Post Great Recession construction boom in Charlotte NC.
Photo by DAS

EXPLORING THE POTENTIAL FOR SPRAWL ALTERNATIVES TO REDUCE ENVIRONMENTAL DEGRADATION AND ACCOMMODATE ECONOMIC GROWTH

Douglas A. Shoemaker
Todd K. BenDor
Melissa McHale
Ross K. Meentemeyer

Urbanization: A Strategic Opportunity

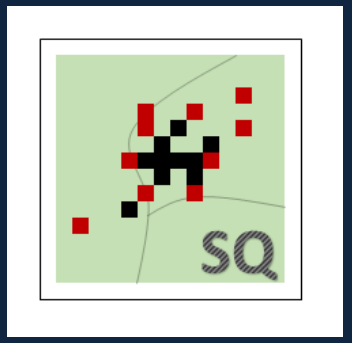
"We do not know the effects of different urban forms, densities, land use mix, and alternative infrastructures. We do not know, for example, how clustered versus dispersed and monocentric versus polycentric urban structures differently affect ecological conditions."

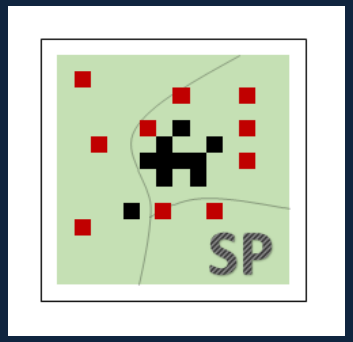
Marina Alberti, 2010

- In information vacuum we routinely exchange nature's benefits for economic growth (Polasky et al 2013)
- Needed are studies that analyze the relationship between urban pattern and ecosystem performance

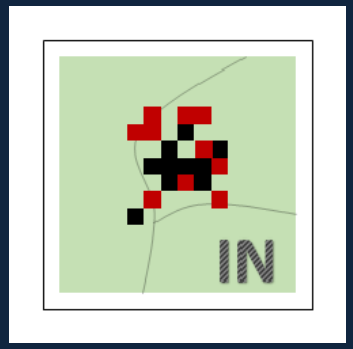
Plausible* Patterns of Urban Growth

Status Quo, or
business as usual

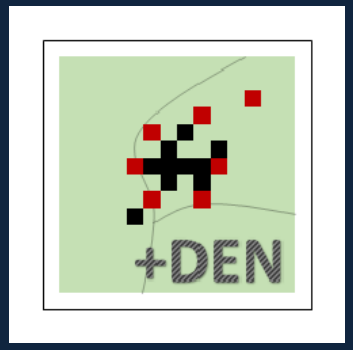




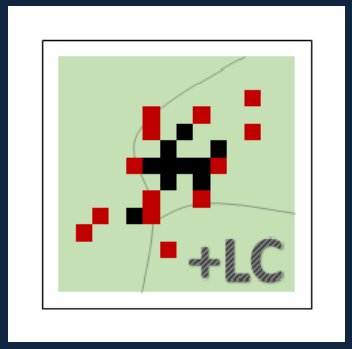
"Sprawl", disjunct and
leapfrog development



Infill, or growing around
existing infrastructure



Entitle increased density, thereby reducing demand
for land consumption

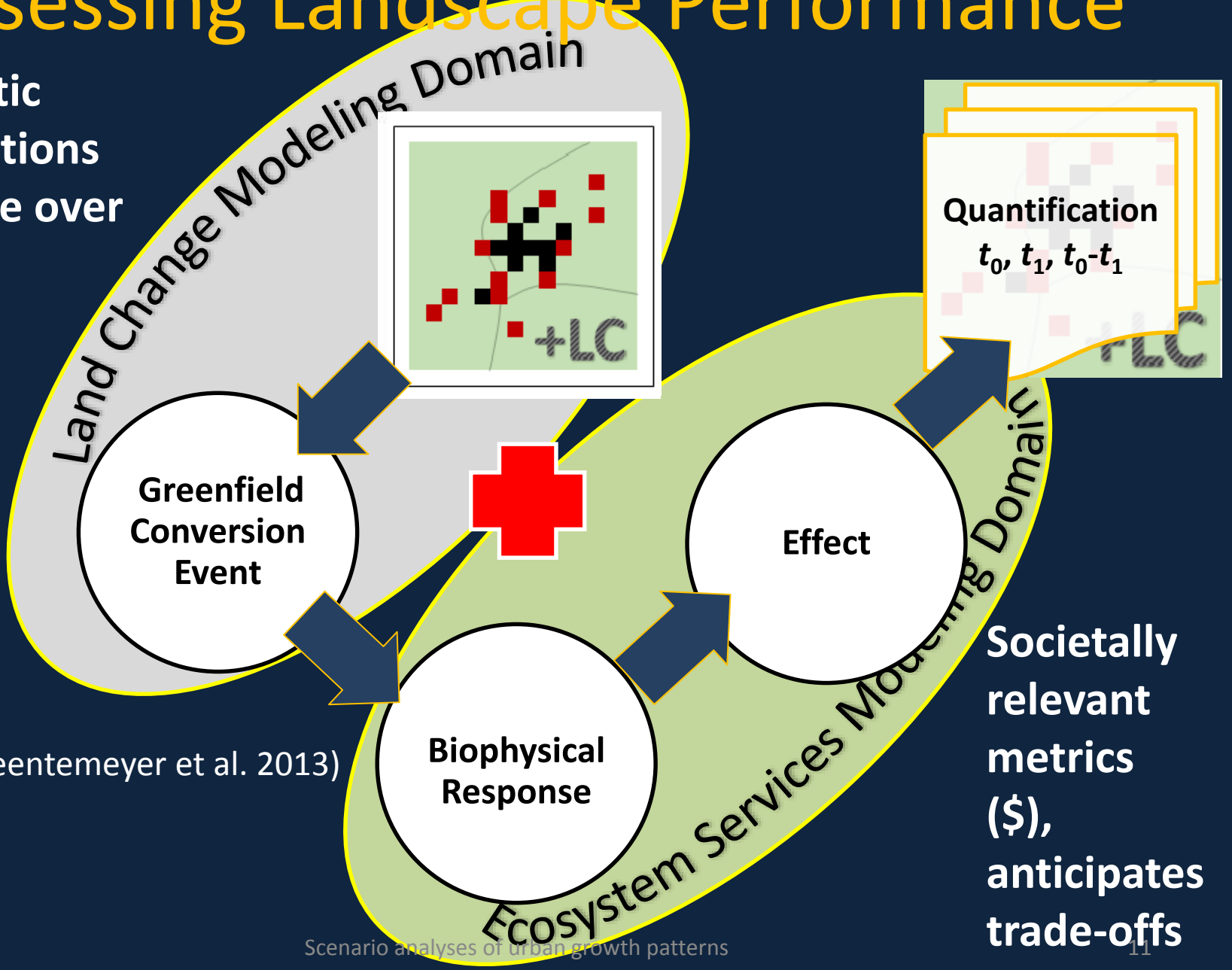


De-regulate, increase per capita land consumption

*US

Assessing Landscape Performance

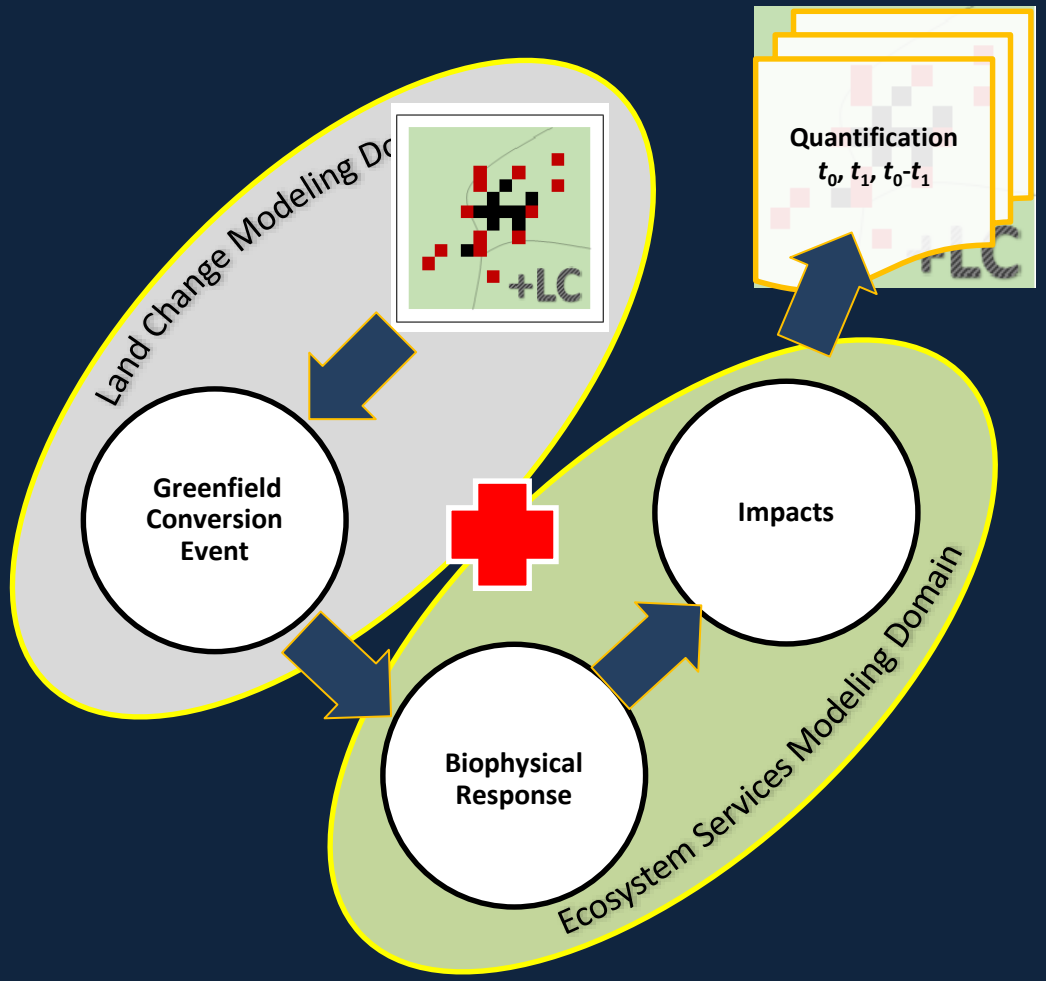
- **Realistic Projections**
- **Change over time**



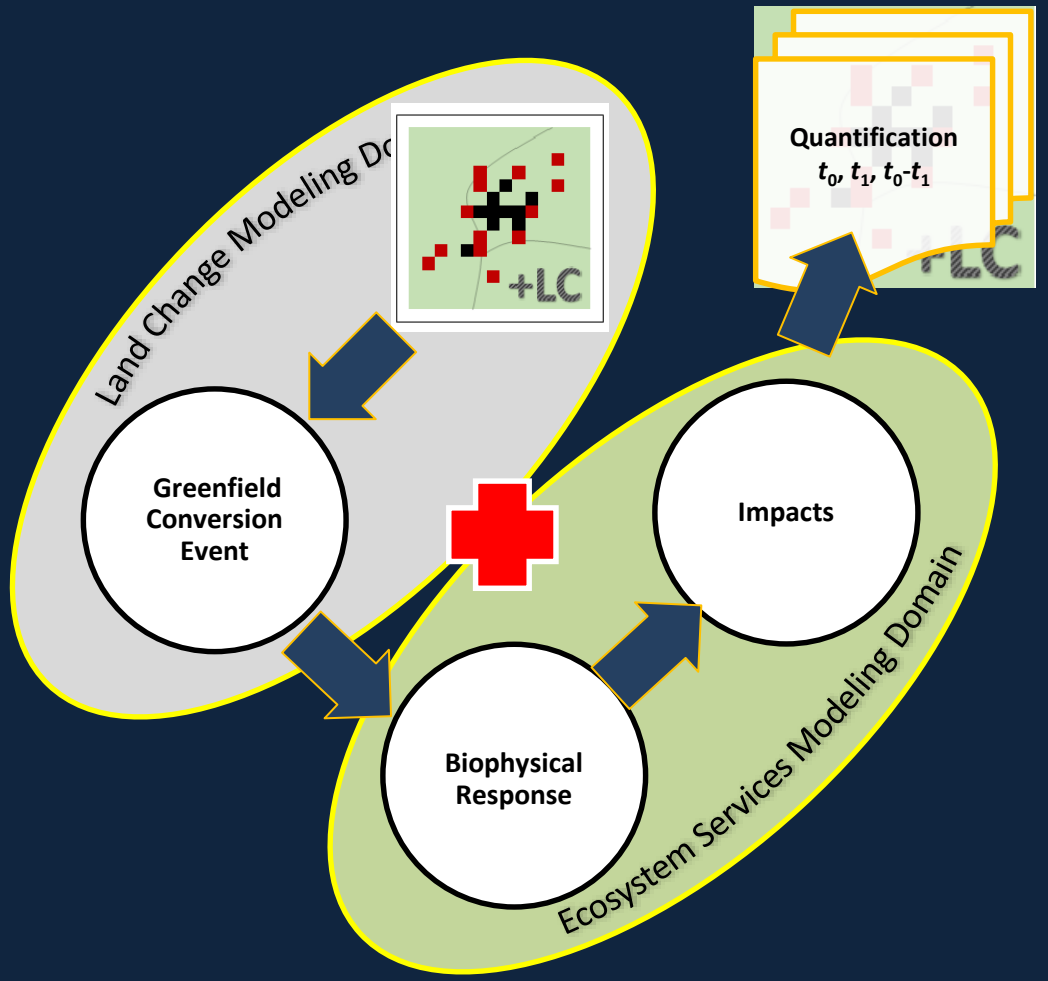
FUTURES (Meentemeyer et al. 2013)

Societally relevant metrics ($), anticipates trade-offs

- **Caveats:**
  - Results drawn from a simulated study system
    - Correspondence with "real world conditions" untested
    - Limit analyses to comparisons of alternative futures



