

Land Use and Land Cover in Vermont

PTAC Scenario Activity Introduction

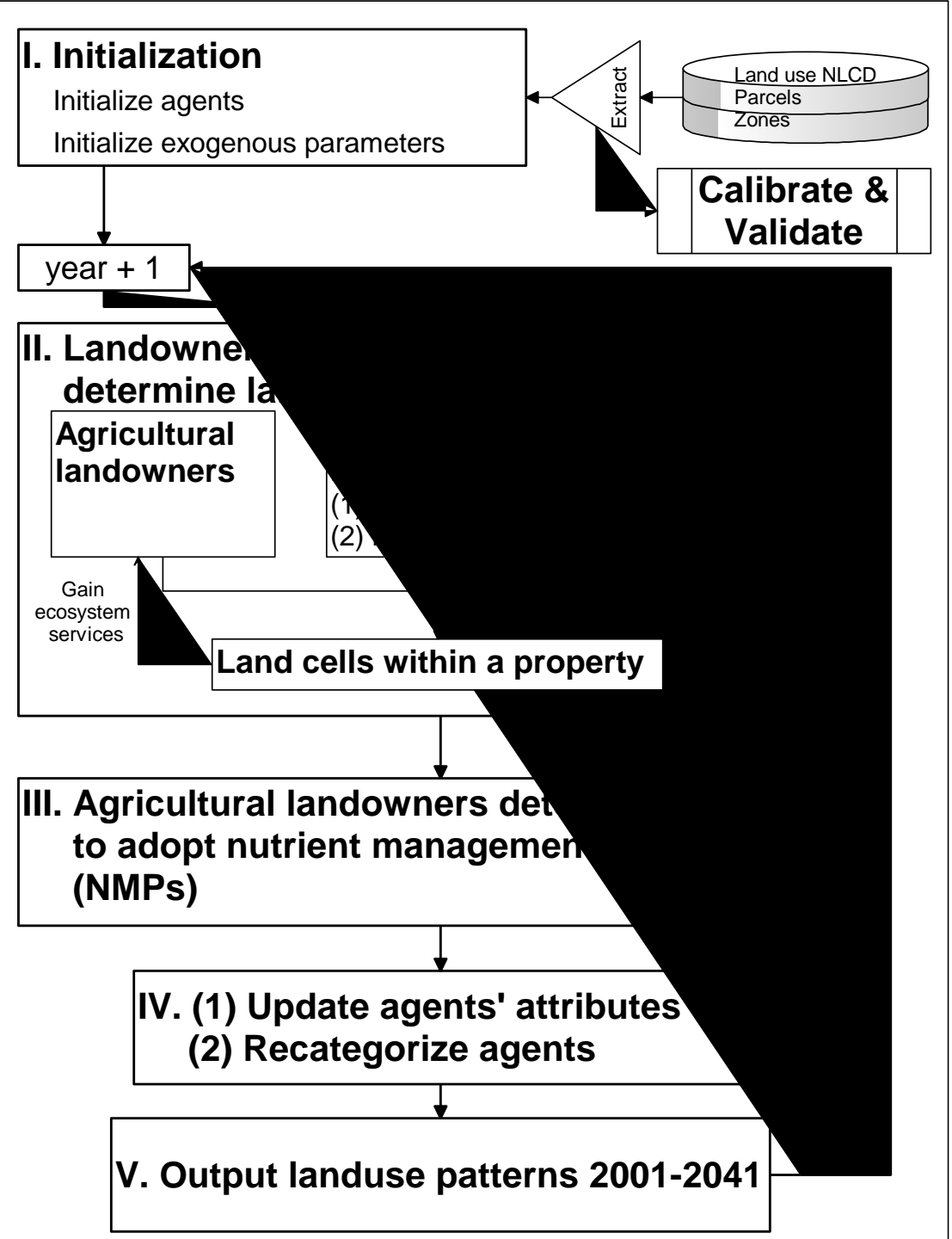


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Post Doctoral Fellow

30 November 2018

The BREE Land Cover and Land Users Model (ALL ABM) now...

- 4 core scenarios:
 - Business As Usual (BAU)
 - Pro-Ag
 - Pro-Forest
 - Pro-Dev
- BAU calibrated over 10 years (2001-2011) to NCLD layers
- 15 NLCD Land cover categories



Observed Land Use 2011



Calibrated 2011



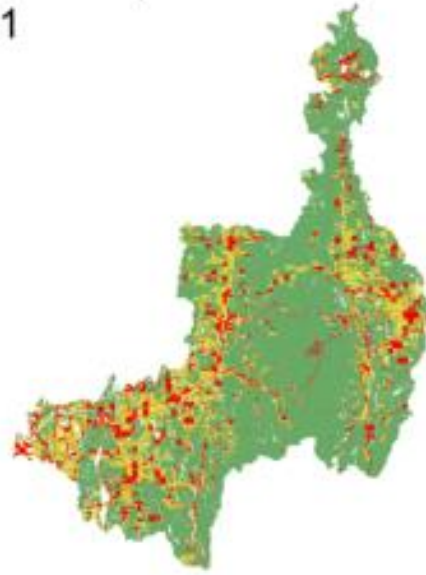
NLCD Land Cover Classification

- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren (Rock/Sand/Clay)
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Crops
- Woody Wetlands
- Herbaceous Wetlands

