# Bigger is Better:
# Optimizing Forest Code Compliance to Sustain Brazilian Agriculture, Biodiversity & Ecosystem Services at a Landscape-Scale


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***The Dow Chemical Company***
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# Socio-Environmental Context


- Cerrado: Global biodiversity hotspot, with less than 50% natural habitat & < 2 % protected (Klink & Machado 2005)
- Land use: cattle ranching and increasingly sugarcane production (Lapola et al. 2010)
- Nature conservation on agriculture (private) lands is vital and regulated by the Brazilian Forest Code (FC) (Soares-Filho et al. 2014)
- Brazil pilot: Guide business decisions about land use to meet the FC and to optimize agricultural production *and* benefits of habitat restoration, biodiversity & ecosystem services

Cerrado

Cattle ranching

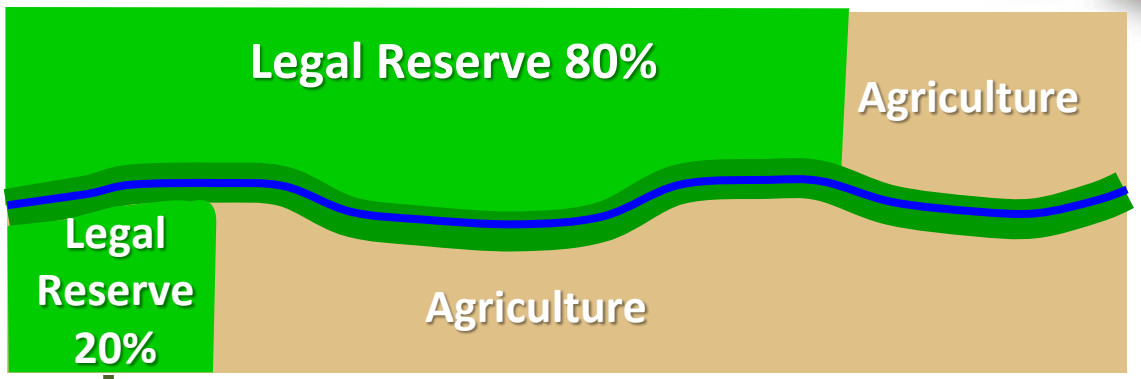
Sugarcane

# Brazilian Forest Code


*Rural Property*

**LEGAL AMAZON**

**NON LEGAL AMAZON**

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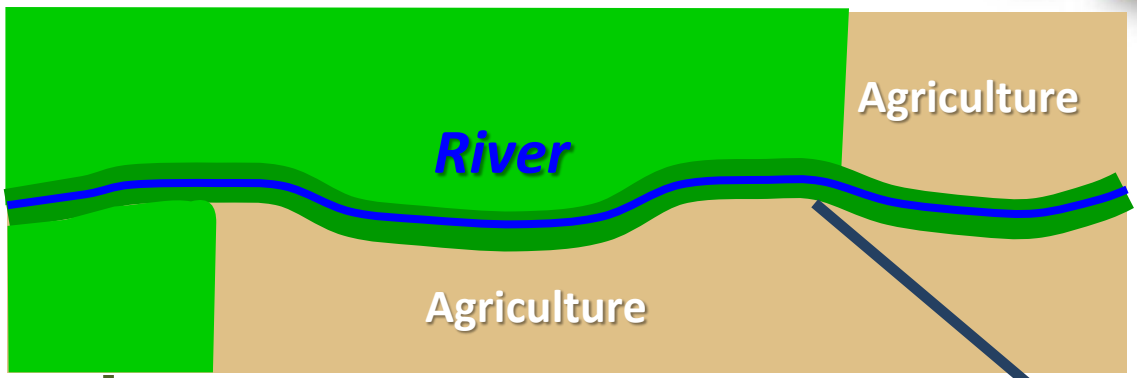
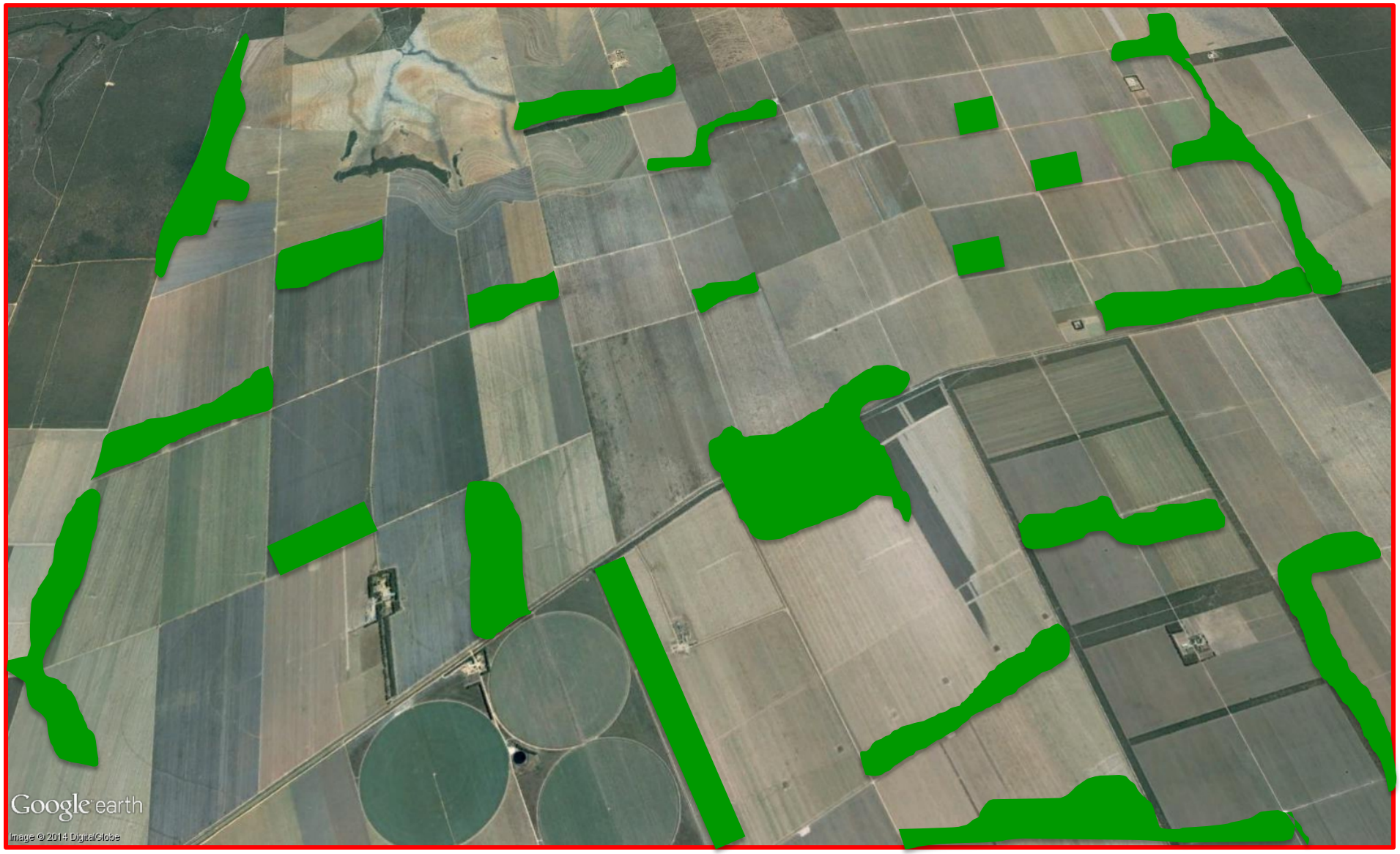