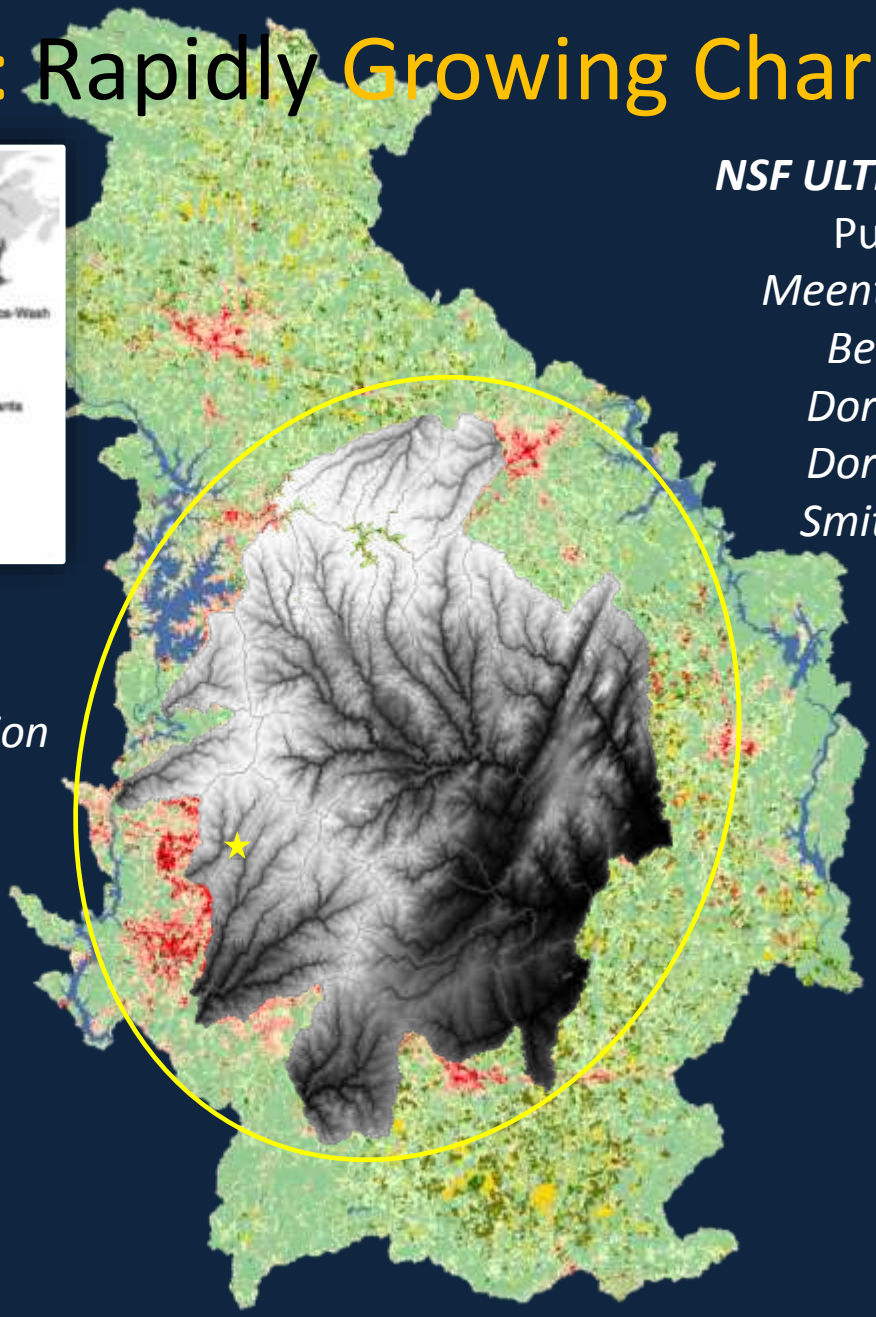
- **Caveats:**
  - Results drawn from a simulated study system
    - Correspondence with "real world conditions" untested
    - Limit analyses to comparisons of alternative futures
  - Many ecosystem services are not monitored
    - Practice should incorporate a wide range of services



Study System: Rapidly Growing Charlotte NC

2006
Population: *approx. 1.1 million*
(+235% since 1976)
Area: *346,000 ha*

Long urban gradient ideal for sampling
46% Canopy Cover*, Tops Med-Large US Cities
***American Forests 2010**

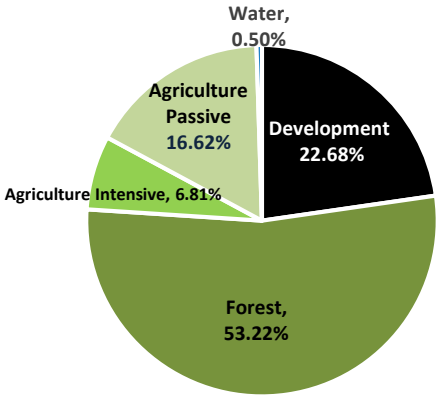


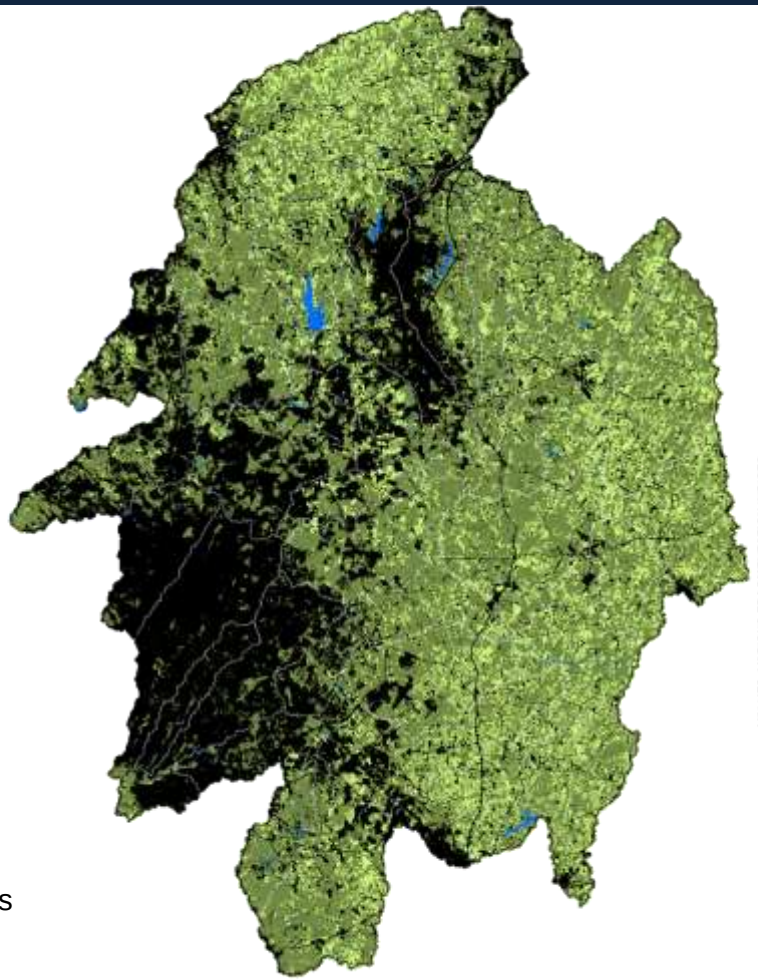
NSF ULTRA-Ex Site 2009-2012
Published Studies
Meentemeyer et al. 2013
Bendor et al. 2014
Dorning et al. 2015a
Dorning et al. 2015b
Smith et al. In review

★ Charlotte

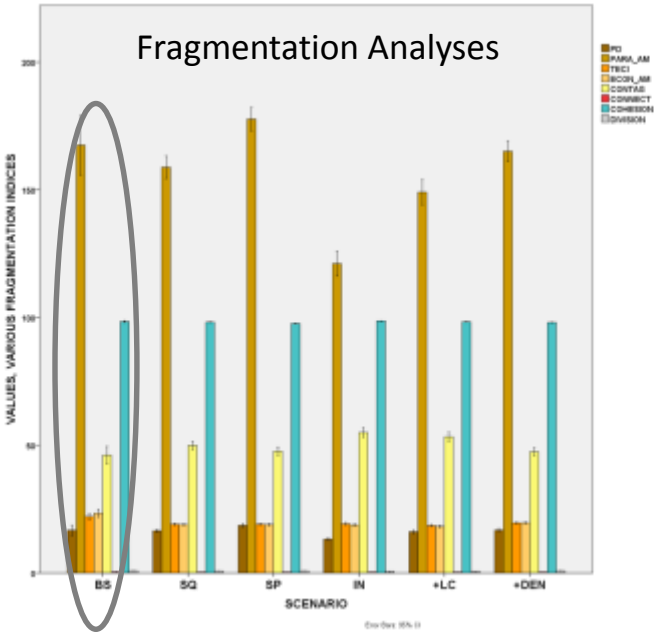
Which Fragments More?

Fragmentation | Habitat | Nitrogen | Phosphorus | Carbon | Revenues





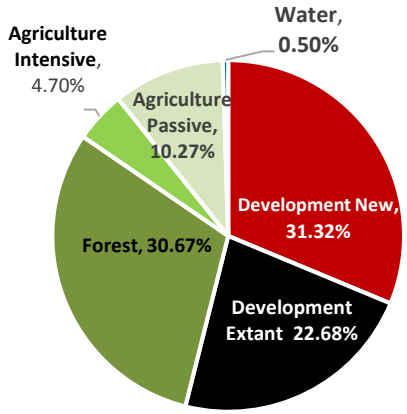
Start 2006

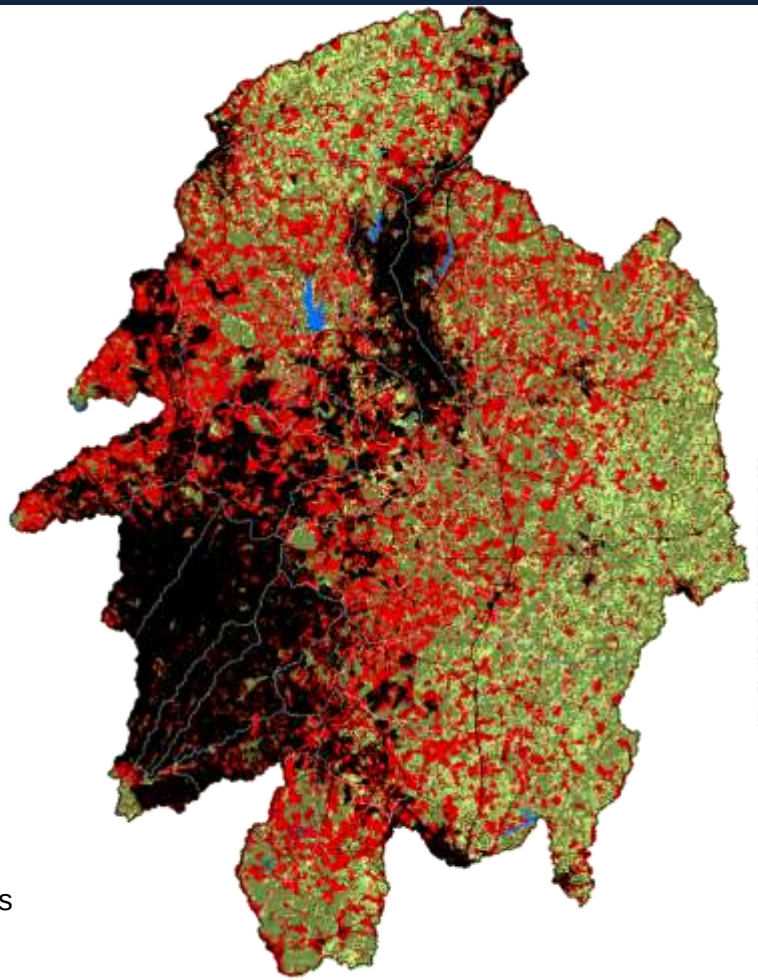


- Extant Development
- Forest/Agricultural Land Covers
- Subwatershed Delineation

Which Fragments More?

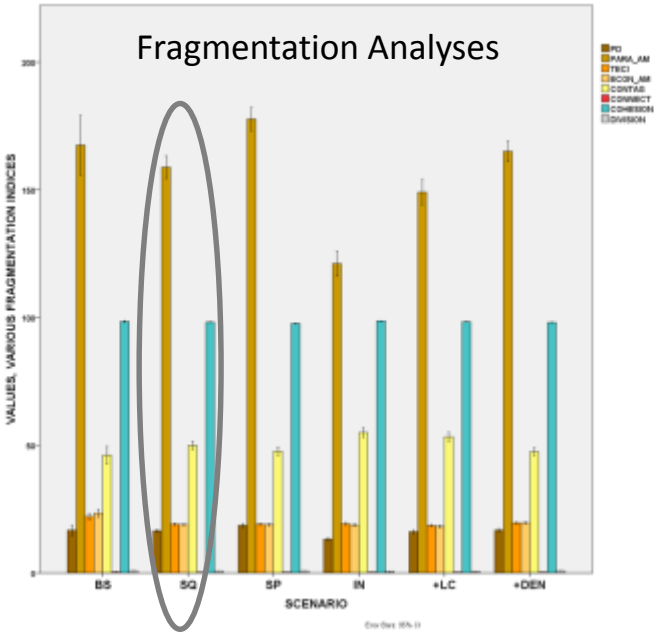
Fragmentation | Habitat | Nitrogen | Phosphorus | Carbon | Revenues





Status Quo

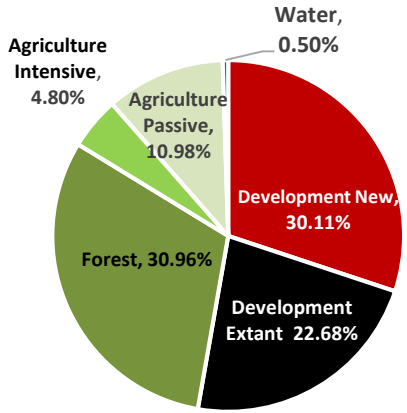
2030

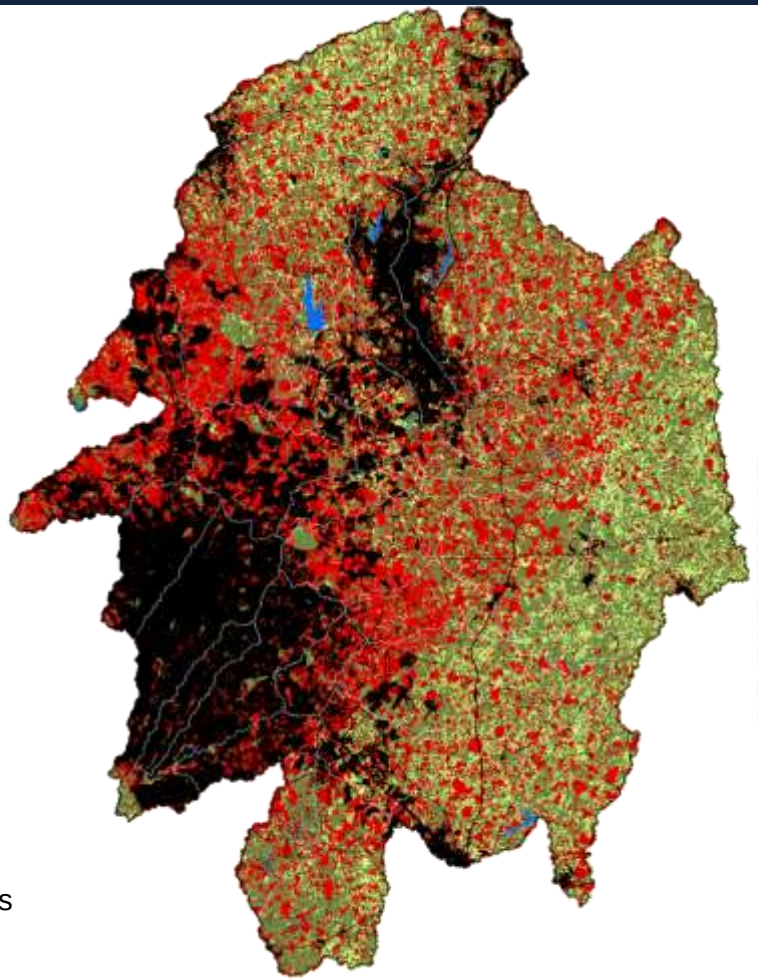


- Extant Development
- Projected Development
- Forest/Agricultural Land Covers
- Subwatershed Delineation

Which Fragments More?