Business As Usual
2101



Pro-Development
2101

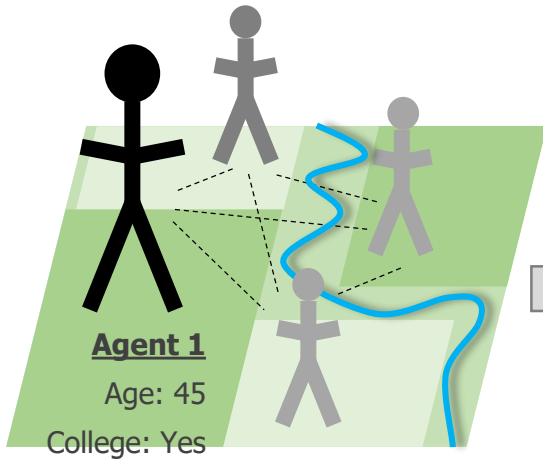


Pro-Forest
2101

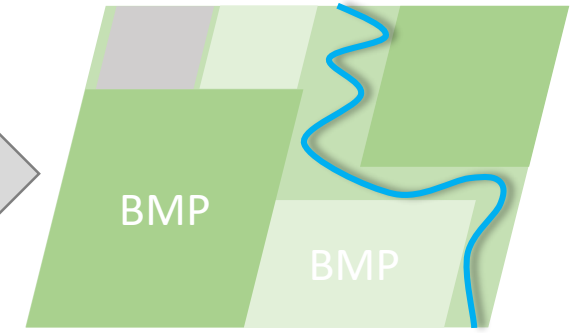
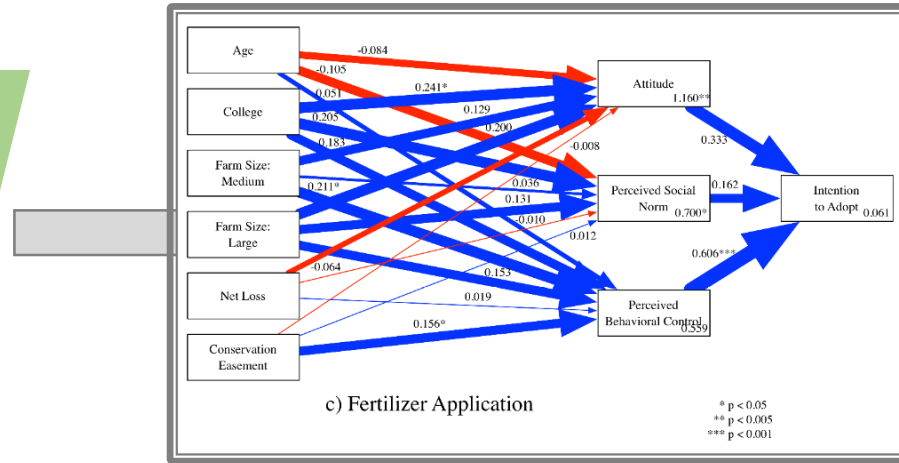


Pro-Agriculture
2101





Farm Size: 14 acres
Land use type: Crop



Land cover

&

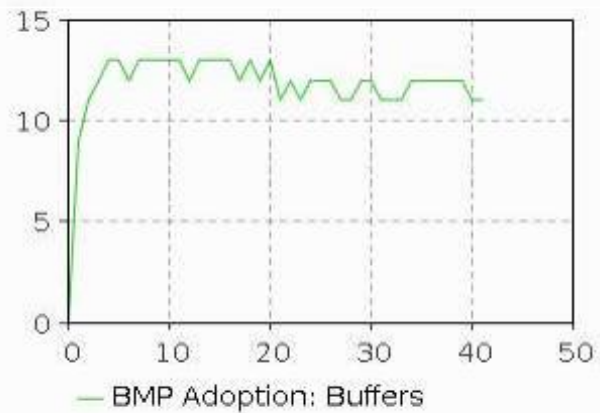
Land use

Urban, Agriculture,
Forest, Wetlands,
Water

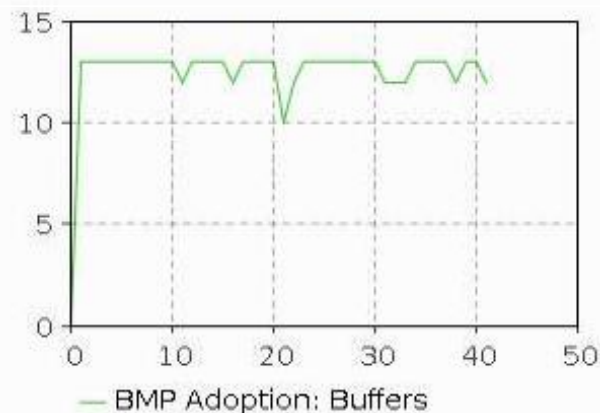
BMPs
AMPs
GSI



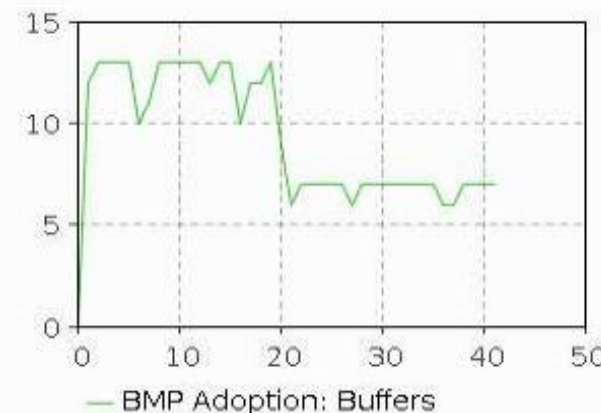
Business as Usual Scenario














Pro Crop Scenario



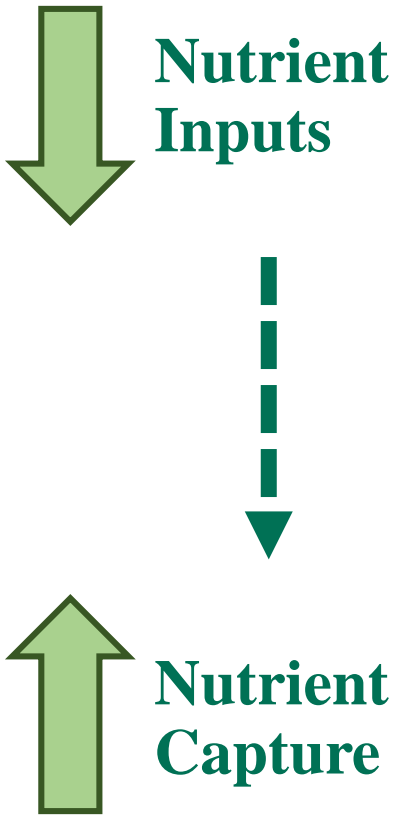
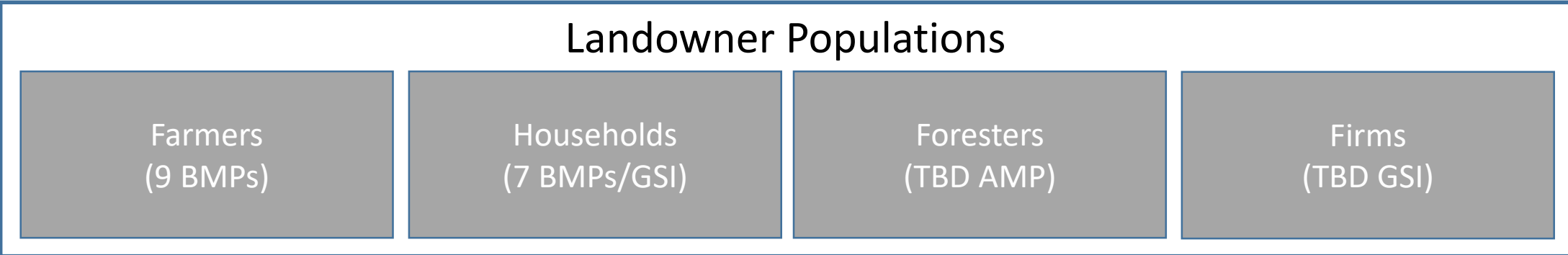
Urbanization Scenario



NLCD Land Cover Classification Legend

- | | | |
|---|--|---|
|  11 Open Water |  21 Developed, Open Space |  41 Deciduous Forest |
|  81 Pasture/Hay |  22 Developed, Low Intensity |  42 Evergreen Forest |
|  82 Cultivated Crops |  23 Developed, Medium Intensity |  43 Mixed Forest |
|  90 Woody Wetlands |  24 Developed, High Intensity | |

To reduce excess nutrient input to lake, suite of **Best Management Practices** (BMPs) implemented across the watershed.



