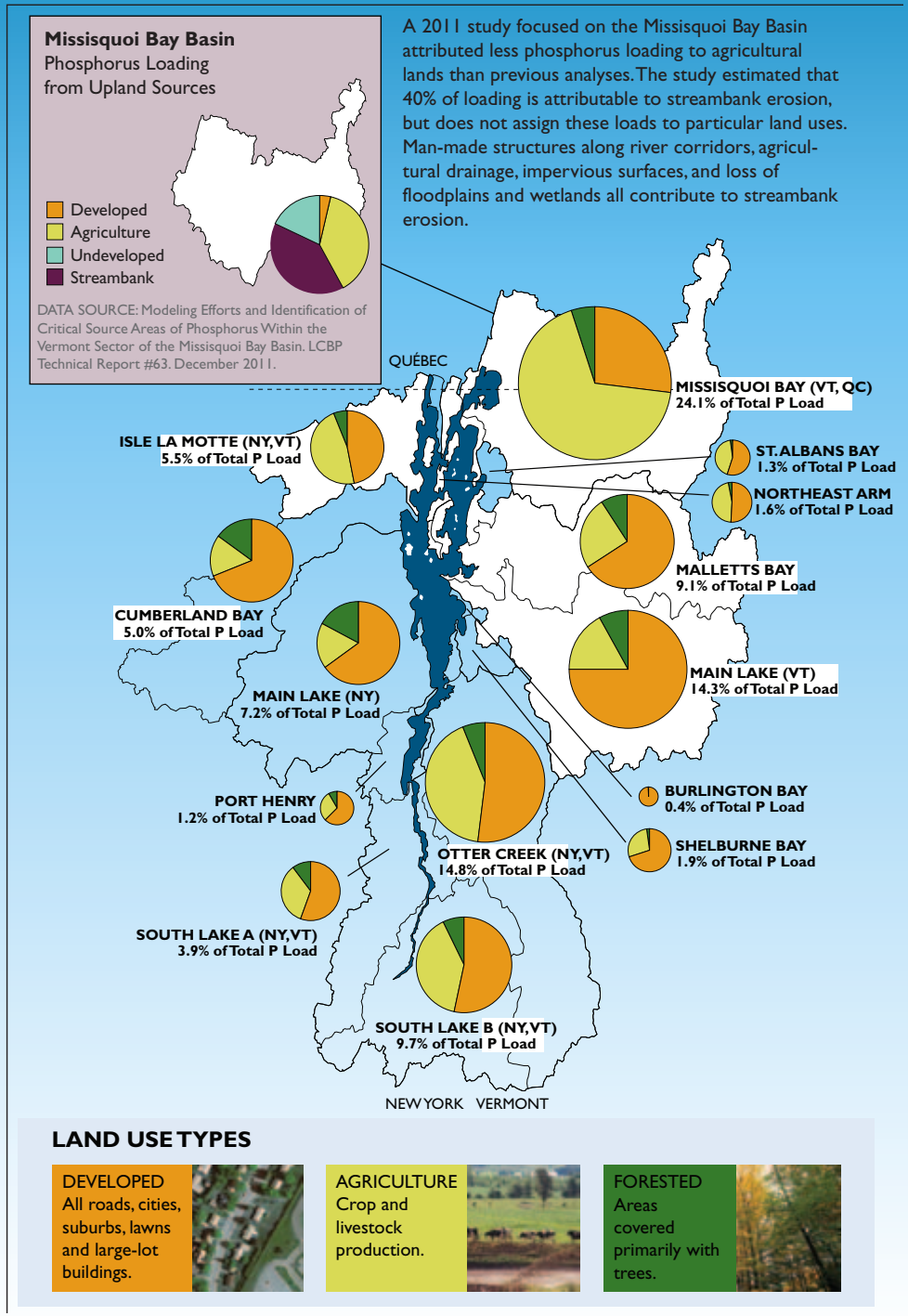
# Dynamics of Land Use and Land Cover Change (LULCC)

Asim Zia & Yu-Shiou Tsai

# Impact of LULCC on Water Quality

Categorization of LULC matters: whether to include stream-banks, roads, wetlands as separate categories?




LCBP 2012

# U.S. Land-Cover Composition in 2000

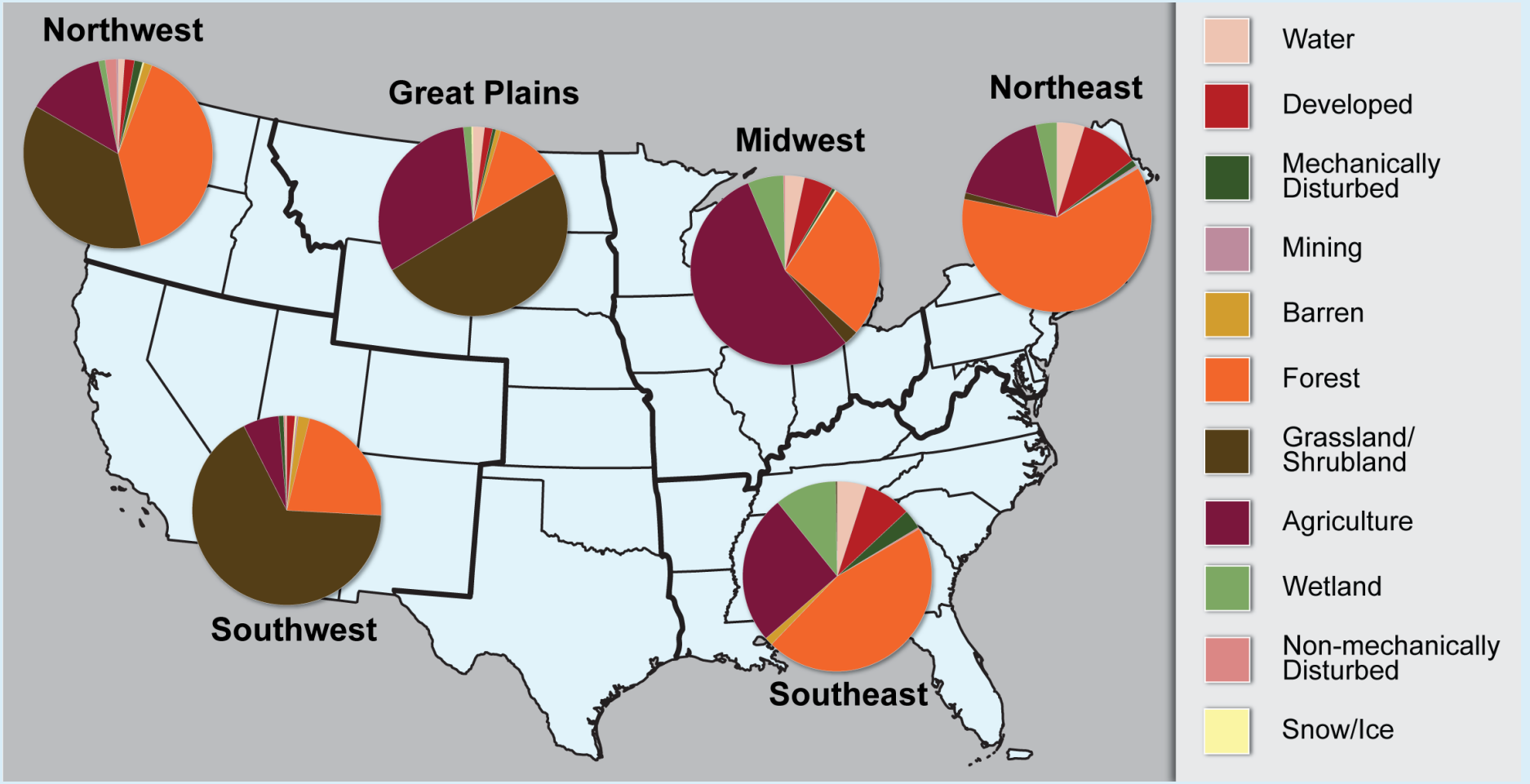



**Figure 13.1.** Map shows regional differences in land cover. These patterns affect climate and will be affected by climate change. They also influence the vulnerability and resilience of communities to the effects of climate change (Figure source: USGS Earth Resources Observation and Science (EROS) Center). (See Table 13.2 for definitions of mechanically and non-mechanically disturbed.)