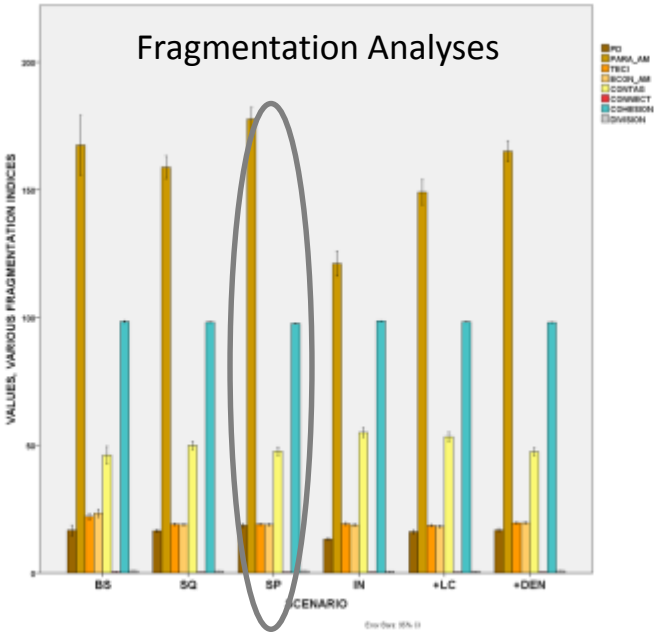
Fragmentation | Habitat | Nitrogen | Phosphorus | Carbon | Revenues





Sprawl

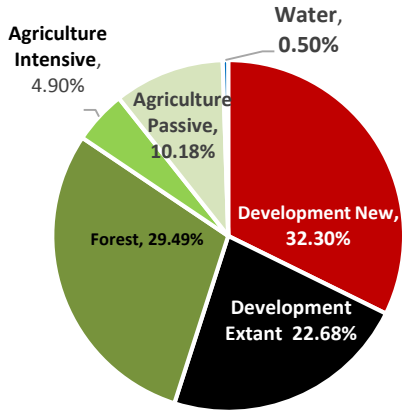
2030

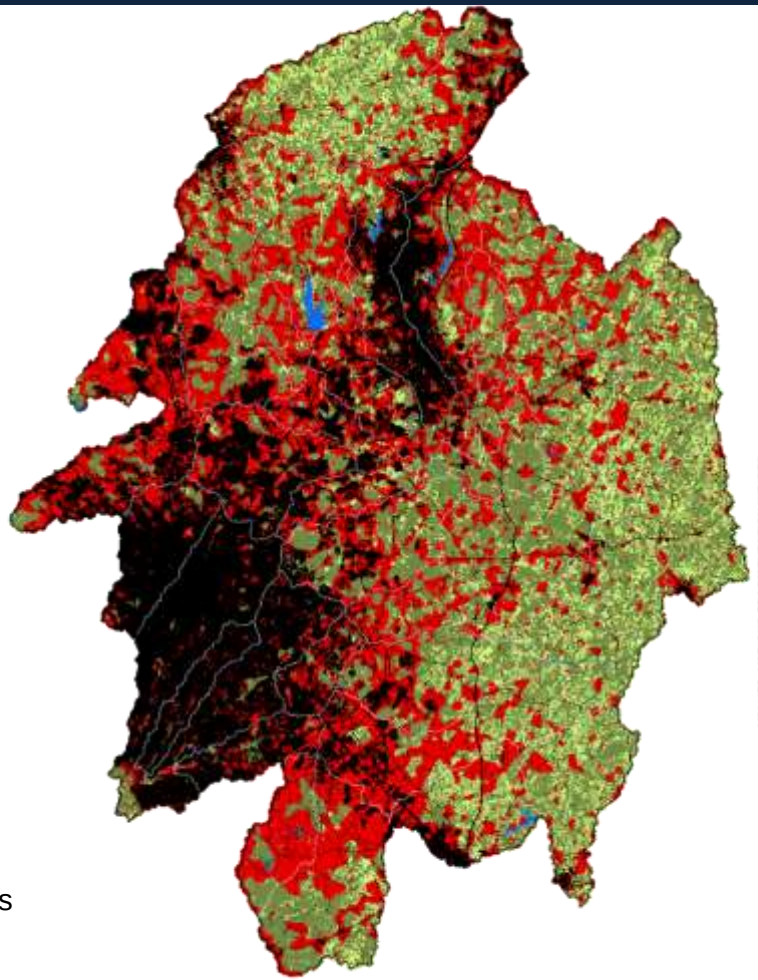


- Extant Development
- Projected Development
- Forest/Agricultural Land Covers
- Subwatershed Delineation

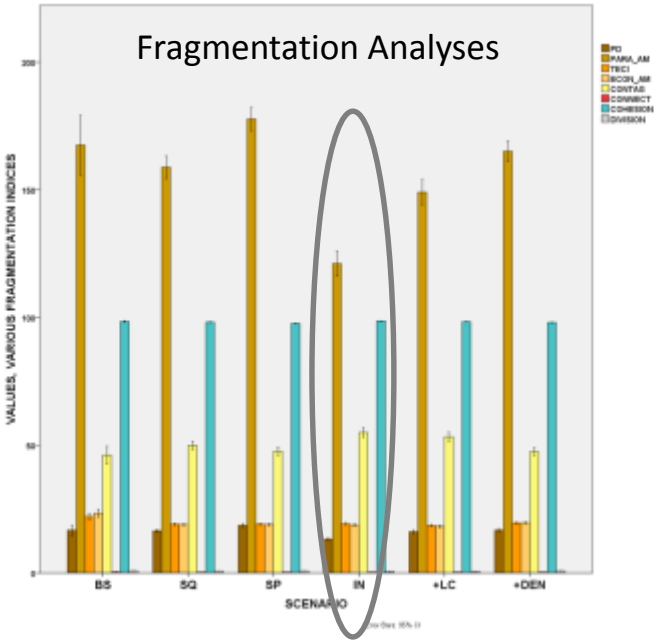
Which Fragments More?

Fragmentation | Habitat | Nitrogen | Phosphorus | Carbon | Revenues





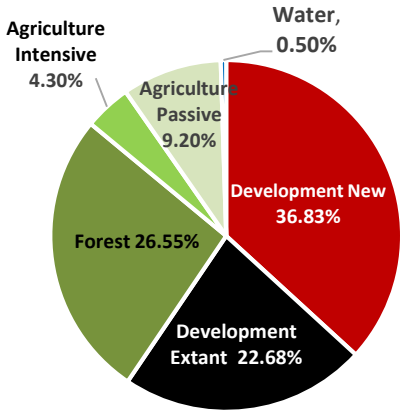
Infill
2030

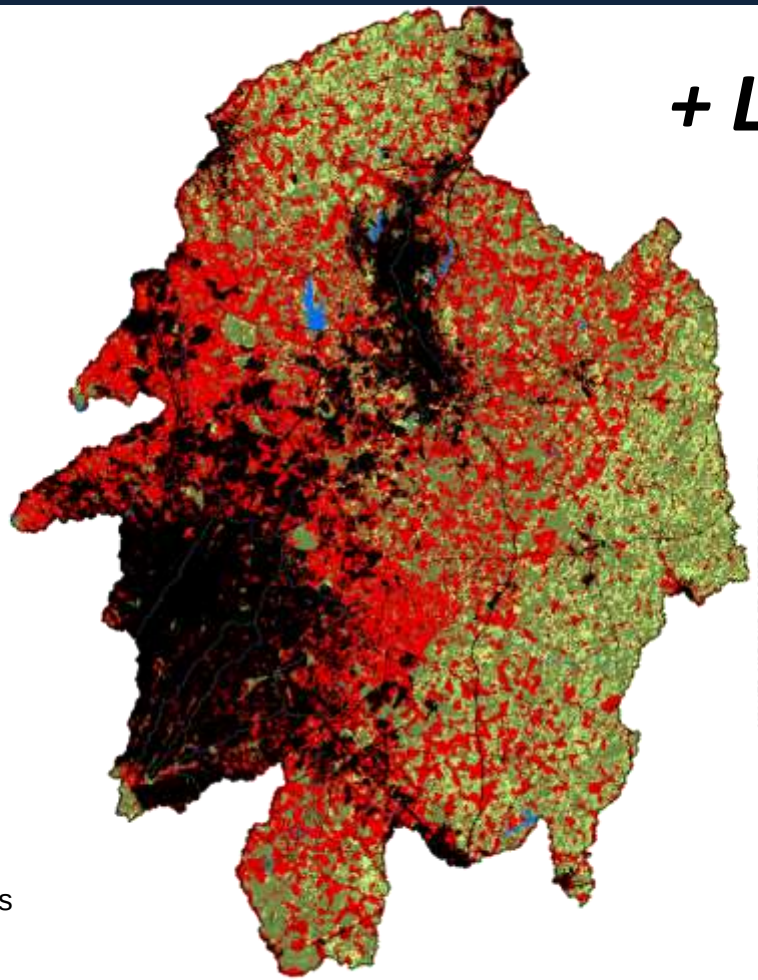


- Extant Development
- Projected Development
- Forest/Agricultural Land Covers
- Subwatershed Delineation

Which Fragments More?

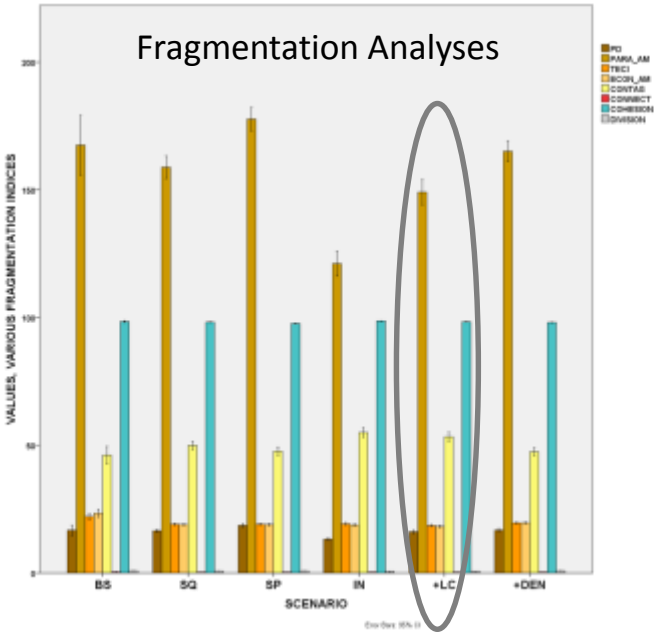
Fragmentation | Habitat | Nitrogen | Phosphorus | Carbon | Revenues





+ Land Consumption

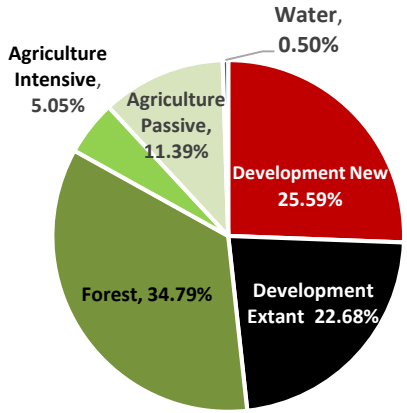
2030

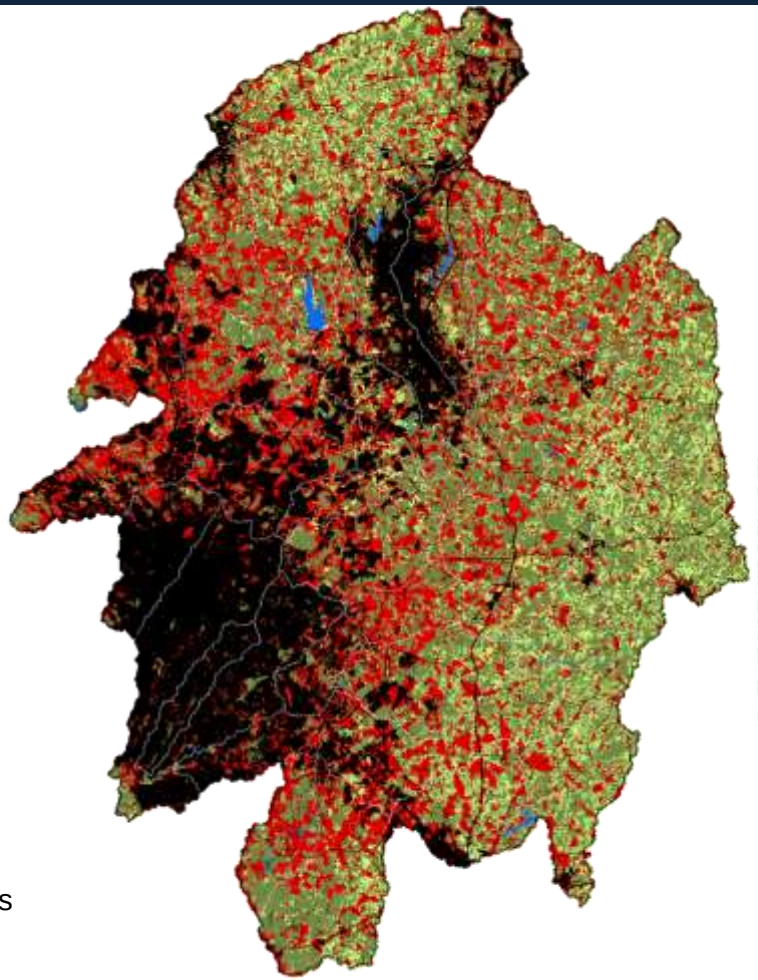


- Extant Development
- Projected Development
- Forest/Agricultural Land Covers
- Subwatershed Delineation

Which Fragments More?