Fertilizer application based on soil testing

Reduced Tillage



Conservation Buffers

Low P Lawn Fertilizer

Picking up dog waste

Rain Barrels

Rain Gardens

Temporary Skidder Bridge



Low/No P Lawn Fertilizer

Pervious Pavement

Constructed Wetlands



Retention Ponds

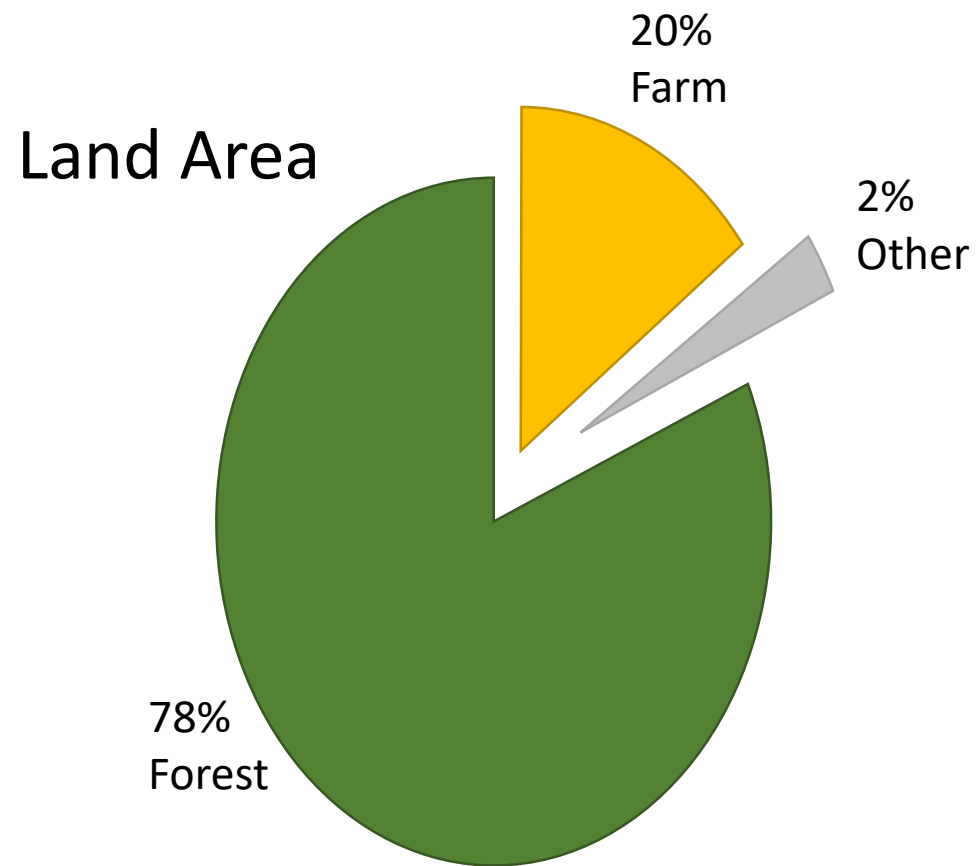
...and the future ALL ABM will have:

- All agent BMPs
 - Regulator-Agent interactions
 - Agent Memory
 - Explicit price/benefit
 - Risk and program enrollment based agent decision-making
 - Machine deep learning driven decision-making
 - Parcelization
- Feedbacks:
 - Forest – Climate feedback (LPJ-GUESS)
 - Lake – Land feedback (possibly via governance)
 - Land – Governance feedbacks

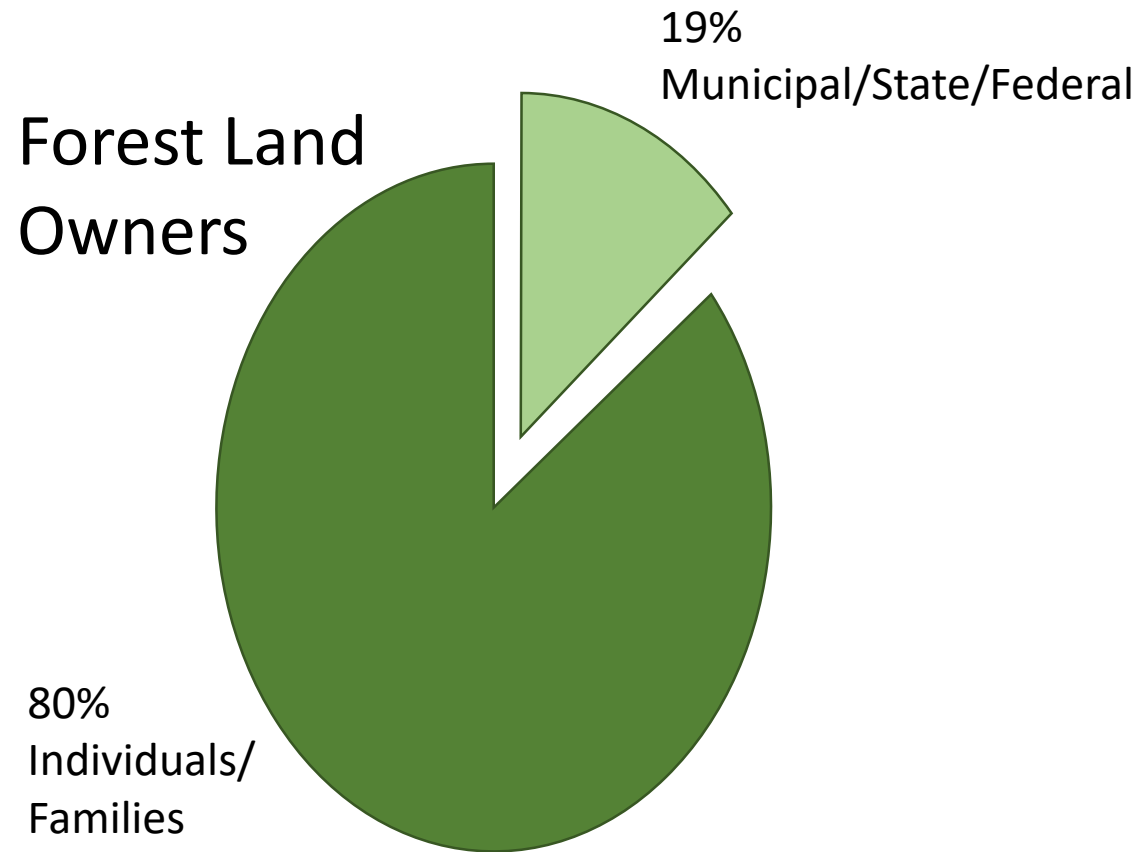
A few quick stats

Where are we?