***Permanent Preservation Area (PPA)***

# Forest Code Compliance at Different Spatial Scales

## *Property (farm)-level*

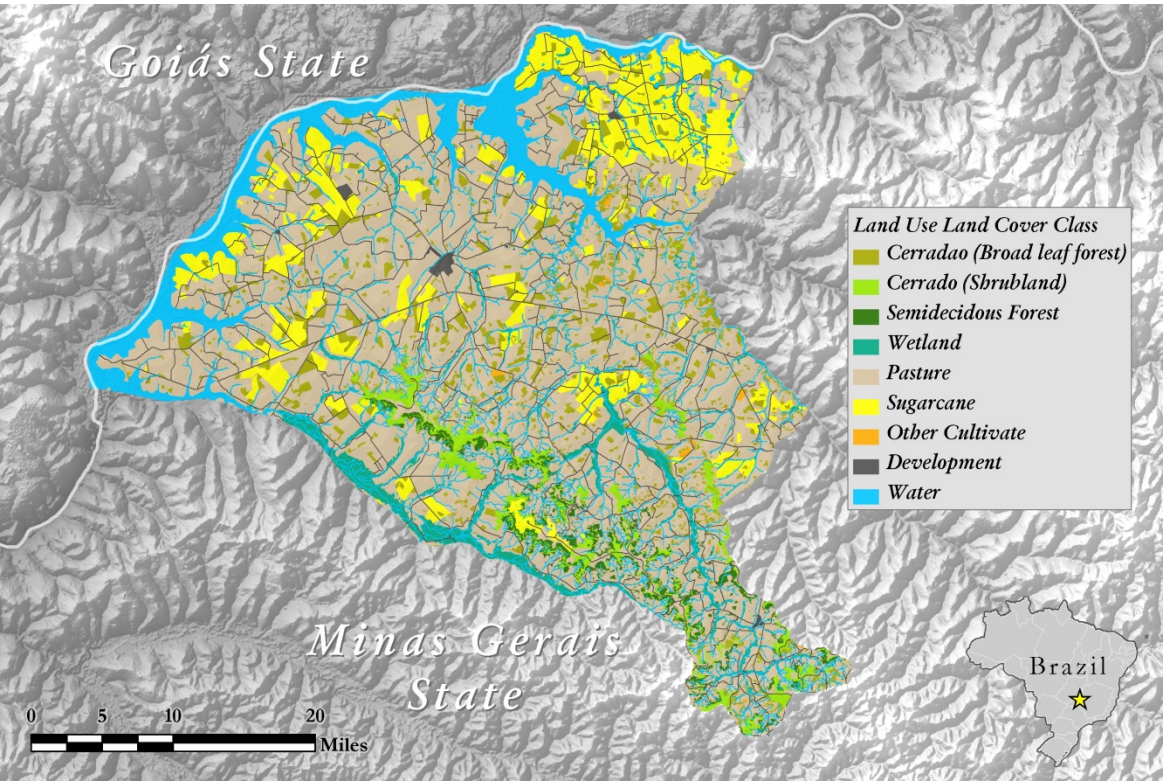


# Forest Code Compliance at Different Spatial Scales

## *Landscape (watershed)-level*

# Spatial Scale to Minimize Business Costs & Maximize Nature Benefits

*Landscape-level Compliance*



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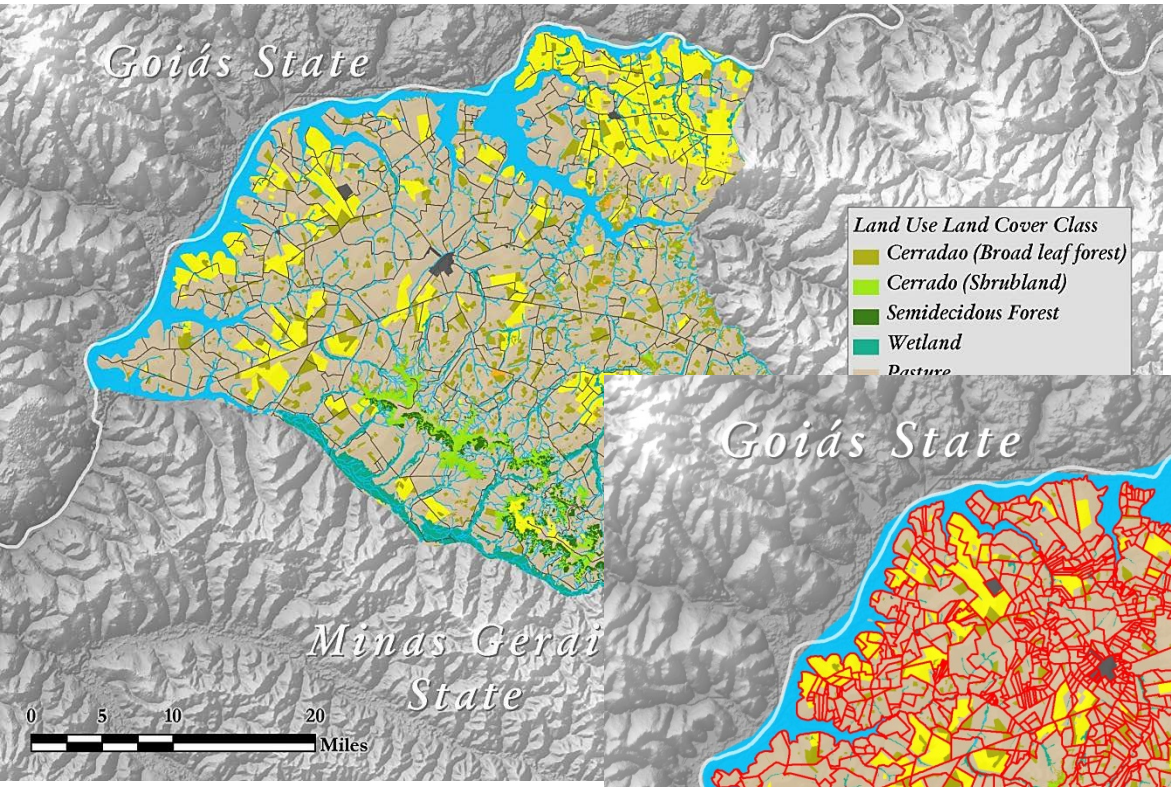
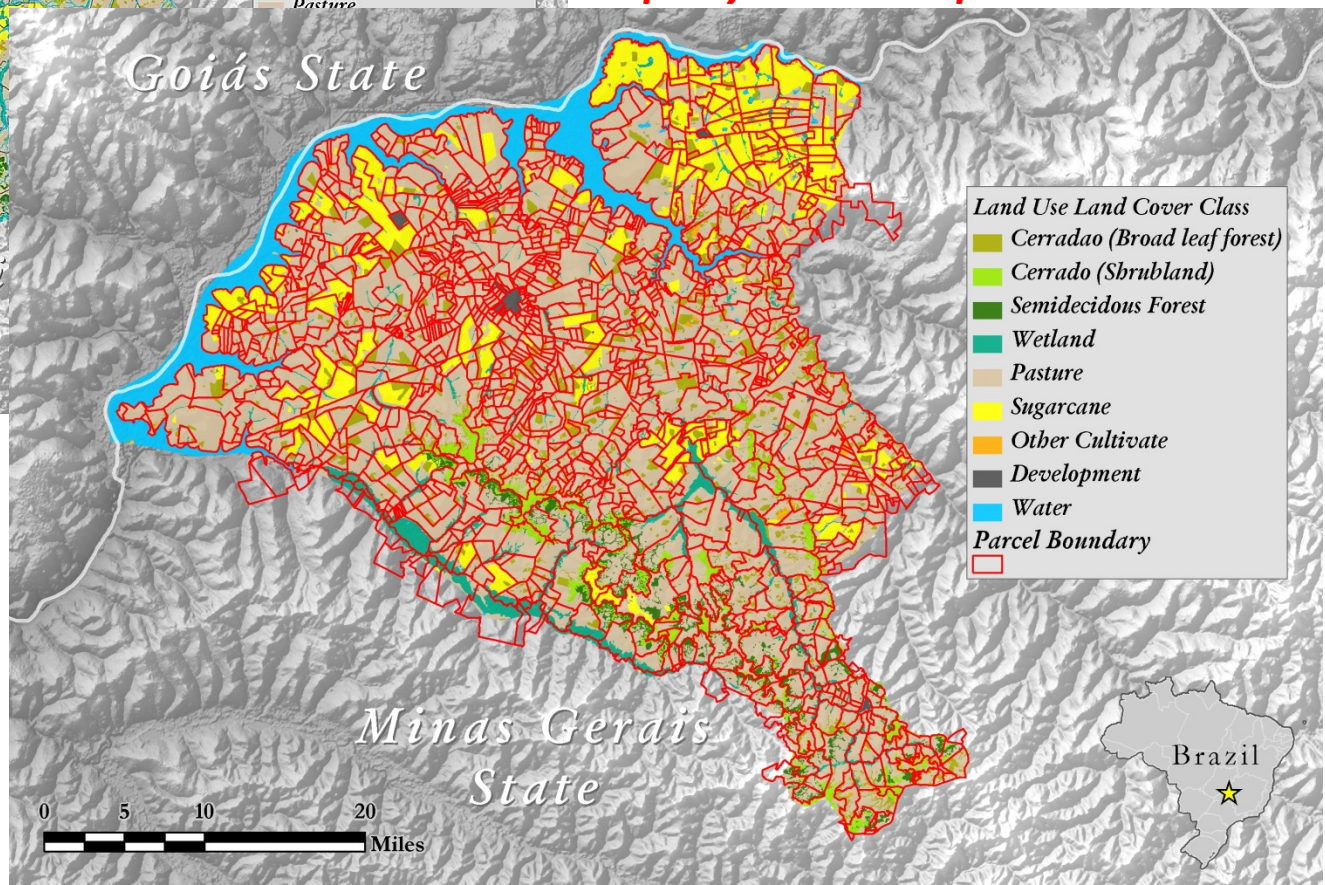



***Property-level Compliance***

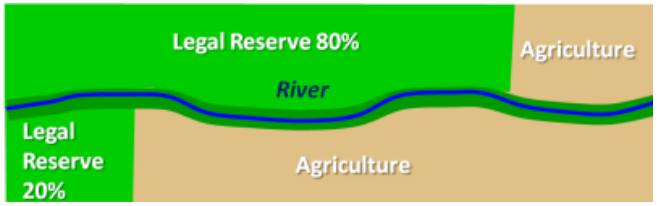


# Economic & Environmental Modeling

**Agriculture**

Cattle ranching
Sugar cane

- Economic return ($)




**Forest Code**

- Amount of habitat required (LRs + PPAs)
- Cost of Forest Code compliance ($)

**Biodiversity**

- # of Birds & Mammals in landscape

**Terrestrial Surface Water Quality & Carbon Sequestration**

- Nutrients & sediments in waterways
- Carbon sequestration from habitats

# 1st Optimization Approach: Minimize Cost

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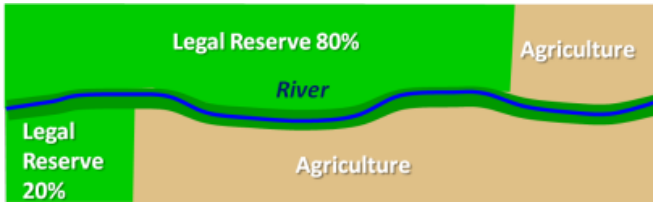


