Indicator Development for Forest Governance

IFRI Presentation

Plan for workshop: 4 parts

- Creating useful and reliable indicators
- IFRI research and data
- Results of analysis
- Monitoring to improve interventions

1. Creating useful and reliable indicators

- What is an indicator?
  - A signal about the state of a system/outcomes/ processes – descriptive *vs.* normative
- Why do we need indicators (what do indicators do?):
  - To gain low-cost, reliable knowledge about an outcome AND about how to move the outcome in a desired direction (make problems visible, highlight trends, help solve problems)

No indicators, No (effective) governance

1.1 Types of indicators for social-ecological systems

- Single indicators
- Composite indicators
- Systems of indicators

Environmental vulnerability index (EVI)

- Created for Small Island Developing States to monitor changes in vulnerability of countries
- Collection of 50 different indicators, each scored from 1-7; EVI is a composite index whose increasing values signal lower resilience
- Other example: Environmental Performance Index (Yale – 22 indicators); MDGs – 60 indicators
- Useful for detecting change, less for identifying responses

Extremely vulnerable	365+
Highly vulnerable	315+
Vulnerable	265+
At risk	215+
Resilient	<215

1.2 Pitfalls of indicator development

- Selection: intuitively appealing indicators, only outcome indicators, only a single indicator
- Interpretation: misunderstanding the implications of a given level or change in value of selected indicators
- Use: failure to examine causal/associational relations; lack of action despite examination

1.3 Monitoring *vs.* intervention indicators

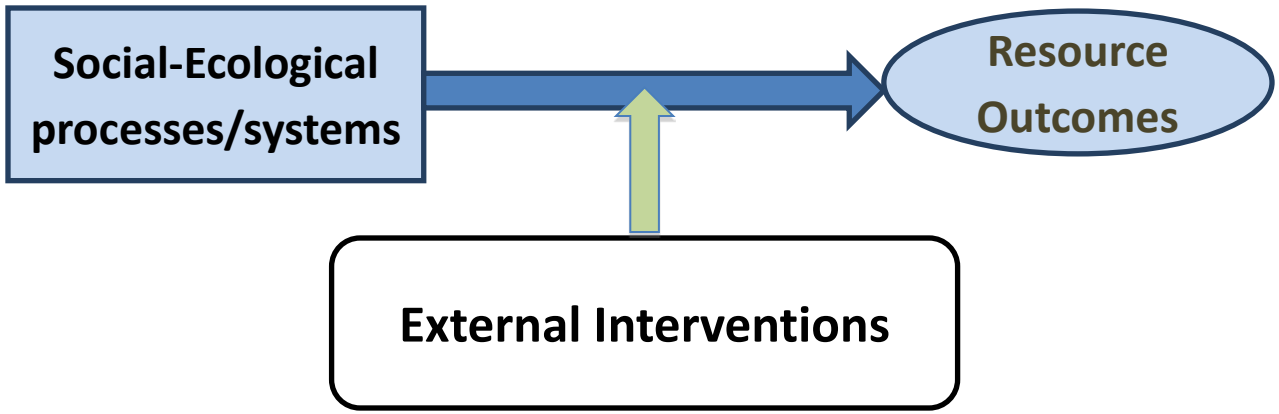
- Focus on outcomes (**performance** indicators) *vs.* attention to causal processes
- Indicators can provide two types of guidance:
  - Directing interventions to change causal processes, thereby outcomes (Examples)
  - Targeting interventions away from situations/locations where effects likely to be limited (examples)

Systems of indicators

- Enable multi-dimensional assessment of the state of a system or a problem
- When based on a system of causal relationships, enable assessment of interventions

1.4 Causal-chain based indicator systems

- For indicators to help manage change in social-ecological systems, need a causal framework



Why is IFRI research relevant?

2. IFRI research and data

- Interdisciplinary, international research network on local forest governance.
- Established in 1992, currently has 12 Collaborating Research Centers as members in 11 countries (approximately 40 researchers)
- A growing international database of cross-national, time-series information on forests, people, and institutions.