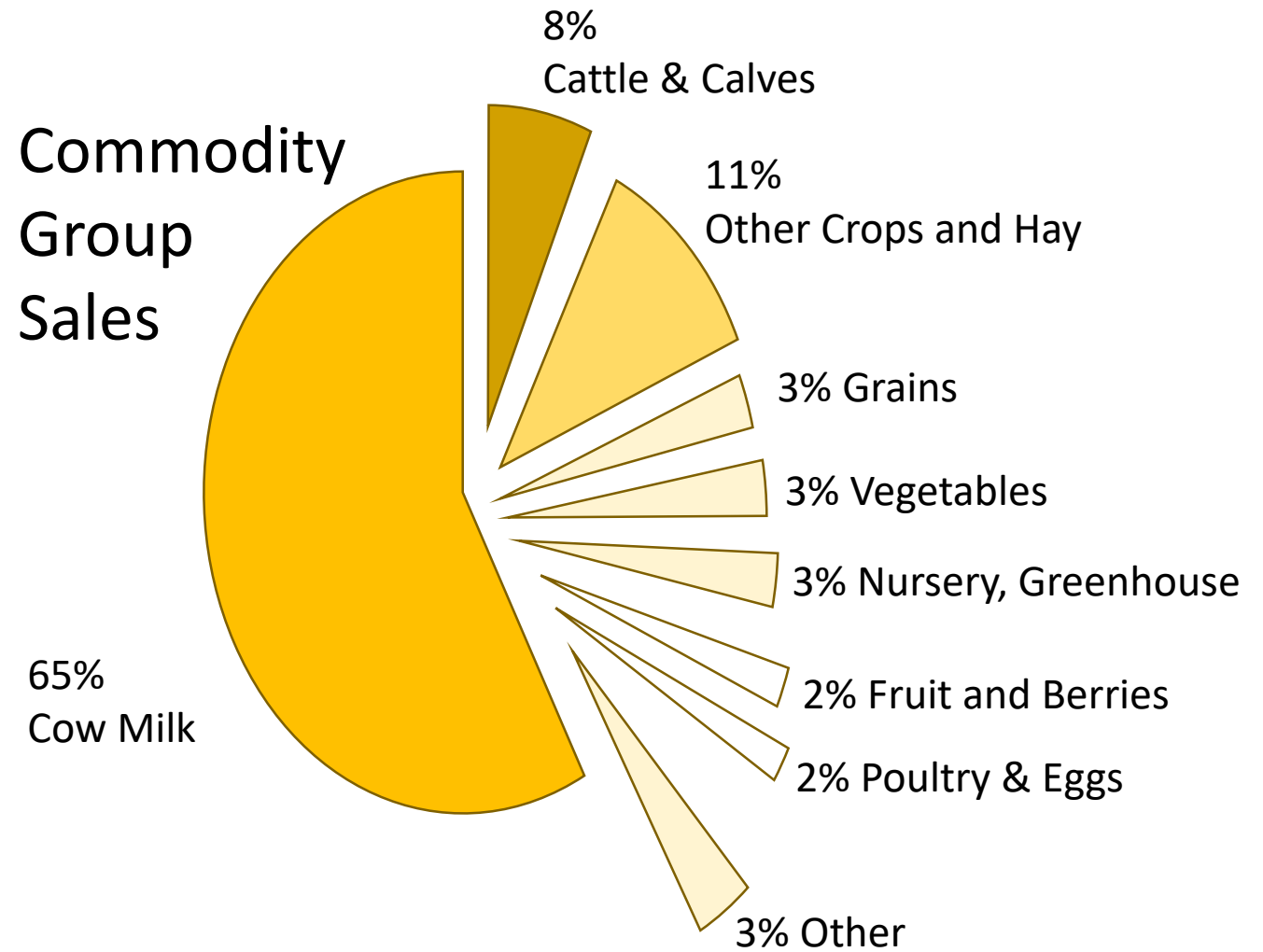
In Vermont



In Vermont



In Vermont



**Tracking Parcelization Over Time:
Updating the Vermont Database to Inform Planning and Policy**

Phase III Report



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September 2018

Trends of note

Total Land Value

Between 2004 and 2016...

*“the value of land statewide went from \$990/acre in 2004 to \$1,827/acre in 2016 – an increase of **185%**.”*