Brown et al. (2014) LULCC, National Climate Assessment

**Fairly stable trends projected for Northeast!**

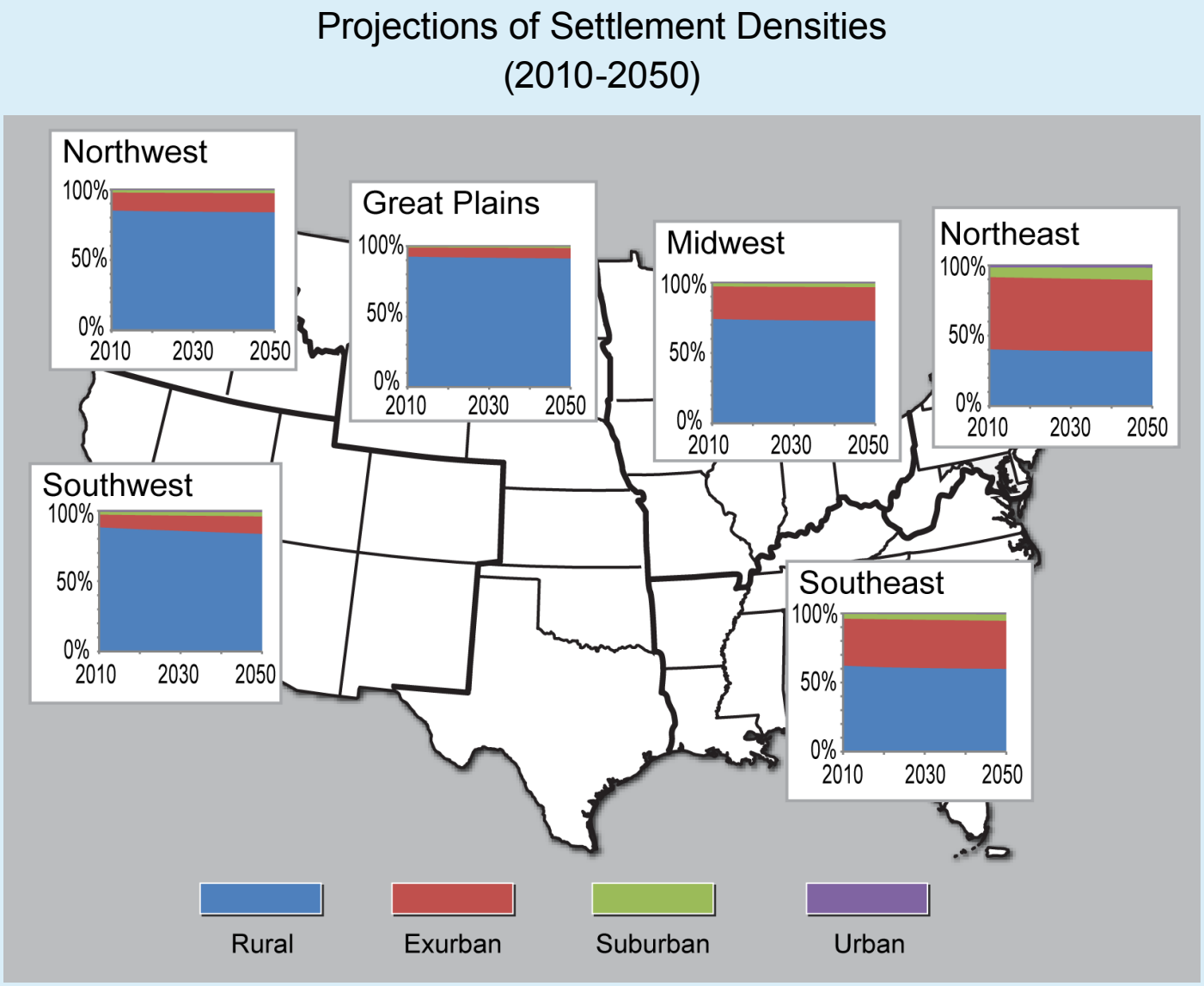



**Figure 13.2.** Projected percentages in each housing-unit density category for 2050 compared with 2010, assuming demographic and economic growth consistent with the high-growth emissions scenario (A2). (Data from U.S. EPA Integrated Climate and Land Use Scenarios).

Brown et al. (2014) LULCC, National Climate Assessment

**Uncertainties surrounding ecological, economic and policy drivers of LULCC are mostly ignored in these baseline projections!**