What makes IFRI different?

- Long-term investment in a coherent research program on social and ecological outcomes
- Common research instruments and data infrastructure
- Increasing number of sites with data from more than one time period – continuing data collection

2.1 What kind of data is there with IFRI

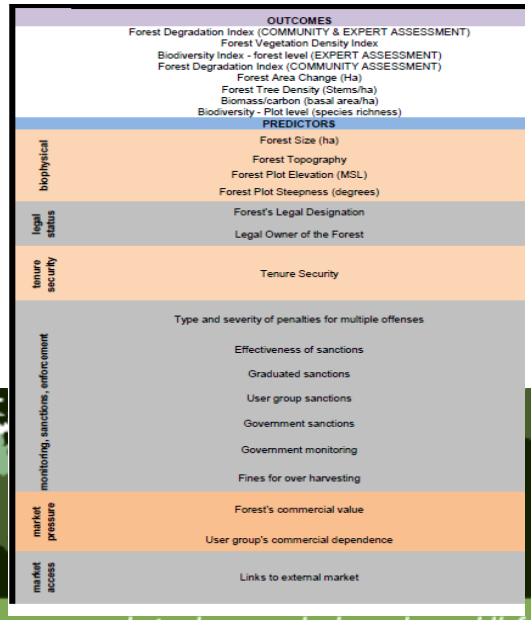
	Databases – "Collapsed"	# Variables	# Observations
1	Forest	52	475
2	Plot (P)	15	12,890
3	Product (R)	46	1454
4	User group (U)	39	722
5	Settlement(S)	22	858
6	Inter-Gov (I)	34	1009
7	Governance (V)	54	722
8	User-forest (G)	40	722
9	Association (A)	98	257

Categories	# indicators
Outcomes	8
Biophysical	4
Legal Status	2
Tenure Security	1
Monitoring, Sanctions, Enforcement	2
Market Pressure	1
Market Access	1
Dependence	2
Poverty	2
Local Autonomy	2
Governance	6
Accountability	2
Population	1
Social cohesion	4
Education	1

Why is IFRI data useful for indicator development?

Breakout group discussion on desirable qualities of indicators for forest outcomes;

Illustrative list of indicators – build on list sent out to participants (30 minutes-Basis for mobile data collection app)