-- Fidel et al., 2018



2004



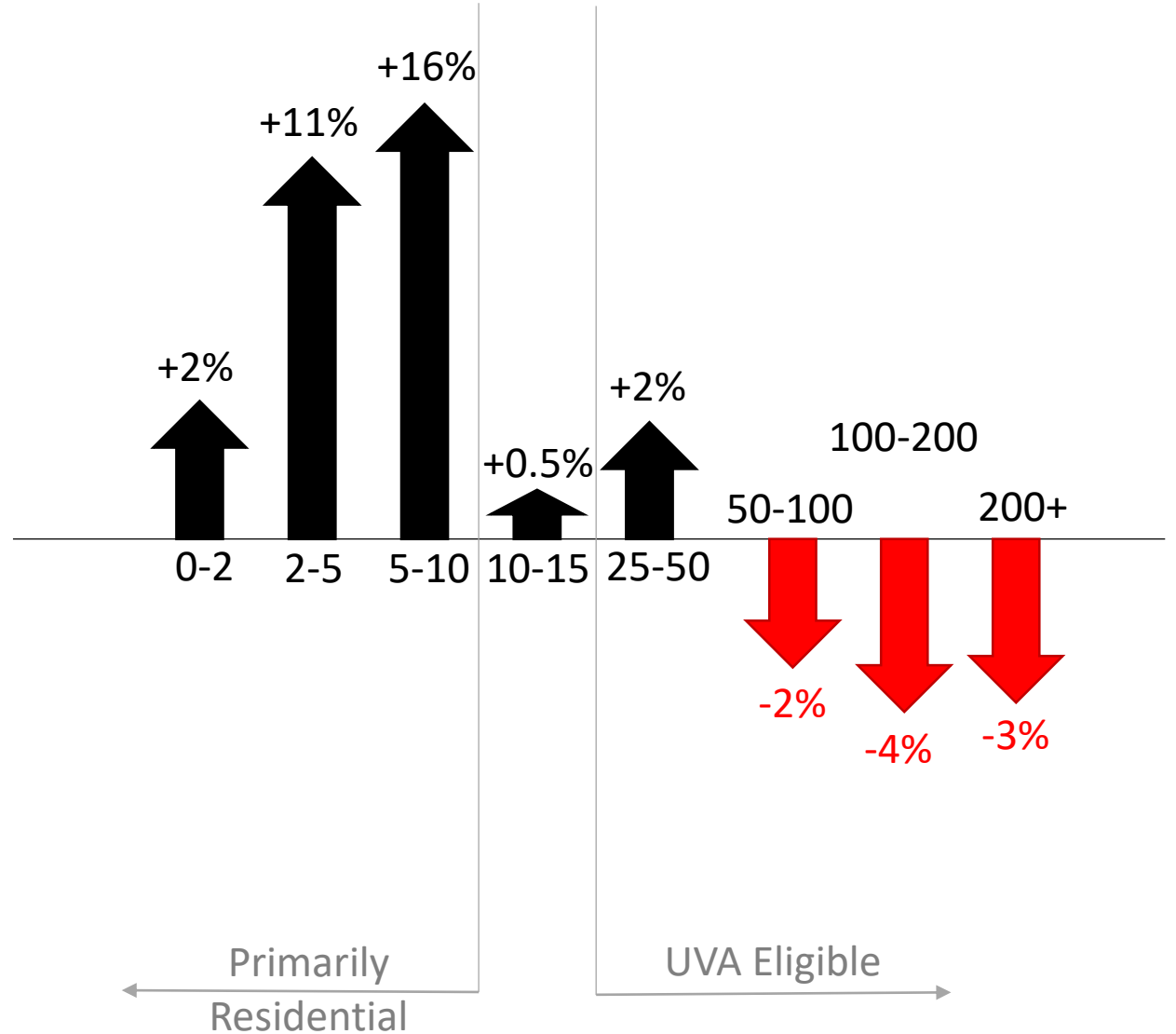
2016

Size of Land Parcels

Between 2004 and 2016...

“Larger parcels lost acreage..., while smaller parcels gained” both size and number. “Fortunately, a large percentage [~70%] of Vermont’s land remains in parcels” larger than 50 acres.

