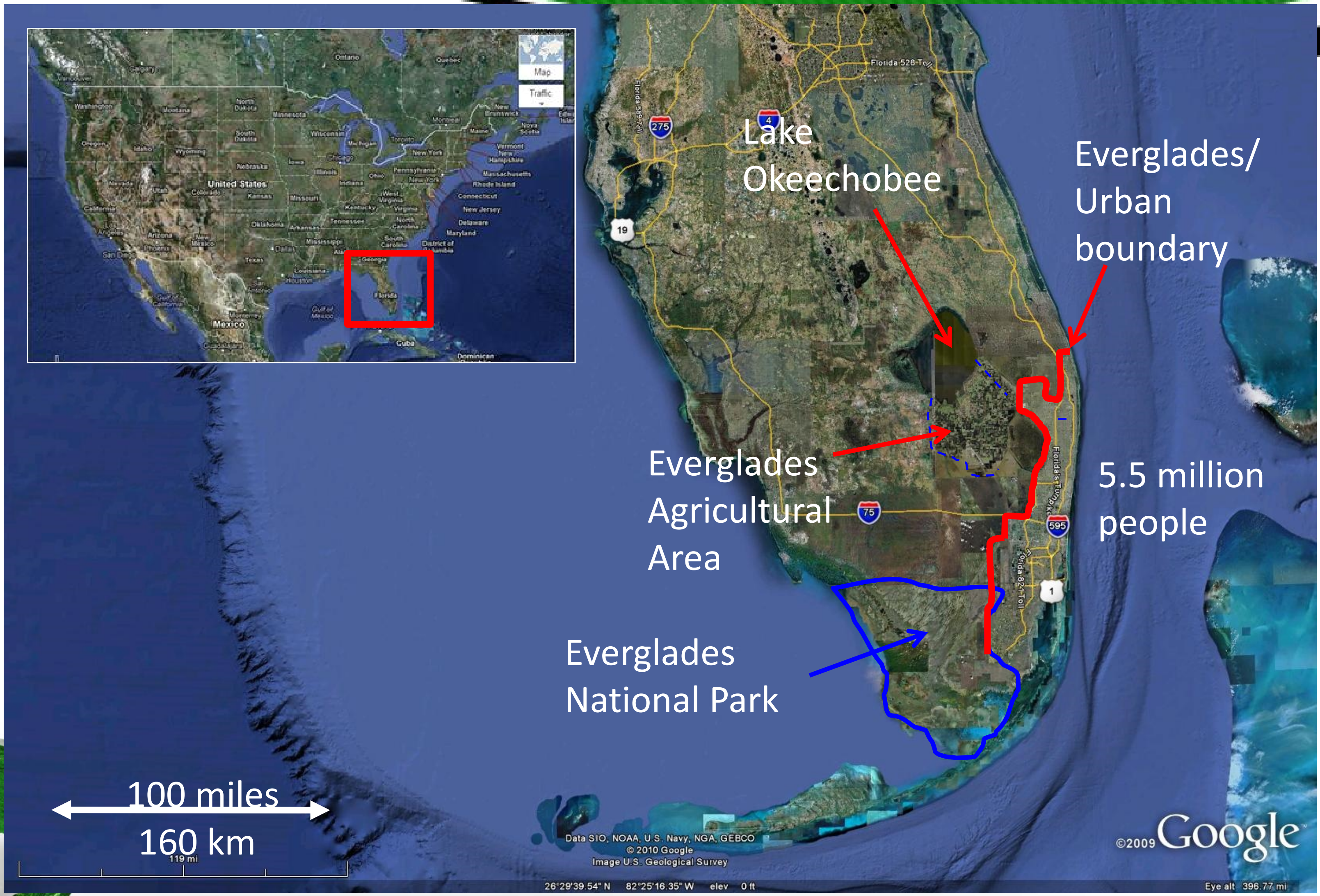


Source: Marques et al. (2010)

