How well can we predict land use?

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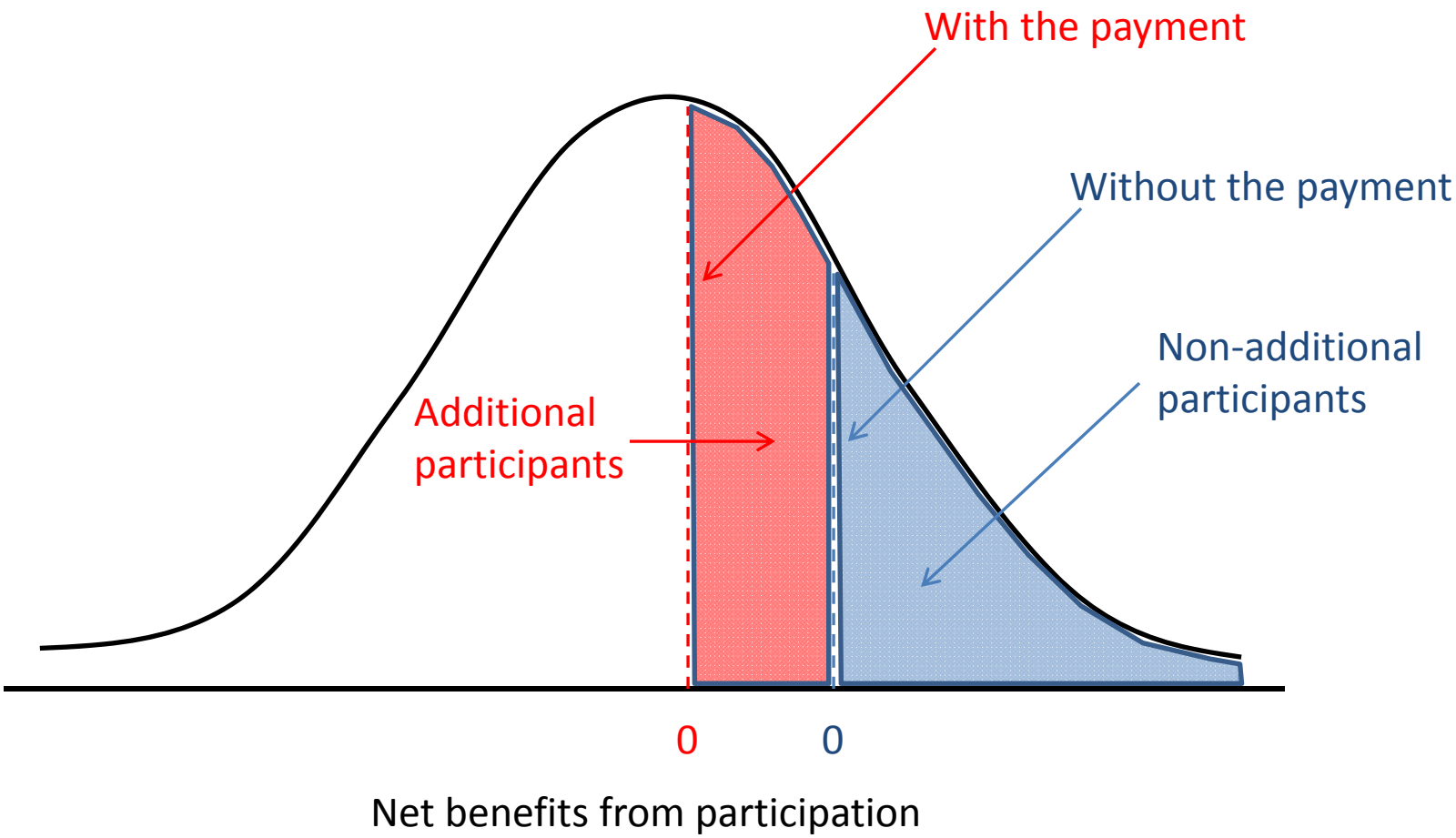
Why predict land use?

