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# Land Supply Elasticities in the Americas

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## Introduction

- ▶ Treatment of the extensive margin in CGE models is constrained by lack of econometric evidence on land supply elasticities as well as by functional forms
- ▶ Econometric studies (whether focusing on yield response, land rents, or crop choices) assume land as fixed. [e.g., Cline (2007); Mendelsohn and Seo (2007); Lobell, Schlenker, and Costa-Roberts, 2011; Schlenker and Roberts, 2006].
- ▶ To my knowledge, only two studies attempt to estimate country level land supply elasticities: Lubowsky (2002) for the US and Barr et al (2011) for the US and Brazil.
- ▶ Only Lubowsky effectively deals with land heterogeneity.

## Research objective

Exploit global gridded datasets on land cover and agricultural productivity to estimate land supply curves that take into account land quality heterogeneity

## Methods

We use the spatially explicit framework devised by Chomitz and Gray, whereby a Von Thunen model is used to relate land use decisions to measures of market access. The derived land-choice equation is estimated using the spatial logit model proposed by Klier and McMillen.

## Data

- ▶ Regressand: a binary variable  $Z$  built using harvested area (as % of each gridcell, circa 2000) from Monfreda, Ramankutty and Foley (2008). These are in a 5 min ( $\approx$  9.16 km/5.69 miles) by 5 min latitude-longitude grid covering the world. I set  $Z = 1$  if more than 5% of gridcell is under crops and  $Z = 0$  otherwise.
- ▶ Market access index by Verburg et al.
- ▶ Independent variables: Potential Vegetation, Soil Fertility Constraints, Average annual precipitation, Elevation, Soil pH, Soil Carbon, Area equipped for irrigation, Built-up land, Protected Areas



- ▶ We focus on the American continent (No islands).

## Estimating Equations and Market Access Elasticities

$$P(Z = 1|X, Wy^*, WX^L) = \Lambda (\rho Wy^* + X\beta + WX^L\theta)$$

Where  $Z$  and  $y^*$  are the  $n \times 1$  vector of land use decisions and unobservable returns to agriculture discussed above,  $W$  is a  $n \times n$  row-standardized (e.g.,  $\sum_j w_{ij} = 1$ ) weight matrix defining neighborhood relationships between grid-cells,  $X$  is a  $n \times k$  matrix of regressors,  $X^L$  is a  $n \times l$  matrix where  $l$  is a subset of the  $k$  regressors in  $X$ .  $W_i y^*$  is the weighted average of the unobservable land returns of gridcell  $i$ 's neighbors,  $\rho$  is the so-called auto-regressive spatial parameter,  $W_i X^L$  captures the weighted average of the explanatory variables in the neighborhood of gridcell  $i$ ,  $\theta$  is as  $l \times 1$  is the parameter vector associated with the lagged explanatory variables,  $\beta$  is the  $k \times 1$  vector of parameters summarizing the effect of  $X$  on  $y^*$ .

The marginal effect of market access on the probability of land use is given by:

$$\frac{\partial P(Z_i = 1|\cdot)}{\partial ma_i} = \lambda(\rho Wy^*_i + X_i\beta + WX^L_i\theta) (\hat{\beta}_{ma})$$

