The challenge of optimizing payment for watershed services programs: Modeling socio-hydrologic systems in Veracruz, Mexico

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Report: Majority Of Earth's Potable Water Trapped In Coca-Cola Products

CORVALLIS, OR—Fueling humanitarian concerns over the vital resource's scarcity in many parts of the world, a report published Wednesday by researchers at Oregon State University has found that 68 percent of the earth's supply of potable water is trapped in Coca-Cola products.

According to top experts, the new report marks the first comprehensive attempt to measure the planet's freshwater reserves and determine exactly how much of it is currently locked inside sources such as Coke, Diet Coke, Caffeine-Free Coke, Dr. Pepper, Barq's root beer, and other Coca-Cola beverages, making it impossible to use as drinking water, or for bathing or cooking.

For more, visit theonion.com

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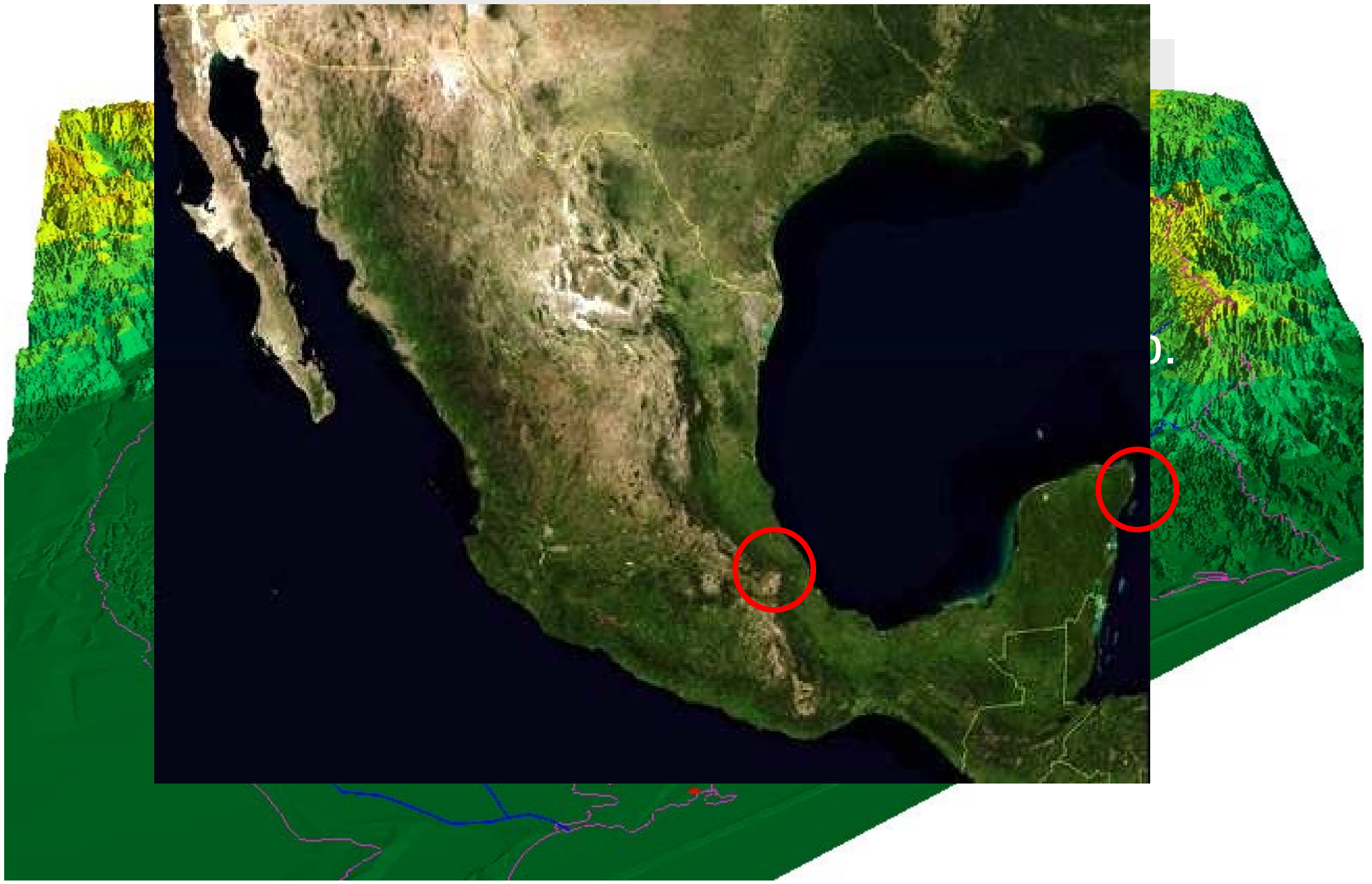
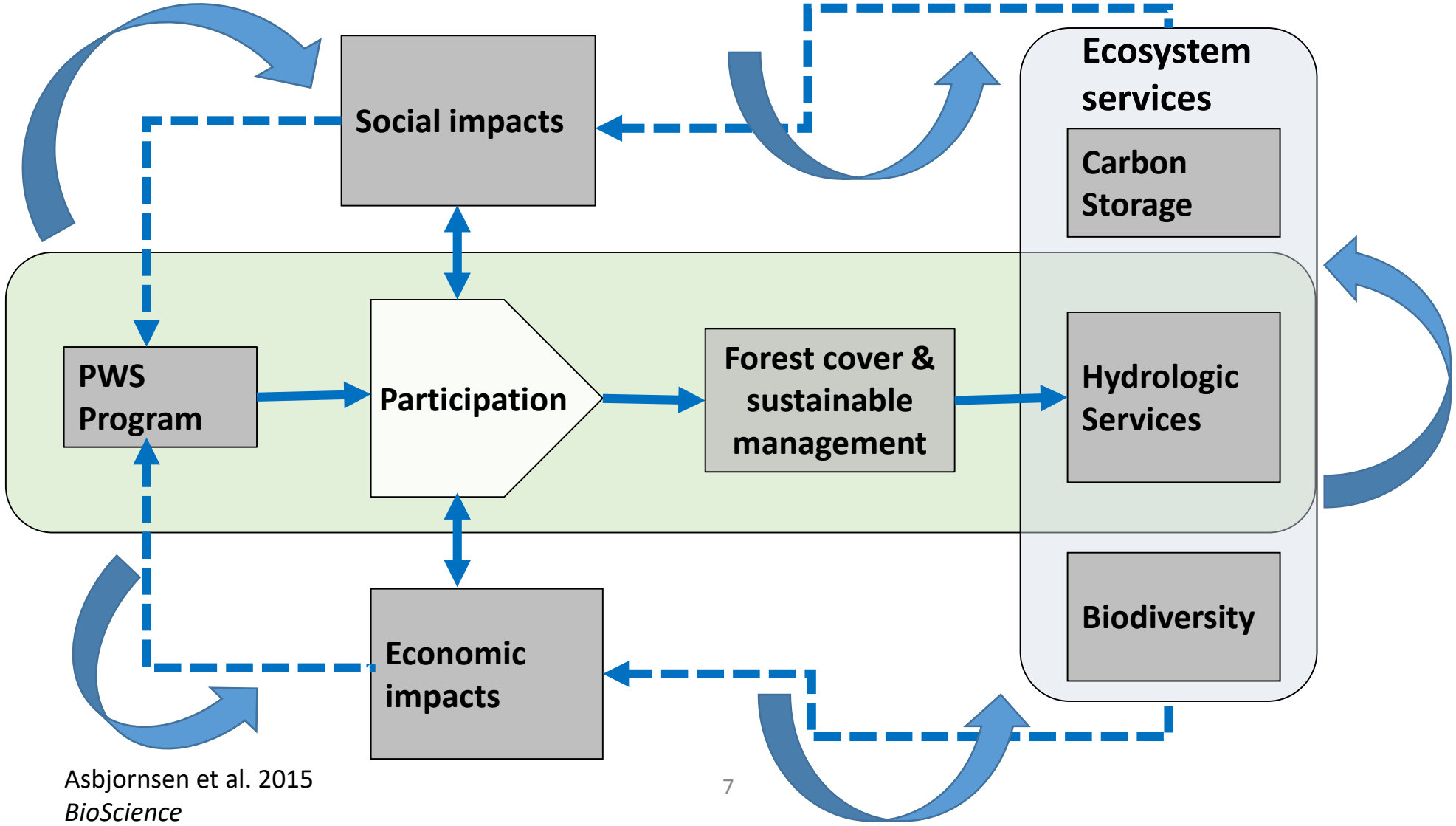
Research questions

- How do we model complex linkages between decision-making, land use and management, and ecosystem services?
- Can modeling of socio-ecological systems contribute to payment for watershed services programs (PWS) design?
- How do we define optimality in PWS program design?