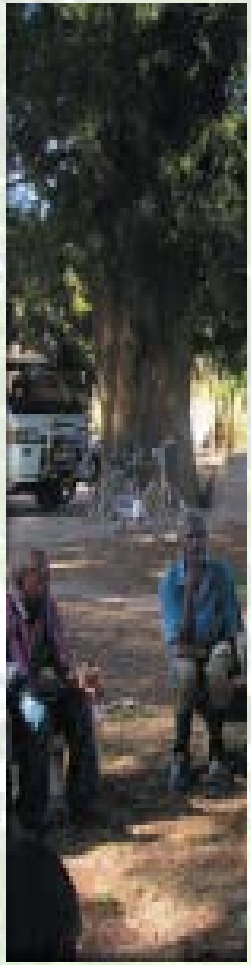
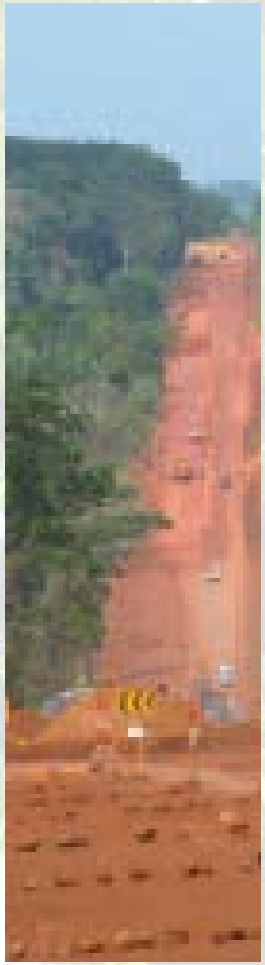
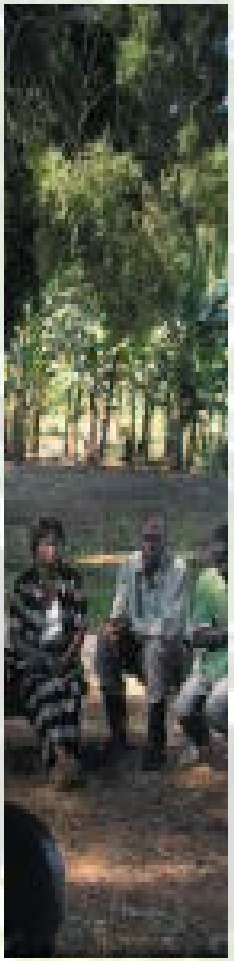
	OUTCOMES
	Forest Degradation Index (COMMUNITY & EXPERT ASSESSMENT)
	Forest Vegetation Density Index
	Biodiversity Index - forest level (EXPERT ASSESSMENT)
	Forest Degradation Index (COMMUNITY ASSESSMENT)
	Forest Area Change (Ha)
	Forest Tree Density (Stems/ha)
	Biomass/carbon (basal area/ha)
	Biodiversity - Plot level (species richness)
	PREDICTORS
biophysical	Forest Size (ha)
biophysical	Forest Topography
biophysical	Forest Plot Elevation (MSL)
biophysical	Forest Plot Steepness (degrees)
legal status	Forest's Legal Designation
legal status	Legal Owner of the Forest
tenure security	Tenure Security
monitoring, sanctions, enforcement	Type and severity of penalties for multiple offenses
monitoring, sanctions, enforcement	Effectiveness of sanctions
monitoring, sanctions, enforcement	Graduated sanctions
monitoring, sanctions, enforcement	User group sanctions
monitoring, sanctions, enforcement	Government sanctions
monitoring, sanctions, enforcement	Government monitoring
monitoring, sanctions, enforcement	Fines for over harvesting
market pressure	Forest's commercial value
market pressure	User group's commercial dependence
market access	Links to external market

3. Preliminary analyses with IFRI data to identify relevant indicators:

Random Forests for IFRI Forests- A new tool for exploratory data analysis

3.1 Background

- High dimensionality problem (small n large p) in the analysis of IFRI data
  - ❖ Especially problematic for country and regional level analysis
- High dimensionality problem compounded by the need to study complex interactions between predictors to understand outcomes of interest




3.2 Motivation

- Standard parametric models often suffer from problems with small n (cases) and large p (predictors)
  - Interaction effects
  - Restrictive functional forms

- Apply a new tool to help explore data that helps to overcome some limitations inherent in classical statistical methods

3.2 Background on Random Forests Classification

- Random Forests = ensemble (set) of decision trees (uses machine learning algorithm)
  - Useful technique to determine how much predictive power is gained by adding a particular covariate to a statistical model
- Popular in other fields – bioinformatics, genetics – slowly making its way into psychology and political science
- Used as an “off-the-shelf” tool for exploring complex datasets

3.3 A bit about the method

- RF = recursive partitioning method
- RF involves a set of regression trees calculated on random subsets of the data
  - Generates a “permutation accuracy” measure for each variable based on the difference in the model accuracy with and without the inclusion of that variable, averaged over all of the trees.
- Covers the impact of each predictor variable individually as well as in multivariate interactions with other predictors (simultaneously)

3.4 Advantages

- Able to deal with a large number of predictor variables as well as multiple interactions among a large # of predictors
- High predictive accuracy
  - Predict out of sample
- Not subject to restrictive functional form of linear models
- Detects important variables that work in interactions but are too complex to be captured by parametric regression models





3.5 Disadvantages

- "Black box" analysis
  - Do not know the relationships of the variables or their functional form in a model; we just know their predictive accuracy





3.6 Alternative approaches

- Alternative approaches use dimension reduction techniques
  - Such as factor analysis, principal components analysis

BUT

- Individual effects are no longer observable when using alternative approaches
- RF is more stable than stepwise variable selection
- RF can process large #s of predictors simultaneously