Fragmentation | Habitat | Nitrogen | Phosphorus | Carbon | Revenues

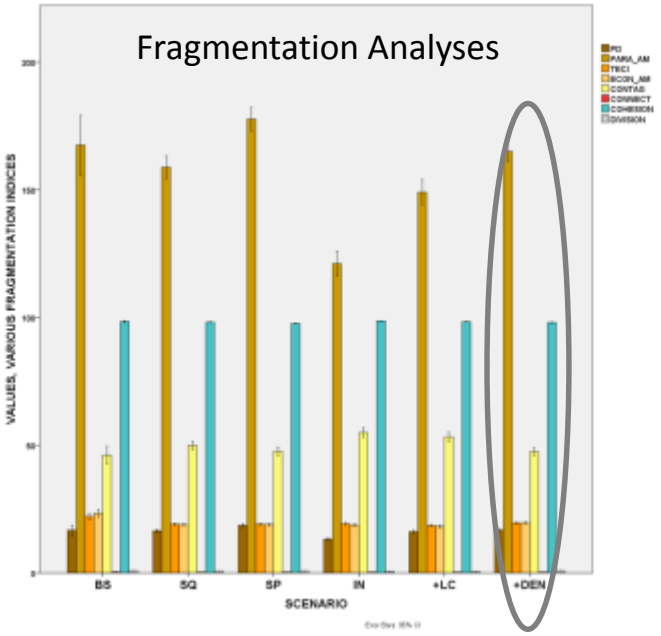




Extant Development
Projected Development
Forest/Agricultural Land Covers
Subwatershed Delineation

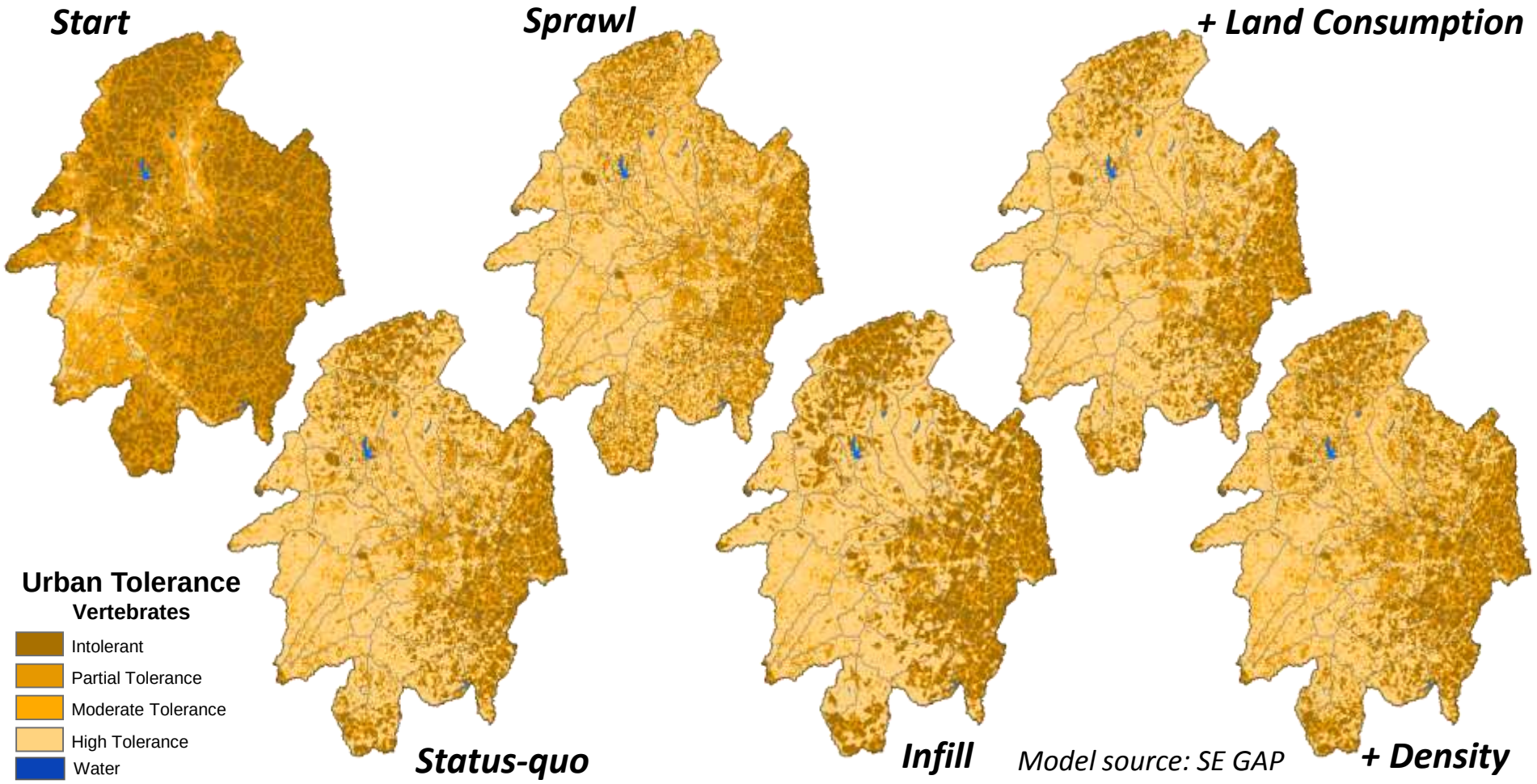
+ Density

2030



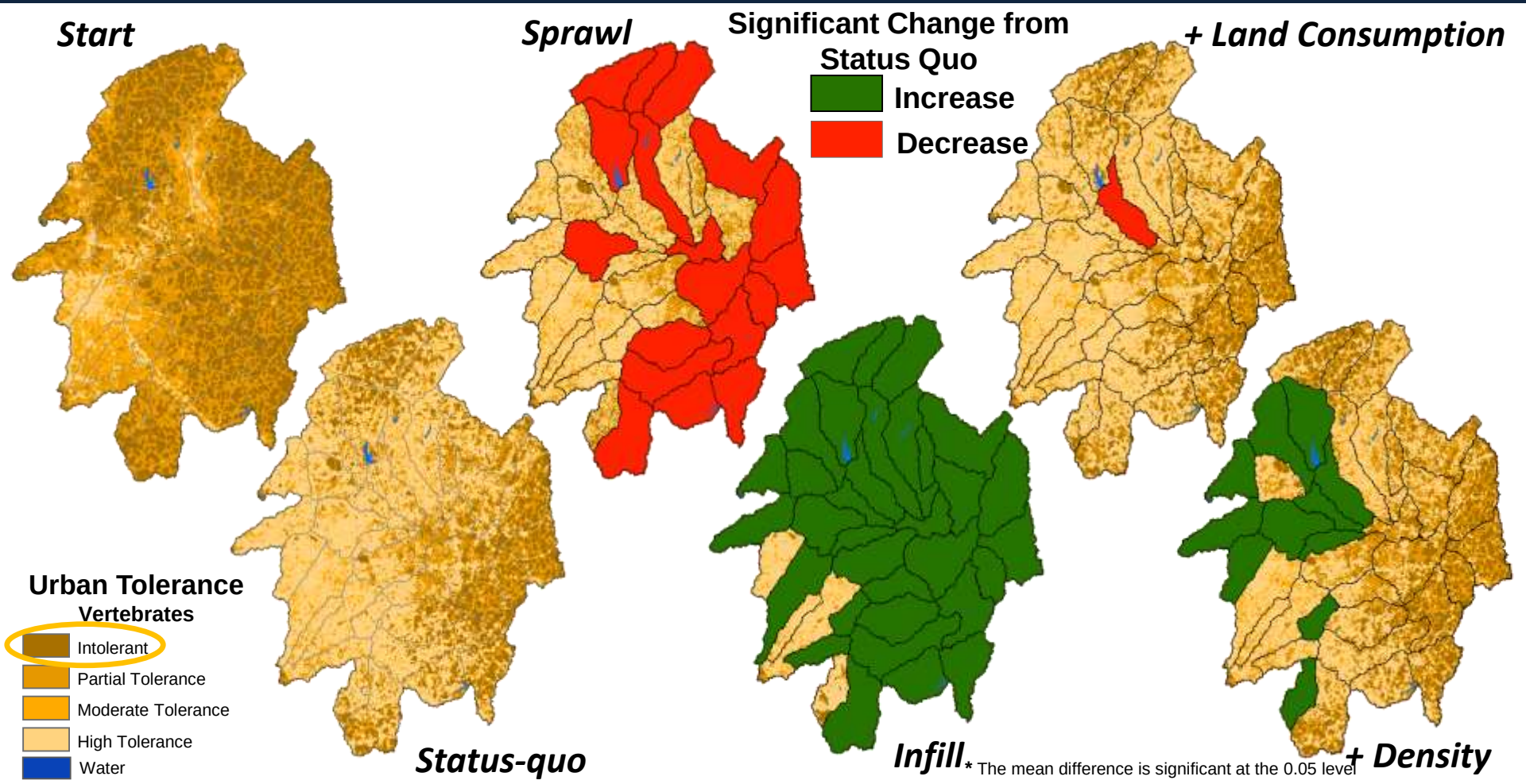
How Does Habitat Change?

Fragmentation | **Habitat** | Nitrogen | Phosphorus | Carbon | Revenues



How Does Habitat Change?

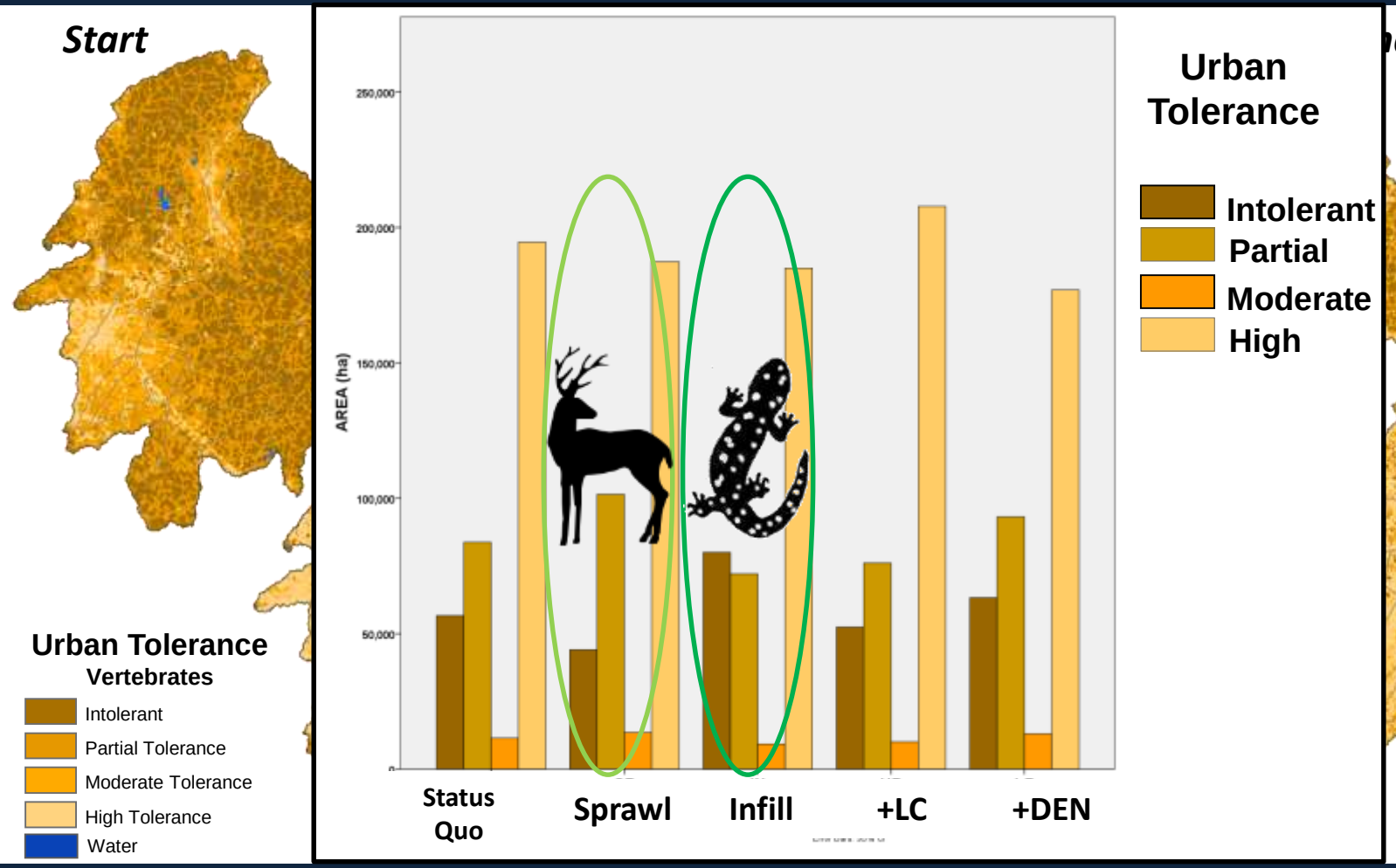
Fragmentation | **Habitat** | Nitrogen | Phosphorus | Carbon | Revenues



* The mean difference is significant at the 0.05 level

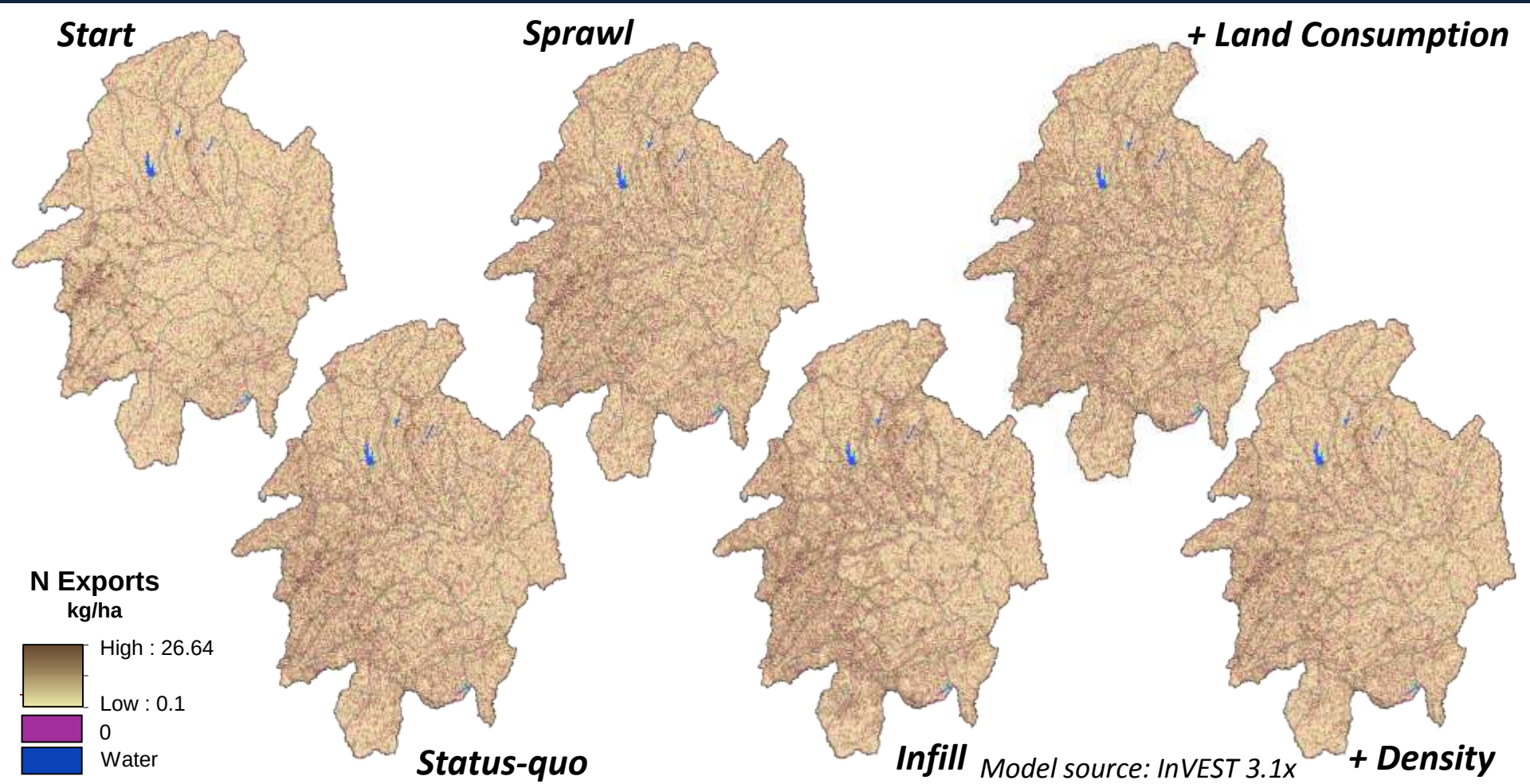
How Does Habitat Change?