-- Fidel et al., 2018

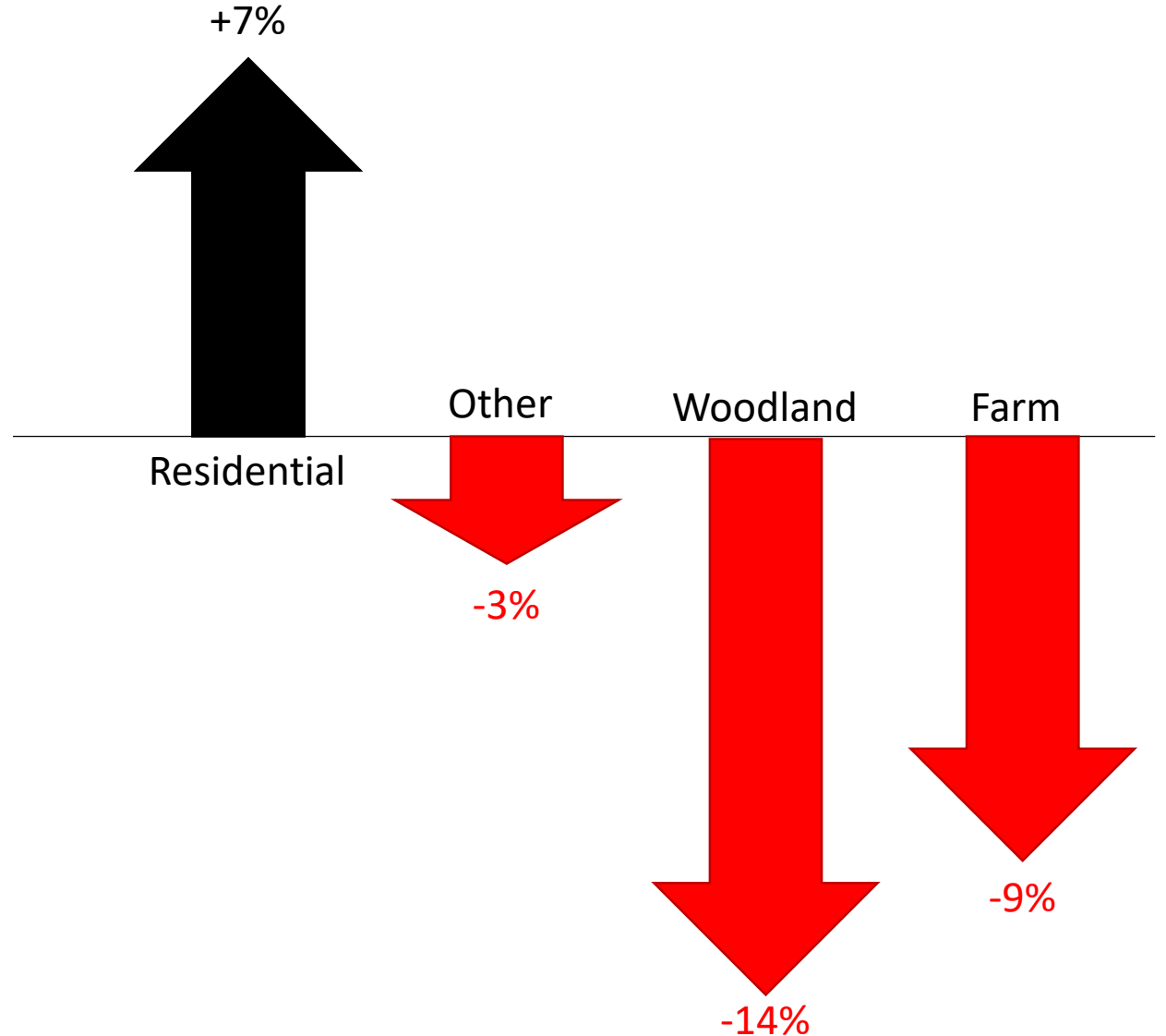


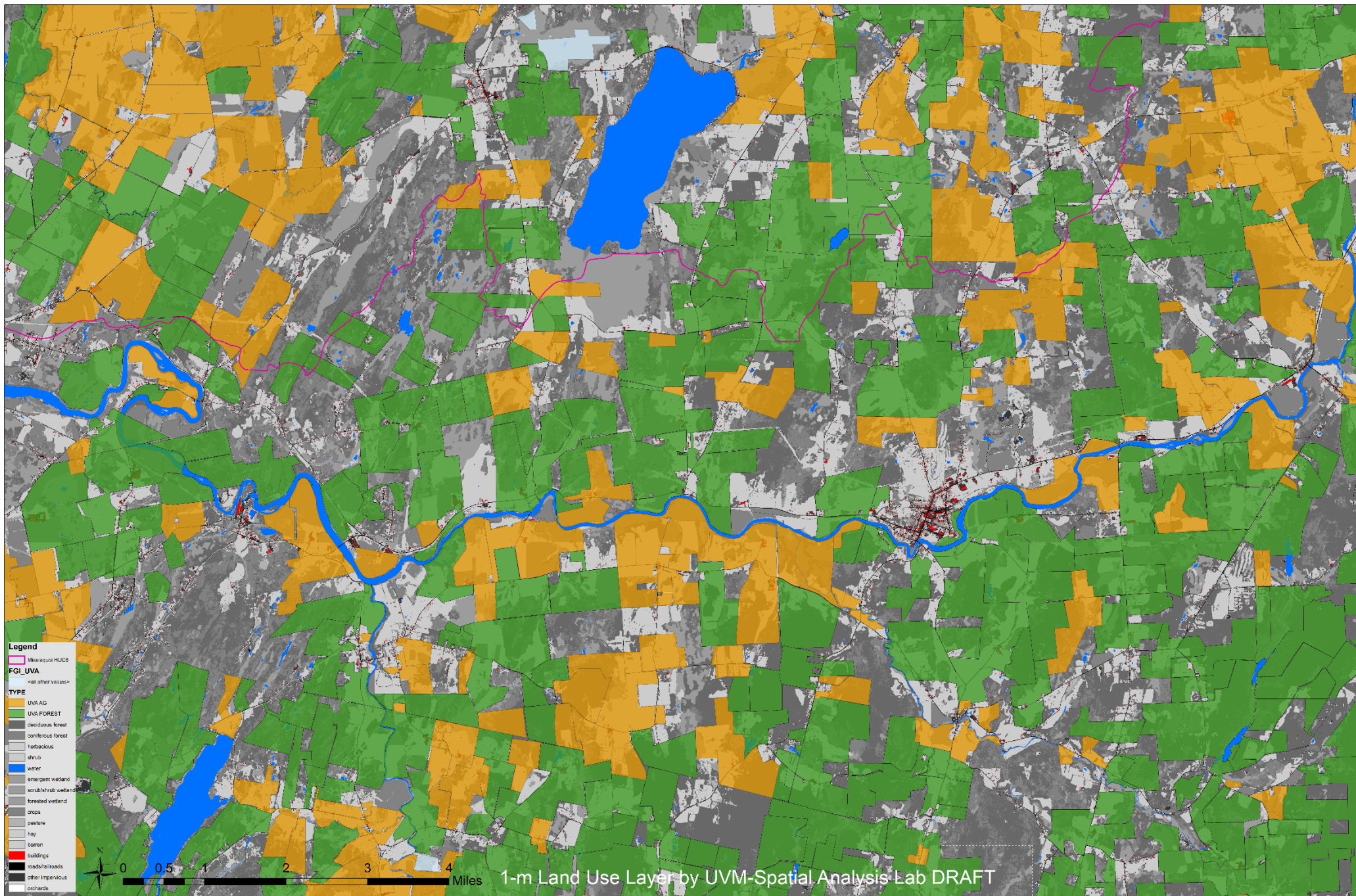
Type of Land Parcels

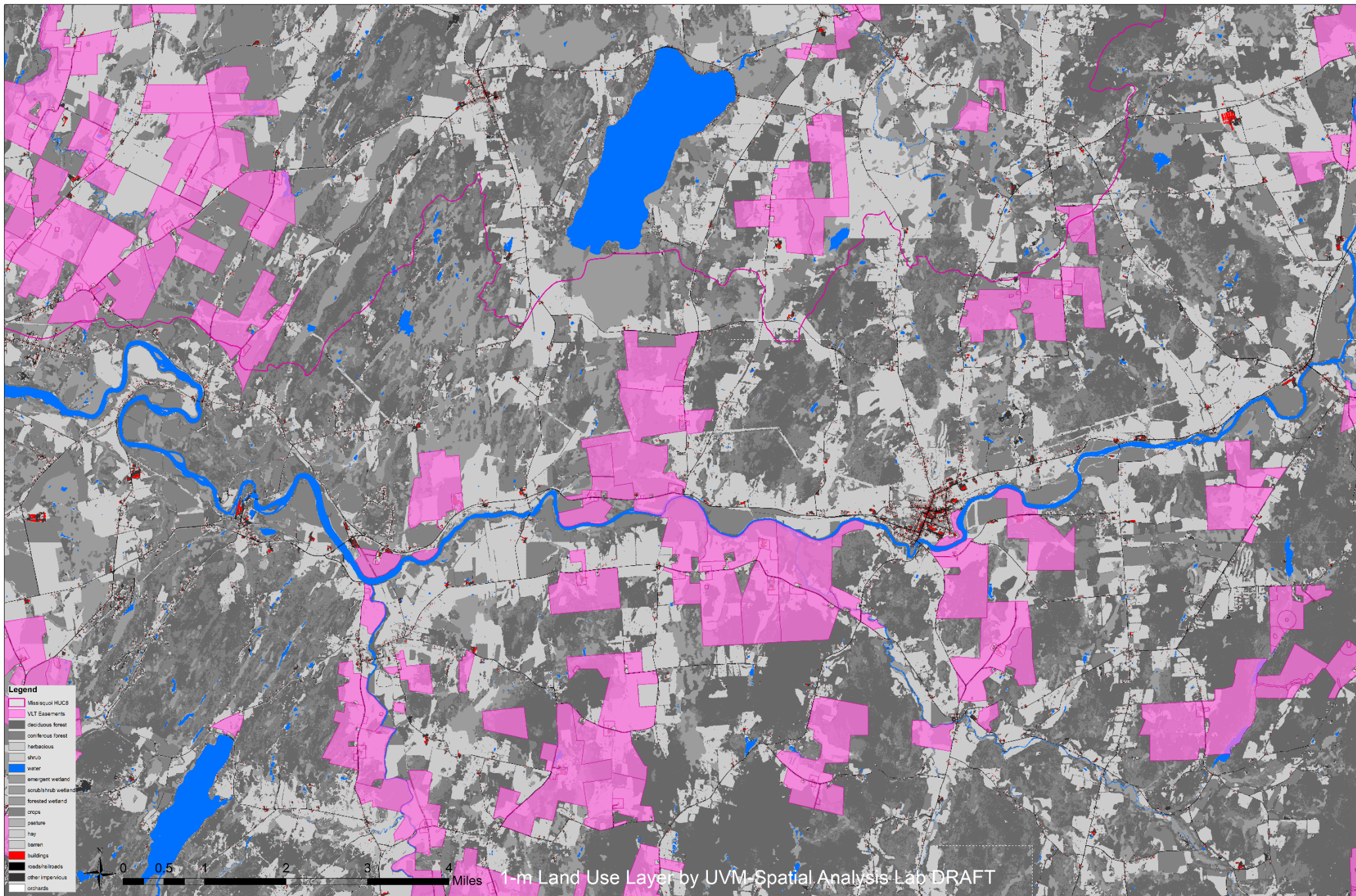
Between 2004 and 2016...

