Alternative Methods to Estimate LUCF Project Baselines using Public Natural Resource Data Sets

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Funding and collaborators

- *Funded by US EPA, Non-CO2 Greenhouse Gas and Sequestration Branch*
- *Collaborators*
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  - *EPA: Ben DeAngelo and Ken Andrasko*
  - *US Fish and Wildlife Service: Kevin Sloan*
  - *Bruce McCarl (Texas A&M), Heng-Chi Lee (U. Western Ontario)*

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Policy Context: Baselines and Additionality

- GHG Offset projects via private markets and/or public programs
- Only “additional” GHGs eligible for credit ?
  - Additionality requires estimation of GHG profile without the project (‘baseline’)
- LULUCF baseline => projecting land use change under BAU (no project) conditions
- Baseline-setting methods to date: *ad hoc*
- Revision of EIA Section 1605(b) voluntary GHG registry guidelines: now- early 2004

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General Baselines Framework for GHG Mitigation (OECD and EIA, 2001)

- **Coverage**
  - Multi-project
  - Project-specific
  - Hybrid (project-specific with standard elements)
- **Comparison basis**
  - Reference group
    - Past performance
    - Ongoing performance (control group)
  - Simulation-based
- **Geographic scale of comparison**
  - Global
  - National
  - Regional
  - Sub-regional
- **Temporal projection**
  - Static
  - Dynamic

LUCF Baselines and Additionality Quantified

1. **Project carbon (future year t)**

$$C^P_t = \sum_{i=1}^{N} L_i \, C_i(t)$$

2. **Baseline carbon (year t)**

$$C^B_t = \sum_{i=1}^{N} \sum_{d=1}^{t} L_{id} \, C_i(t-d)$$

3. **Additionality = $C^P_t - C^B_t$**

* **Key components of baseline projection**

- **Land use change: L_{id}**
- **Carbon (GHG) accounting: $C_i(t-d)$**

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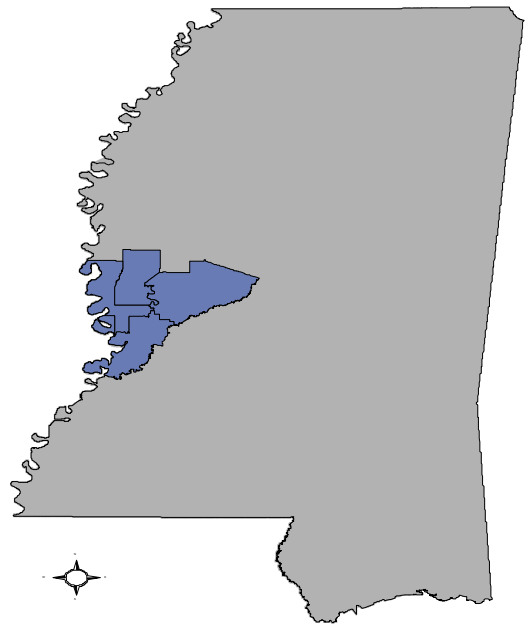
Key Questions for LUCF Baseline Methods Development

- Can natural resource data with national coverage (NRI, FIA, NLCD) be used to develop methods that are portable across regions and LUCF activities?
- Does landscape heterogeneity imply project-by-project (bottom-up) baselines are necessary?
- Or, can regional-scale (top-down) LU and carbon baselines be established for use by multiple project developers, or evaluators?
- Can baseline methods help identify where project additionality is likely to be greatest?

Sequestration Case Study: Forest Restoration in the Lower Yazoo River Basin, Mississippi

Location:
4 counties in
western Miss.



- Hypothetical Project Activity: Convert marginal cropland to bottomland hardwood forest
  - Marginal = in 2-year flood plain
- About half-dozen projects being implemented
- Forest Management regimes
  - Commercial forestry
  - Preservation forestry