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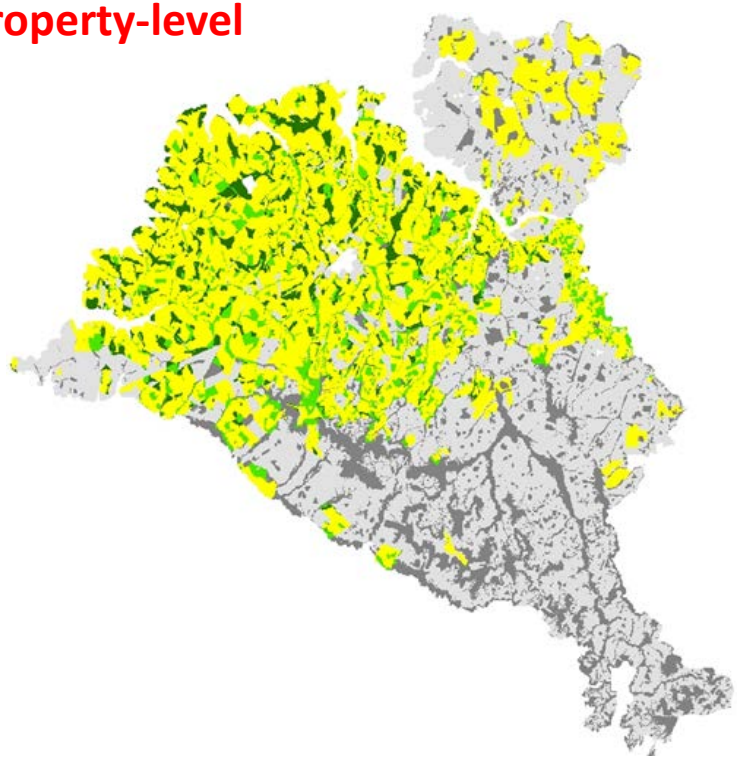
# Landscape-level Planning: Better for Business & Nature

**Property-level**



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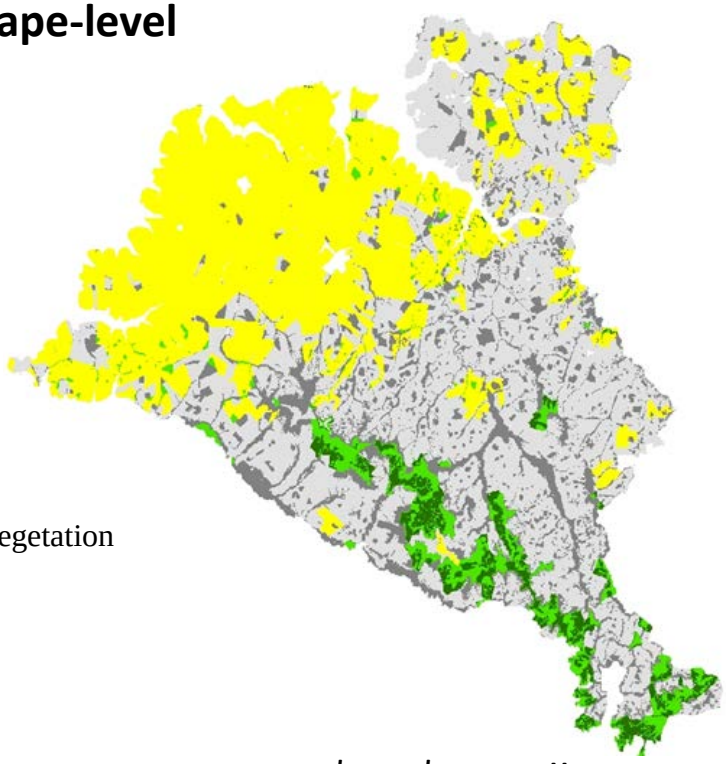
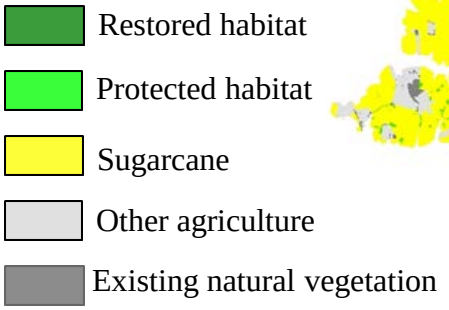




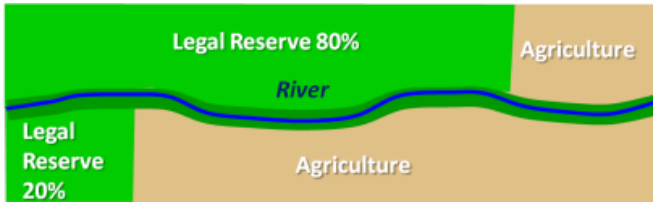

- Profitable land set-aside for FC compliance
- Additional 30-69 farms needed to meet production
- More habitat required for compliance: 11,500 (±2600) ha
- Habitat is more fragmented

- Cost savings: USD $19-$35 million
- Reduced transportation, leasing, and restoration costs
- Supports up to 74 more species
- Stores 151,000 additional tons carbon (with restoration): Valued at $1-17.5 million
- Similar water quality

# 2nd Optimization Approach: Efficiency Frontiers

√ **Agriculture**
Cattle ranching
Sugar cane

- Economic return ($)

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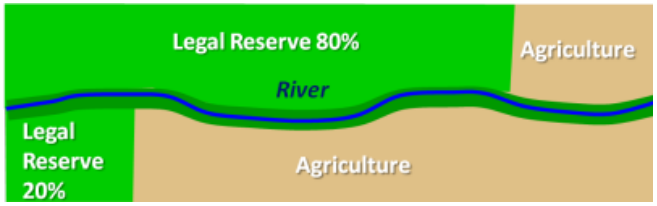


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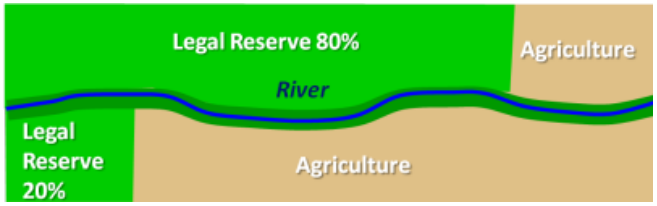