- Additionality
  - Government wants only to pay for activities that are additional (i.e., would not otherwise have happened)
  - When is additionality a concern?
    - Provision of an impure public good
      - Carbon sequestration from afforestation v. CCS
    - Public funds have opportunity costs
    - Government policy is limited to payments for desired actions
    - Asymmetric information
      - The government knows which landowners want to provide the environmental service, but cannot distinguish between additional and non-additional participants.

Asymmetric information



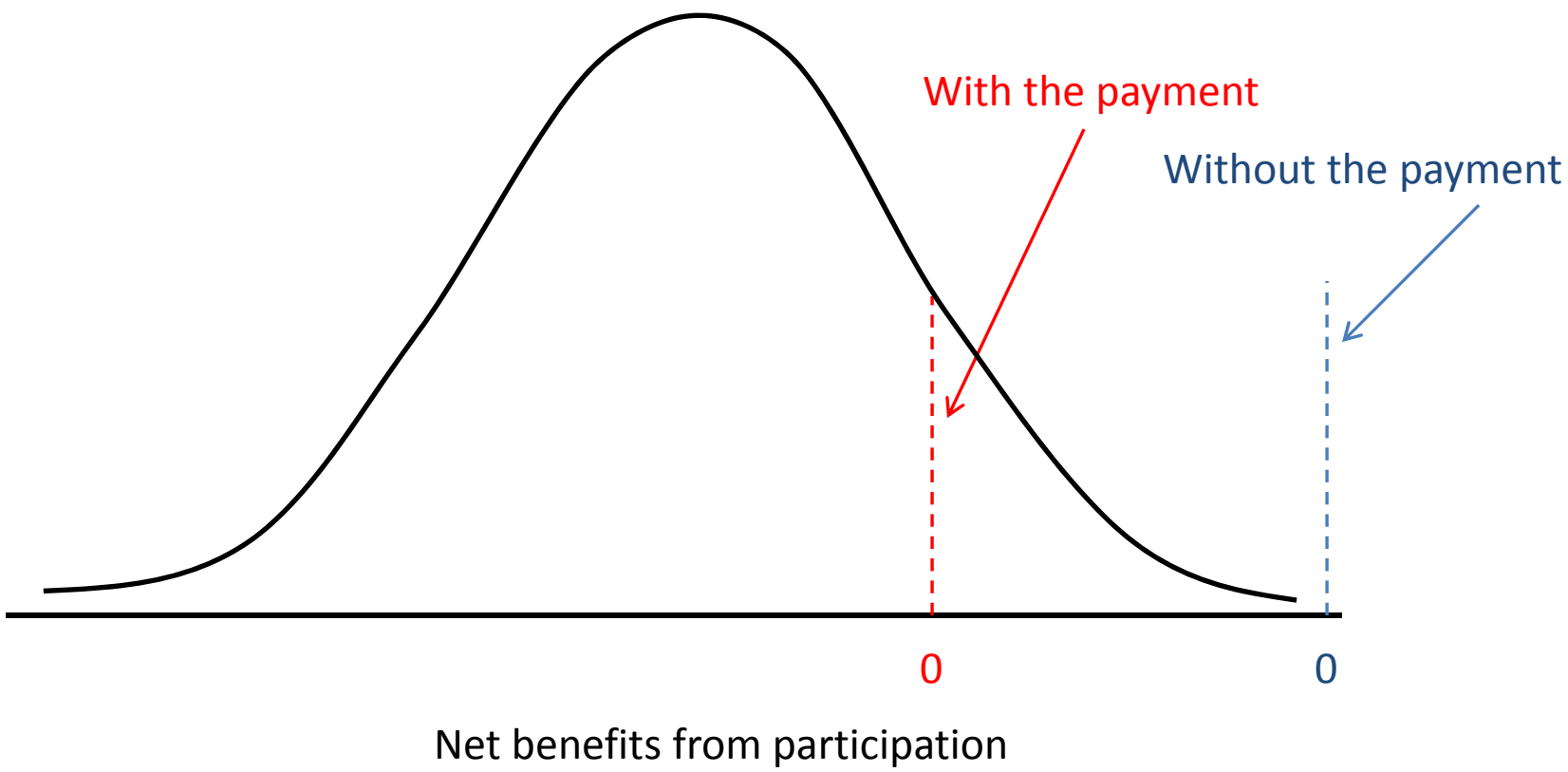
Asymmetric Information Problem

- Government cannot distinguish between additional and non-additional participants
  - Non-additional participants have an incentive to claim their actions are additional (moral hazard)
- Is it possible to identify the unobservable counterfactual (business-as-usual)?
  - Historical behavior
  - Econometric models
  - Policy design