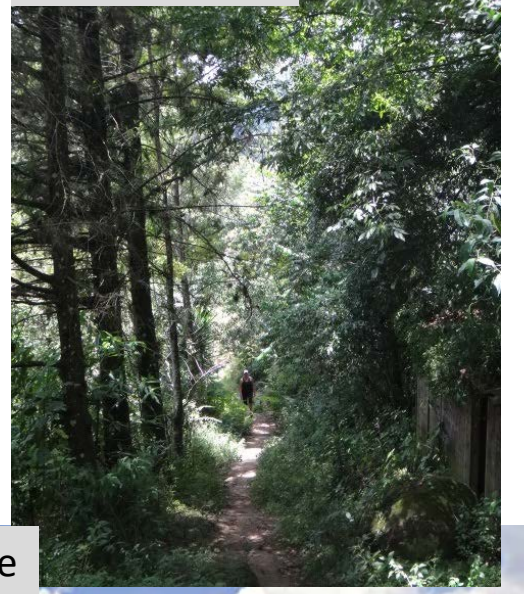

Water
Biodiversity
Carbon

Conceptual Framework



Asbjornsen et al. 2015
BioScience

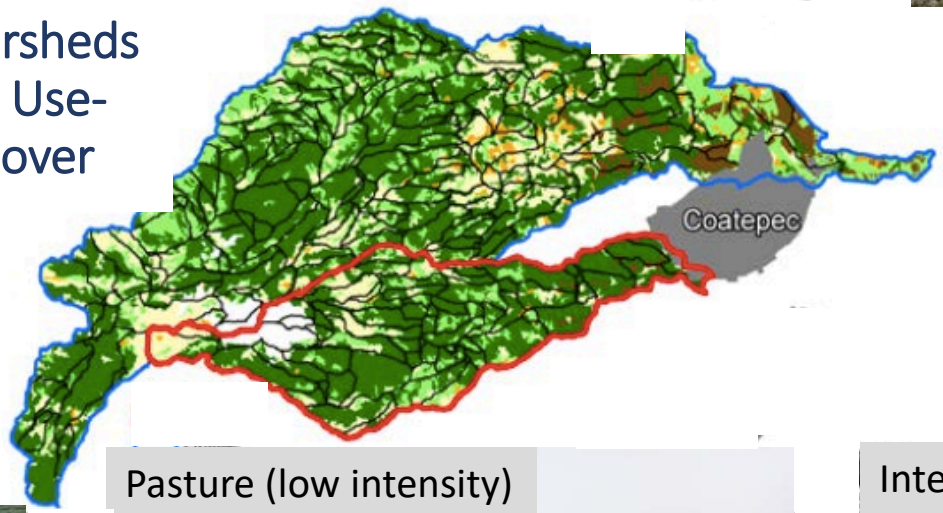
Mature Forest



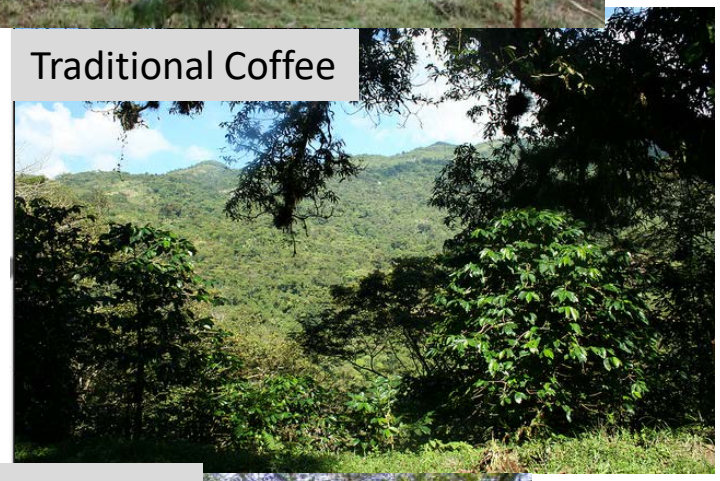
Regenerating Forest

Young Forest

2 watersheds
8 Land Use-Land Cover Types



Traditional Coffee



Sugarcane

Pasture (high intensity)

Pasture (low intensity)