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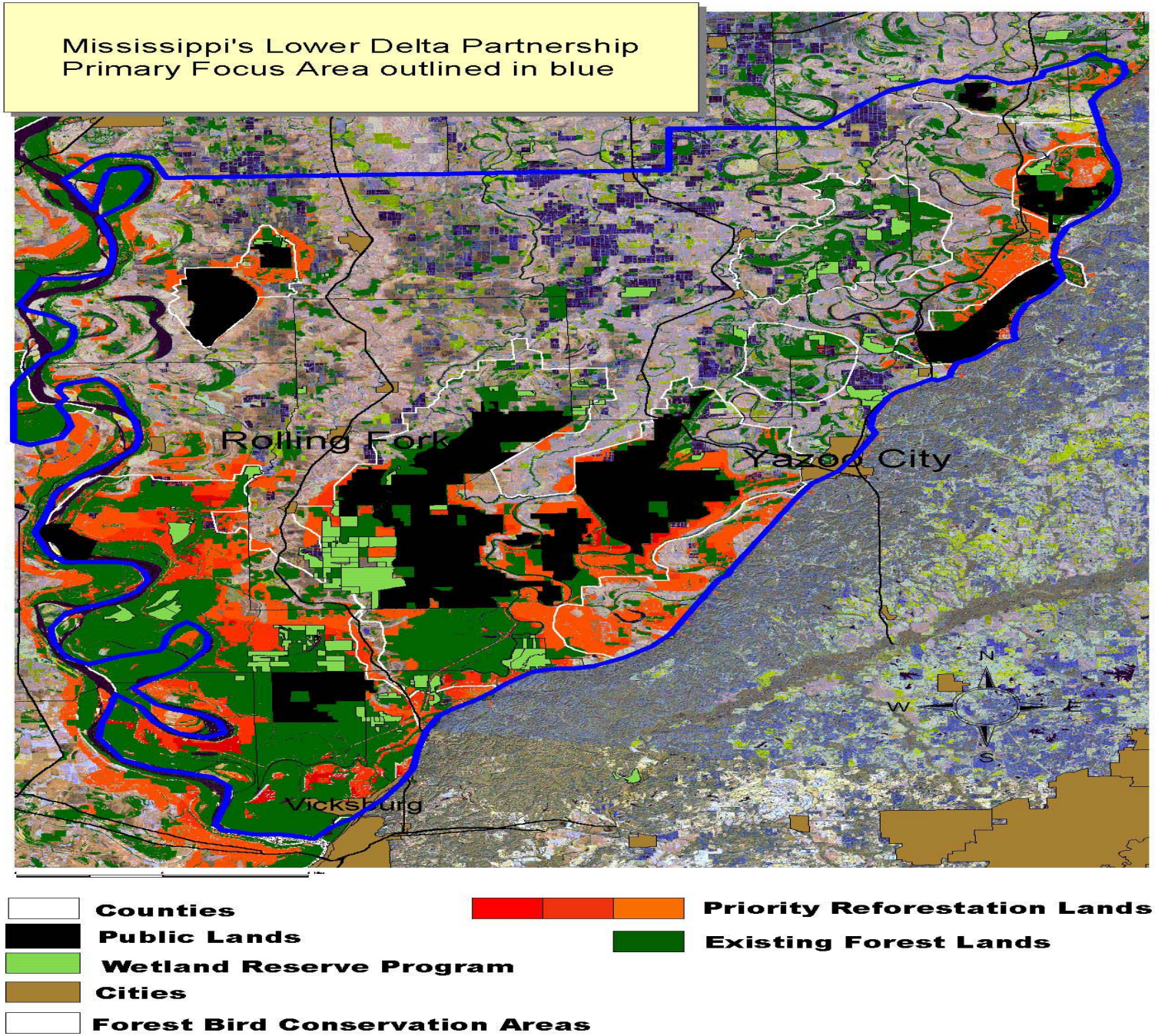
Mississippi's Lower Delta Partnership
Primary Focus Area outlined in blue
Rolling Fork
Yazoo City
Vicksburg
N
W
E
S
Counties
Public Lands
Wetland Reserve Program
Cities
Forest Bird Conservation Areas
Priority Reforestation Lands
Existing Forest Lands

Analysis Steps

Step1 Create GIS database to define project area and underlying resource characteristics

- Land use, soil type, elevation,…

Step 2 Estimate project carbon, w/ forest carbon model (FORCARB), adjusted for local conditions

Step 3 Estimate baseline (w/o project)) LU change

- Afforestation rate of regional/local reference group
- Data and statistical methods at 4 different levels of spatial resolution

Step 4 Combine carbon and land use simulation to estimate baseline carbon totals

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LU Projection Approach 1:
Use existing regional LU model estimates

Baseline afforestation rate for region based on econometric model projections [Plantinga and Ahn (2002)]

- ~ 0.66% per yr for study area, decline over time
- Essentially same for all Ag land in 4-county region
- **Top-down projection:** All cropland in 4-county region assumed to have same baseline rate of afforestation