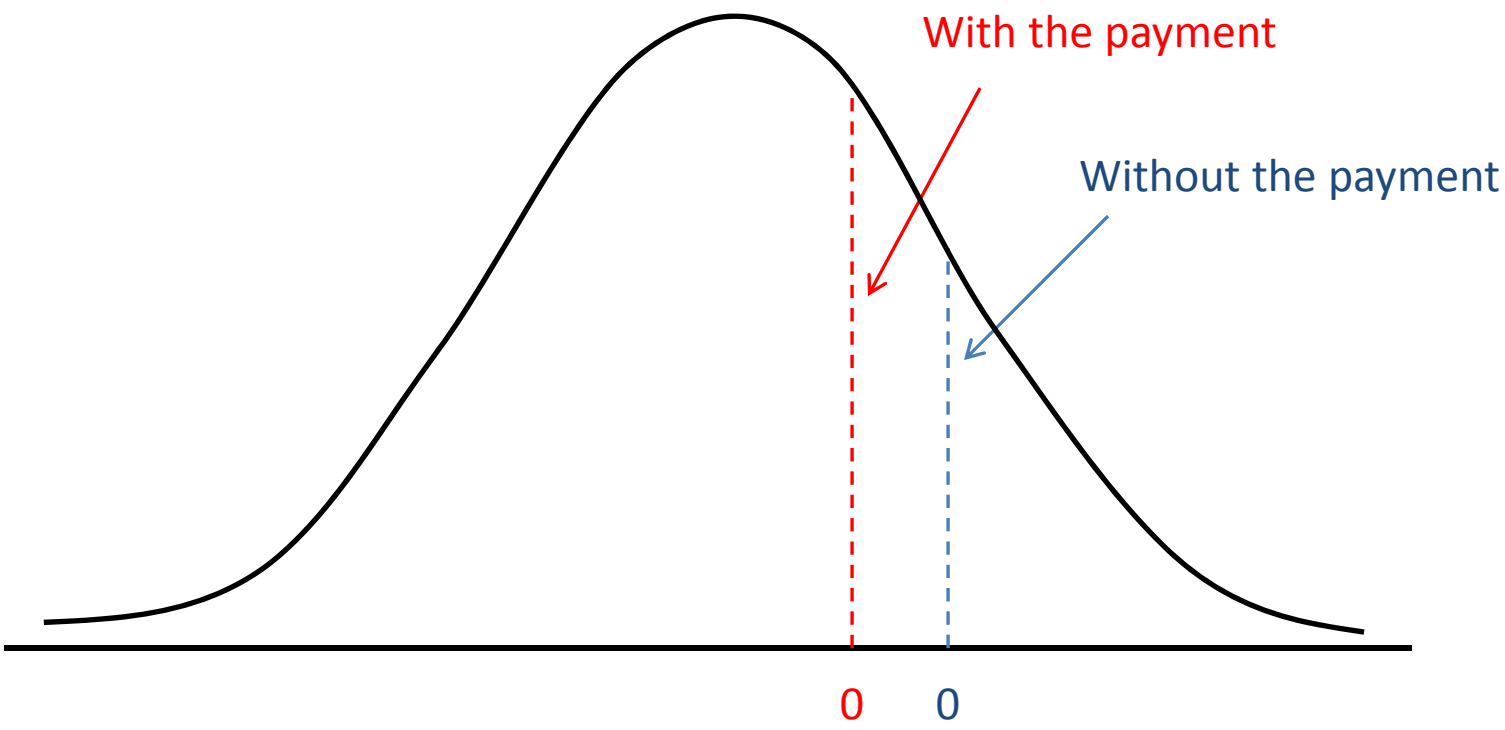
Use data on historical behavior

- Assume that any departure from past behavior is additional
  - For example, landowner X had their land in crops for 10 years. They switched to forest following the introduction of a tree-planting subsidy.
- Potential problem