“Statewide, acreage in farm and woodland (undeveloped forestland) is decreasing, while residential acreage is increasing.”

-- Fidel et al., 2018

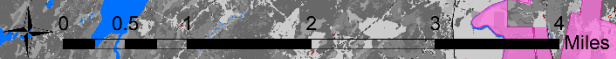






Legend

- Mosaic HUCs
- VLT Easements
- deciduous forest
- coniferous forest
- herbaceous
- shrub
- water
- emergent wetland
- scrub/shrub wetland
- forested wetland
- crops
- pasture
- hay
- barren
- buildings
- roads/airroads
- other impervious
- orchards



1-m Land Use Layer by UVM Spatial Analysis Lab DRAFT

Conservation



Vermont's return on investment in land conservation



TABLE 1. HISTORICAL ACRES AND STATE FUNDING ON LAND CONSERVATION⁴

Year	Acres	Spending
1988	1,910	\$1,420,000
1989	5,250	\$2,600,000
1990	5,280	\$3,470,000
1991	6,260	\$3,590,000
1992	4,160	\$2,180,000
1993	9,630	\$2,970,000
1994	10,500	\$5,310,000
1995	17,600	\$5,670,000
1996	9,170	\$2,880,000
1997	7,010	\$2,810,000
1998	9,740	\$2,880,000
1999	145,000	\$8,190,000
2000	3,350	\$1,760,000
2001	7,960	\$3,220,000
2002	8,150	\$3,480,000
2003	7,950	\$3,150,000
2004	3,720	\$2,020,000
2005	4,120	\$2,720,000
2006	4,860	\$3,970,000
2007	3,240	\$2,770,000
2008	5,970	\$5,490,000
2009	2,740	\$1,530,000
2010	5,570	\$4,120,000
2011	4,030	\$2,670,000
2012	7,170	\$4,620,000
2013	3,760	\$2,750,000
2014	4,200	\$2,500,000
2015	3,790	\$2,510,000
2016	2,720	\$2,100,000
Total	315,000	\$95,400,000
Median	5,280	\$2,880,000

All numbers reported in the text and tables are rounded to three significant digits unless otherwise noted. Because of rounding, some report figures and tables may appear not to sum.

9:1 ROI

State invested funds

TABLE 3. LANDS CONSERVED BY LAND COVER TYPE

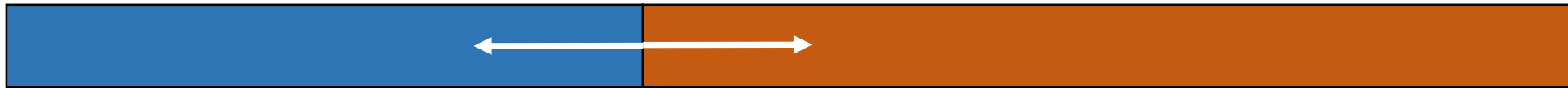
Land cover type	Acres	Percent land cover
Deciduous Forest	114,000	36.1%
Mixed Forest	55,900	17.7%
Pasture/Hay	48,100	15.3%
Evergreen Forest	30,400	9.64%
Cultivated Crops	27,500	8.73%
Woody Wetland	21,000	6.67%
Shrub/Scrub	7,270	2.31%
Emergent Herbaceous Wetland	3,130	0.99%
Developed Open Space*	2,740	0.87%
Open Water	2,060	0.65%
Developed (Low, Medium, High)**	2,430	0.77%
Grassland/Herbaceous	866	0.28%
Barren Land	73	0.02%
Total	315,000	100.0%

* Developed open space/parks are areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total land cover.

** The developed category combines low-, medium-, and high-intensity development land cover types. This includes areas with a mixture of constructed materials and vegetation with impervious surface accounting for between 20 percent and 100 percent of the total land cover.