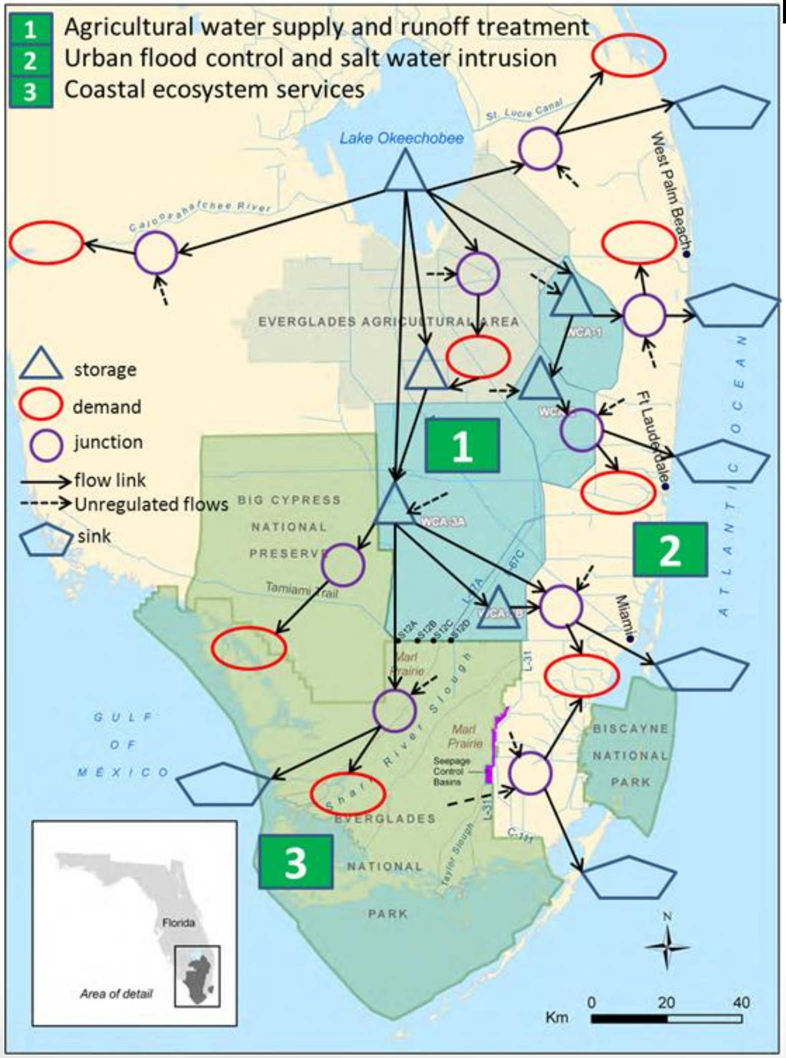
Land Use Change and Irrigated Biofeedstock Production in Brazil (Nuñez et al., 2013)

- Given vast pasture lands, Brazil may be able to help meet demands for bioethanol in domestic and international markets, but sugarcane expansion could be limited by water availability.
- An economic simulation model considers competition for limited resources between sugarcane and other major crops and determines the equilibrium in global commodity and fuel markets.
- Without water limitations, 21 million ha of additional land is allocated to crop production (50% increase) by 2030, 60% of which is used for sugarcane production.
- With water scarcity, lands allocated to corn and soybeans increase slightly, and the sugarcane area is reduced ~40%, mainly due to water scarcity in regions that are most suitable for sugarcane production.