  - If historical participation is low, then it is likely that getting a high level of participation will be costly
  - In other words, in low-cost areas where a limited budget will go further, additionality is likely to be a greater concern

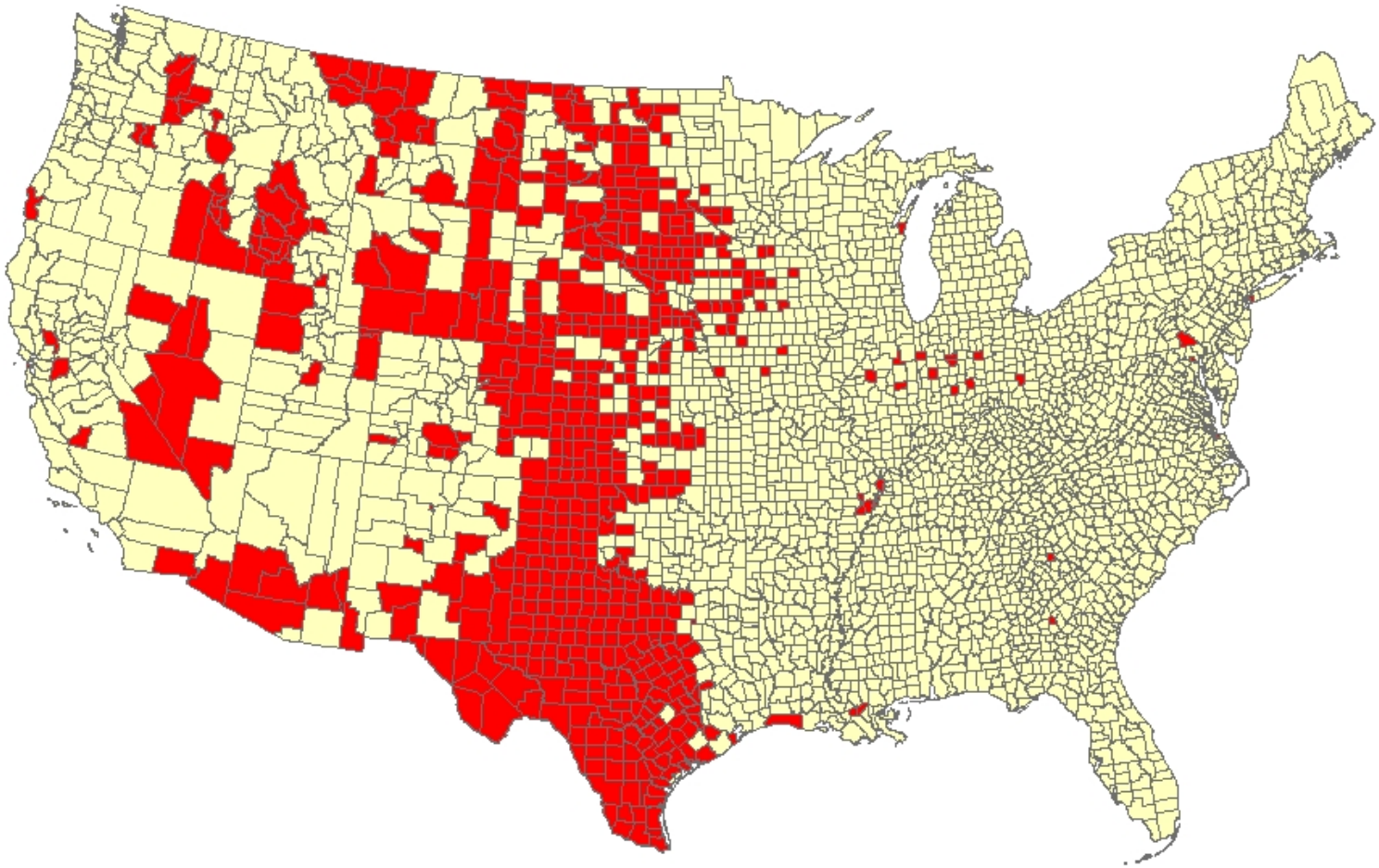
An area with low historical participation