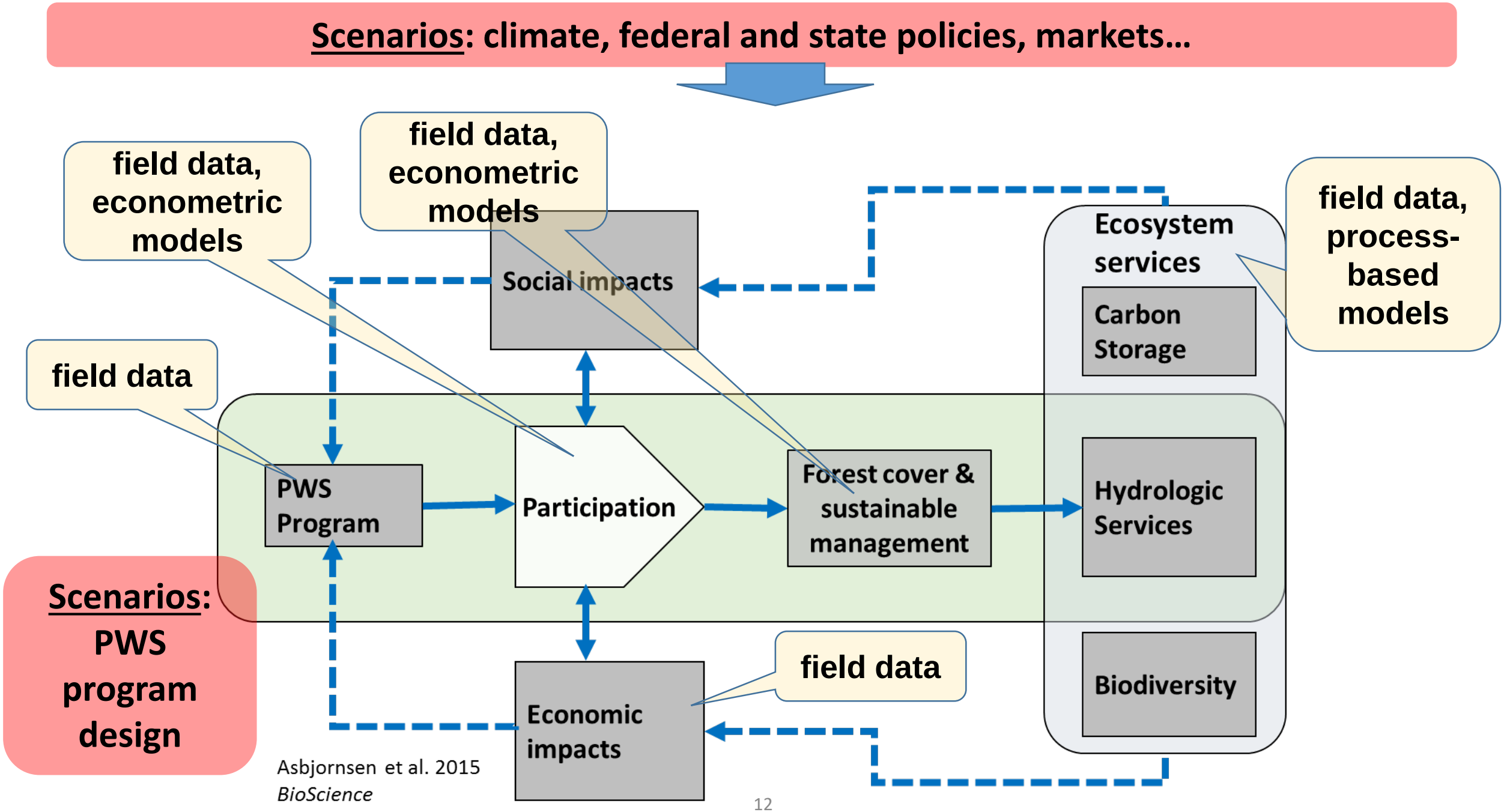
Intensive Coffee

Data Collection: Biophysical System

Data Collection: Socioeconomic Dimensions

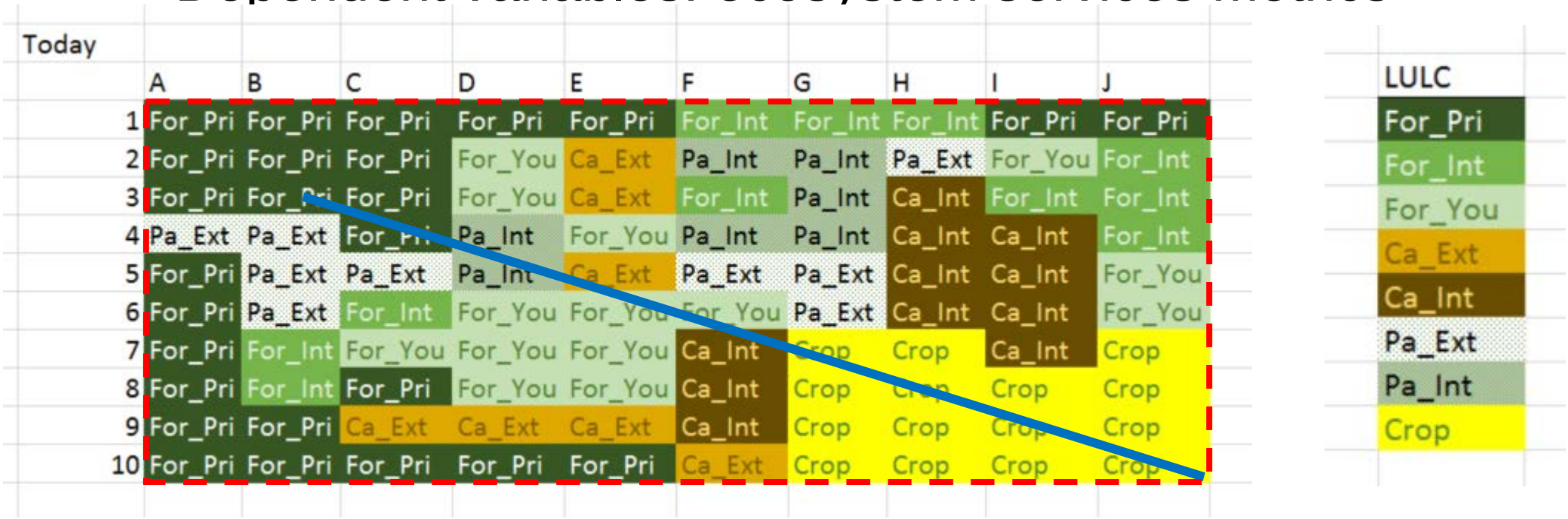
A few results from fieldwork

- For the most part, older forests tend to be “better” in terms of ecosystem services metrics and pastures and crops tend to be “worse” (Berry et al.)
- But, there are some unexpected results for biodiversity and flows which will likely lead to tradeoffs between ecosystem services (Berry et al.)
- PWS participants tend to be older, environmentally inclined, and own more land area compared to non- participants. (Salcone & Jones)
- ~70% of participants would not change their land use if the PWS program did not exist (low additionality). (Cordoba & Selfa)


Scenarios: climate, federal and state policies, markets…
field data, econometric models
field data, econometric models
field data, process-based models
field data
Social impacts
Ecosystem services
Carbon Storage
PWS Program
Participation
Forest cover & sustainable management
Hydrologic Services
Biodiversity
Economic impacts
field data
Scenarios: PWS program design
Asbjornsen et al. 2015
BioScience

“Toy” model

- Pixels = land use/land cover (LULC) type
- Independent variables (socioeconomic, biophysical)
- Dependent variables: ecosystem services metrics



Model parameterization (watershed pixels)