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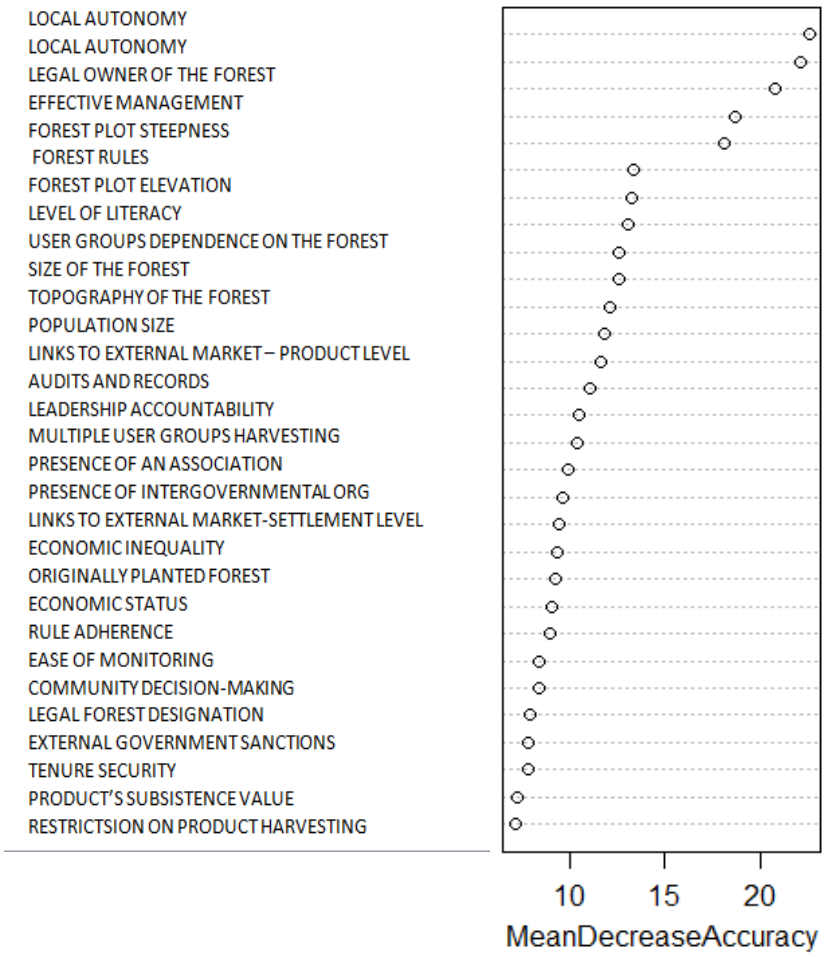
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LOCAL AUTONOMY
LEGAL OWNER OF THE FOREST
EFFECTIVE MANAGEMENT
FOREST PLOT STEEPNESS
FOREST RULES
FOREST PLOT ELEVATION
LEVEL OF LITERACY
USER GROUPS DEPENDENCE ON THE FOREST
SIZE OF THE FOREST