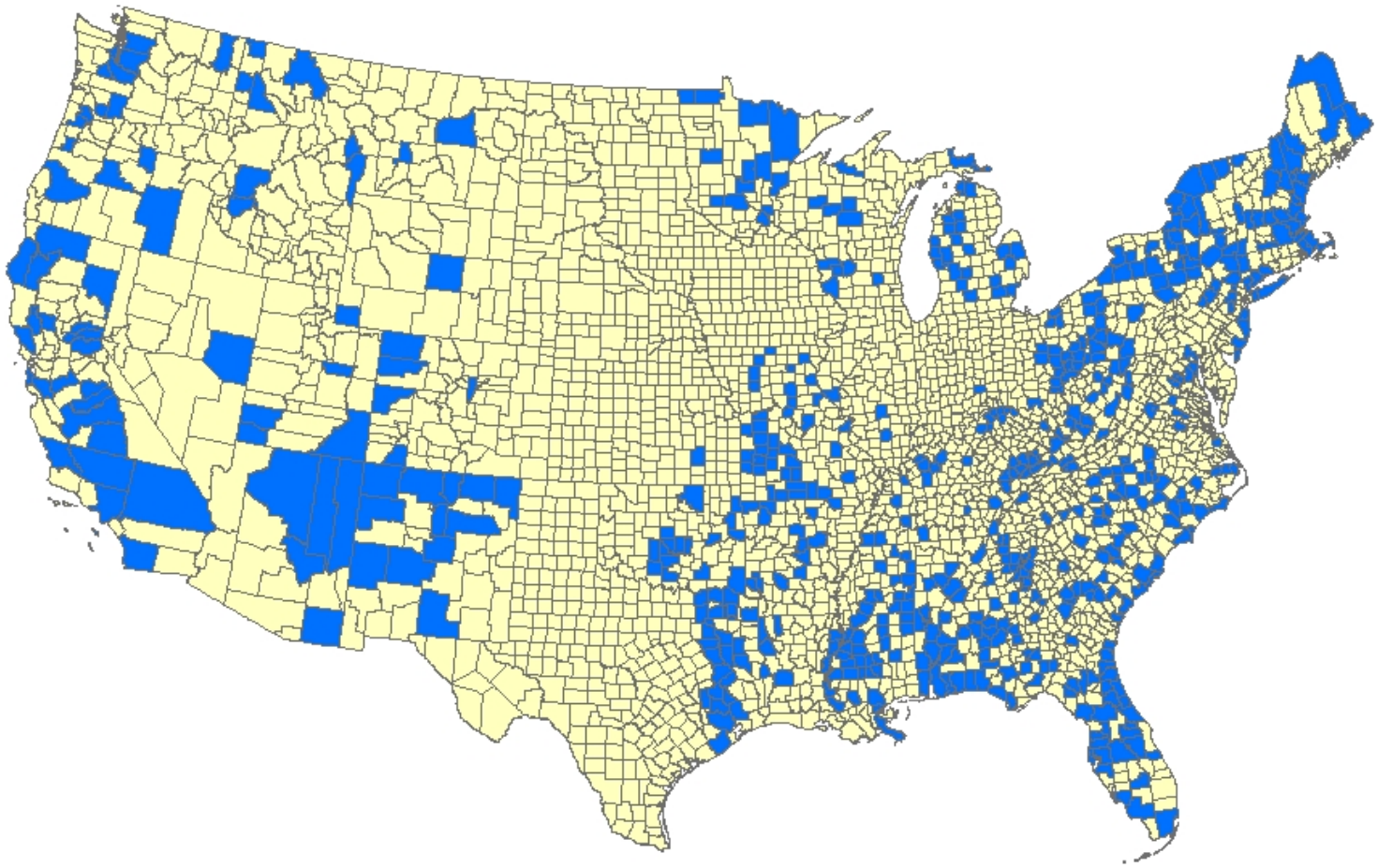
An area with high historical participation