- **Independent variables**
- Socioeconomic
  - Income
  - Conservation awareness
- Biophysical
  - Soil physical properties
  - Slope
  - Precipitation

- **Dependent variables:**
- Participation in PWS: model
- LULC change: model
- Low flow: model, field data
- Annual yield: model, field data
- Biodiversity: field data
- Carbon storage: field data
- **Watershed Sustainability Index** = equal weighting of above

Worst Case

	A	B	C	D	E	F	G	H	I	J
1	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Int
2	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Ca_Ext	Pa_Int	Pa_Int	Pa_Ext	Pa_Int	Pa_Int
3	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Ca_Ext	Pa_Int	Pa_Int	Ca_Int	Pa_Int	Pa_Int
4	Pa_Ext	Pa_Ext	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Ca_Int	Ca_Int	Pa_Int
5	Pa_Int	Pa_Ext	Pa_Ext	Pa_Int	Ca_Ext	Pa_Ext	Pa_Ext	Ca_Int	Ca_Int	Pa_Int
6	Pa_Int	Pa_Ext	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Ext	Ca_Int	Ca_Int	Pa_Int
7	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Ca_Int	Crop	Crop	Ca_Int	Crop
8	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Ca_Int	Crop	Crop	Crop	Crop
9	Pa_Int	Pa_Int	Ca_Ext	Ca_Ext	Ca_Ext	Ca_Int	Crop	Crop	Crop	Crop
10	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Ca_Ext	Crop	Crop	Crop	Crop

worst case simulation:

all Forests → Intensive Pasture

Start from “initial” distribution of LULC (8 categories)