LU Projection Approach 2:
Estimate County-level LU Trends Using NRI Data

- Data
  - National Resources Inventory (NRI)
  - 1982-1997, 5 year increments
  - 1,371 plots in 4 county region
  - 58 LU categories (collapsible)
- Method
  - Compute county-specific land use transition matrices using historical data
  - Apply historical afforestation rate (1982-97) as future baseline rate projection

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LU Projection Approach 3:
Multivariate regression analysis of NRI plot data

- Dependent variable (Y):

  Discrete change in land use over time period, 1982-1997

- Explanatory variables (Z):

  County indicators, soil characteristics, elevation, other suitability factors

- Estimate Discrete Choice Model (Logit) of Y on Z

  Parameterizes relationship of plot characteristics on land use change

Logit Results: NRI Plot Data

Dependent Variable Cropland conversion to forest, 1982-1997

Independent Variables	**Coef.**	**Std. Err.**	**z**	**P>|z|**
Issaquena	1.6555	0.9418	1.76	0.079
Warren	2.3292	0.9459	2.46	0.014
Yazoo	1.1898	0.9348	1.27	0.203
Flooding_freq	***1.2045***	***0.7584***	***1.59***	***0.112***
Constant	-4.3811	0.8455	-5.18	0

Number of obs	400	**Log likelihood**	-73.456
LR chi2(4)	12.35	**Pseudo R2**	0.0775
Prob > chi2	0.0149		

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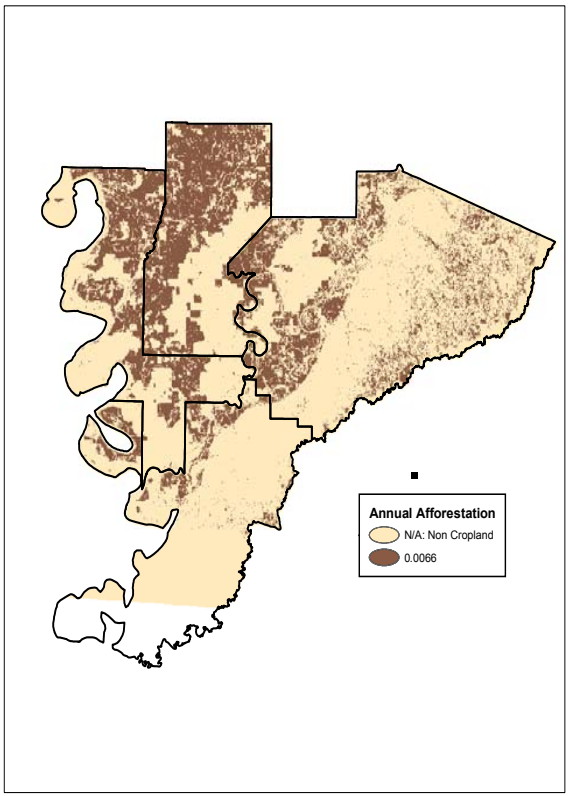
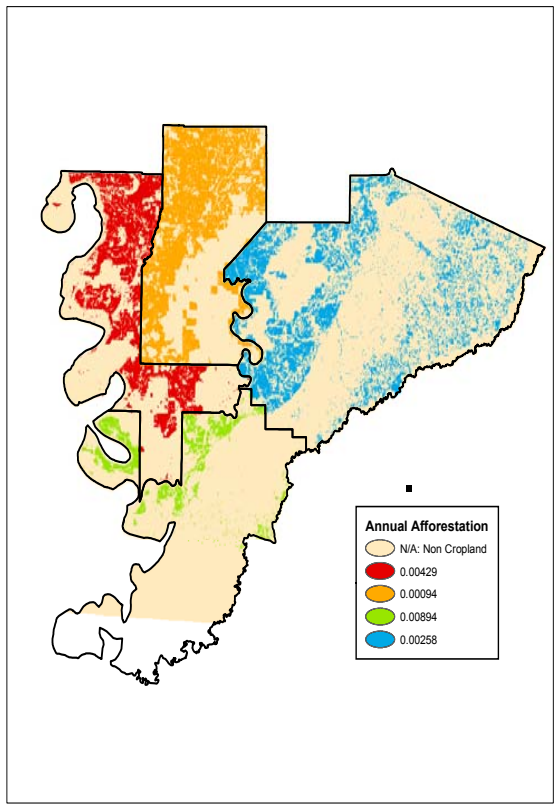
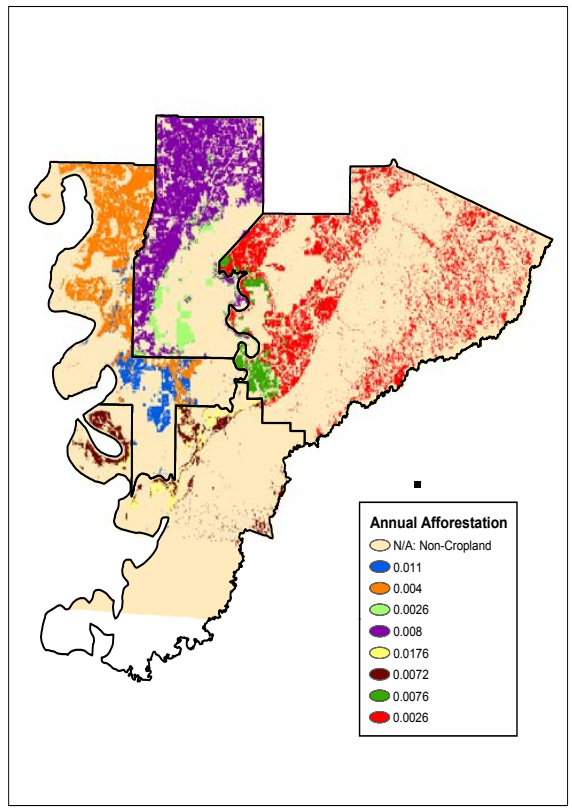
Baseline Afforestation Rates in LYRB by Estimation Approach