TOPOGRAPHY OF THE FOREST
POPULATION SIZE
LINKS TO EXTERNAL MARKET – PRODUCT LEVEL
AUDITS AND RECORDS
LEADERSHIP ACCOUNTABILITY
MULTIPLE USER GROUPS HARVESTING
PRESENCE OF AN ASSOCIATION
PRESENCE OF INTERGOVERNMENTAL ORG
LINKS TO EXTERNAL MARKET-SETTLEMENT LEVEL
ECONOMIC INEQUALITY
ORIGINALLY PLANTED FOREST
ECONOMIC STATUS
RULE ADHERENCE
EASE OF MONITORING
COMMUNITY DECISION-MAKING
LEGAL FOREST DESIGNATION
EXTERNAL GOVERNMENT SANCTIONS
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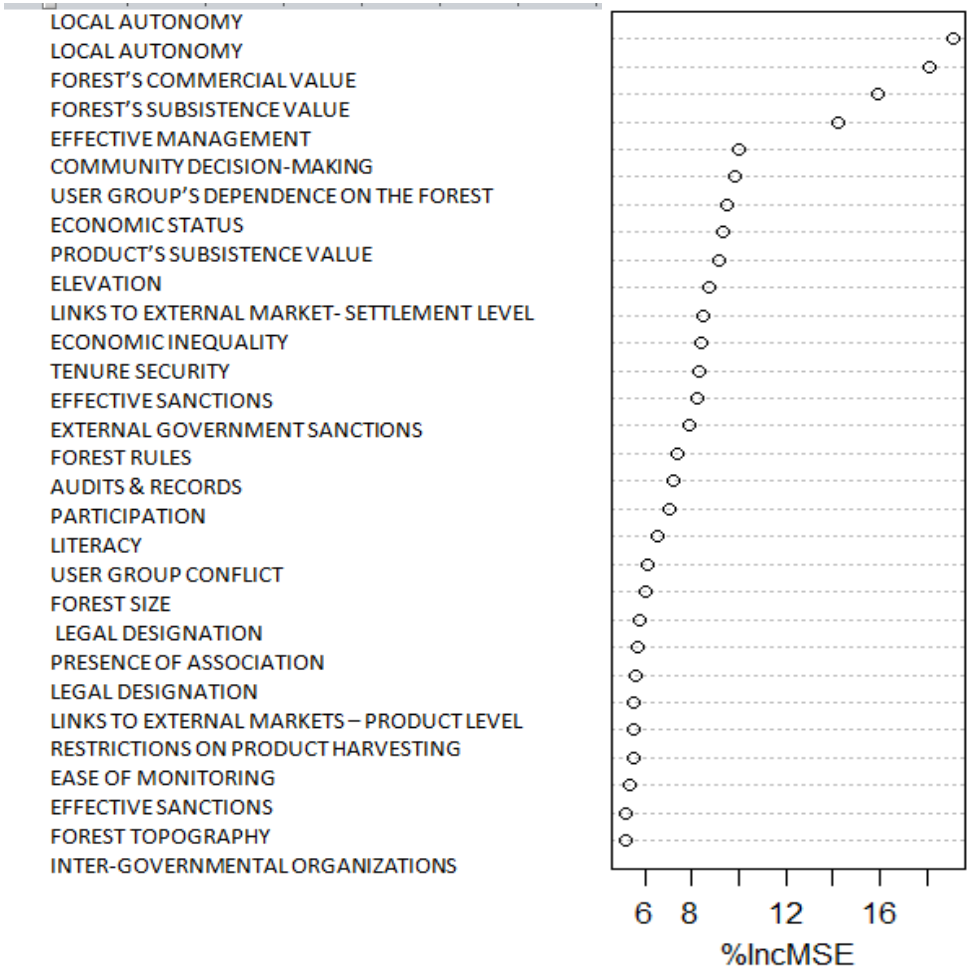
LOCAL AUTONOMY
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FOREST'S COMMERCIAL VALUE
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RESTRICTIONS ON PRODUCT HARVESTING