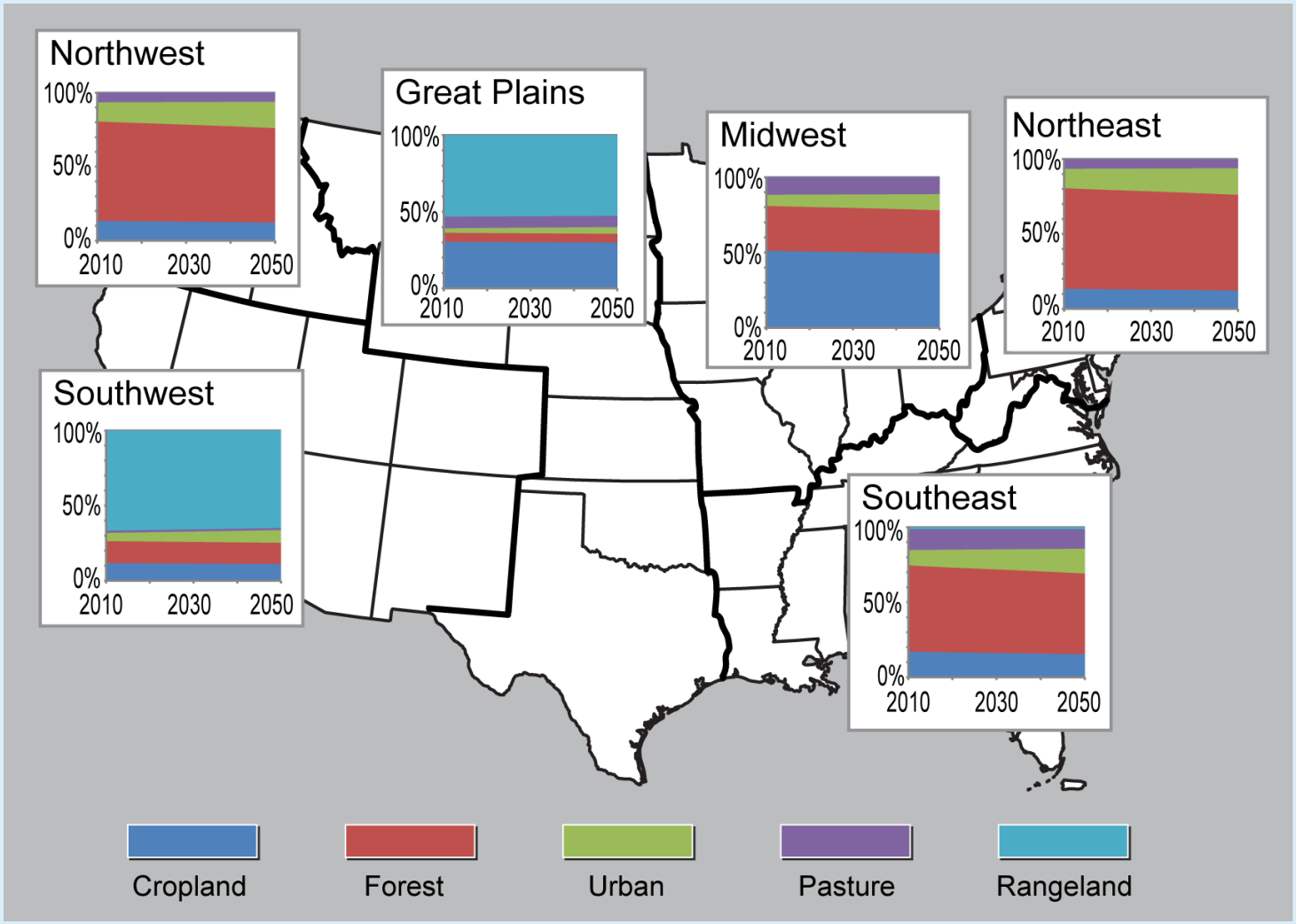
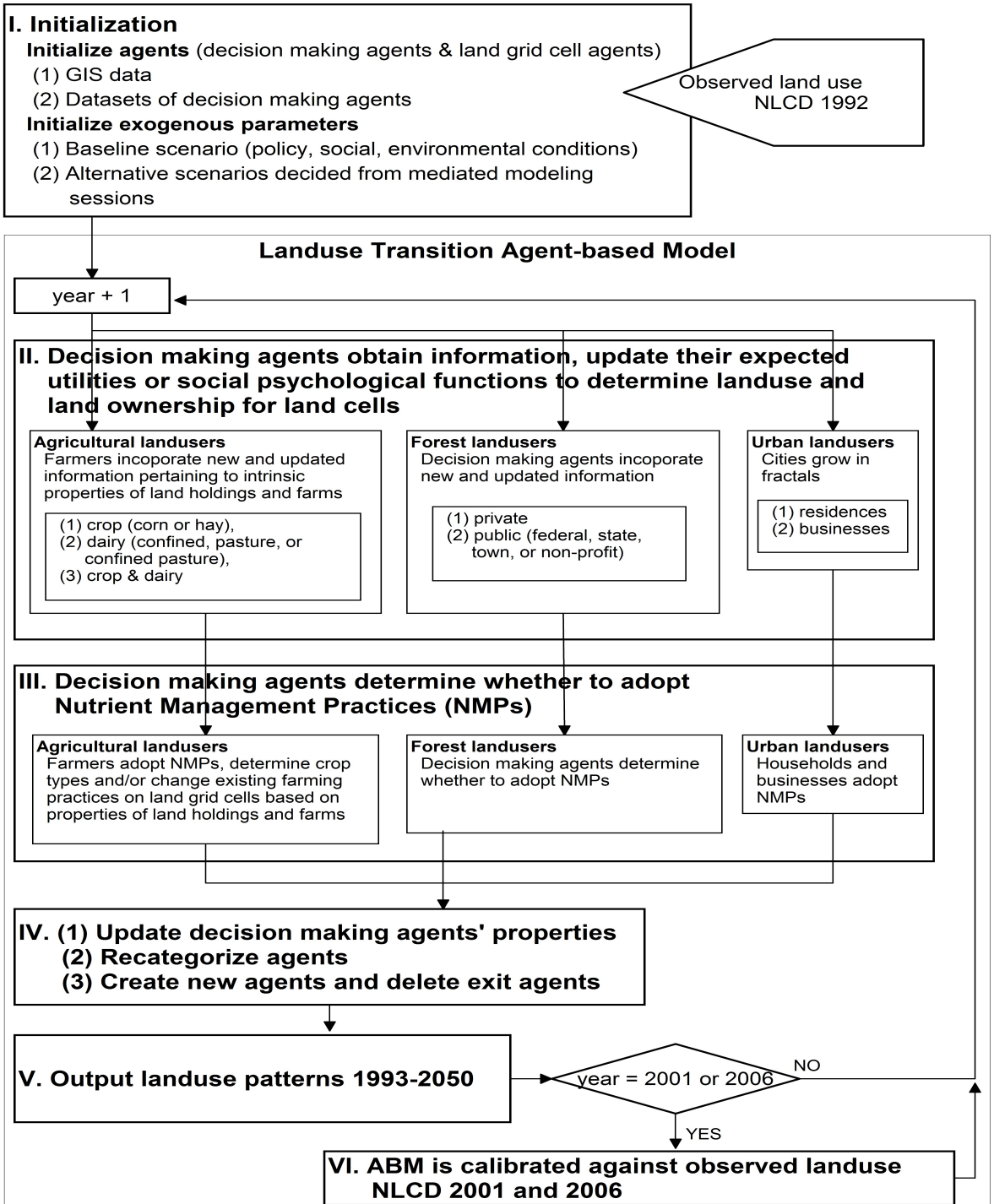



**Figure 13.3.** Projected percentages in each land-cover category for 2050 compared with 2010, assuming demographic and economic growth consistent with the high-growth emissions scenario (A2) (Data from USDA).