589 counties with no forest area change, 1982-1997



589 counties with the largest absolute changes in forest area, 1982-1997



Econometric models

- Estimate the relationship between land use and economic determinants (rents associated with different uses, soil quality, etc.).
- Plug the current values of determinants into the estimated econometric model to predict the counterfactual

Predictions of forest area

- Ahn, S., Plantinga, A.J., and R.J. Alig. 1998. Predicting future forestland area: A comparison of econometric approaches. *Forest Science* 46(3): 363-76.
- Model of forest and agricultural land shares in Alabama estimated with panel data on counties
  - Explanatory variables include county average rents and land quality
  - OLS, fixed and random effects specifications
  - Out-of-sample forecasts evaluated

State-level predictions

Table 5. The accuracy of forest area forecasts from models estimated with data from 1964 to 1982.

Forecast year	Model	State-level forest area (1,000 ha)	Theil's inequality coefficient (U) and decomposition into proportions of inequality (U^m, U^s, U^c)*				
			U	U^m	U^s	U^c	$U^m+U^s+U^c$
1987	Actual	8,381					
	OLS	8,611	0.072	0.083	0.093	0.837	1.00
	Dummy variables	8,364	0.026	0.013	0.016	0.986	1.00
	Error components	8,350	0.077	0.008	0.112	0.895	1.00
1992	Actual	8,433					
	OLS	8,594	0.075	0.039	0.123	0.852	1.00
	Dummy variables	8,337	0.051	0.036	0.023	0.956	1.00
	Error components	8,325	0.083	0.000	0.129	0.886	1.00

* Theil's inequality coefficient (U) and the proportions of inequality (U^m, U^s, and U^c) are defined in Equations (16) and (17), respectively.

