Socioecological Tradeoffs of Bioenergy

Kathleen E. Halvorsen,
Social Sciences Department, Environmental and Energy Policy Program; School of Forest Resources and Environmental Science

Acknowledgements

- National Science Foundation Partnerships in International Research and Education (PIRE) Program; National Science Foundation Research Coordination Network (RCN) Program; USAID PEER Program; InterAmerican Institute for Global Change Research (IAI) CRN3 Program; MTU Sustainable Futures Institute and Ecosystem Science Center

- Jill Fisher, Rob Handler, Amy Spahn, and ≥ 100 other PIRE team members…

Policy scientist

- Policy studies using sociological, political science, economic methods and theories
- In interdisciplinary teams with social, natural, and engineering scientists
- Climate change-related:
  - Mitigation through bioenergy
  - Adaptation through water management
  - Public understandings of causes, impacts, solutions
- North and South Americas focus

Forests and Climate Change

- Biological carbon sequestration
  - Afforestation
  - Retention
  - Regeneration post-harvest
- Substitution for fossil fuels:
  - Bioenergy

Climate Change & Forests

- Global release 8 Gt CO2 year fossil fuels, deforestation; plants absorb 2.5 Gt year (Gt = 1 bill tons)

- Forests – could sequester an additional 60-87 Gt (total by 2050)

- Globally, forests store 2/3 terrestrial carbon mostly in soil, only a fraction stored in tree biomass (~ 20% for temperate forests)

(IPCC 2001 cited in Smith R.A., B.L. McFarlane, J.R. Parkins, and P.A.M. Pohrebniuk 2005)

What is Bioenergy?

- Energy from biological materials
- Used to produce heat, power (electricity), liquid transportation fuels (biofuels)

Bioenergy Feedstocks

- Heat and power (electricity)
  - Wood and wood mill/harvesting residues
- Biodiesel
  - Soybeans
  - Jatropha oil
  - Algae
  - Wood and wood residues
  - Palm oil
  - Agricultural residues
- Ethanol
  - Corn
  - Grasses
  - Wood and wood residues
  - Sugarcane
  - Algae
  - Agricultural residues

Fossil Fuels as an Energy Source

- Coal, petroleum, natural gas
- Benefits:
  - Established extraction, production and consumption infrastructure
  - Abundant domestic supplies: coal, natural gas
  - Relatively cheap, portable, intensive