Brown et al. (2014) LULCC, National Climate Assessment

# Overarching ABM Design



# Land-Use Transition Agent Based Model [Tsai et al. 2013 IEEE Systems]

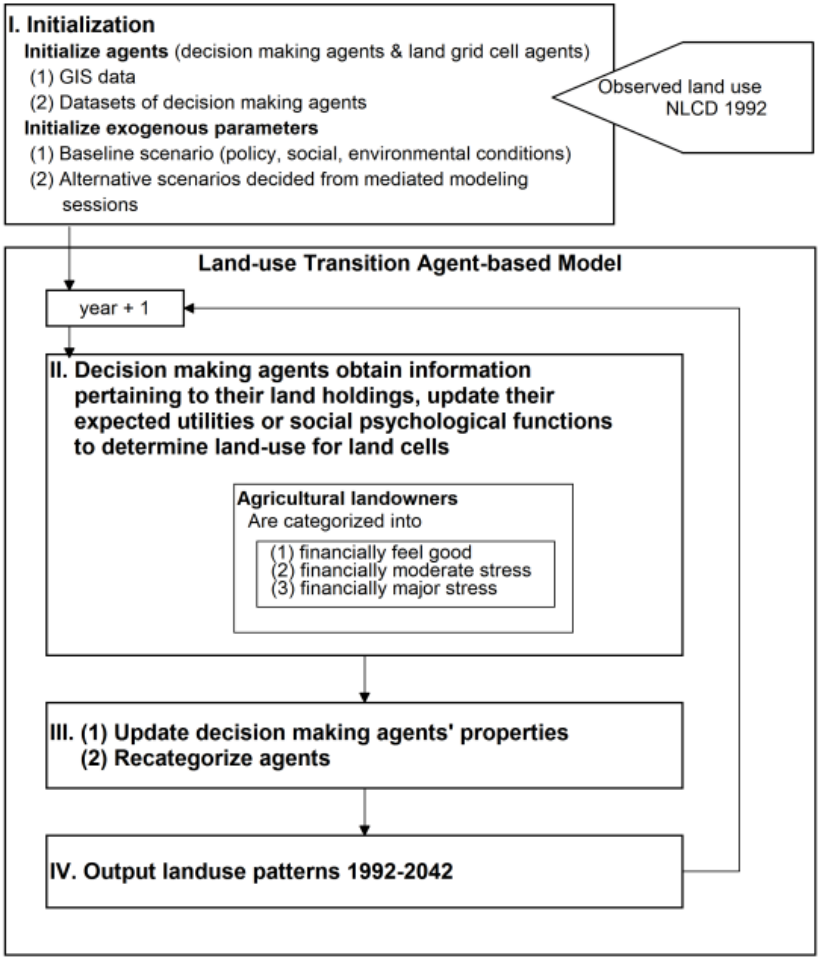



Fig. 1. Flow chart of the land-use transition agent-based model for the Missisquoi Watershed.

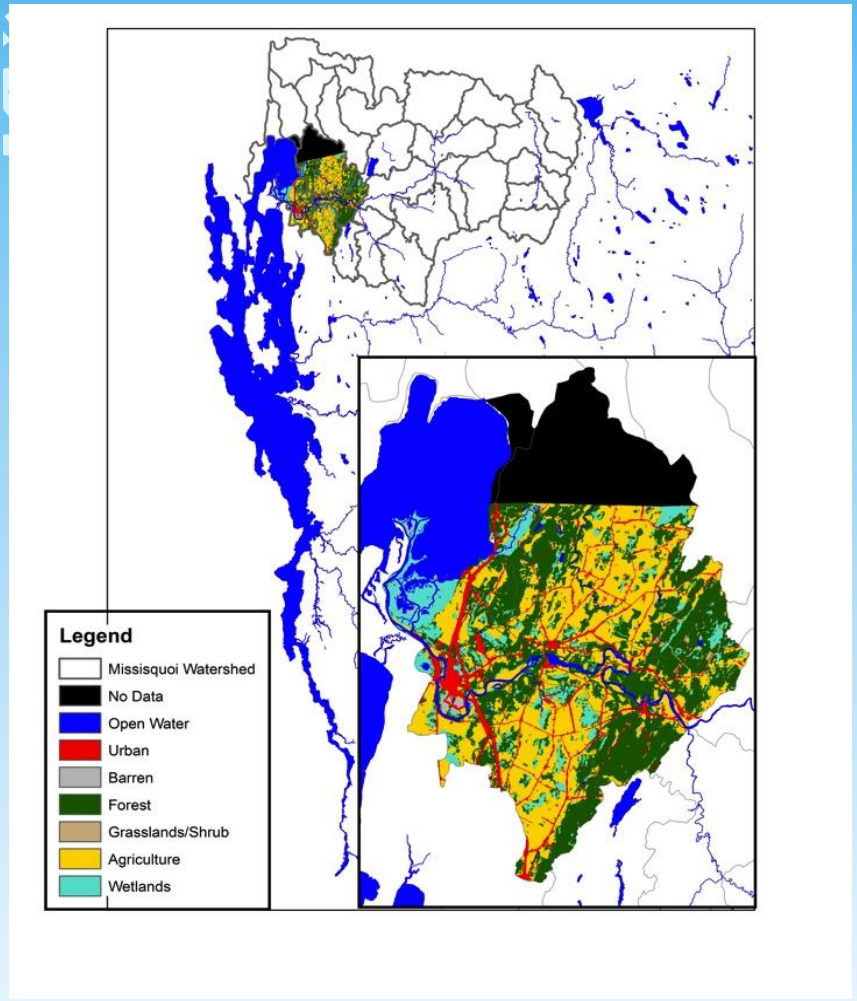



Fig. 2. The western Missisquoi Watershed (colored area) versus the entire Missisquoi Watershed. The colored area displays the observed land-use pattern of the NLCD 1992 eight-class classification system.

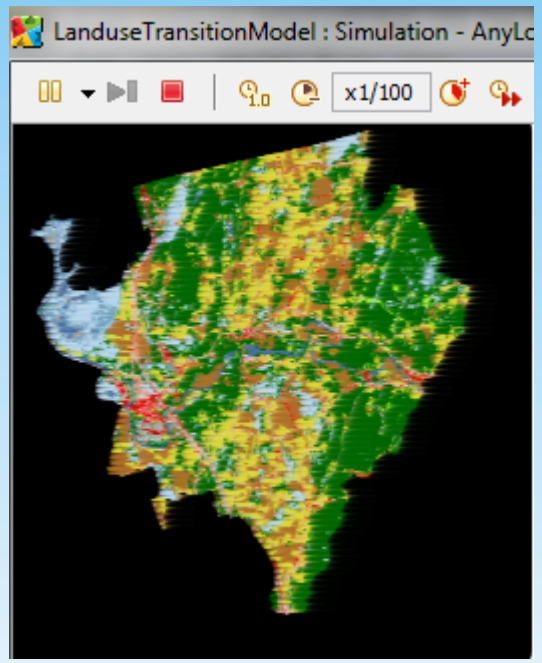
# Land-Use Transition Agent Based Model: Simulated Versus Observed Patterns

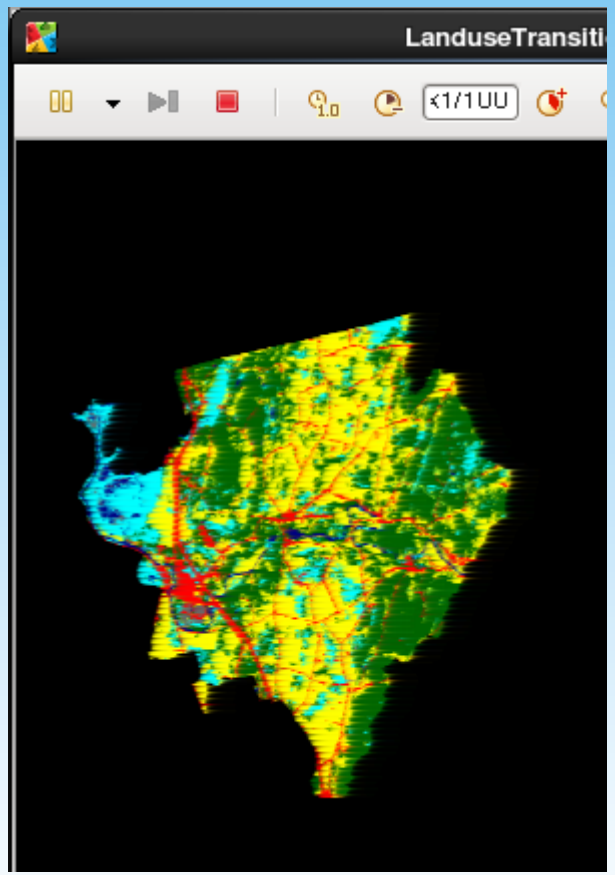
TABLE III. Comparison of the percentages of land-use types 3: Barren, 4: Forest, 5: Grass/Shrub, and 6: Agriculture resulting from the baseline scenario to the observed land-use percentages.