Fragmentation | **Habitat** | Nitrogen | Phosphorus | Carbon | Revenues



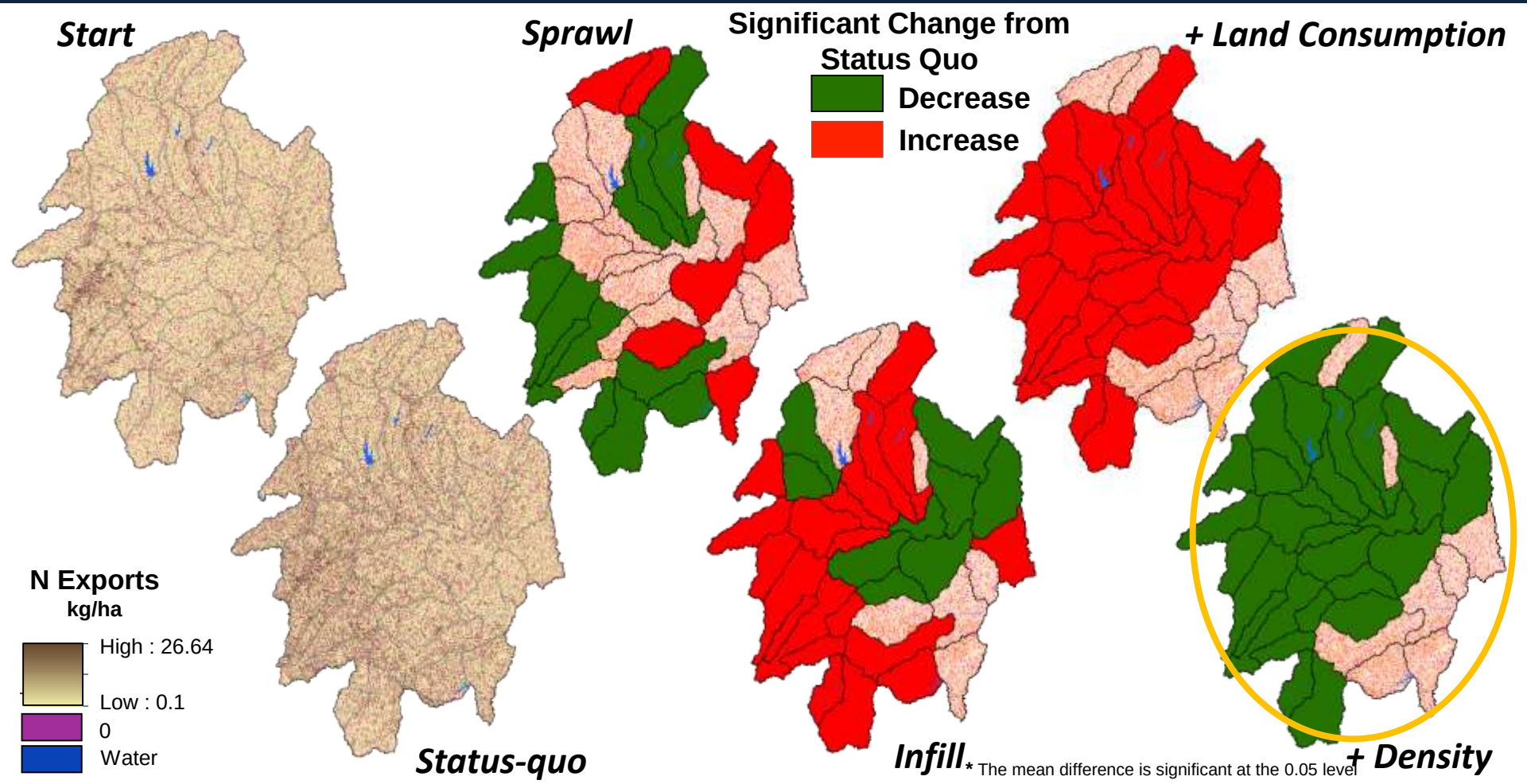
Which Exports Least N NPS Pollution?

Fragmentation | Habitat | **Nitrogen** | Phosphorus | Carbon | Revenues



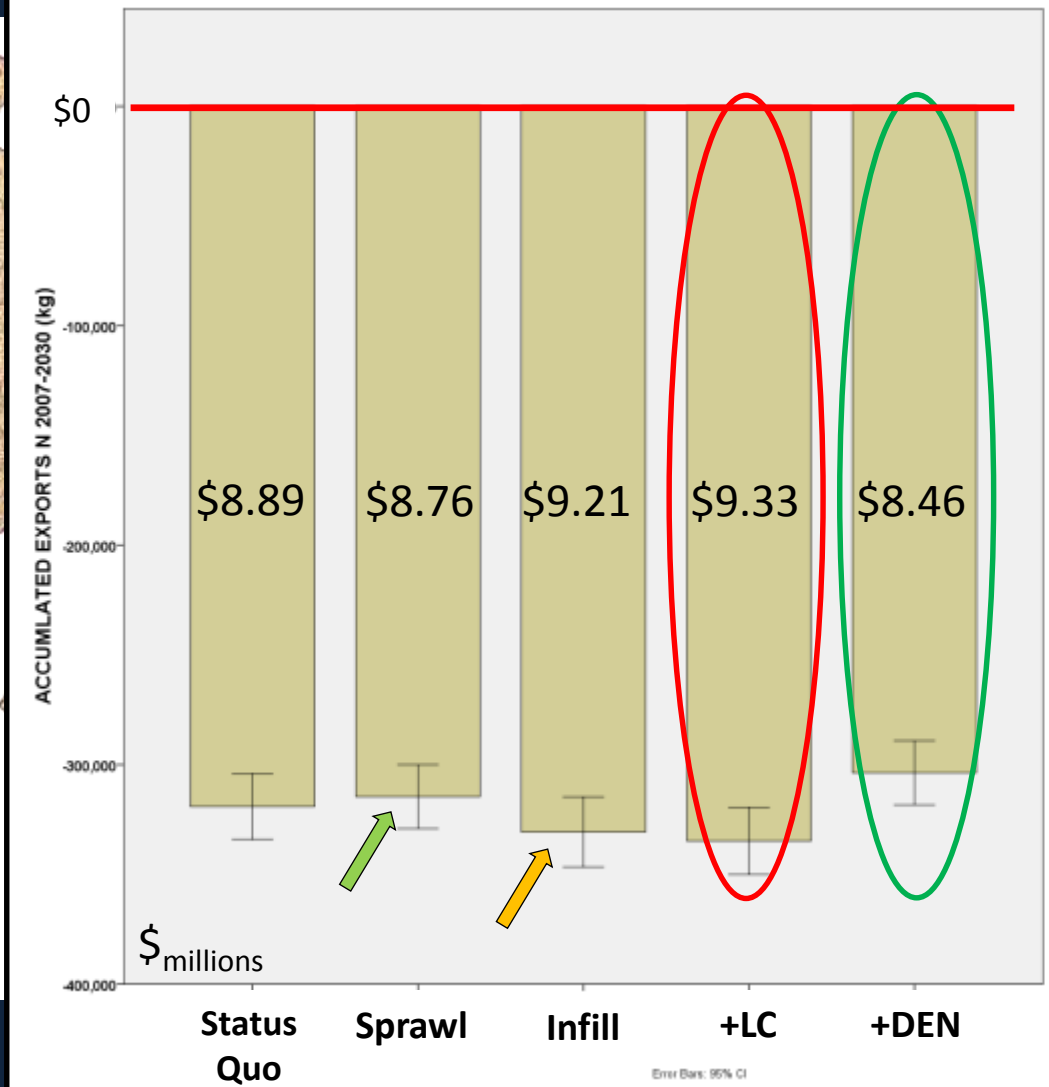
Which Exports Least N NPS Pollution?

Fragmentation | Habitat | **Nitrogen** | Phosphorus | Carbon | Revenues



What Are The Costs Over Time?

Fragmentation | Habitat | **Nitrogen** | Phosphorus | Carbon | Revenues



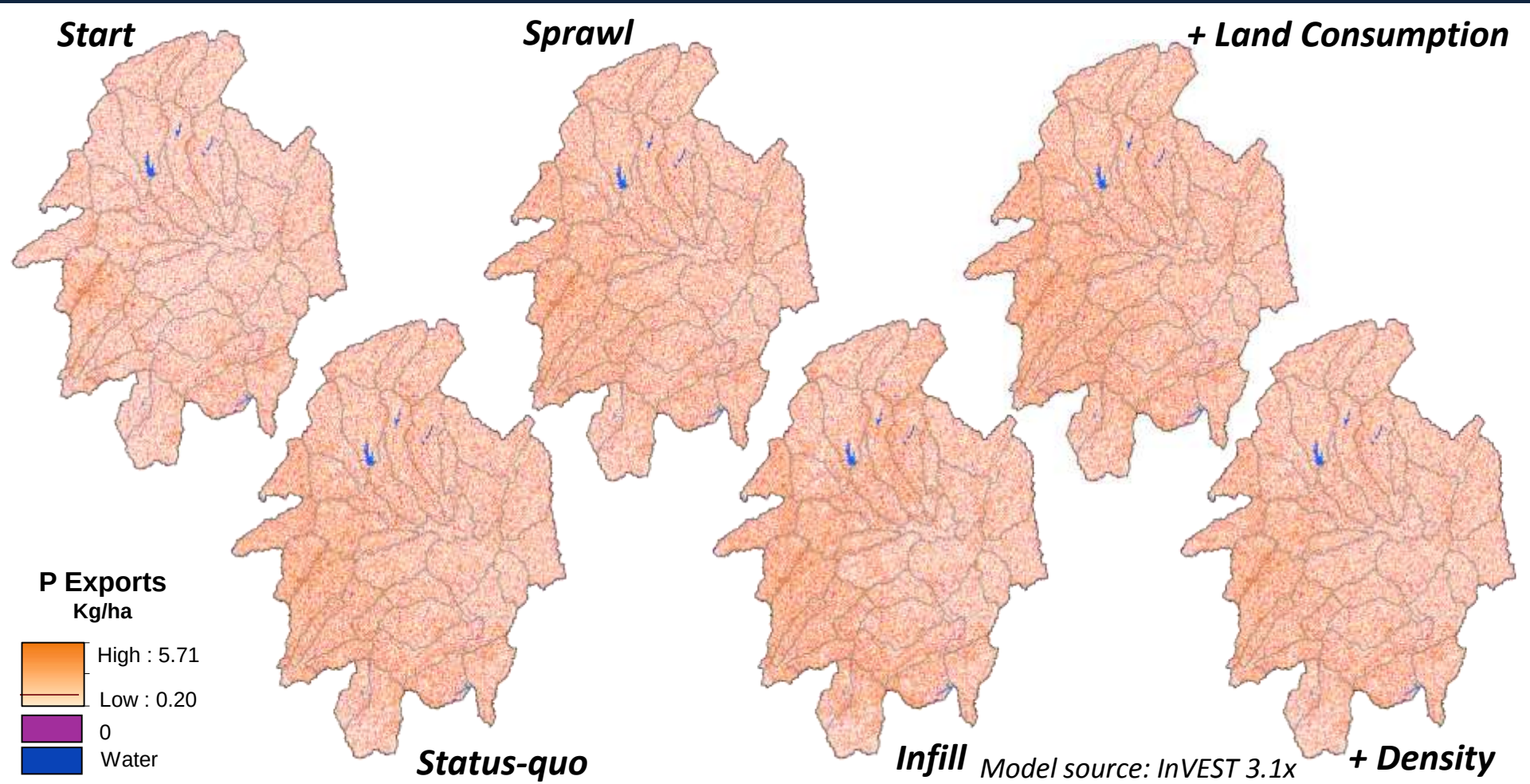
NC Nitrogen offset Fee = $43.85/kg

Present value of the cost of N offsets=

N kg/yr * $43.85/kg * 24 yrs, discounted 4.0%/yr

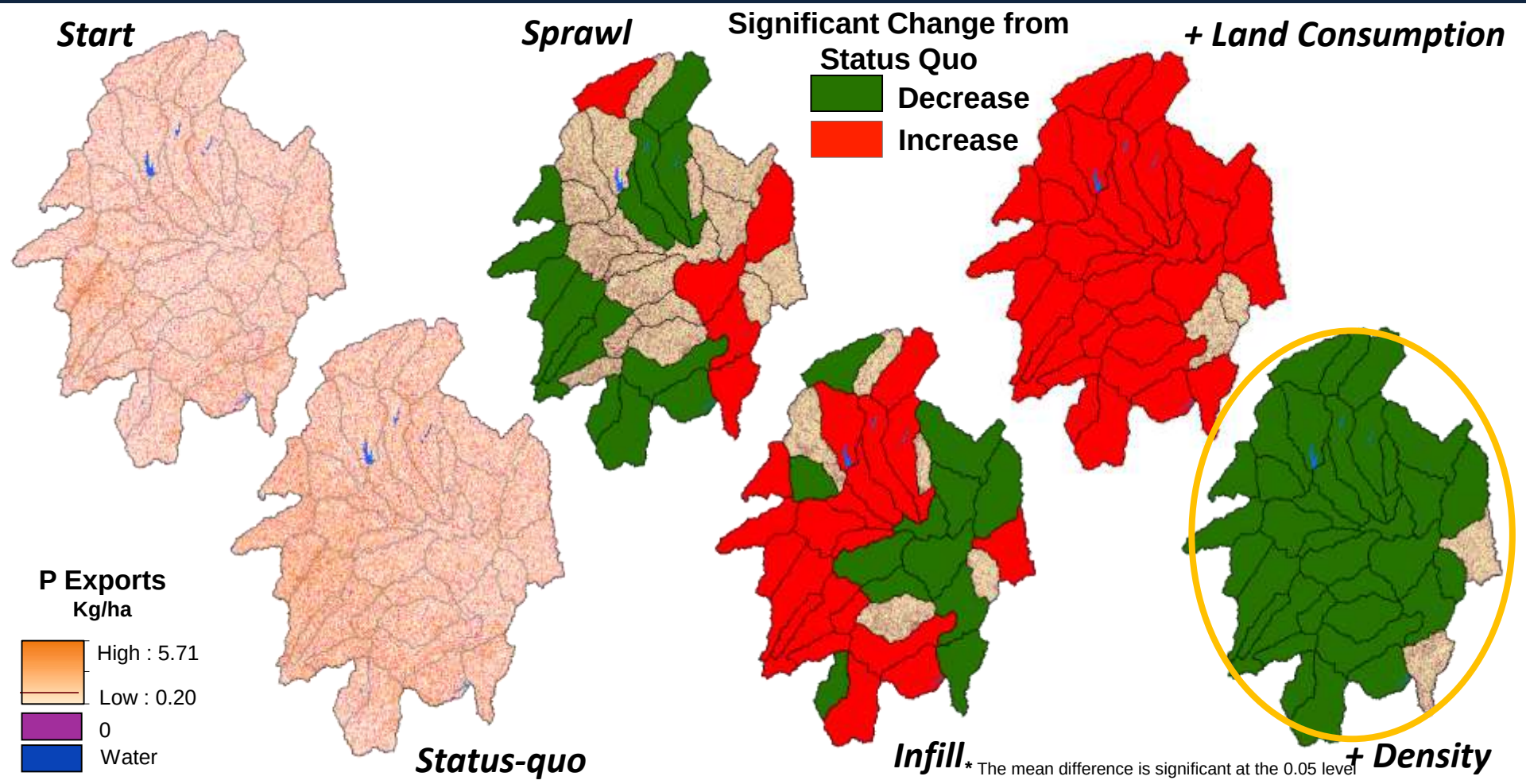
Which Exports Least P NPS Pollution?