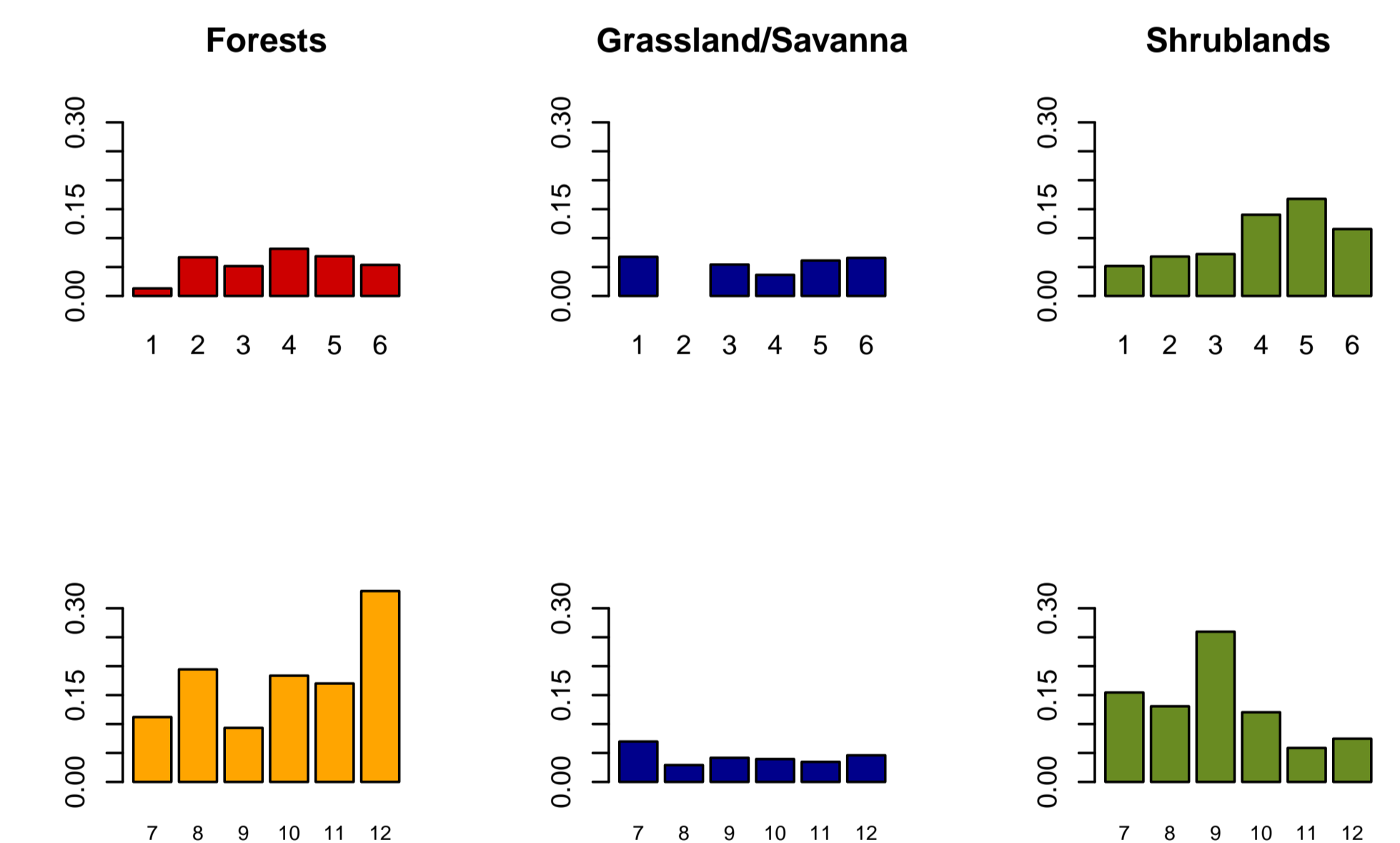
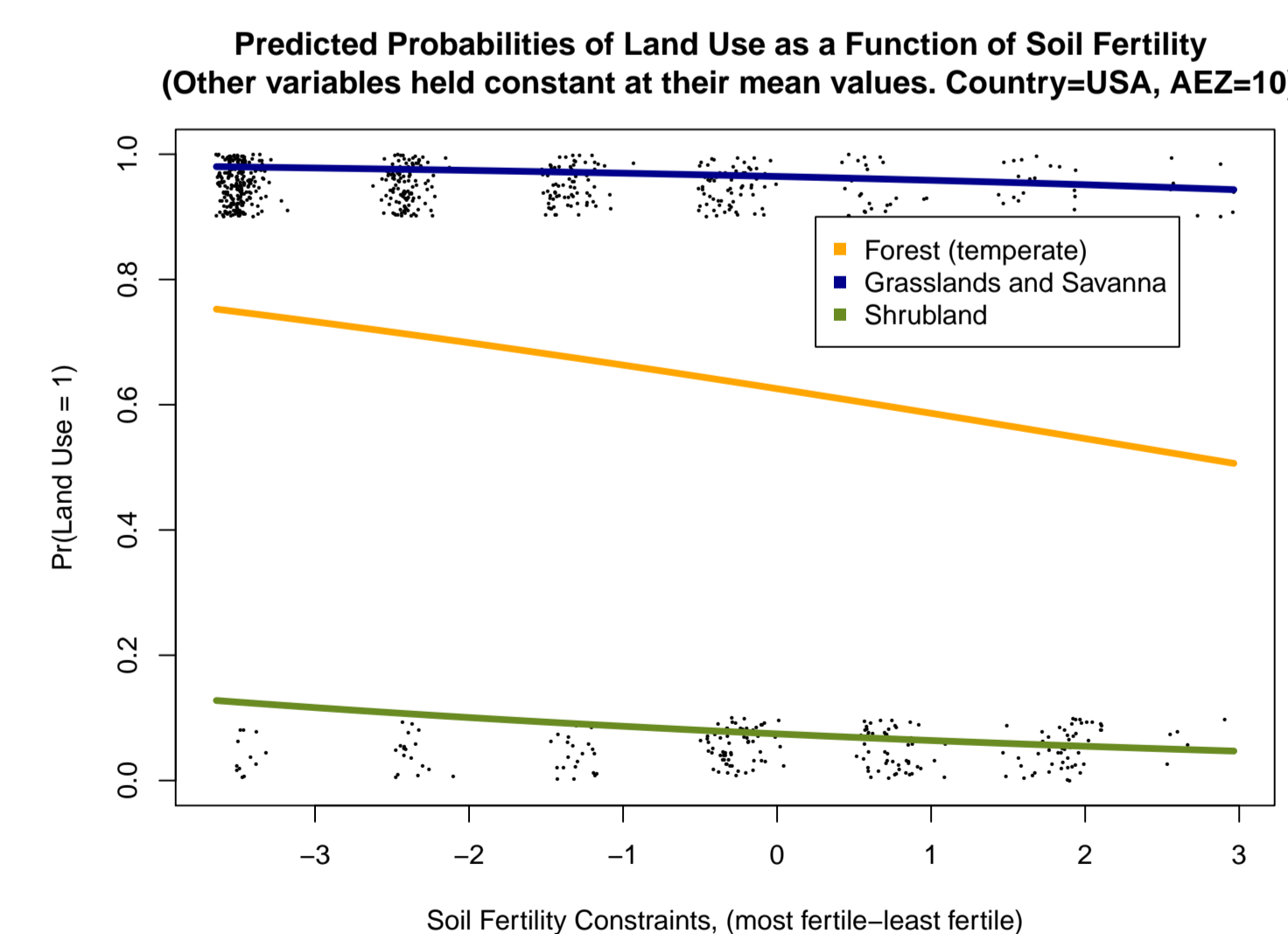
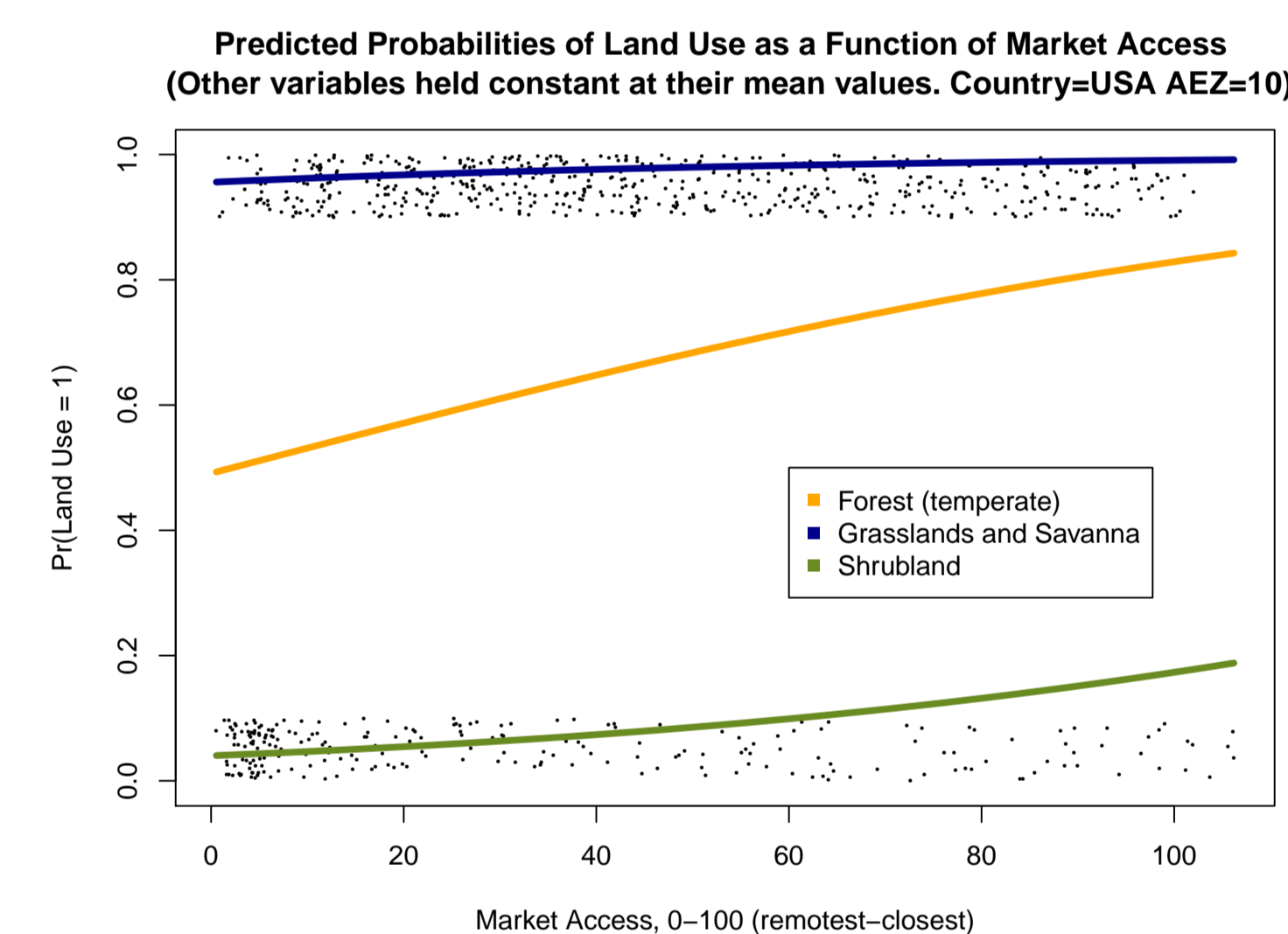
where  $\lambda$  is the probability density function of the logistic distribution. The elasticity to market access is given by:

$$\epsilon_{ma_i} = \lambda(\cdot) (\hat{\beta}_{ma}) \frac{ma_i}{P(Z_i = 1|\cdot)}$$

## Results & Discussion

The model can be used to identify

- ▶ the effects of market access on the responsiveness of each cover type while holding land quality and other variables constant (left), or
- ▶ the effects on land quality on the probability of land use holding market access and other variables constant (right).



AEZs 1-6 are tropical and 7-12 are temperate. The reported values are AEZ-cover average elasticities to market access weighted by the predicted probability of land use. The only work we have to put these estimates in perspective is Lubowski (2002), who focuses on the US. His forest-to-cropland elasticity (from a nested Logit specification, evaluated at the means) is 0.2104, our analogous estimate is 0.2339. His pasture-to-cropland elasticity (conditional Logit, evaluated at the means) is 0.0598. Ours is 0.0572.

## References

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