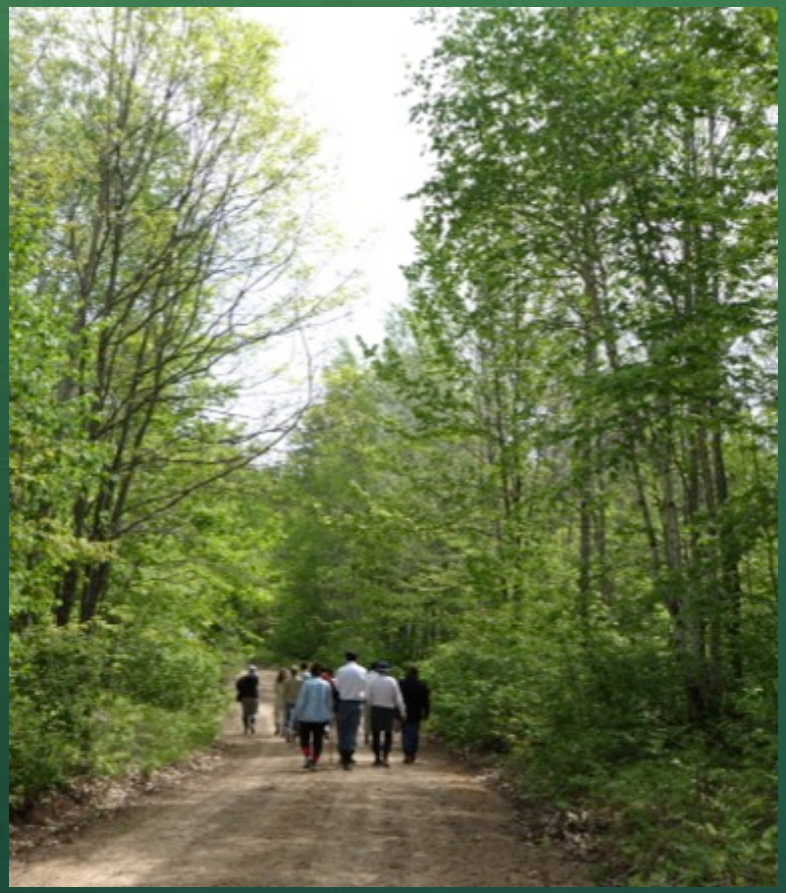
Fossil Fuels as an Energy Source

- Costs:
  - Finite supply
  - Reliance foreign petroleum, expense of protecting that supply
  - Environmental impacts of extraction
  - Environmental impacts of processing and transportation
  - Environmental impacts of combustion
    - Air, water, soil pollution; habitat loss
    - Climate change and greenhouse gas emissions

Bioenergy and Tradeoffs

- Positives:
  - Avoid reliance on foreign fossil fuels, cost, political instability
  - Avoid negative environmental impacts of fossil fuel extraction
  - Local, regional availability
  - Economic development
  - Renewable versus nonrenewable, flexible
  - Carbon loop closure

Bioenergy: Closing the Carbon Loop

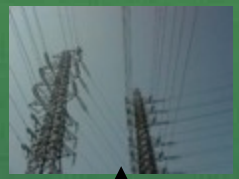


Bioenergy and Tradeoffs

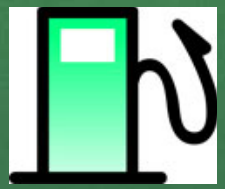
- Negatives:
  - Environmental impacts - soils, water, biodiversity
  - New system – difficult to develop and integrate, high risk
  - Low-value, low-btu energy feedstocks
  - Disagreement about carbon benefits
  - Imposition of new, international system on human communities – loss of land rights, unstable jobs

Michigan Technological University Wood-to-Wheels (W2W) Research Team

Research Thematic Areas (Shonnard et al. 2008)



Sustainability Assessments / Decision-Making

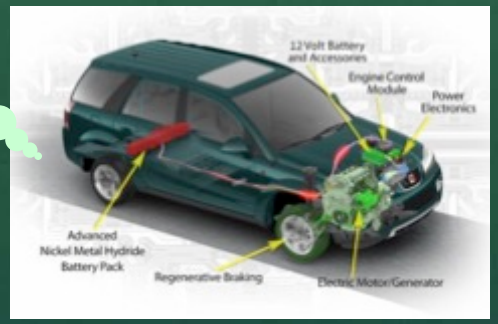


Bio-Processing Research

Photo: Glacial Lakes Energy

Woody Biomass Resource Research

CO_2



Vehicle Systems Research

PIRE Team Research Question

How is Pan American forest-related bioenergy development impacting socioecological systems, and associated ecosystem services, and how can those impacts best be measured, modeled, and mitigated?

Bioenergy Tradeoffs

- Reduce the likelihood of catastrophic climate change (Pimental 2008; Tilman et al. 2006)?
- Impacts on land access, local jobs, local environments (Halvorsen et al. 2011; Van Dam et al. 2009).
- Impacts on biodiversity, water quality and quantity, carbon cycling, soil nutrients (Flaspohler et al. 2008; Janowiak and Webster 2010; Webster et al. 2010).

Sustainability, Ecosystem Services, and Forest-related Bioenergy Development across the Americas

- Six countries: Argentina, Brazil, Canada, Mexico, Uruguay, and the United States
- 100+ social, natural, and engineering scientists and students
- Four subteams: Socioeconomic, Ecosystem, Metrics, and Policy
- Six bioenergy development cases
- Five years (2012-2017)