| | Percentage of A Land-use Type | | | |
|---|---|---|---|---|
| | 2001 | | 2006 | |
| Land-use Code | Observed | Baseline Simulation (Minimum, Mean, Maximum) | Observed | Baseline Simulation (Minimum, Mean, Maximum) |
| 3, Barren | 0.581 | (0.627, 0.646, 0.673) | 0.663 | (0.647, 0.671, 0.710) |
| 4, Forest | 37.872 | (37.992, 38.007, 38.021) | 38.181 | (37.995, 38.015, 38.032) |
| 5, Grass | 0.936 | (0.879, 0.886, 0.894) | 1.186 | (0.859, 0.869, 0.884) |
| 6, Ag | 37.922 | (37.525, 37.545, 37.564) | 36.982 | (37.498, 37.530, 37.556) |

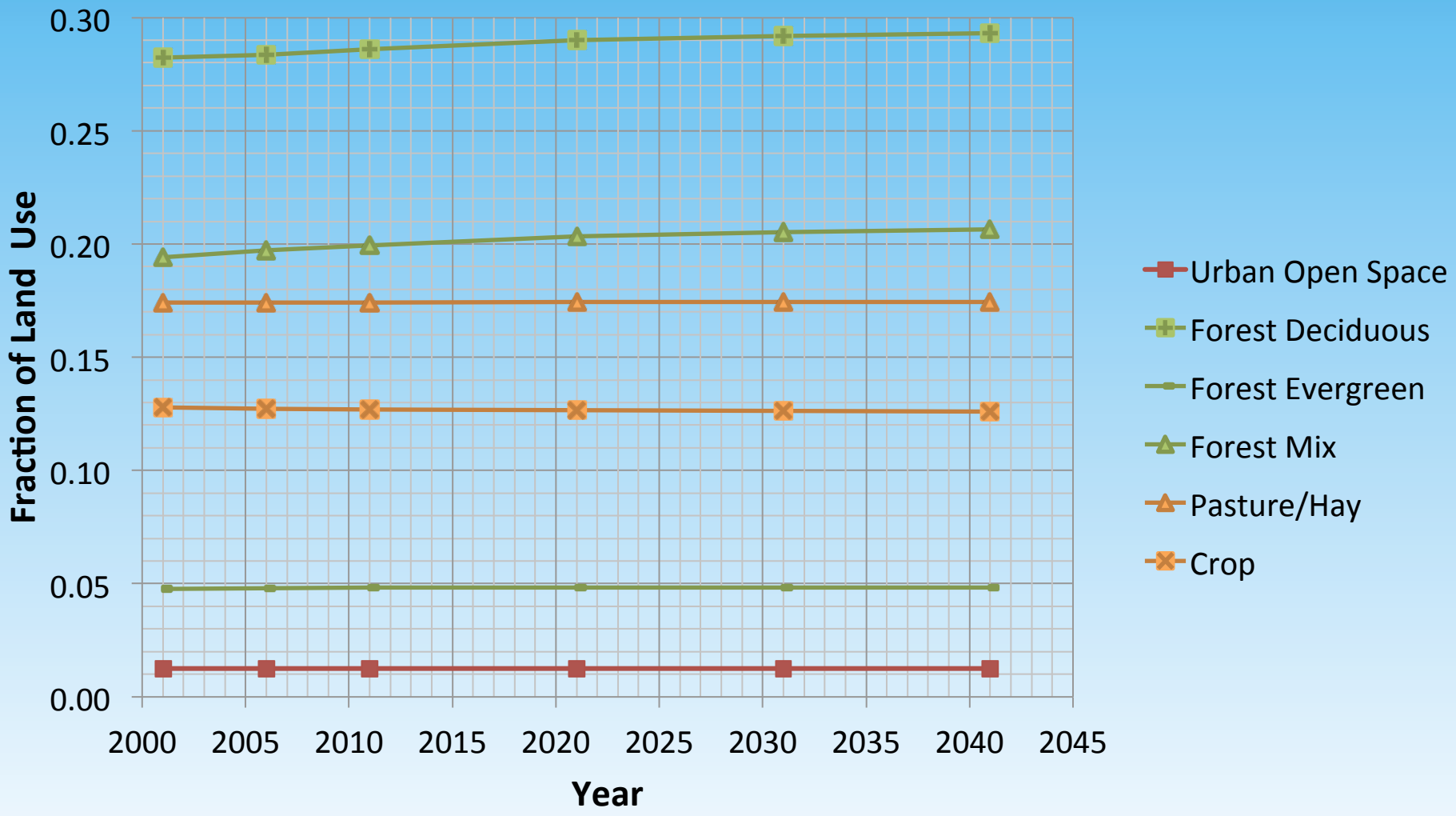
# Land-use Transition Agent-based Component: Recent Update