Old

	A	B	C	D	E	F	G	H	I	J
1	For_Pri	For_Pri	For_Pri	For_Pri	For_Pri	For_Int	For_Int	For_Int	For_Pri	For_Pri
2	For_Pri	For_Pri	For_Pri	For_You	Ca_Ext	Pa_Int	Pa_Int	Pa_Ext	For_You	For_Int
3	For_Pri	For_Pri	For_Pri	For_You	Ca_Ext	For_Int	Pa_Int	Ca_Int	For_Int	For_Int
4	Pa_Ext	Pa_Ext	For_Pri	Pa_Int	For_You	Pa_Int	Pa_Int	Ca_Int	Ca_Int	For_Int
5	For_Pri	Pa_Ext	Pa_Ext	Pa_Int	Ca_Ext	Pa_Ext	Pa_Ext	Ca_Int	Ca_Int	For_You
6	For_Pri	Pa_Ext	For_Int	For_You	For_You	For_You	Pa_Ext	Ca_Int	Ca_Int	For_You
7	For_Pri	For_Int	For_You	For_You	For_You	Ca_Int	Crop	Crop	Ca_Int	Crop
8	For_Pri	For_Int	For_Pri	For_You	For_You	Ca_Int	Crop	Crop	Crop	Crop
9	For_Pri	For_Pri	Ca_Ext	Ca_Ext	Ca_Ext	Ca_Int	Crop	Crop	Crop	Crop
10	For_Pri	For_Pri	For_Pri	For_Pri	For_Pri	Ca_Ext	Crop	Crop	Crop	Crop

PWS program simulation:

Target: reduce deforestation

Payment = .0001 $/pixel

Some Forests → Intensive Pasture

PWS Program Design

participation

	A	B	C	D	E	F	G	H	I	J
1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2	Y	Y	Y	Y	NE	NE	NE	NE	Y	Y
3	Y	Y	N	N	NE	N	NE	NE	N	N
4	NE	NE	N	NE	N	NE	NE	NE	NE	N
5	Y	NE	NE	NE	NE	NE	NE	NE	NE	N
6	Y	NE	N	N	N	N	NE	NE	NE	N
7	Y	Y	N	N	N	NE	NE	NE	NE	NE
8	Y	Y	N	N	N	NE	NE	NE	NE	NE
9	Y	Y	NE	NE	NE	NE	NE	NE	NE	NE
10	Y	Y	N	N	N	NE	NE	NE	NE	NE