South Florida, USA



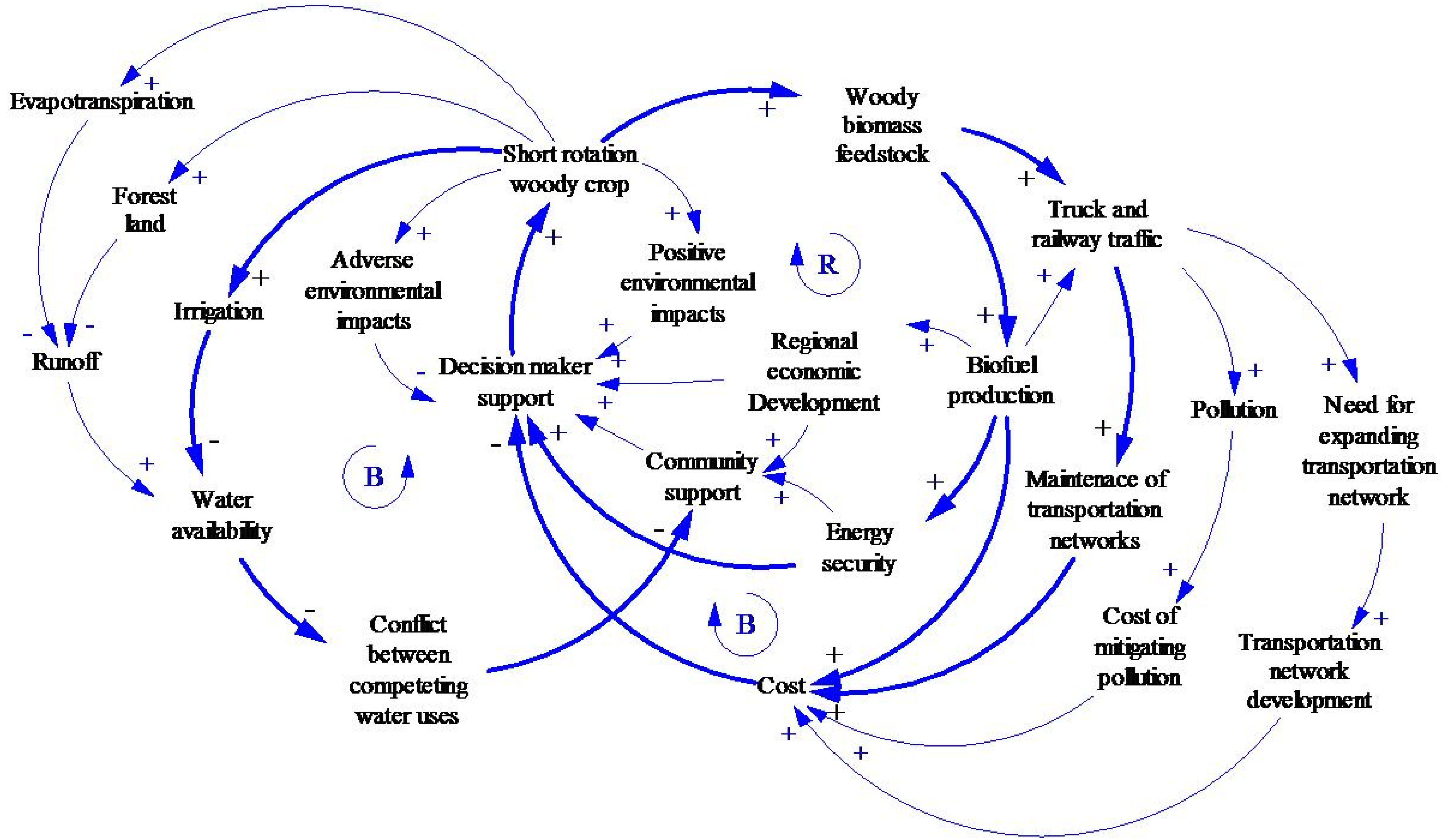
Hydro-economic Modeling



Stormwater Treatment Areas

http://sofia.usgs.gov/publications/ofr/2007-1374/

A Broader Systems Approach



Conclusions and Recommendations

- Research is needed to better understand hydrologic impacts and trade-offs of many bioenergy systems, particularly monoculture and mixed forest-based systems.
- Water quality impacts of bioenergy systems are expected to be similar to those of other agricultural systems, where best management practices can greatly reduce impacts.
- Cumulative impacts of large-scale bioenergy development at watershed scales may be difficult to avoid, however, due to spatial variability in factors affecting pollutant transport to affected water bodies (e.g., soils, fertilizer application rates, drainage networks).

Conclusions and Recommendations

- Although integrated management approaches can significantly increase water use efficiency and reduce water quality impacts, bioenergy production in many locations is expected to be limited by water availability in the near future.
  - Country-level analysis are often not appropriate for policy making.
- Water use policies and instruments for bioenergy must be evaluated not only in relation to their effectiveness and efficiency, but also with respect to their socio-economic impacts.
  - Policies should be evaluated based on measures of direct and indirect economic impacts, impacts on all water users and uses, and lifecycle impacts.