- Read in 15 categories from the NLCD data
  - instead of 8 categories



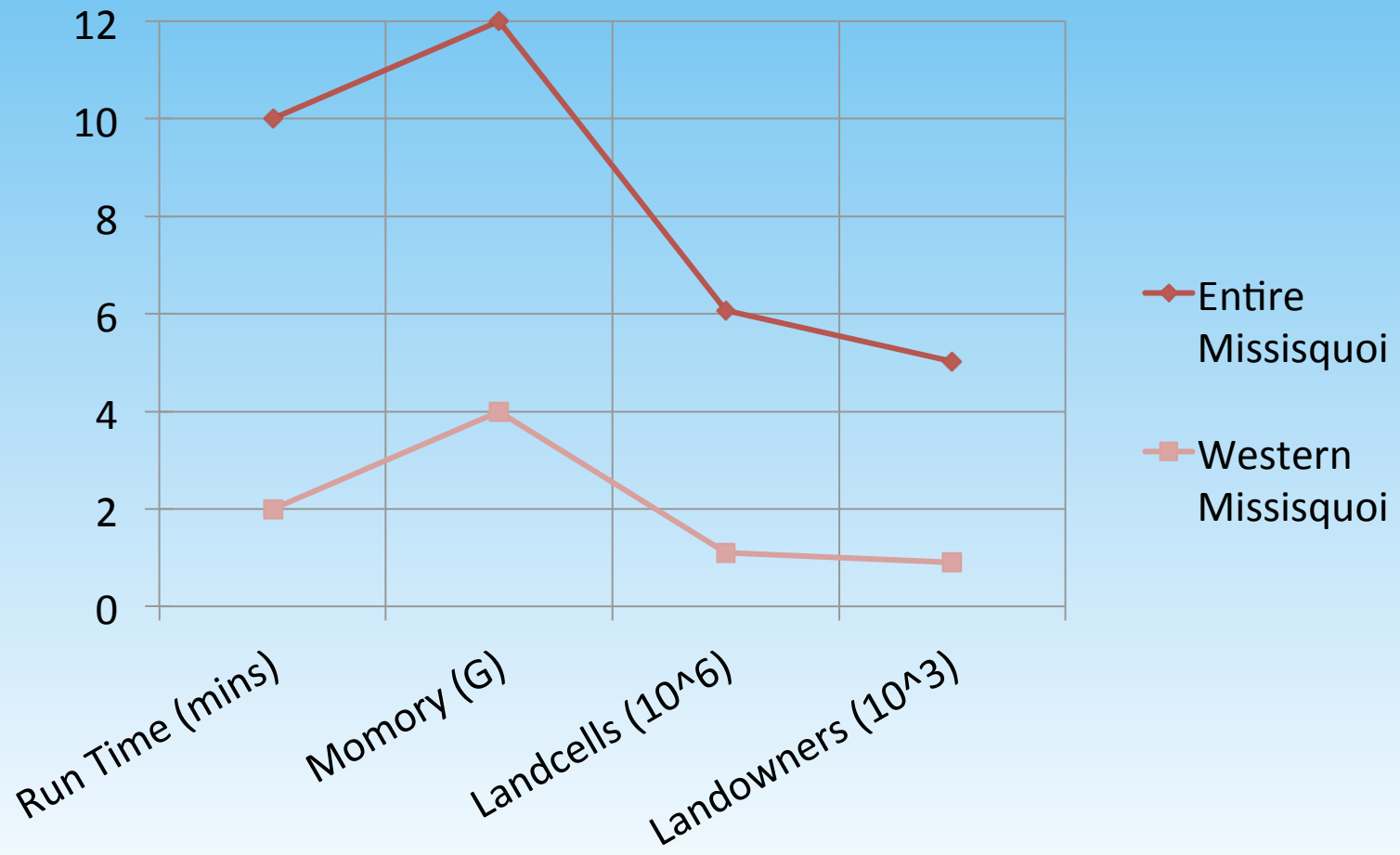
# Simulated Land Use under Baseline



# Simulated Land Use under Baseline

| Land use | 2001 | 2006 | 2011 | 2021 | 2031 | 2041 |
|---|---|---|---|---|---|---|
| Urban Open Space (up trend) | 0.01239 | 0.01241 | 0.01242 | 0.01244 | 0.01246 | 0.01247 |
| Forest Deciduous (up trend) | 0.28229 | 0.28347 | 0.28590 | 0.28996 | 0.29192 | 0.29309 |
| Forest Evergreen (up) | 0.04766 | 0.04808 | 0.04816 | 0.04827 | 0.04833 | 0.04837 |
| Forest Mix (up) | 0.19413 | 0.19713 | 0.19938 | 0.20351 | 0.20535 | 0.20647 |
| Pasture/Hay (up) | 0.17421 | 0.17414 | 0.17421 | 0.17436 | 0.17445 | 0.17449 |
| Crop (down) | 0.12773 | 0.12717 | 0.12690 | 0.12650 | 0.12618 | 0.12590 |

# Performance:
# Entire vs. Western Missisquoi



# Predicting NMP Adoption Under Alternate Policy and Behavioral Scenarios

- A pilot-tested 22-page 43-question survey instrument implemented by NASS, USDA on a stratified random sample of farmers in two watersheds

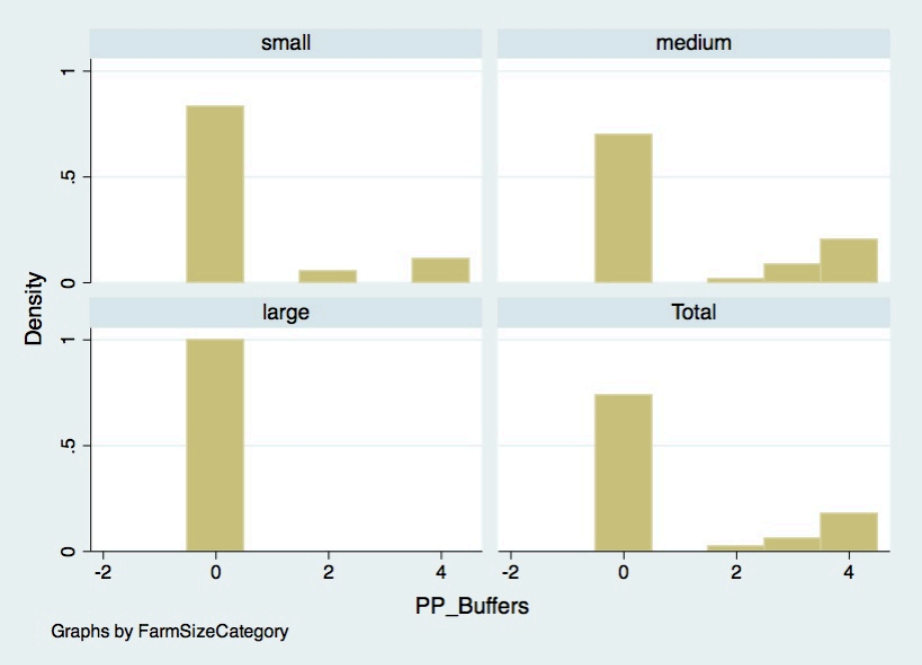
- Bounded-rational (Conjoint Analysis) approach to estimate the likelihood of NMP adoption under alternate policy incentives and regulations

- Theory of Planned Behavior approach to estimate the likelihood of NMP adoption under different behavioral and social norm conditions

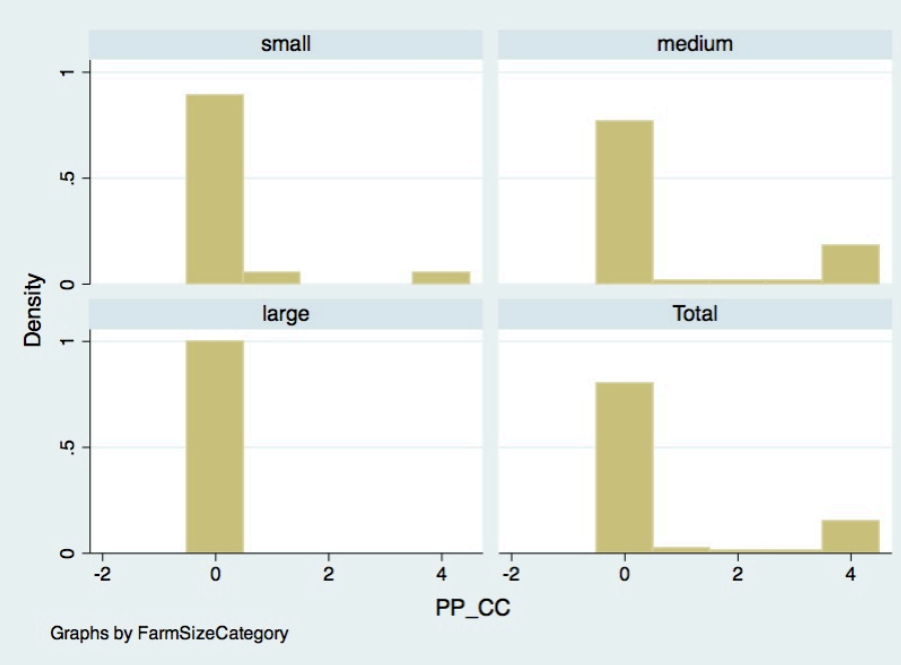
## **Extent of NMP Adoption** (N = 80)

(0 = No adoption …4 = Max. adoption)