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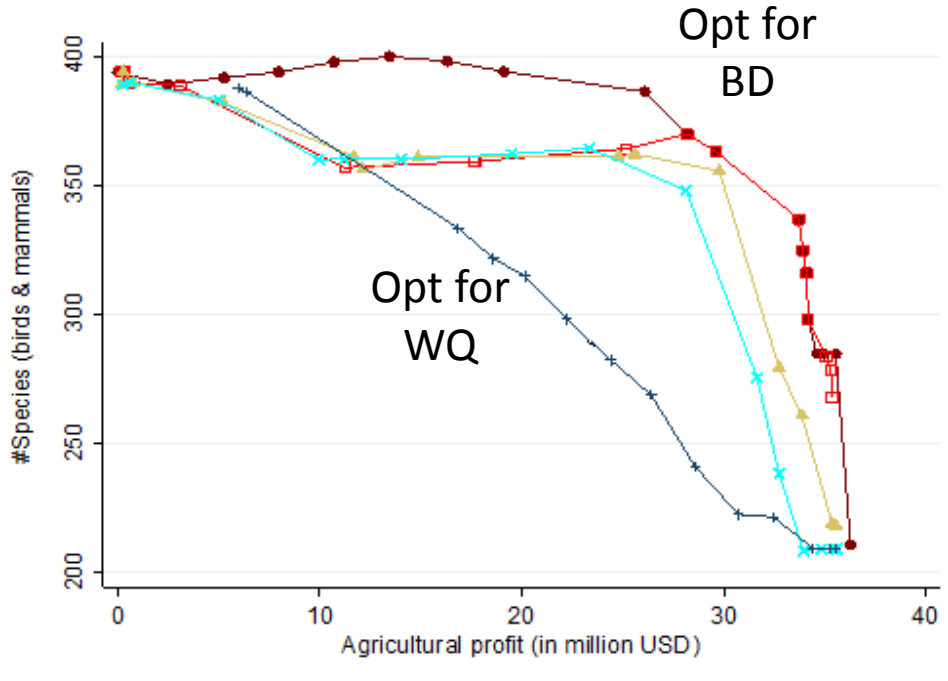
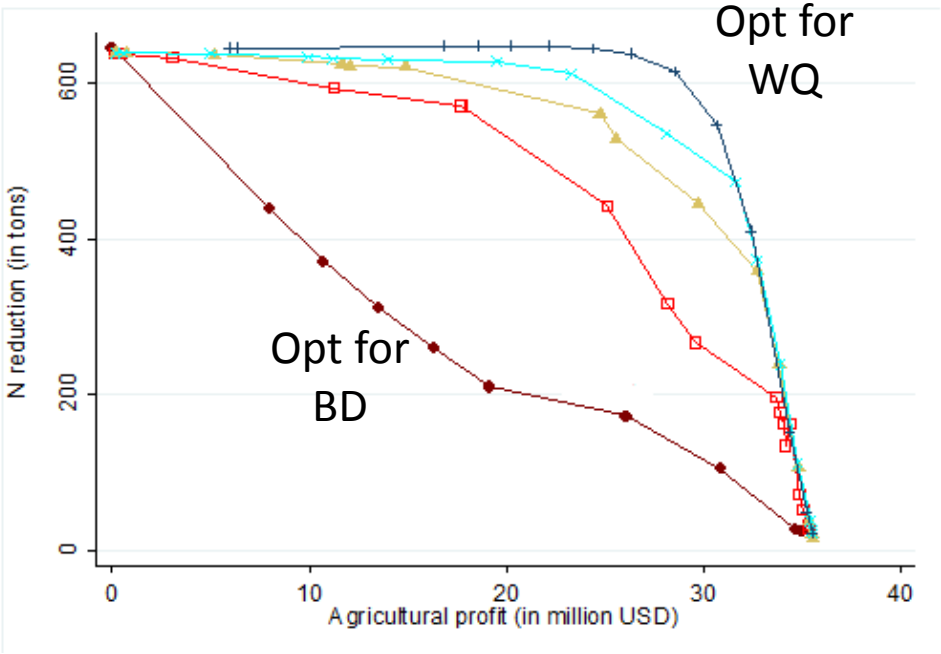
# Efficiency Frontier: Service Trade-offs