Subteam Research Questions

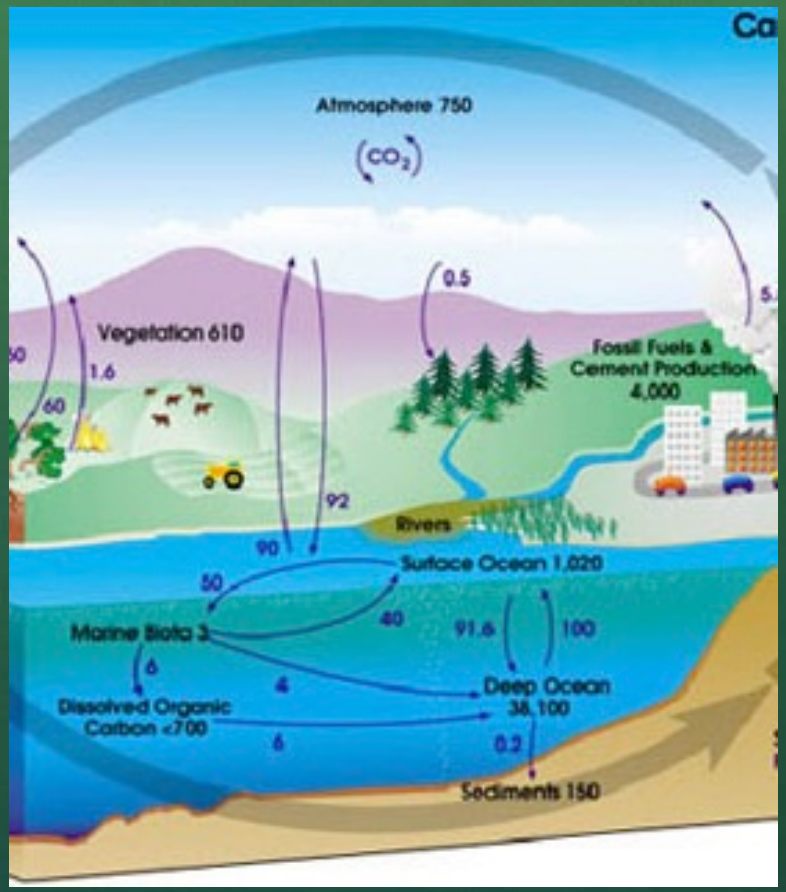
- Socioeconomic Subquestion 1: How does forest-related bioenergy development affect socioeconomic systems?
  - Culture
  - Economies
  - Environmental
  - Land tenure

Subteam Research Questions

- Ecological Subquestion 2: How does forest-related bioenergy development affect ecological systems?
  - Carbon and other soil nutrients/components
  - Biodiversity:
    - Pollinators
    - Birds
  - Water quality and quantity

Subteam Research Questions

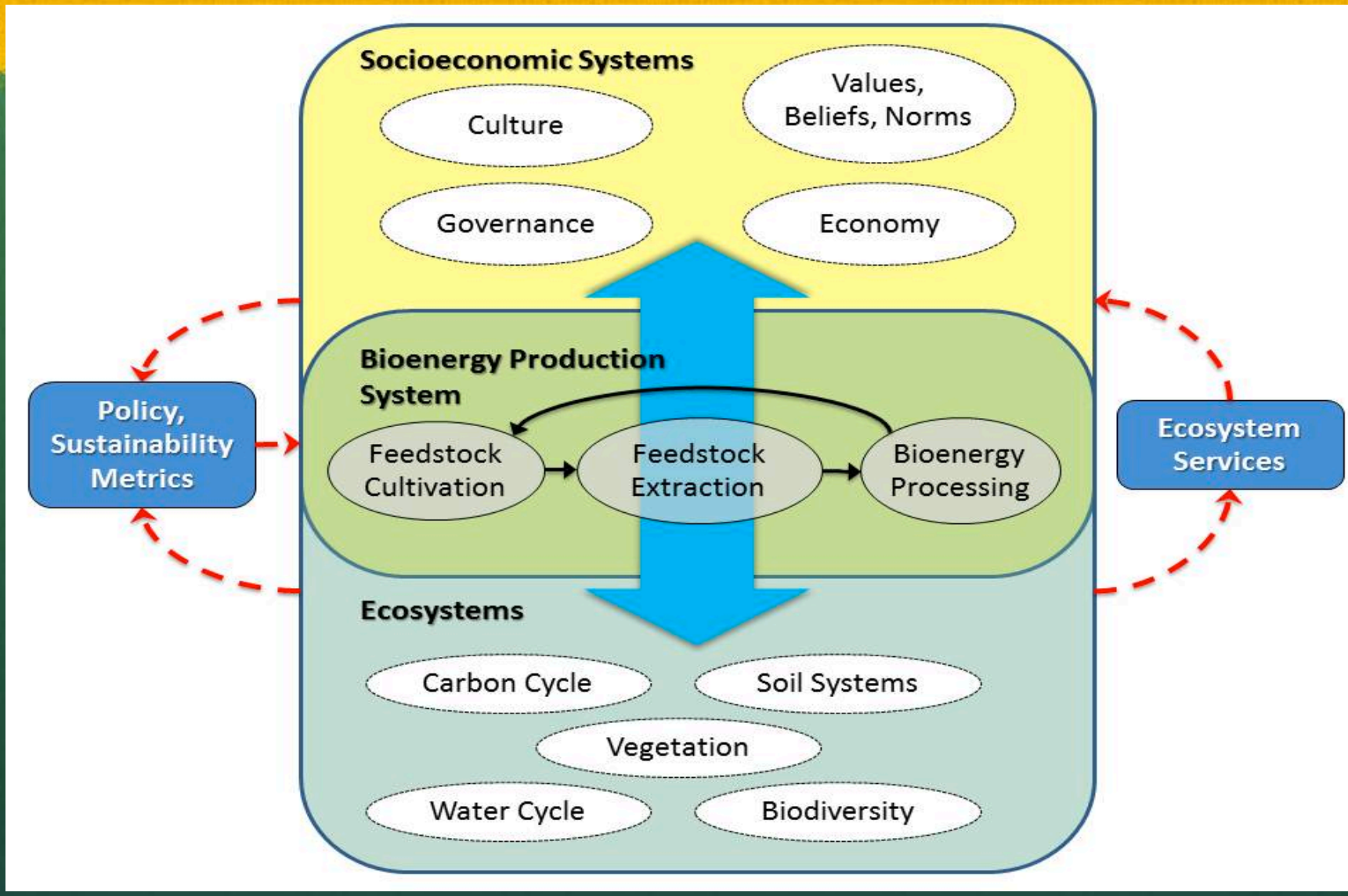
- Metrics Subquestion 3: What sustainability indicators and metrics best assess forest-related bioenergy sustainability across highly variable Pan American socioecological systems?