### Buffers at Field Edges



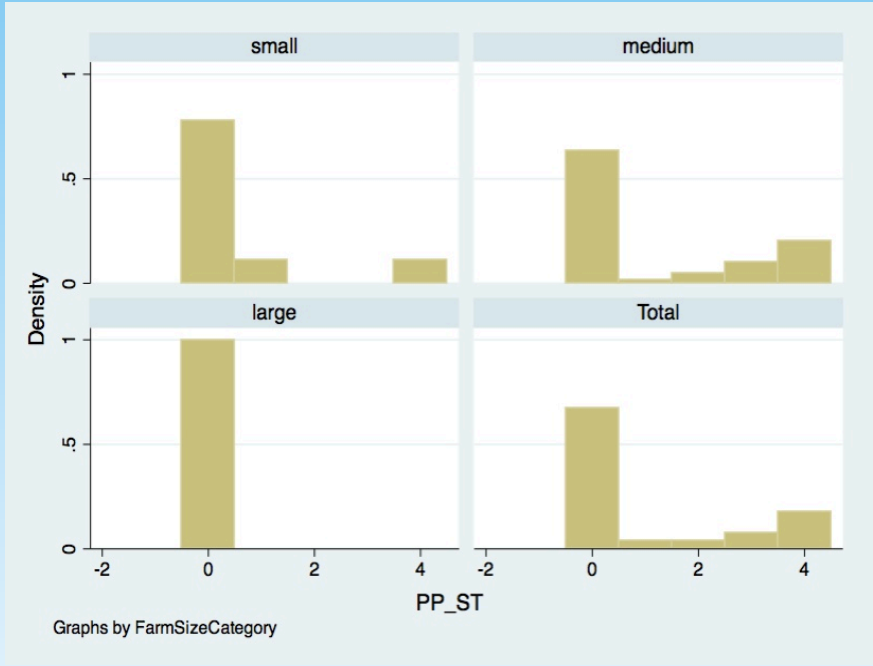

### Cover Cropping



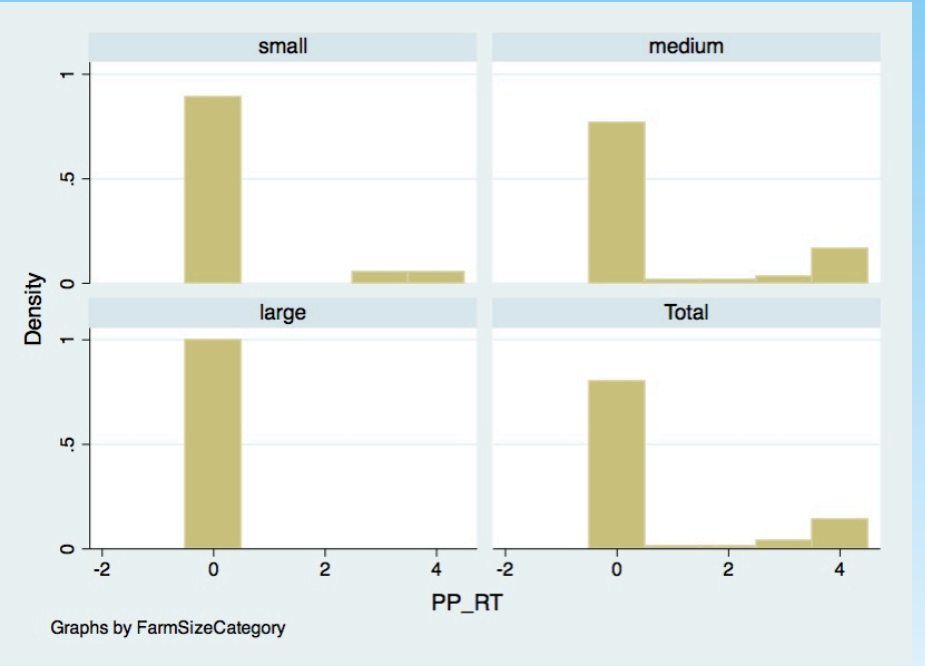
# **Extent of NMP Adoption** (N = 80)

(0 = No adoption …4 = Max. adoption)

## Soil Test at least every 3 years




## Reduced Tillage



## Weighted OLS Regression Models Predicting Farmer Intention to Adopt Nutrient Management Practices in Missisquoi and Lamoille Watersheds (N=80)

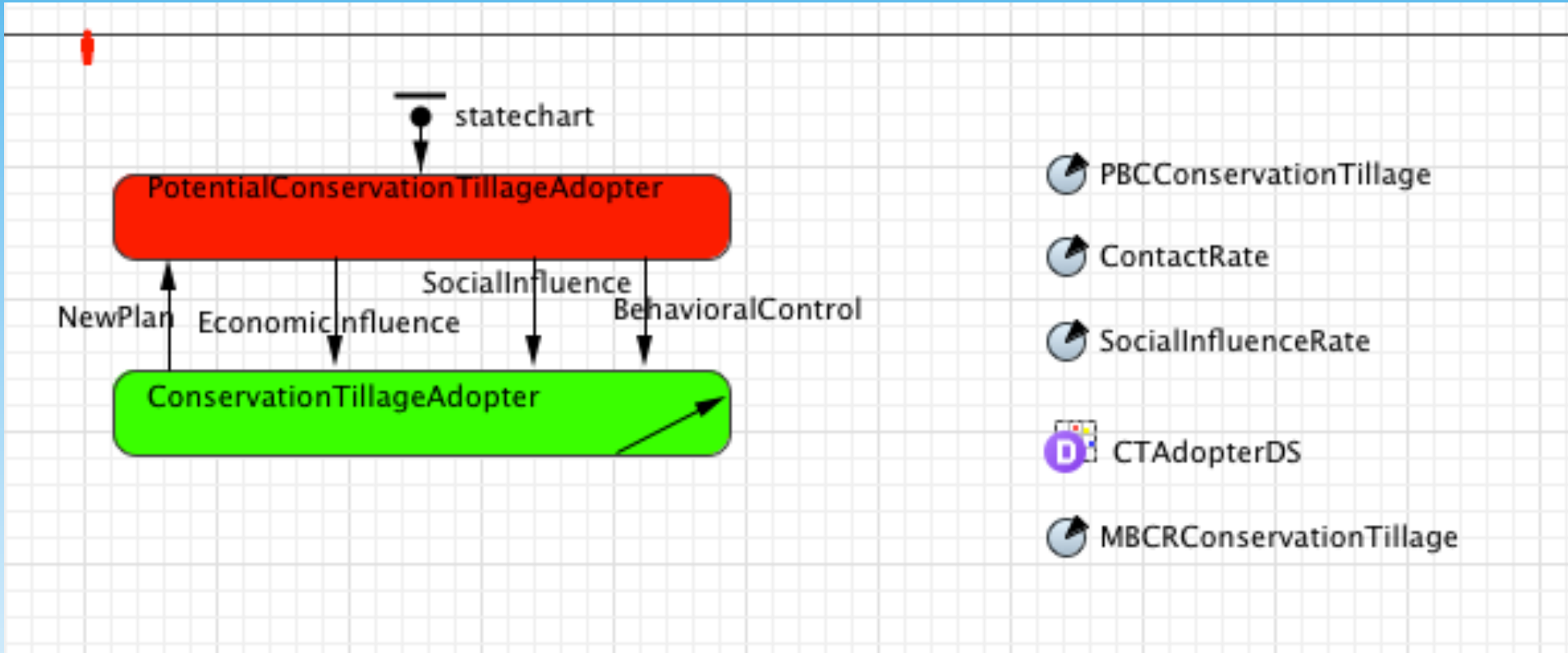
| | Cover Cropping | Reduced Tillage (strip, zone and no) | Applying fertilizer at recommended rates and times | Incorporating manure and fertilizer as quickly as possible after application | Manure spreading setbacks (from water bodies and private/public wells) |
|---|---|---|---|---|---|
| **Past Practice** | 0.7609** (0.2590) | 0.3709** (0.1407) | 0.1471 (0.2499) | 0.4115** (0.1754) | 0.2553** (0.1158) |
| **Attitude** | -0.0522 (0.1884) | 0.3152** (0.1412) | -0.0267 (0.1732) | -0.0396 (0.0768) | -0.0821 (0.0823) |
| **Perceived Social Norm** | 0.2960** (0.1422) | 0.1543* (0.0872) | 0.3507** (0.1441) | 0.1388 (0.0878) | 0.1830 (0.0971) |
| **Perceived Behavioral Control** | 0.6145*** (0.1716) | 0.5615*** (0.1247) | 0.7171*** (0.1145) | 0.8013*** (0.1252) | 0.9167*** (0.0944) |
| **Constant** | 0.4697** (0.2076) | 0.0767 (0.1288) | 1.2703** (0.4244) | 0.7623* (0.4455) | 0.3407 (0.2402) |
| **$R^2$ and (BIC)** | 0.6960 (351.46) | 0.8322 (286.98) | 0.5676 (384.53) | 0.6678 (370.70) | 0.7575 (349.75) |