vs

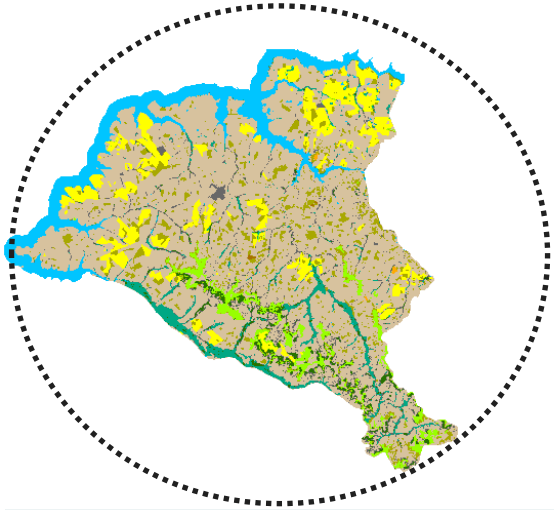


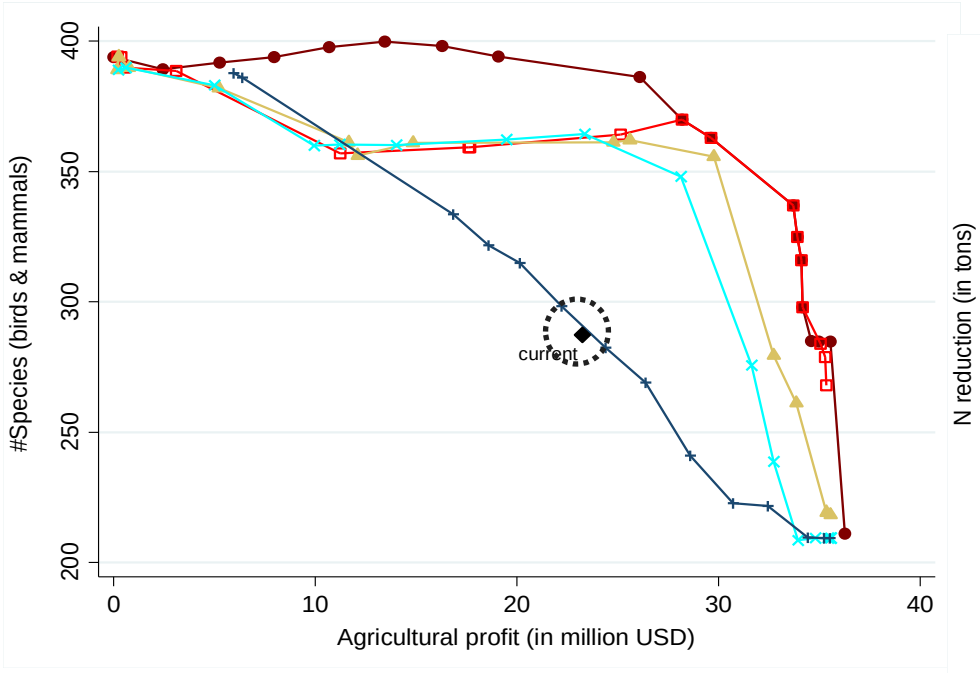



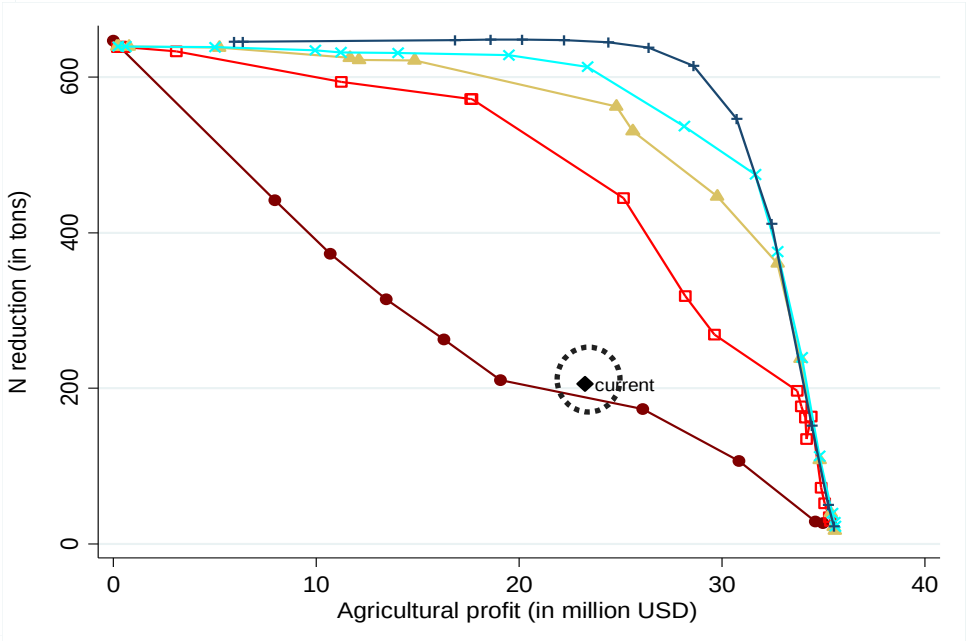

Only BD — High BD — Medium BD — Low BD — Only WQ

# Efficiency Frontier: Improving Outcomes

Current Landscape





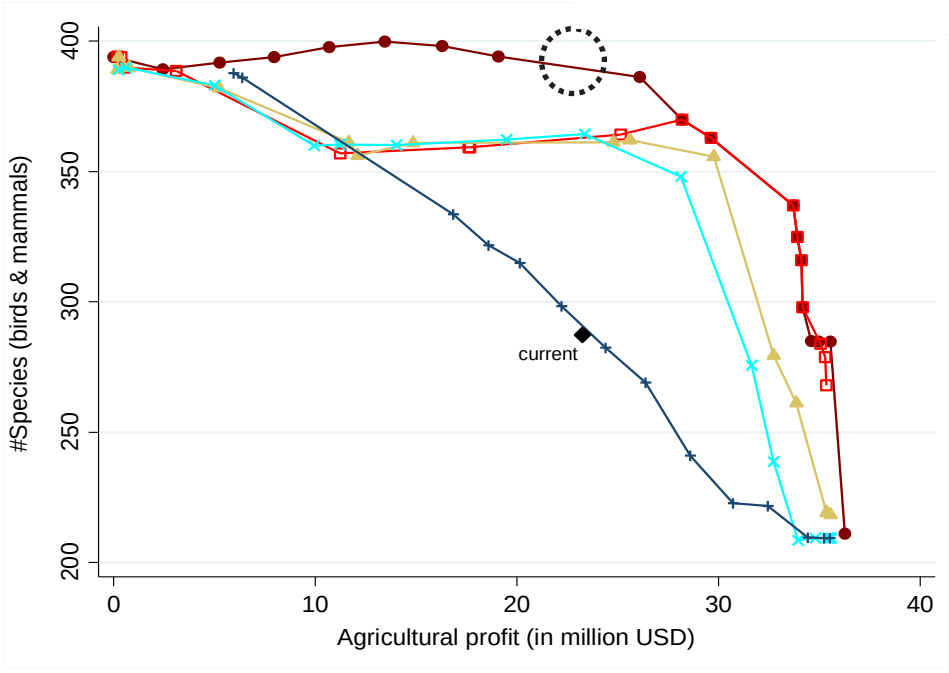



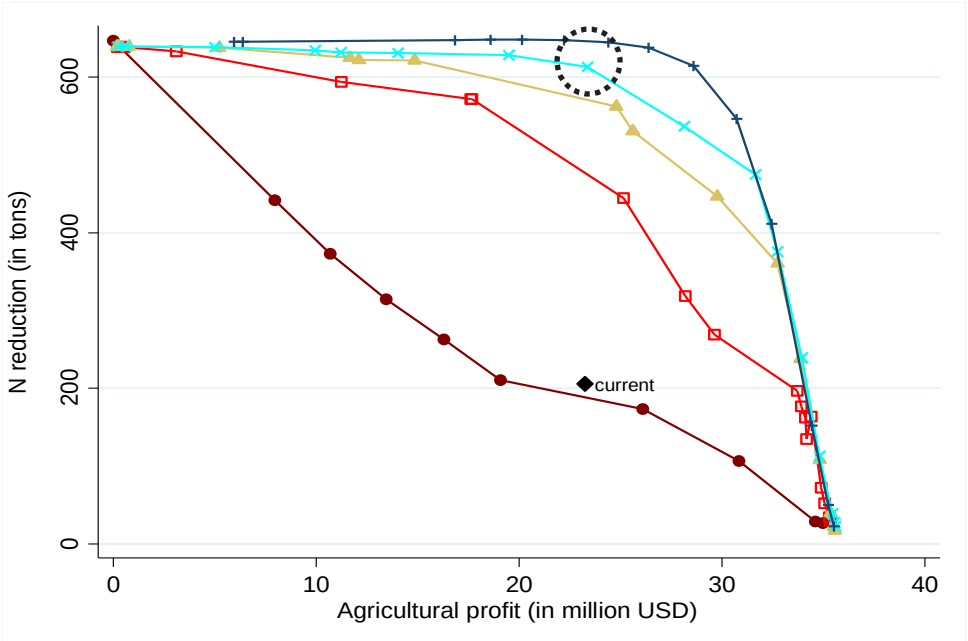

Only BD  High BD  Medium BD  Low BD  Only WQ

# Efficiency Frontier: Improving Outcomes

- Gain >100 species

- 3x Reduction of nutrients in waterways

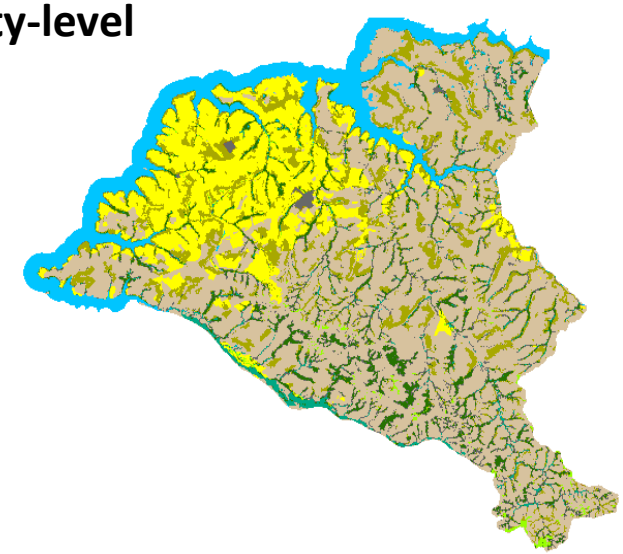


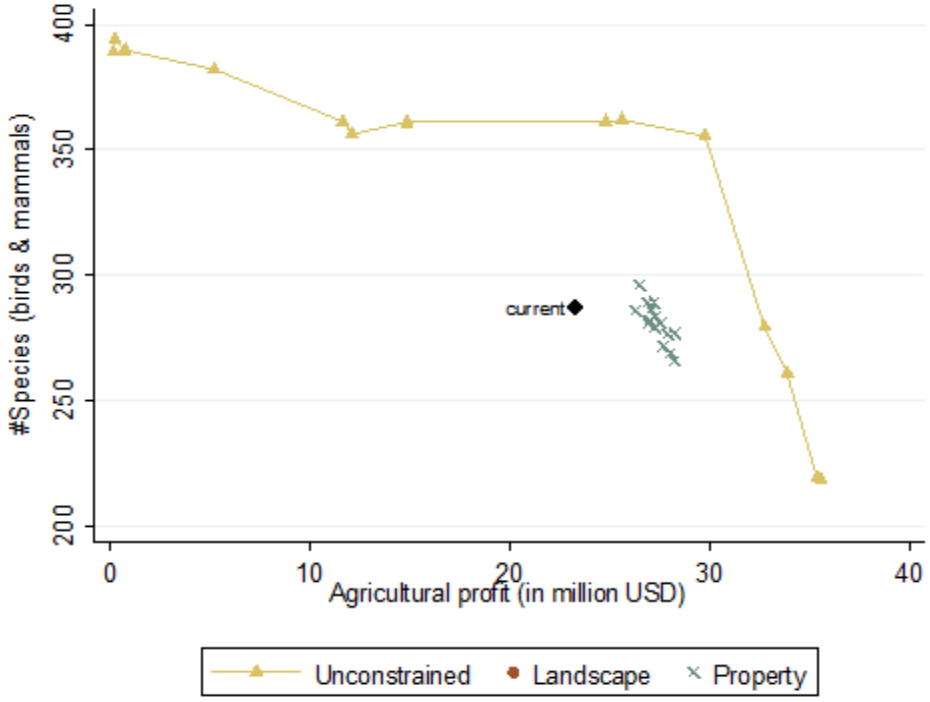



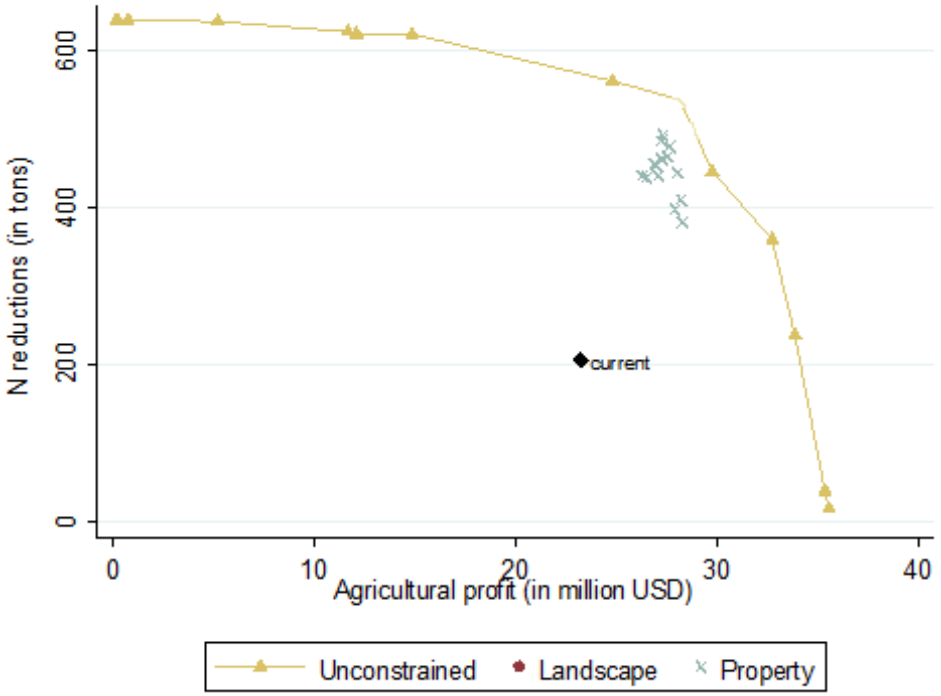

Only BD  High BD  Medium BD  Low BD  Only WQ

# Joint BD-WQ Planning at Different Scales

- **Property-level**

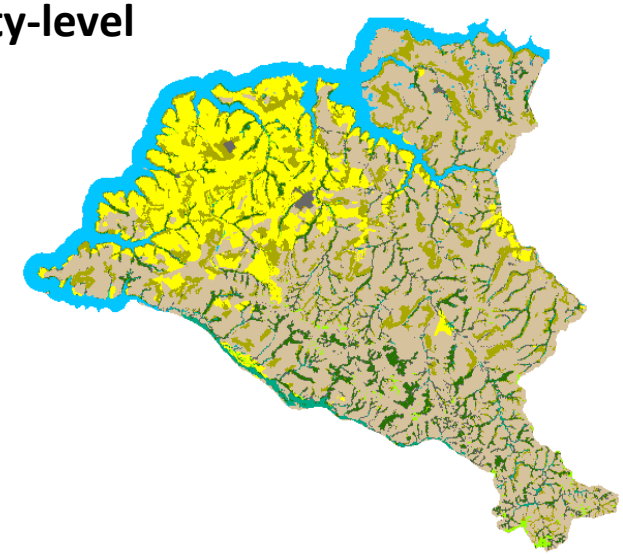




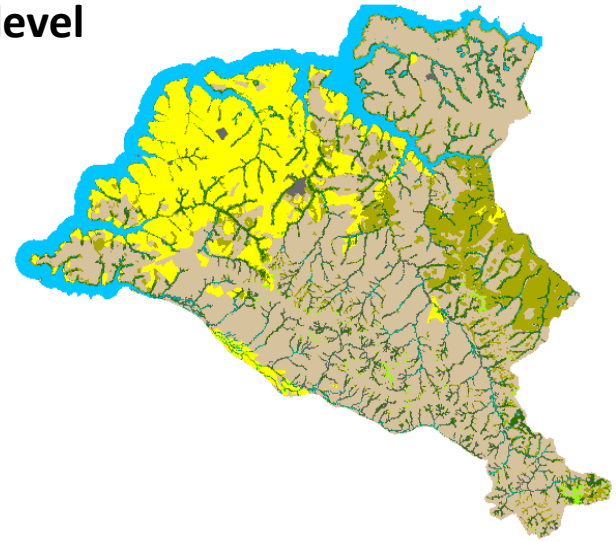