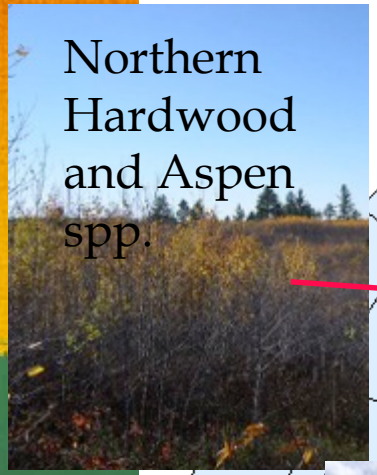
Subteam Research Questions

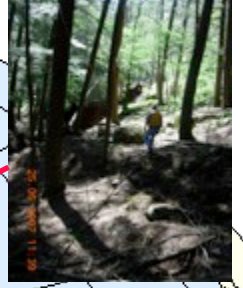
- Policy Subquestion 4: How can policy minimize negative forest-related bioenergy impacts on and maximize benefits for socioecological systems?

Conceptual Framework



Study areas


Northern Hardwood and Aspen spp.

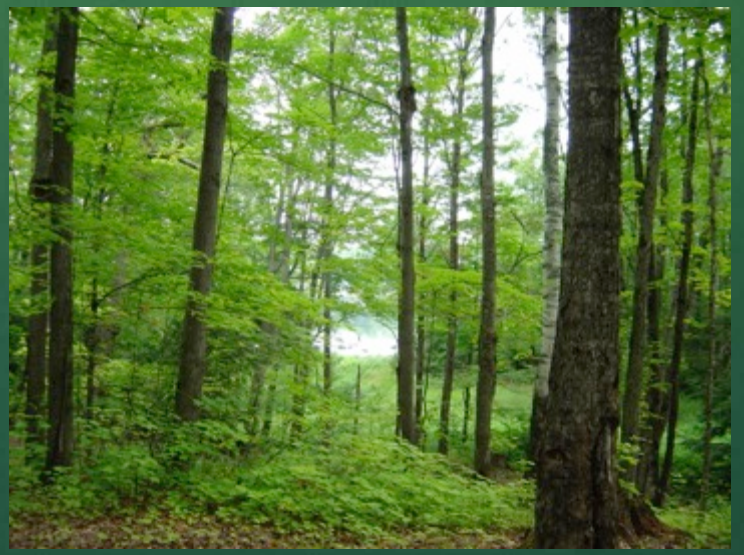

N. Hard-woods

Jatropha
Oil Palm
Eucalyptus

Case 1: Woody biomass cultivation and production for heat from eucalypts in Entre Rios, Argentina