Coefficients with * are significant at p>0.01; ** at p>0.05; and *** at p>0.001. Standard Errors are in Brackets.

## Weighted OLS Regression Models Predicting Farmer Intention to Adopt Nutrient Management Practices in Missisquoi and Lamoille Watersheds (N=80)

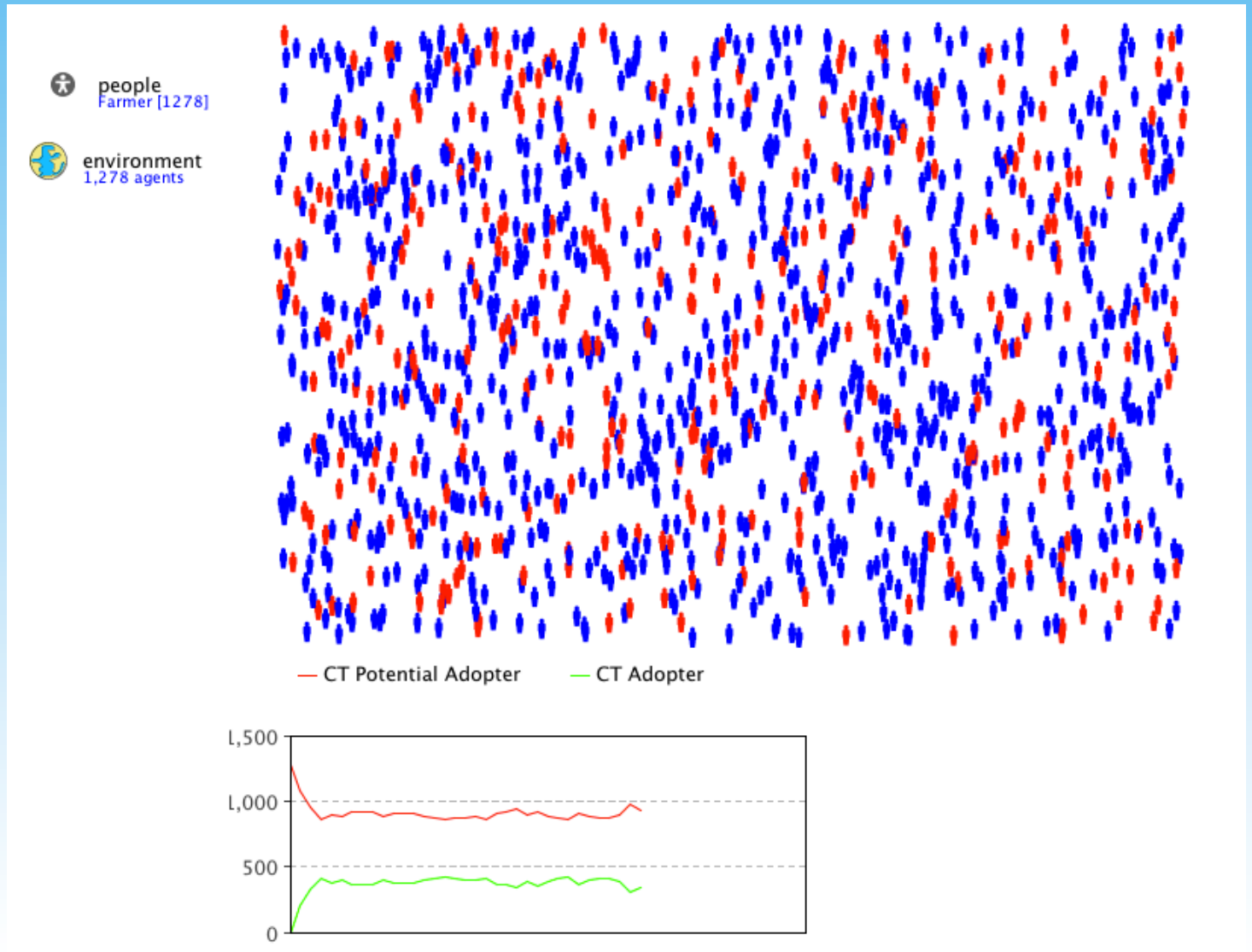
| | Planned Crop Rotations | Soil Test at least every three years | Strip Cropping | N, P & K Applications at rates recommended by soil tests | Buffers at field edges |
|---|---|---|---|---|---|
| **Past Practice** | 0.6889** (0.2182) | 0.1248 (0.2407) | 0.9137** (0.4307) | -0.0274 (0.2103) | 0.7296** (0.3449) |
| **Attitude** | -0.2184 (0.1663) | 0.1425 (0.1330) | -0.2848 (0.2388) | 0.1429 (0.1389) | -0.3071* (0.1797) |
| **Perceived Social Norm** | Omitted due to MC | Omitted due to MC | Omitted due to MC | 0.1556* (0.0890) | 0.1854 (0.1259) |
| **Perceived Behavioral Control** | 0.9077*** (0.1378) | 0.7750*** (0.0924) | 0.8056*** (0.2437) | 0.8672*** (0.0936) | 0.7883*** (0.1034) |
| **Constant** | 0.7445** (0.2467) | 1.0419** (0.4376) | 0.3423** (0.0932) | 0.7392** (0.2663) | 0.7616** (0.3064) |
| **$R^2$ and (BIC)** | 0.7354 (343.70) | 0.6984 (338.98) | 0.8163 (264.53) | 0.7909 (321.23) | 0.6522 (372.31) |

# Conservation Tillage Adoption Behavior ABM Design and Calibrated Parameters




| Parameters | Calibrated Scenario Value |
|---|---|
| PBC (Conservation Tillage) Rate | 0.08 per year |
| Contact Rate | Uniform (20-60) |
| Social Influence Rate | `triangular(0.005,0.1, 0.01)` |
| MBCR (Conservation Tillage) | `triangular(0.01,0.08,0.04)` |
| New Plan | `triangular(0.2,2,1 )` |

# NMP Adoption Behavior ABM: Baseline Policy Mix Scenario



# NMP Adoption Behavior ABM: Policy mix scenario with twice as much technical and financial assistance