Coarser resolution → Finer resolution







1. Regional Land Use Model

2. NRI – county trends

3. NRI - Multivariate Regressions

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Higher Resolution Approaches Yield More Baseline LUC Rates

- Spatial resolution of LUC estimates
  1. Regional LU model: **1** baseline rate
  2. NRI County Trend: **4**
  3. NRI Regression: **8**
  4. More refined data/variables => more rates
- Spatial resolution of Forest C yield estimates: **3** soil types
- LUC/Forest C combo's => **3, 12, 24 …** baseline C est's

Next step: Combine baseline LUC/carbon yield estimates with project-specific data on location, elevation, and soil type to develop **carbon quantity baselines at the project level.**

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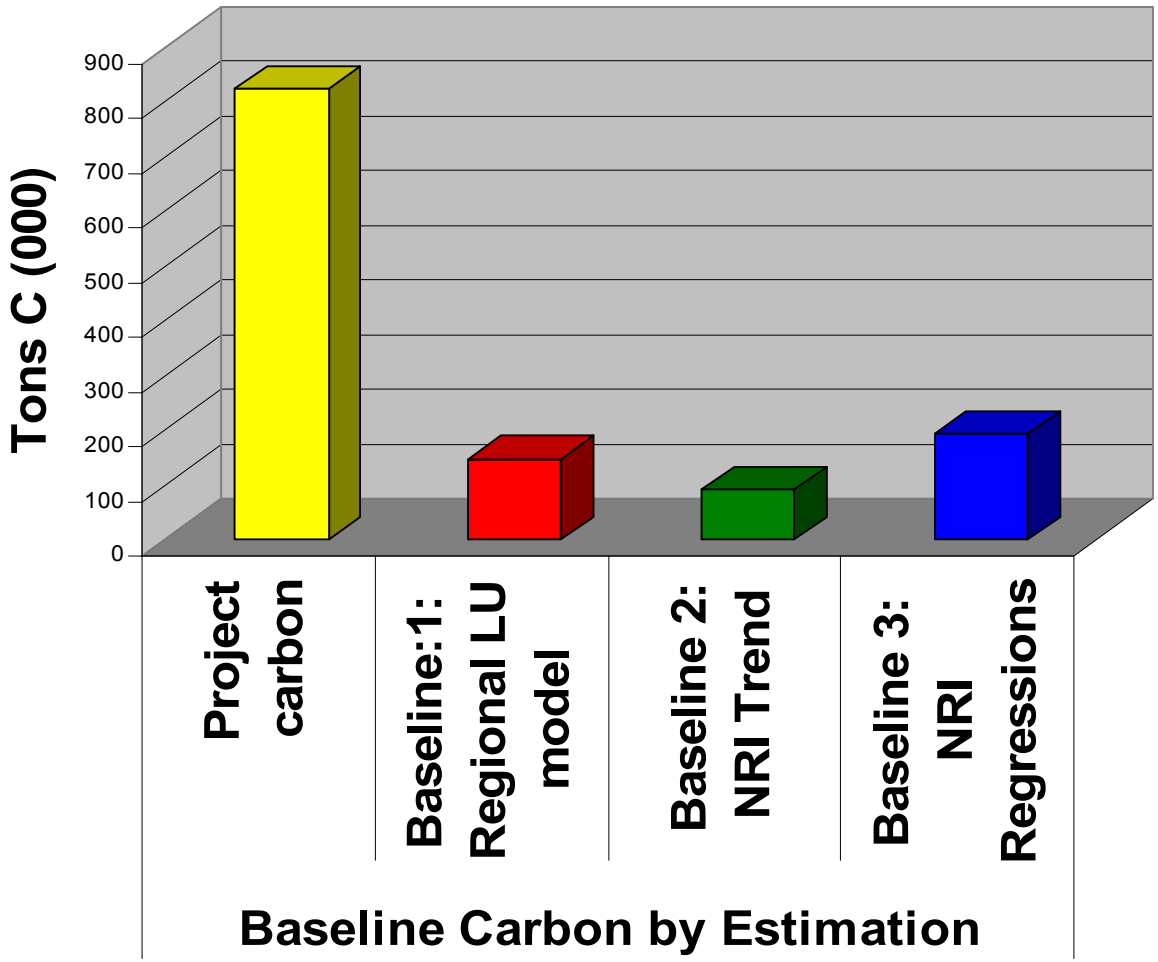
Project and Baseline Accumulated Carbon Stock at End of Project (60 Years)