Case 2: Palm oil-based cultivation and production for biodiesel in Para, Brazil

Case 3: Atitkokan woody biomass cultivation and production for electricity in Ontario, Canada



Case 4: Jatropha cultivation and production for biodiesel in Yucatan, Mexico

Case 5: Oil palm cultivation and production for biodiesel in Tabasco, Mexico

Case 6: Eucaplyptus cultivation and production for heat and power in Fray Bentos, Uruguay

Case 7: Rothschild woody biomass cultivation and production for heat and power in Wisconsin, USA

Uruguayan country team: Improving the quality of bioenergy-related sustainability indicators and metrics

Some early results

Socioeconomic/Policy Subteam Data

- 2013-2015 800+ qualitative interviews across 5 countries, policy makers, proximate community members

- 2015 1000+ quantitative surveys of proximate community makers across 4 countries

Argentina Qualitative Results: How are communities impacted by increased eucalyptus and pine plantations? (Chelsea Silva, Northern Arizona University)

- Clear differences in perceptions between La Criolla and Ubajay

"…our community has changed…from very poor to…modest and it was primarily due to the sawmills…" [Interviewee in Ubajay]

- *"…today everyone invests in wood, but only three or four people actually benefit from it because [tree plantations] do not demand much labor. On the other hand, citrus provides a lot of jobs…" [Interviewee in La Criolla]*

- Characteristics of well-being perceived more positively in Ubajay

- Similarities in descriptions of labor conditions and ecological effects (e.g. water regulation)

Results: N. WI, USA Local Support for Harvesting Woody Biomass for Electricity (Brad Barnett, MTU)

General support for forest biomass to be used for electric production	
Yes	49.3%
No/Neutral	50.7%
N = 278	
Confidence Interval = +/- 5.63%, 95% confidence level	

Support for specific forest biomass sources to be used for electricity production					
Source	Support	Neutral	Opposed	N	Confidence Interval
Mill residues	84.3%	8.4%	7.3%	286	+/- 5.54%
Forest residues	81.5%	8.7%	9.8%	287	+/- 5.53%
Low-value timber	62.4%	28.0%	9.6	282	+/- 5.58%
Land clearings for development	32.0%	25.2%	42.8%	283	+/- 5.57%
Forest thinnings to improve forest health	85.4%	11.8%	2.7%	287	+/- 5.53%
County-owned forestland	38.1%	32.2%	29.7%	283	+/- 5.57%
Privately-owned forestland	32.9%	42.4%	24.7%	283	+/- 5.57%
Confidence intervals estimated based on 95% confidence level					