For 1992, OLS estimate is off by 2%; fixed effects estimate is off by 1%

County-level forecast errors

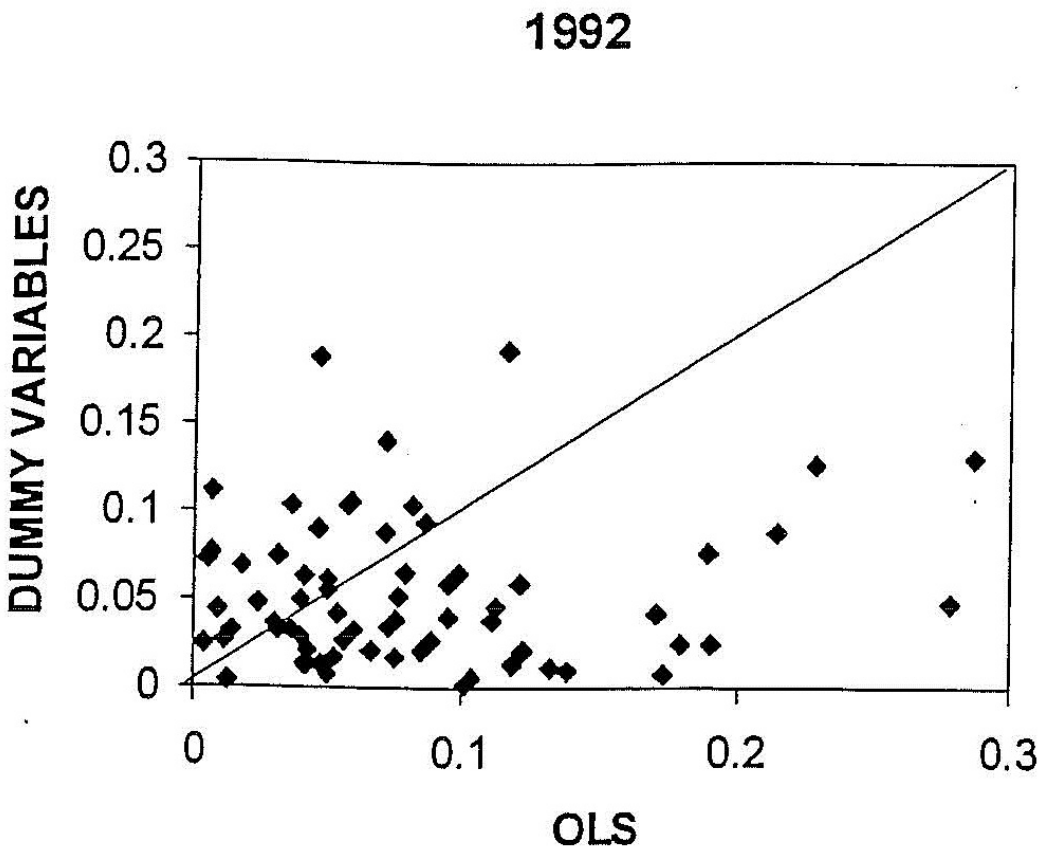
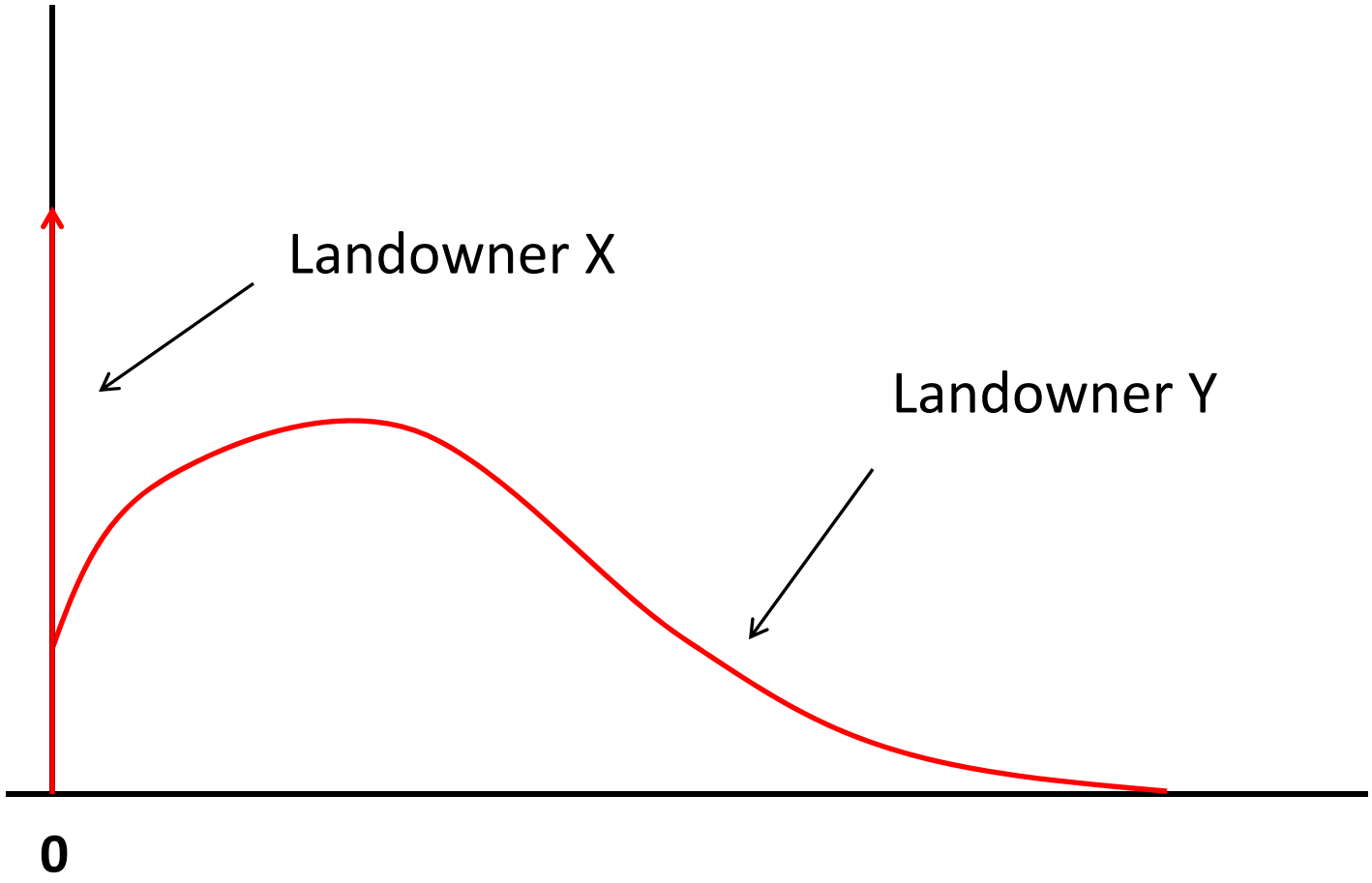