Fragmentation | Habitat | Nitrogen | **Phosphorus** | Carbon | Revenues



Which Exports Least P NPS Pollution?

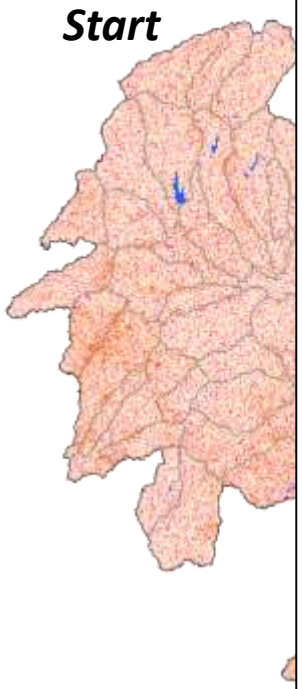
Fragmentation | Habitat | Nitrogen | **Phosphorus** | Carbon | Revenues



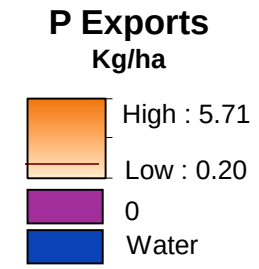
* The mean difference is significant at the 0.05 level

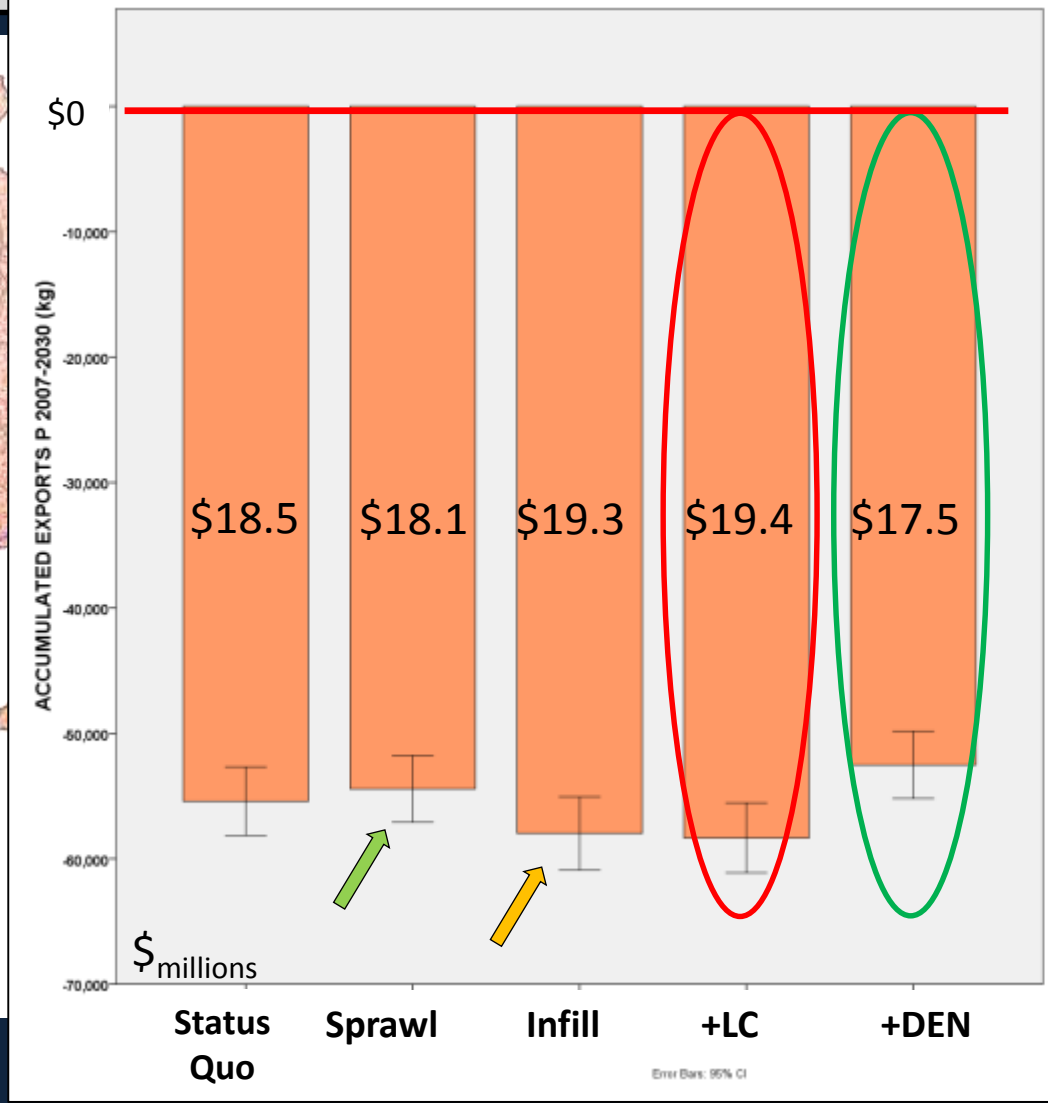
What Are The Costs Over Time?

Fragmentation | Habitat | Nitrogen | **Phosphorus** | Carbon | Revenues



Start





NC Phosphorus offset Fee = $524.32/kg

Present value of the cost of P offsets=

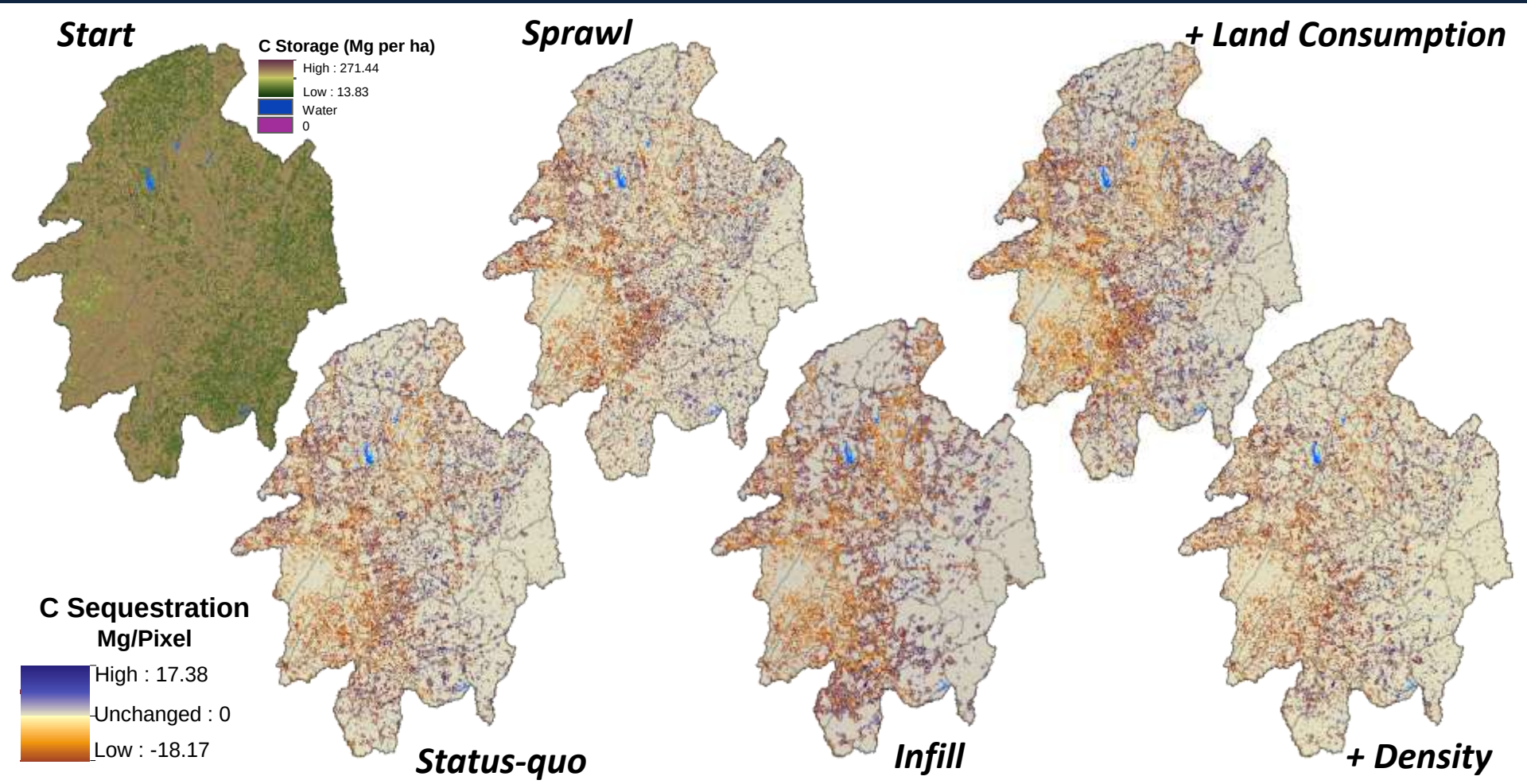
N kg/yr * $524.32/kg * 24 yrs, discounted 4.0%/yr

nsumption

+ Density

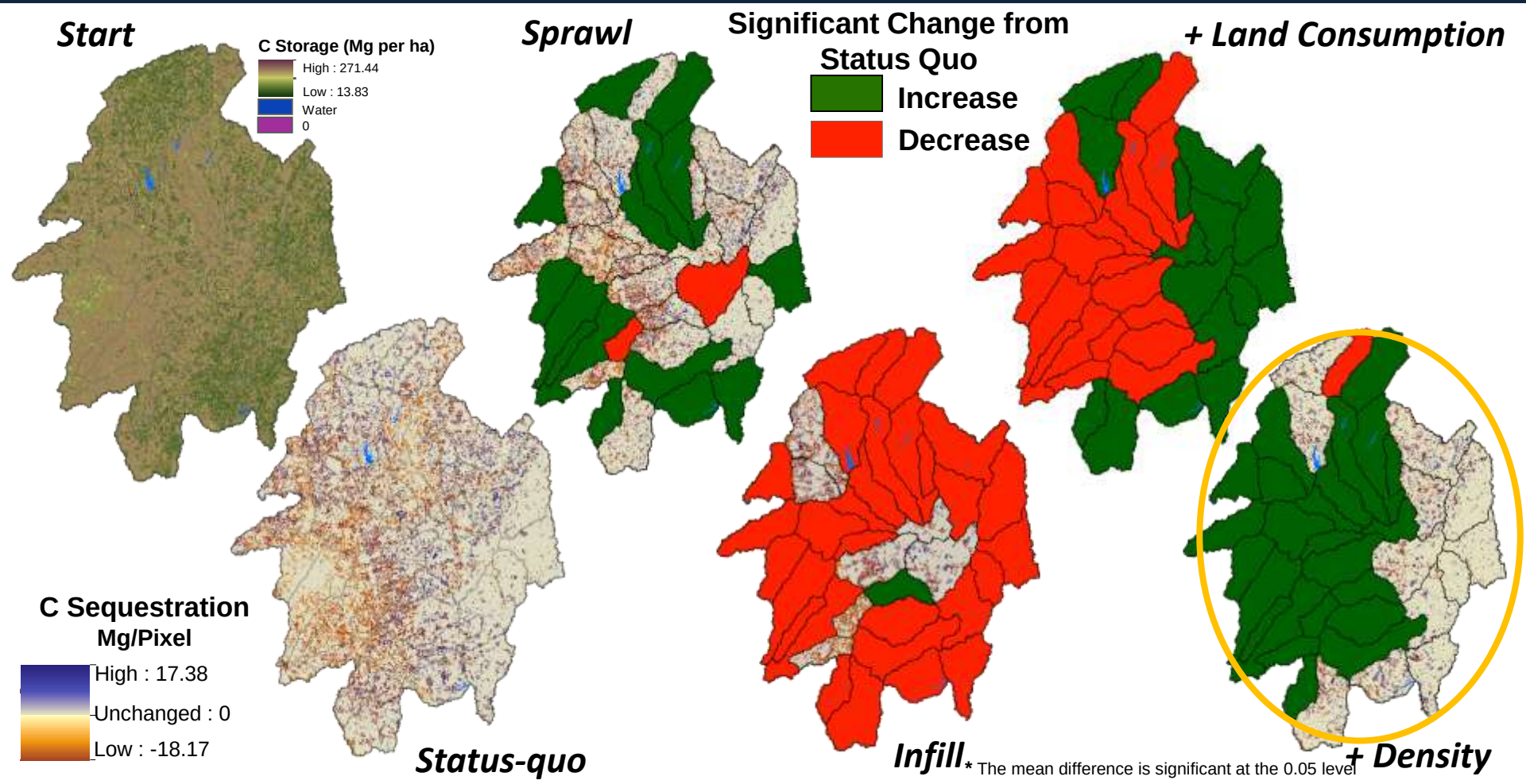
Which Sequesters the Most Carbon?

Fragmentation | Habitat | Nitrogen | Phosphorus | **Carbon** | Revenues



Which Sequesters the Most Carbon?

Fragmentation | Habitat | Nitrogen | Phosphorus | **Carbon** | Revenues



What Are The Costs Over Time?