Ecosystem Subteam Research

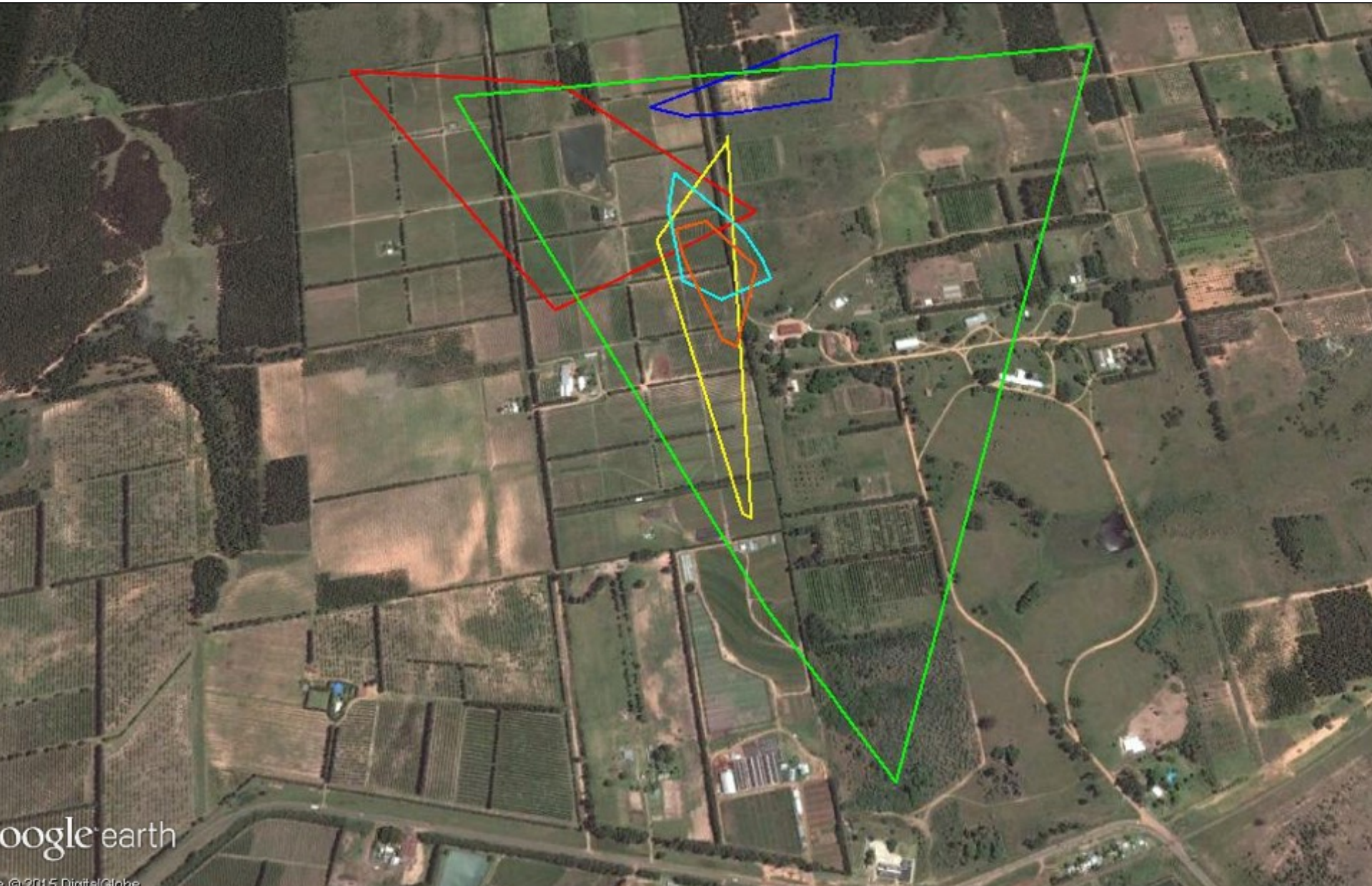
- Data collection across 4 countries on impacts of bioenergy projects on:
  - Birds,
  - Pollinators,
  - Soil nutrients,
  - Water quality,
  - Water Quantity.

WI USA Pollinator Results – the Numbers (Colin Phifer, David Flaspohler, Chris Webster)