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EFFECTIVE SANCTIONS
FOREST TOPOGRAPHY
INTER-GOVERNMENTAL ORGANIZATIONS
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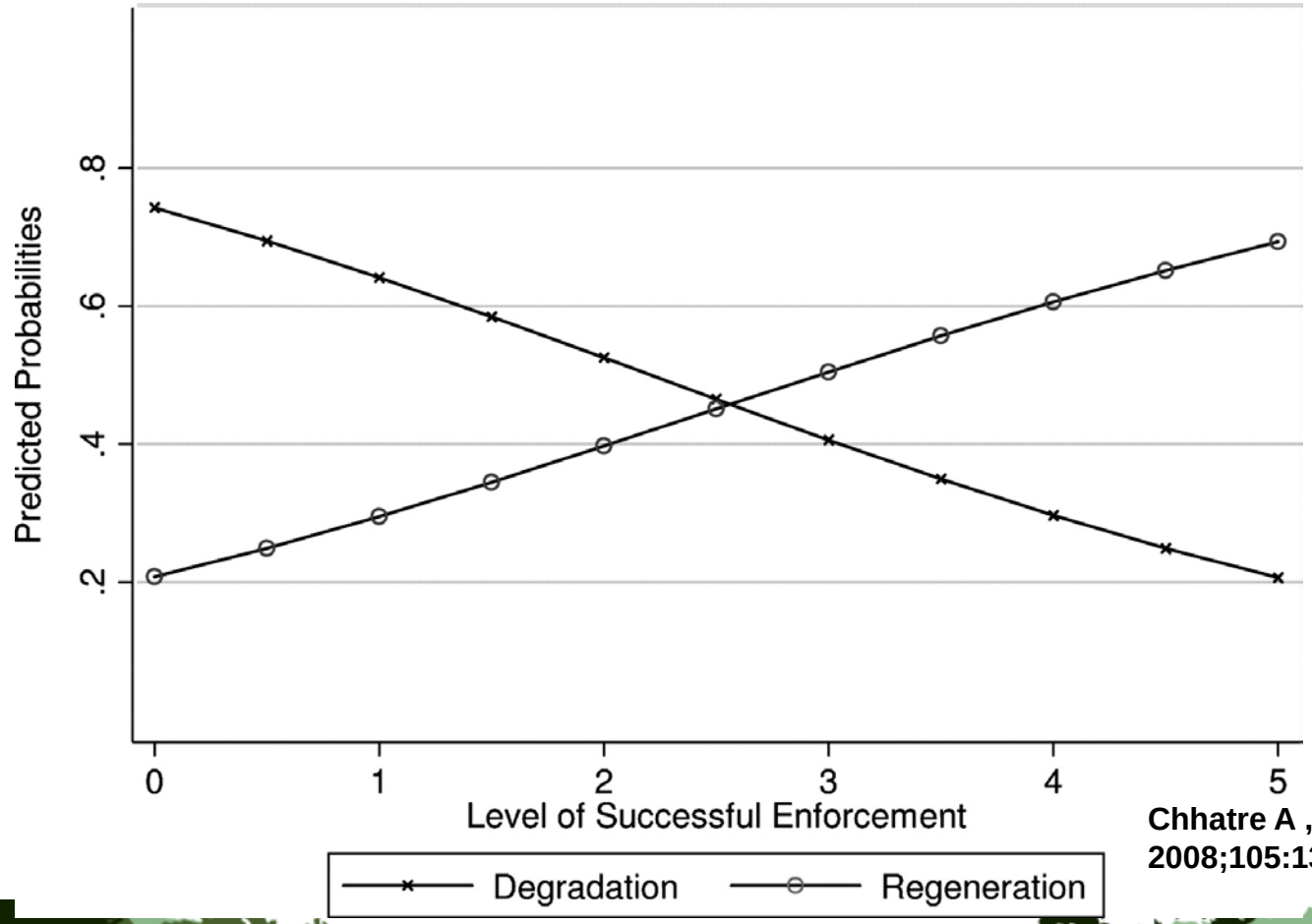
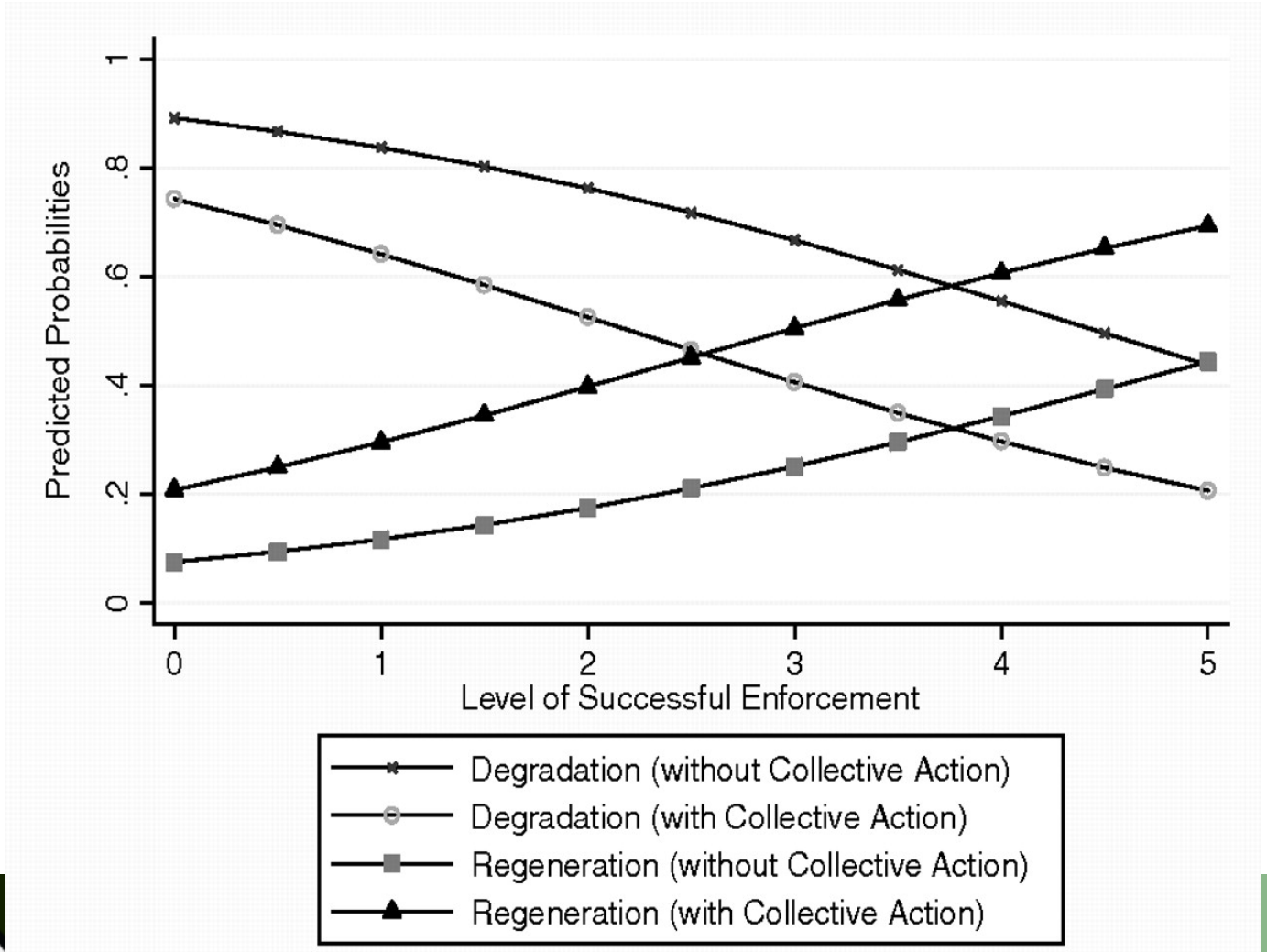
Moving from exploring data to developing causal process indicators