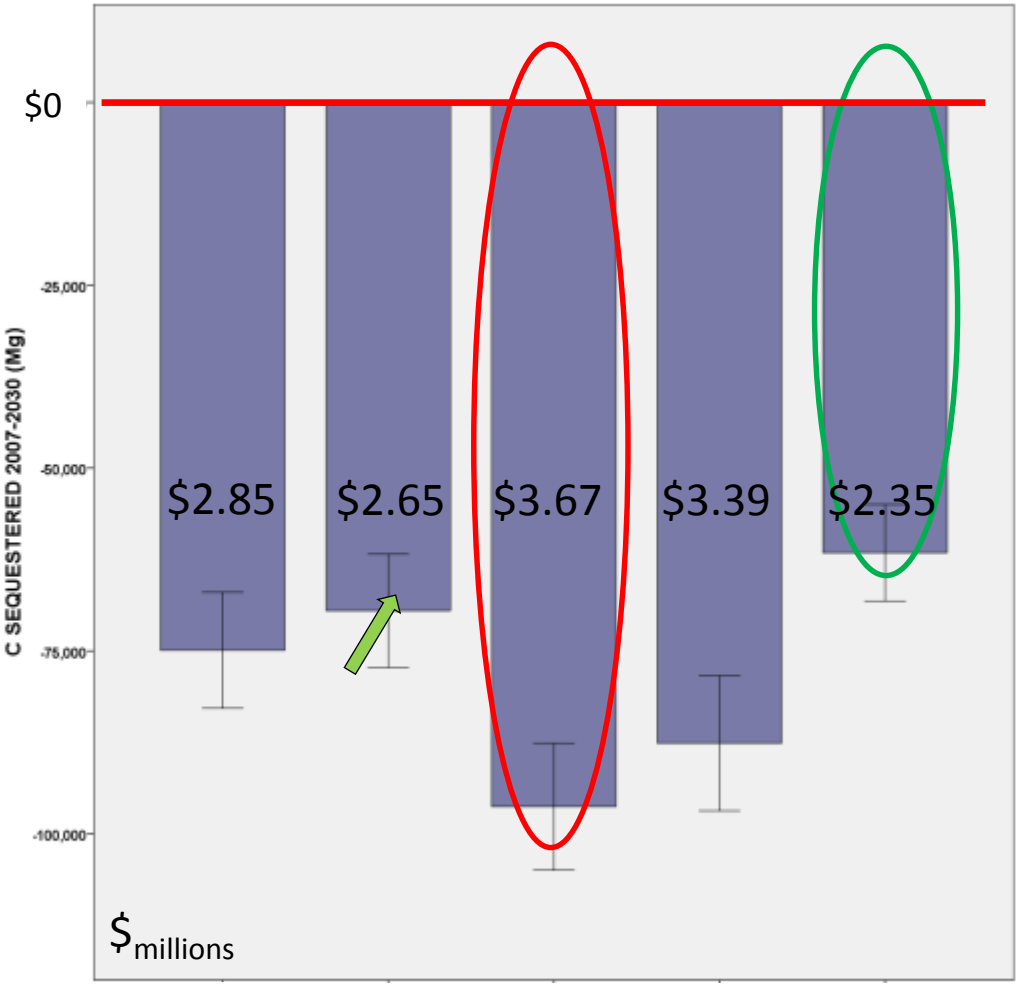
Fragmentation | Habitat | Nitrogen | Phosphorus | **Carbon** | Revenues

Start

C Sequestration
Avoided Cost / ha
$USD, 2006-2030 @$60

High : $34,122

Low : -$35,671

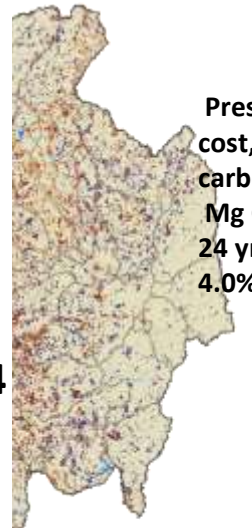


nsumption

Societal Cost of Carbon = $60/Mg

Present value of C sequestration =

C Mg/yr * $60.00/Mg * 24 yrs, discounted 4.0%/yr

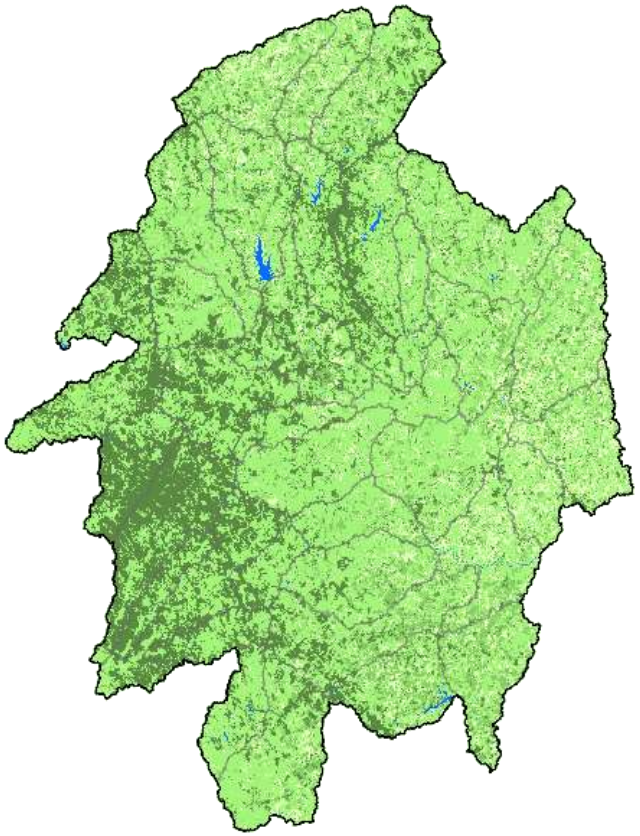


+ Density

Research Design

Fragmentation | Habitat | Nitrogen | Phosphorus | Carbon | **Revenues**

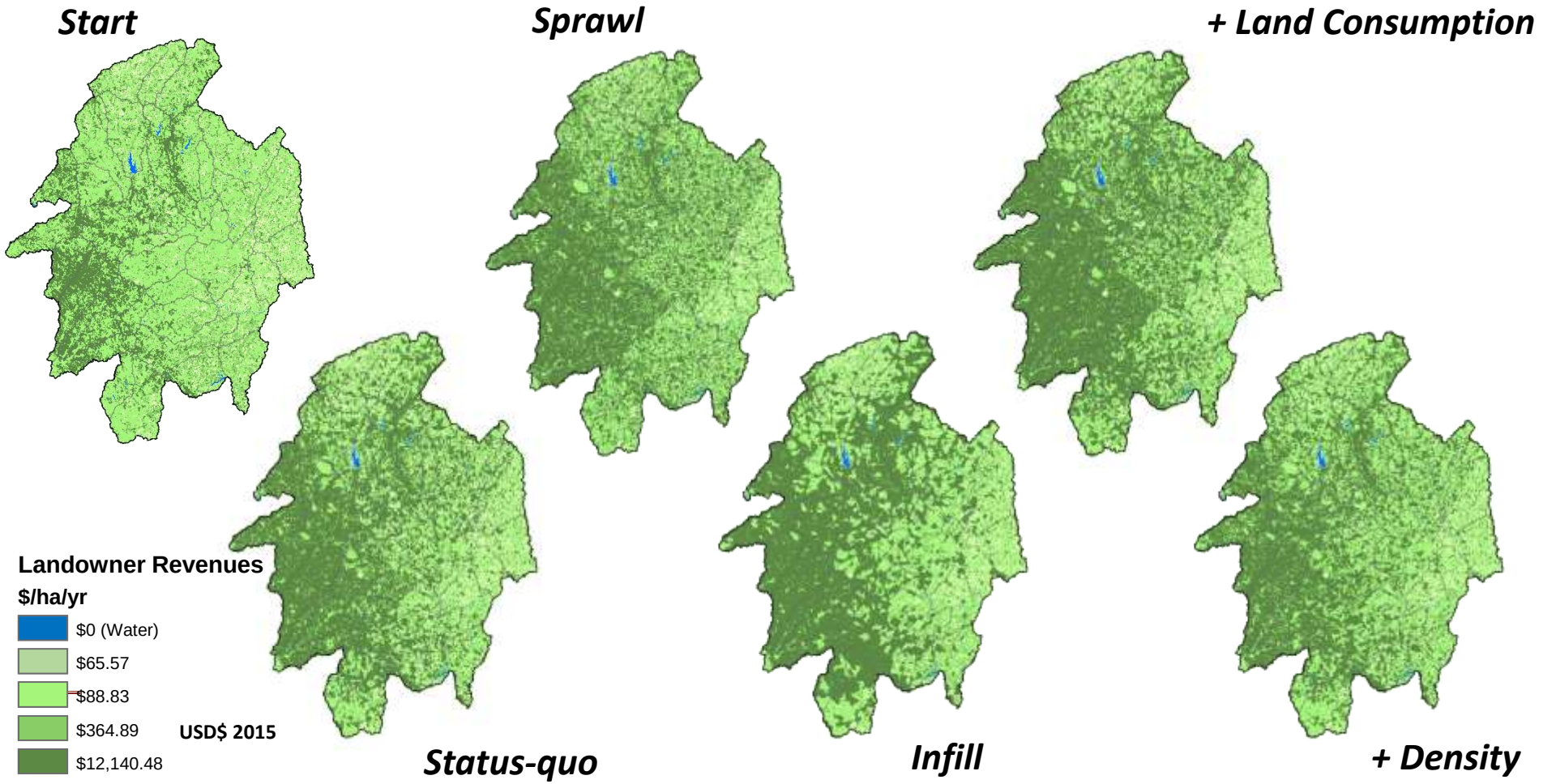
Start 2006



- **Estimate of net returns to landowners from urban development, forests, cropland and pasture, 2015 dollars ($USD/year)**
- **Source: Lubowski et al 2008, cited in Polasky et al 2010.**
- **Character: Spatially implicit**
- **Method: Relate land covers to empirically derived net return estimates**
- **Caveats: Revenues for + Density and + Land Consumption adjusted to per-pixel population (scaling factor 1.4, 0.6 respectively)**

Which Generates the Most Returns to Landowners Over Time?

Fragmentation | Habitat | Nitrogen | Phosphorus | Carbon | **Revenues**



- Source: Lubowski et al 2008, cited in Polasky et al 2010.

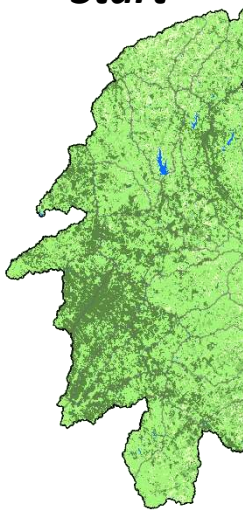
Which Generates the Most Returns to Landowners Over Time?

Fragmenta

evenues

Start

nsumption



+ Density

Landowner Rev

$/ha/yr

$0 (Water)