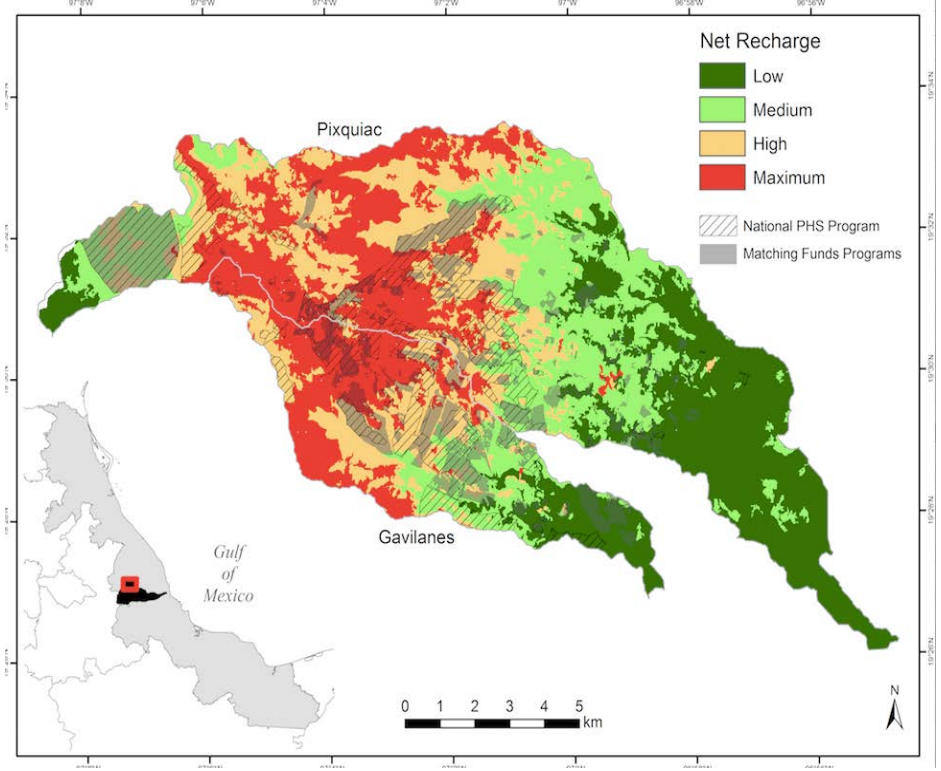
New

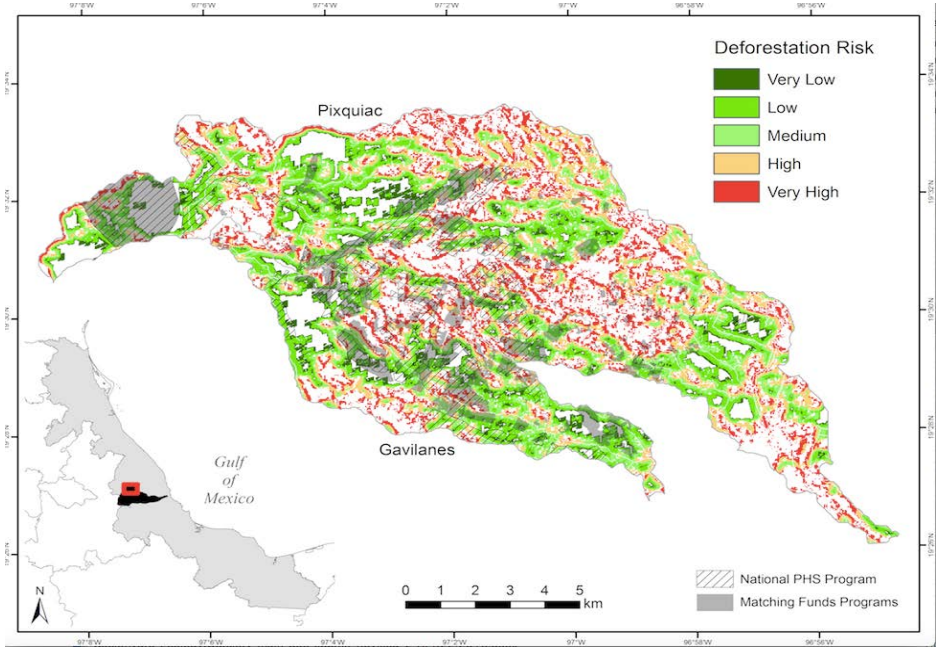
	A	B	C	D	E	F	G	H	I	J
1	For_Pri	For_Pri	For_Pri	For_Pri	For_Pri	For_Int	For_Int	For_Int	For_Pri	For_Pri
2	For_Pri	For_Pri	For_Pri	For_You	Ca_Ext	Pa_Int	Pa_Int	Pa_Ext	For_You	For_Int
3	For_Pri	For_Pri	Pa_Int	Pa_Int	Ca_Ext	Pa_Int	Pa_Int	Ca_Int	For_Int	For_Int
4	Pa_Ext	Pa_Ext	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Pa_Int	Ca_Int	Ca_Int	For_Int
5	For_Pri	Pa_Ext	Pa_Ext	Pa_Int	Ca_Ext	Pa_Ext	Pa_Ext	Ca_Int	Ca_Int	Pa_Int
6	For_Pri	Pa_Ext	Pa_Int	Pa_Int	Pa_Int	For_You	Pa_Ext	Ca_Int	Ca_Int	For_You
7	For_Pri	For_Int	For_You	For_You	For_You	Ca_Int	Crop	Crop	Ca_Int	Crop
8	For_Pri	For_Int	For_Pri	Pa_Int	Pa_Int	Ca_Int	Crop	Crop	Crop	Crop
9	For_Pri	For_Pri	Ca_Ext	Ca_Ext	Ca_Ext	Ca_Int	Crop	Crop	Crop	Crop
10	For_Pri	For_Pri	For_Pri	Pa_Int	Pa_Int	Ca_Ext	Crop	Crop	Crop	Crop

PHS Scenario: Vary PHS target/eligibility

- All Forests (LULC)
- Primary Forests Only (LULC)
- All Forests plus Coffee (LULC)
- High Hydro Recharge (Map based)
- High Deforestation Risk (Map based)