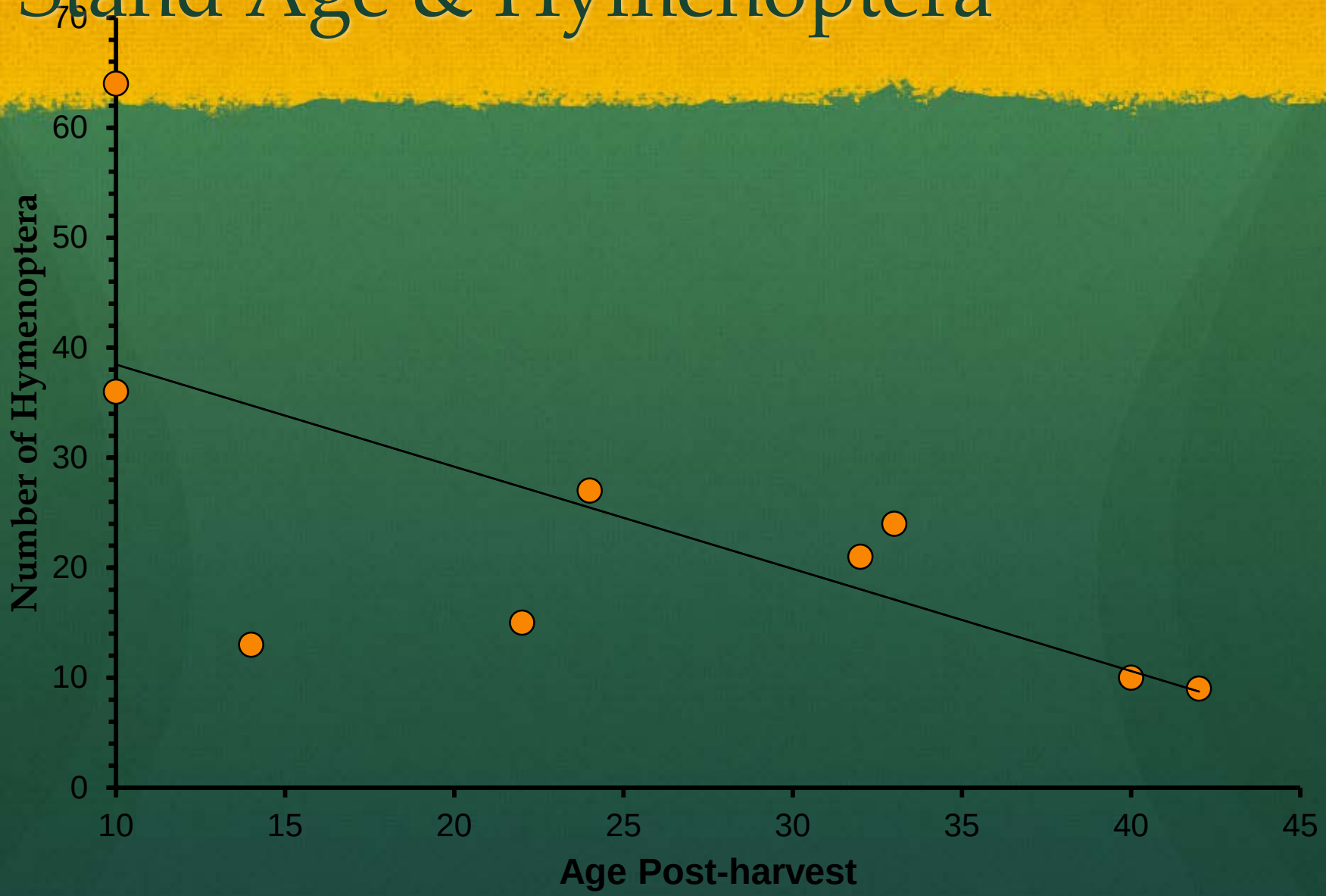
- How are bees being impacted by harvesting for bioenergy? (aspen, mixed hardwood, younger versus older stands)
- More than 1,600 insects collected! ~ 75% Ided family, and many to genus
- ~ 500 bees or wasps (priority for ID)
- 576 veg plots completed
- 3,456 floral surveys completed

Corrientes, Argentina
Bumblebee Telemetry (Phifer, Cavigliasso, et al.)