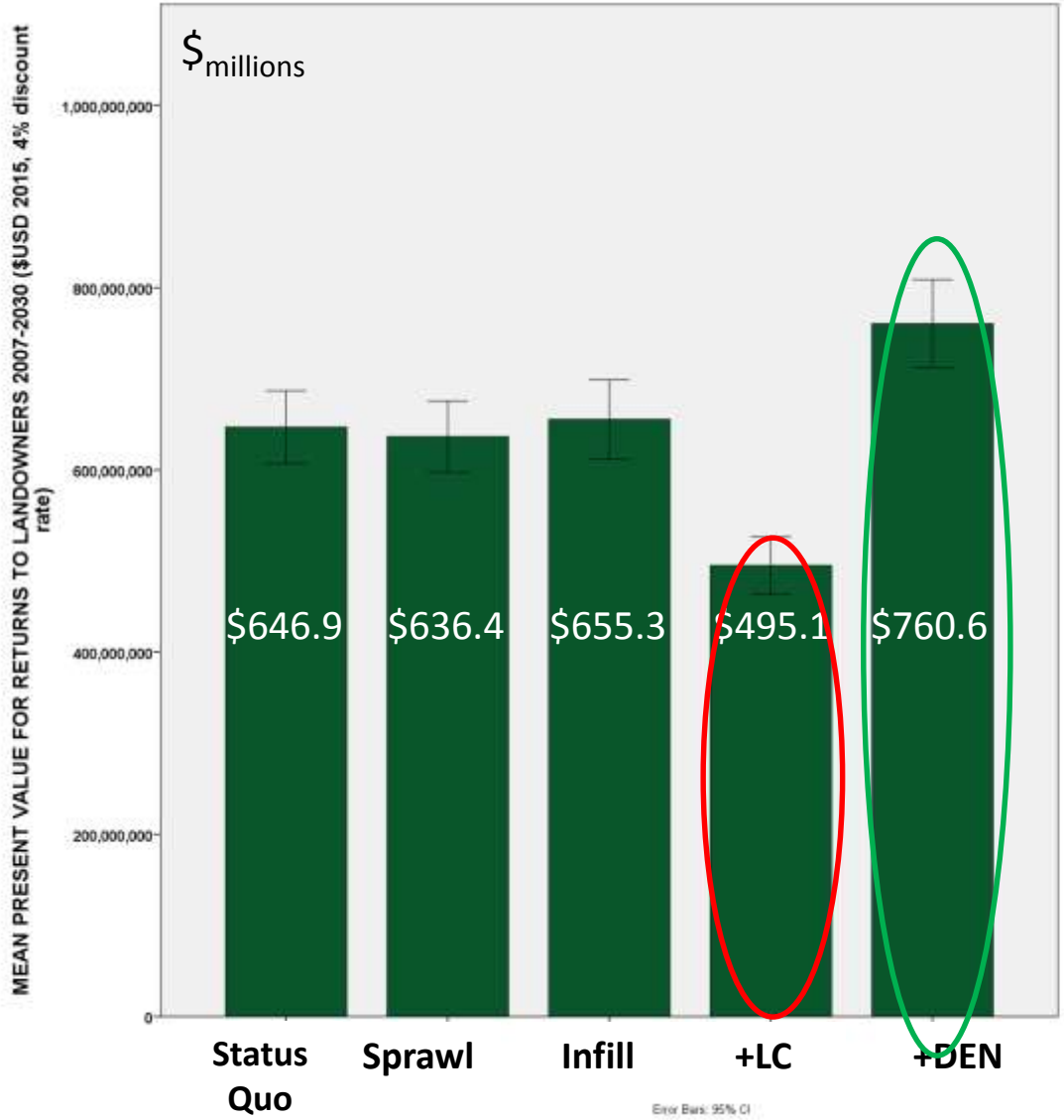
$65.57

$88.83

$364.89

$12,140.48

US



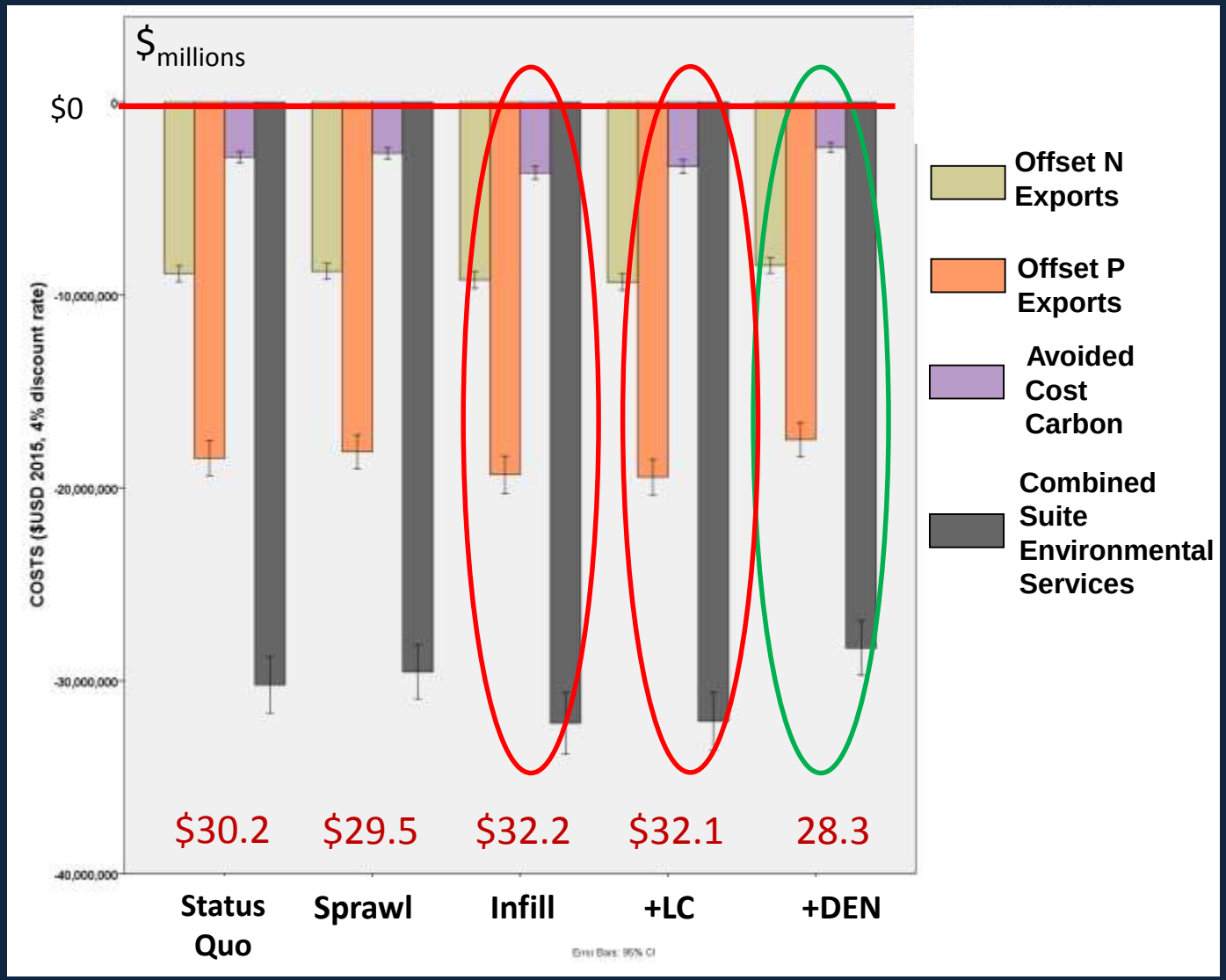
Present value of returns of land 2007-2030 ($USD 2015, discount rate 4%)

Which Is Least Costly Environmental Services (N, P, C)?

Costs, Environmental Services

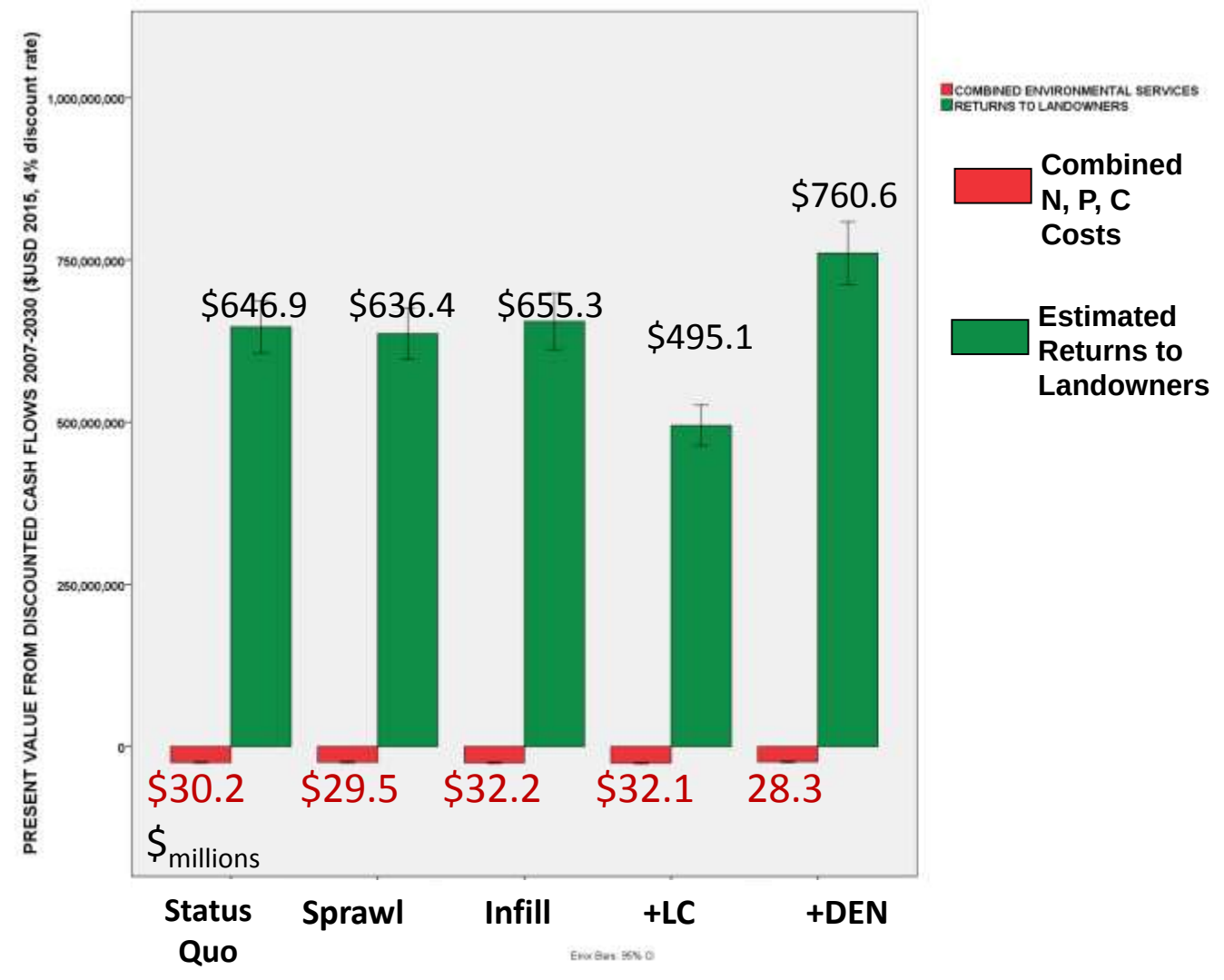
Trade-offs

Role of Configuration



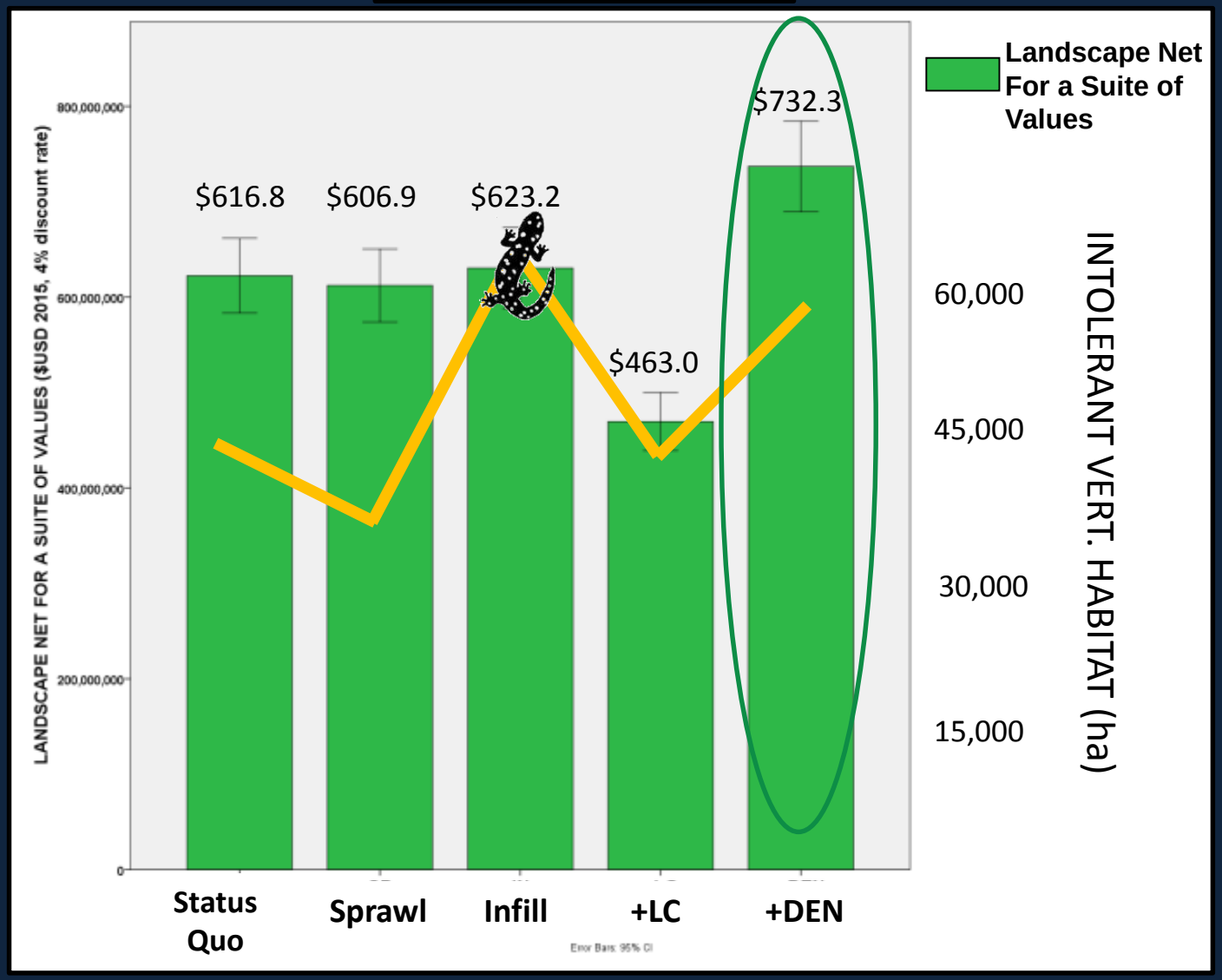
How Do Environmental Costs Compare with Revenues?

Costs, Environmental Services | **Trade-offs** | Role of Configuration



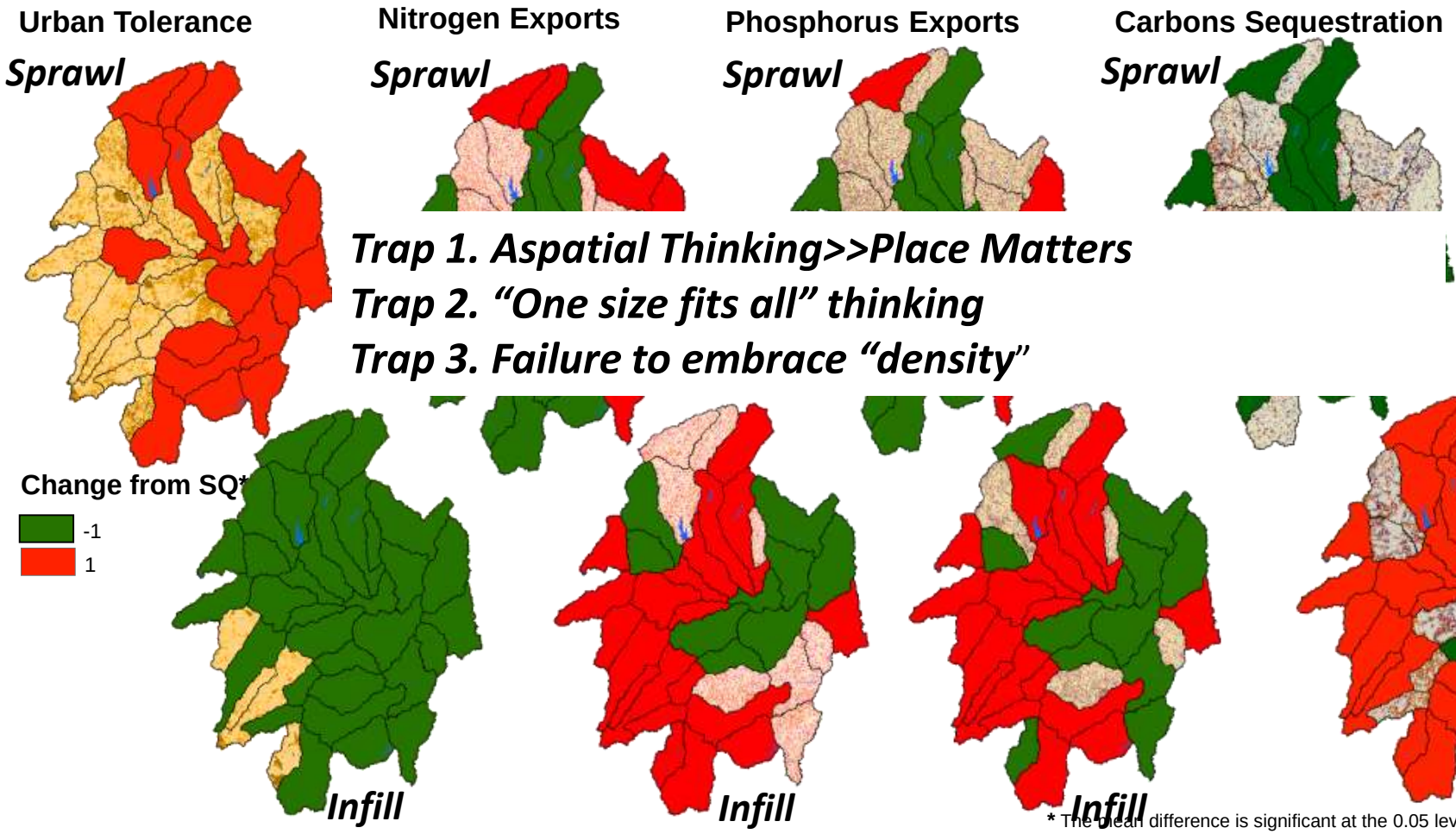
What are Trade-offs with Biodiversity?

Costs, Environmental Services | **Trade-offs** | Role of Configuration



Are There "Traps" to Avoid?

- Costs, Environmental Services
- Trade-offs
- **Role of Configuration**



Trap 1. Aspatial Thinking>>Place Matters

Trap 2. "One size fits all" thinking

Trap 3. Failure to embrace "density"