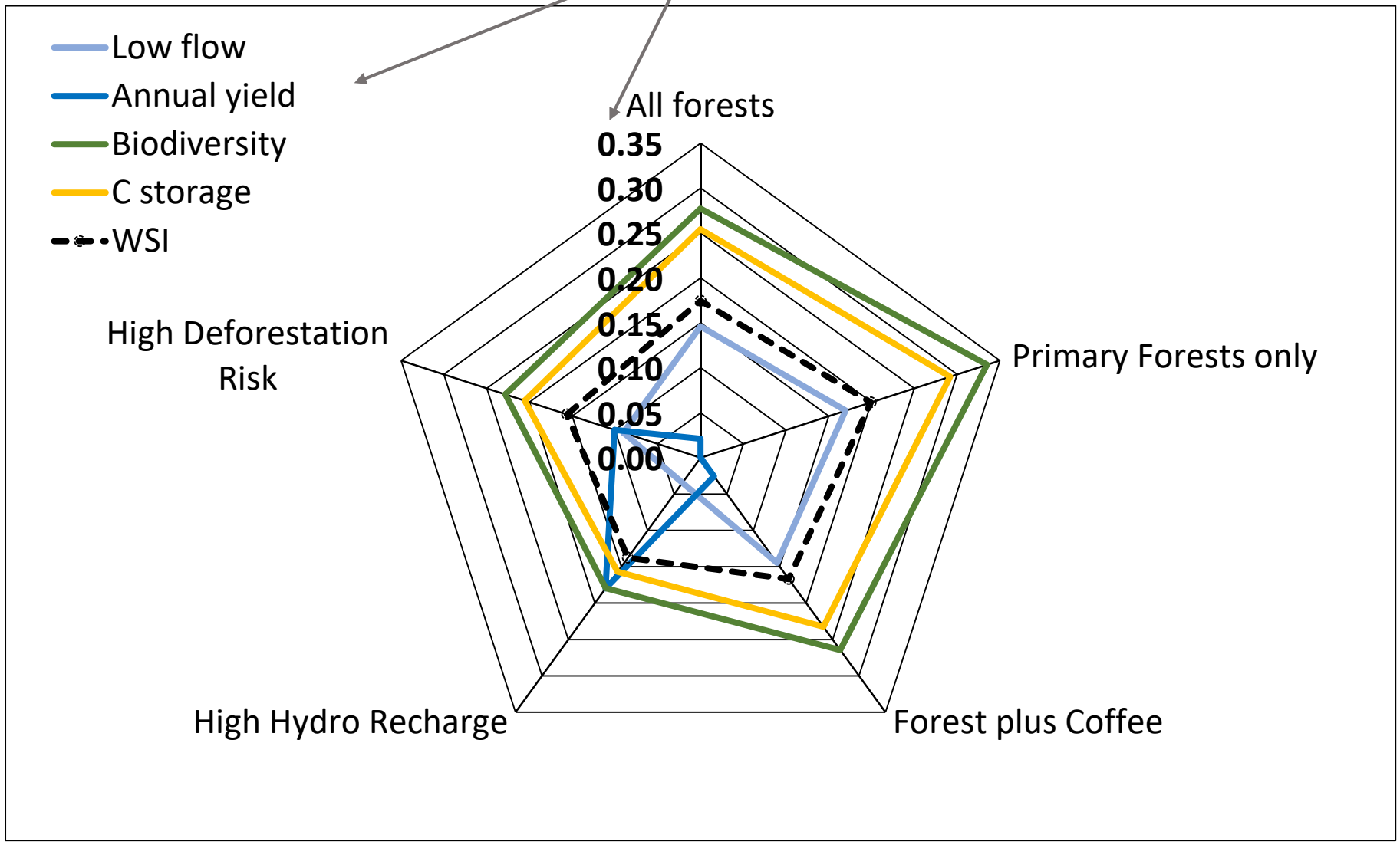
- Payment = 0.001 $/pixel





Ecosystem service tradeoffs

Values are relative to the “worst case” (conversion of all forests to intensive pasture)



Summary and Next Steps

- We've established a conceptual framework describing the complex interactions and feedbacks created by PWS within CNHS.
- We've developed and tested a "toy" PWS-CNH model that will have the ability to simulate impacts of different PWS scenarios on ecosystem service benefits and trade-offs.
- Gaps to fill:
  (a) integration of qualitative with quantitative information on outcomes and decision-making;
  (b) scaling of household- and plot-level data to the watershed level;
  (c) development of a holistic watershed sustainability index that integrates biophysical and socioeconomic metrics;
  (d) improved ecosystem services models

Payments for Watershed Services