Argentina Bumblebee Telemetry Preliminary Results



2014 WI USA Bee Results – Forest Stand Age & Hymenoptera



Forest Reserve

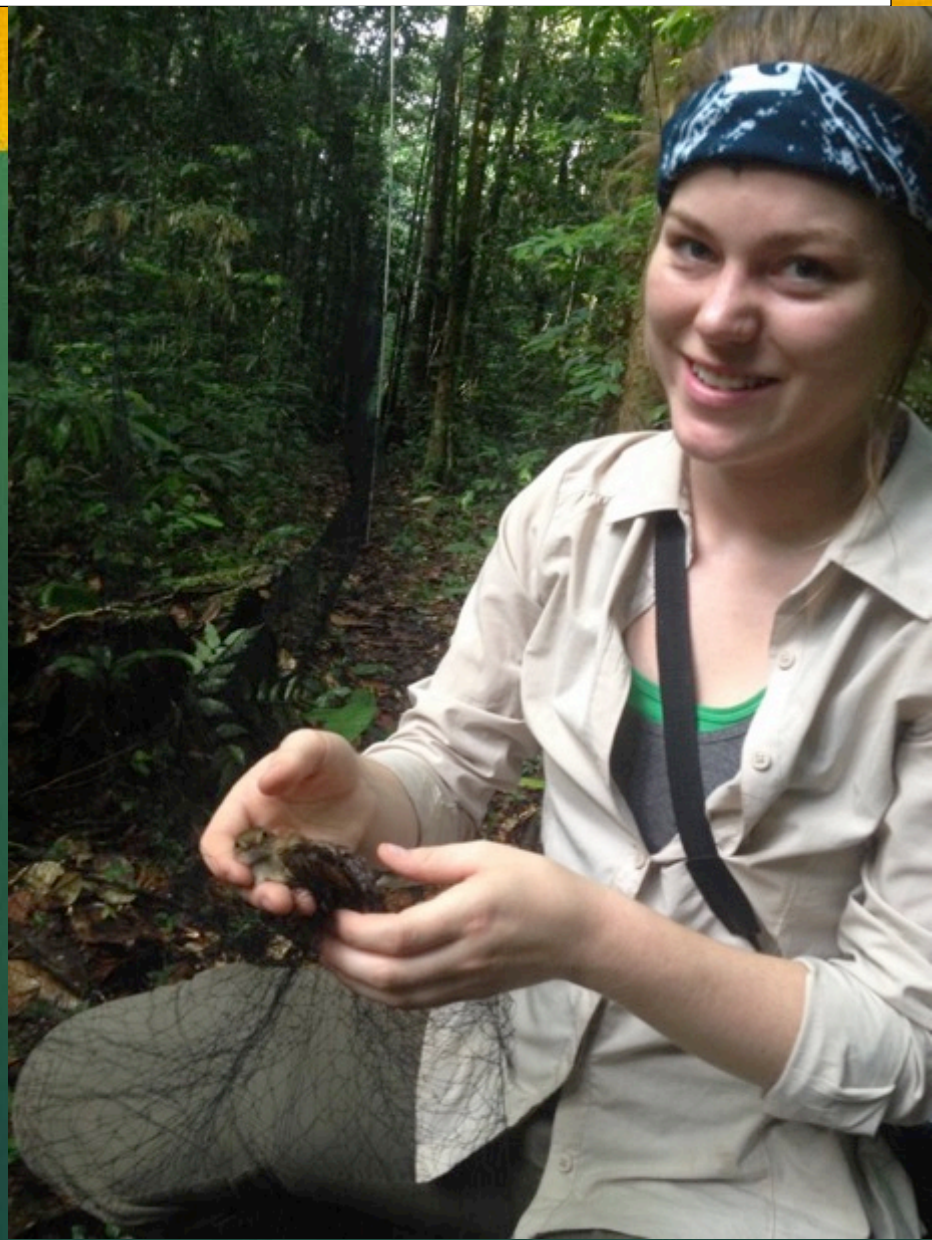
Organic Palm

Conventional

APP

Para, Brazil Methods – Palm Plantation Bird Impacts (Knowlton, Fiser, Becker, Flaspohler, Persio et al.

- Cinereous Antshrikes (*Thamnomanes caesius*)
- Mist-netted birds along forest trails with targeted recordings and tagged
- *Control* – released in forest
- *Treatment* – translocated across palm and released in APP
- Birds relocated daily and GPS location marked
- Compare home ranges and path taken back to forest



Results - Birds

- 18 birds captured and radio-tagged
  - 9 Control – released in forest near net
  - 9 Treatment – translocated to APPs, up to 4 km away
- Most translocated birds "homed" to where captured and reestablished territories
- Most took the longer route back through the APPs!
- Comparing home ranges using Minimum Convex Polygon and Kernel Density

Tears and S'mores…ID, int'l science teamwork challenges and solutions

The tears…


INTA

And s'mores….

Annual PIRE meeting, Houghton 2015


VIVA

International, Interdisciplinary Teamwork Challenges

- The larger and more heterogeneous the group, the greater the challenges
- Integration across disciplines, countries
- Sustaining interest over time and space
- Effective communication across time, space, and disciplines
- Ensuring respect across disciplines and countries

Int'l, ID Science Teamwork Best Practices

(from Halvorsen et al. 2016; Pischke et al. In dev.)

- The development of group cohesion and identity takes time but it is essential to success
- Choose members wisely for social *and* scientific skills, choose experienced core members
- Be more explicit and organized about roles, goals, structure, leadership
- Include discussion, resolution of different norms of respect, terms, methods, cultures, expectations

PIRE Project Strategies

- Structure: Four subteams, Six country teams
- Subteam and Country team leaders
- Metrics and Policy components enhance integration
- Monthly Project Director/Subteam leader, Subteam, Full team GoToMeeting and Instant Conference calls
- Yearly in-person meetings, rotating between countries

Questions?