Figure 1. A comparison of 1987 and 1992 forecast errors for OLS and dummy variables models estimated with data for 1964 to 1982.

Econometric models

- Ideally, we would make predictions for individual landowners. If models are estimated with individual-level data, we should expect significant prediction error at the individual scale.
  - Data limitations
  - Unobservable landowner heterogeneity
- At best, one could characterize distributions over business-as-usual actions conditioned on observables (e.g., county, soil quality)

Hypothetical distribution over b-a-u increases in forest area



Baseline forest share distributions

- Mason, C.F., and A.J. Plantinga. 2011. Contracting for Impure Public Goods: Carbon Offsets and Additionality. NBER Working Paper 16963.

Lower and upper bounds on future forest shares by selected states and land quality classes

State	LCC I&II		LCC III&IV		LCC V&VI		LCC VII&VIII	
	lower	upper	lower	upper	lower	upper	lower	upper
AL	0.010	0.485	0.209	0.658	0.600	0.856	0.528	0.812
MN	0.011	0.318	0.170	0.490	0.543	0.813	0.573	0.790
W. OR & WA	0.002	0.441	0.159	0.684	0.358	0.920	0.129	0.830

Policy Design

- Mason, C.F., and A.J. Plantinga. 2011. Contracting for Impure Public Goods: Carbon Offsets and Additionality. NBER Working Paper 16963.
- We design a menu of contracts for forestation (afforestation and avoided deforestation) involving a per-acre payment combined with a clawback (a lump-sum transfer).
  - Uses subsidies: total payment to each participating landowner is positive
  - Voluntary: landowners choose the contract they want, including possibly no contract
  - Assumes the government knows the distribution over landowner responses, but landowners have private information about individual responses

Empirical Results

- With contract approach, government pays only for additional forestation and its expenditures are considerably lower with than with a uniform payment to all landowners

State	Maximum forest area	Increase in forest	Government costs		Private costs	
			Contracts	Subsidy	Contracts	Subsidy
	1000 acres		million dollars		million dollars	
AL	28338	181	12.0	59.5	4.2	1.6
MN	42640	1262	84.5	163.0	31.6	19.8
Western OR & WA	18788	7	0.4	8.0	0.2	0.0

Questions?