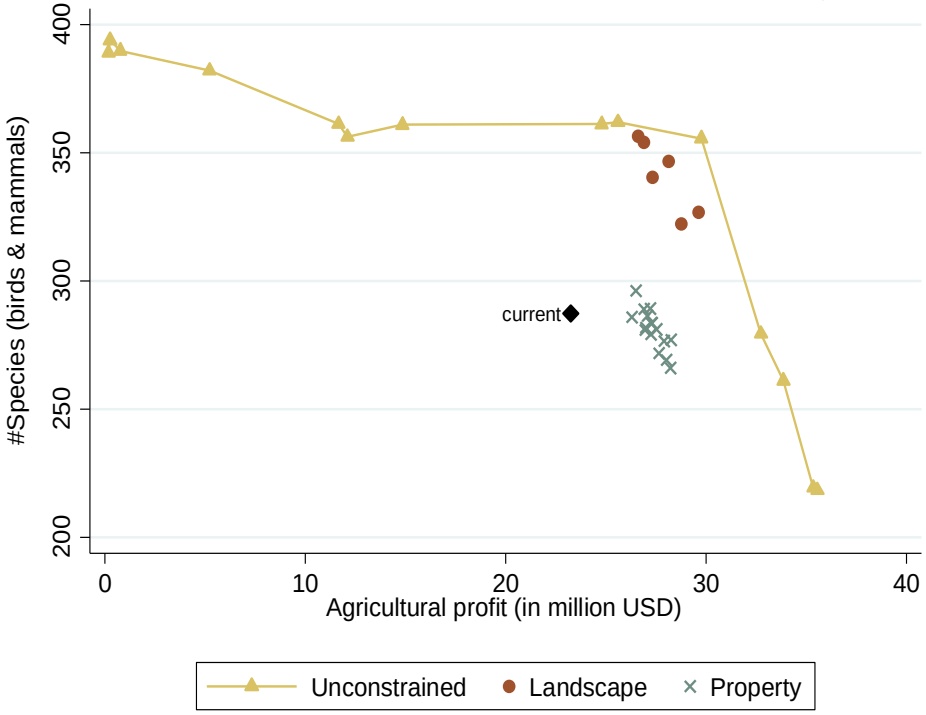
# Joint BD-WQ Planning at Different Scales

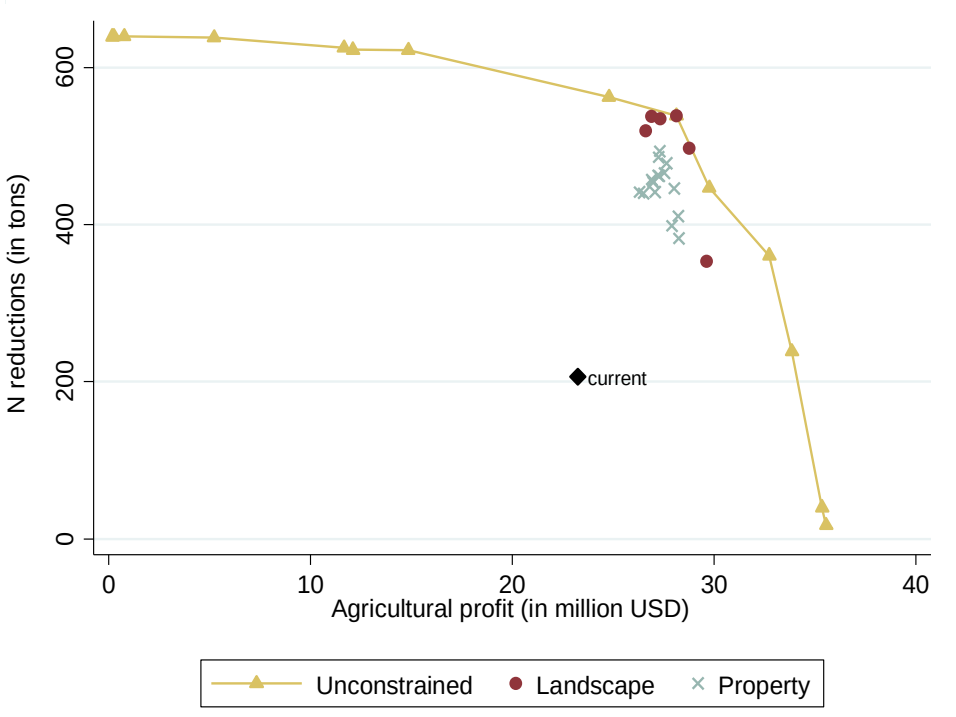
X Property-level



Landscape-level





# Designing Sustainable Landscapes

- **1 Billion new hectares** of agricultural land projected to sustain global demands for food, fodder, and fuel (Tilman et al. 2011)

- **Mitigation** is key mechanism to influence **environmental decision-making** (Madsen et al. 2011)

- Call for mitigation to **scale up**: move beyond site-specific to **landscape-level** (Hayes et al. 2014)

- Results indicate that landscape-level mitigation can provide *both* **business & conservation benefits**
  - Reduce costs to private landowners/developers
  - Enhance biodiversity
  - Provide additional carbon sequestration
  - Maintain water quality

- Need for mitigation to **broaden in scope**
  - Balance *both* **economic** & **environmental** trade-offs
  - Jointly plan for *both* **BD** & **ES** to prevent inadvertent losses
  - Proactively design **sustainable, multi-functional** landscapes

# Acknowledgments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The Dow Chemical Company
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## *Business Context*

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## *Hydrologic Modeling*

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## *Biodiversity Modeling*

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## *Carbon Valuation*

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Timm Kroeger
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