Relationship of level of enforcement with the predicted probability that a forest has degraded or regenerated.



Chhatre A , and Agrawal A PNAS 2008;105:13286-13291

Relationship of level of enforcement with the predicted probability that a forest has degraded or regenerated, conditional on collective action around forest commons.



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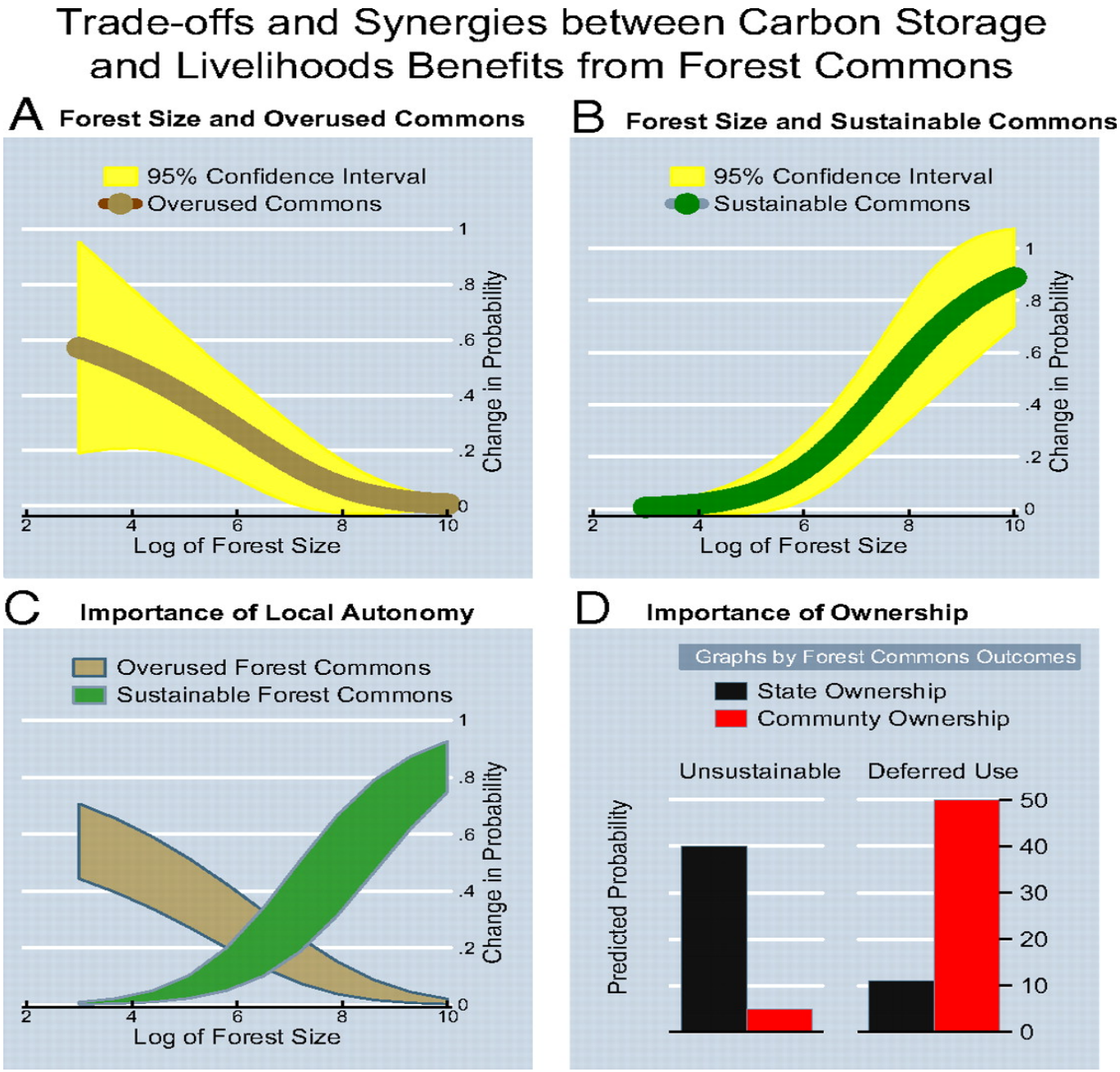
Forest size, rule-making autonomy, and ownership of forest commons.



Indicators and actions

- Some indicators direct attention to action on the underlying factors: local autonomy; strengthening enforcement
- Others direct attention away from locations where policy impact would be limited or non-existent (inequality, dependence, market pressure)
- Others are mixed – promoting larger size of forest commons might yield more positive outcomes (commercial value)

In conclusion: close interplay between useful data and reliable indicators

- Indicator development is not a one-off task; two main reasons
  - relationships among causal processes and outcomes of interest change over time, vary across places
  - in social systems, human behavior changes depending on what is being measured – without necessary changes in system performance
  - enabling low-cost data collection and access, greater numeracy, are key to robust, reliable, low-cost indicator development