(Work in-progress)
LU Projection Approach 4:
Multivariate regression analysis of GIS pixel data

- Data: USGS National Land Cover Data Base (NLCD)
  - Resolution: 30 m^2 pixels
  - Time period: 1992-1999
  - Abundance of pixels (> 1 mm) needs to be aggregated for meaningful analysis
- Discrete choice model
  - Y: Pixel-level land use change
  - X: site characteristics, spatially defined variables (distance, spatial lags)
  - Spatial autocorrelation adjustments

NRI/NLCD Data Validation: Identification of LU Requires Ground Truthing

	NRI 1992-97	NLCD Affor Method 1 1992-99	NLCD Affor Method 2 1992-99
Acres Crop to Forest	24,000	529	52,248
Total Acres Crop. 1992	587,000	456,211	456,211
Afforestation Rate	**4.09%**	**0.12%**	**11.45%**

Implications:

1. **Remote sensing uses spectral signatures**
2. **Need to identify activities of interest & ground truth**
3. **Requires independent reclassification of signatures**

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Summary Comparison of Approaches

Baseline Approach	Advantages	Disadvantages
1: Transfer estimates from regional LU model	• Existing model outputs available • Economic dynamics	• Low resolution: All ag land in all counties have same afforestation rate • Region/practice specific
2: Sample plot data (NRI) – County Trends	• 4 data points, 1982-97 • 58 LU categories • County-specific LU trends	• NRI sample size may be limited for some practice-region combinations • County-level resolution
3: Sample plot data (NRI) – regression analysis	• Allows sub-county resolution • Allows use of other explanatory variables	• More complex; requires manipulation of NRI data
4: Pixel-level data (NLCD) analysis	• High spatial resolution • Ability to assess many spatial variables (eg, distance to cropland)	• Limited time period: 1992-99 • Ground-truthing required for some spectral signatures and land uses • Expensive

Summary

- Additionality test requires estimation of project carbon baselines
- Baseline estimation requires models of: (a) land use change (LUC), and (b) GHG (carbon) accounting
- Baselines can be established at multi-county, county, and sub-county scales using NRI data, for LU changes and practices in the NRI.
- More spatially refined LUC estimates [appear] more costly to develop, but are more precise.
- Baselines could be set using agreed, transparent protocols and national datasets portable across U.S. & across land-use activities.

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Observations and Discussion

- **Tradeoff**: Multi-project (regional) baselines economize on project development costs, but homogenize potentially heterogeneous circumstances.
  - Key policy decisions:
    - At what level of resolution are regional baselines credible? Or … How many different baseline rates do we need for a region?
    - When is a unique, project-specific baseline necessary?
  - The [analytic] answer to these questions will depend on heterogeneity of LU, and the environmental, economic, and institutional determinants within the region.
  - A screening tool could help evaluate the tradeoff and advise on the appropriate level of regional/project resolution