Gradients for Discussion

Conservation – Development



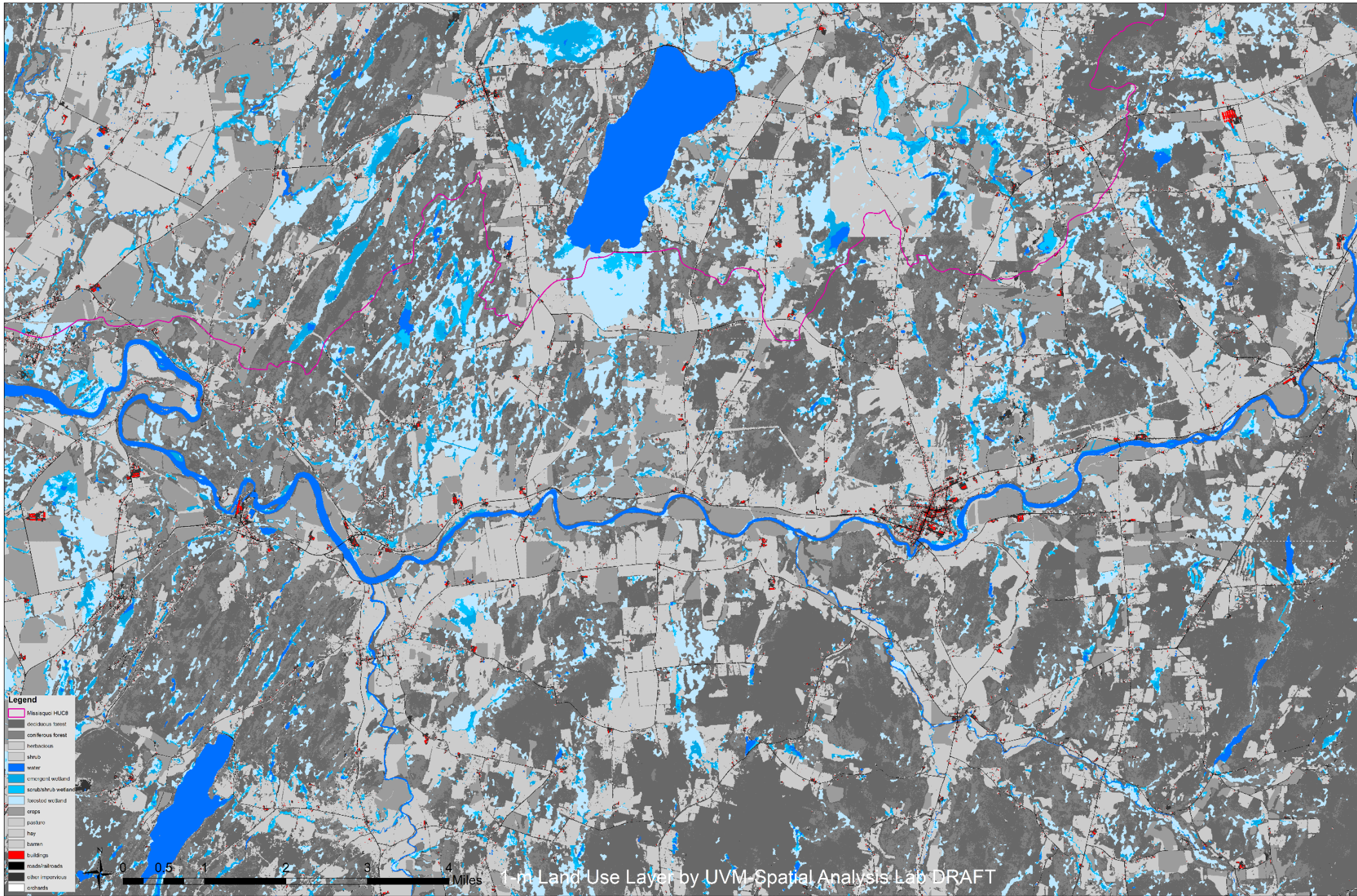
Working Landscape – Wild Nature



Disruptive Externalities



Extra Slides

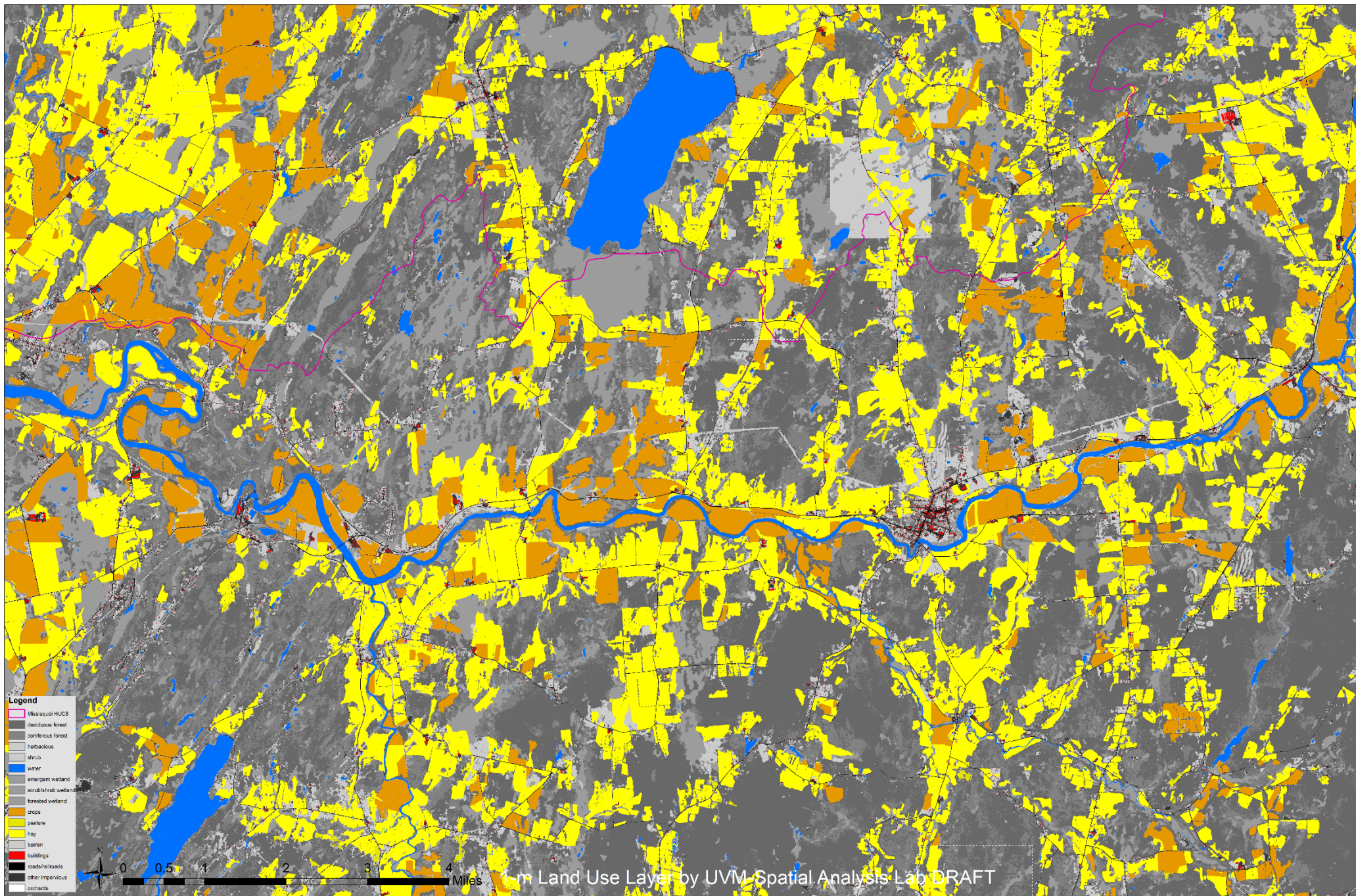


- Legend**
- Mississippi HUC8
 - deciduous forest
 - coniferous forest
 - herbaceous
 - shrub
 - water
 - emergent wetland
 - scrub/shrub wetland
 - lowland wetland
 - cropland
 - pasture
 - hay
 - barren
 - buildings
 - roads/highways
 - other impervious
 - orchards



Land Use Layer by UVM Spatial Analysis Lab DRAFT



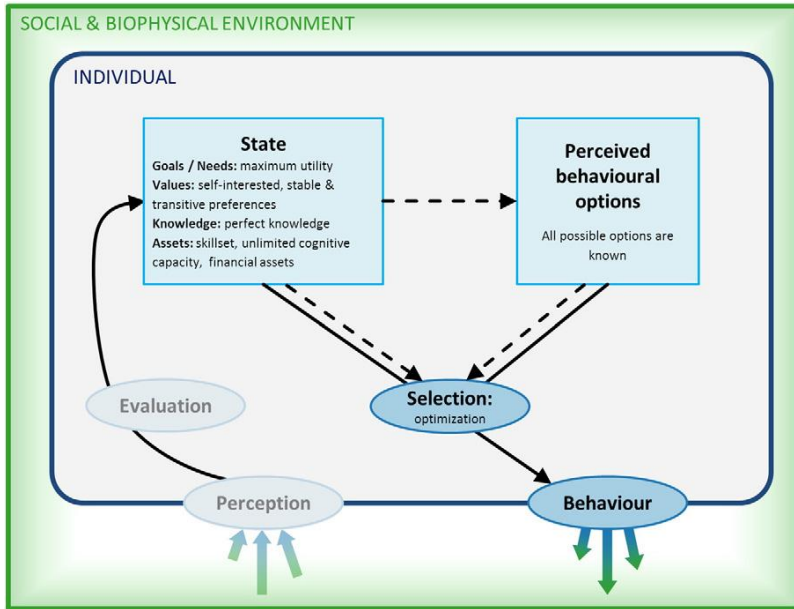


Parcels with Dwellings

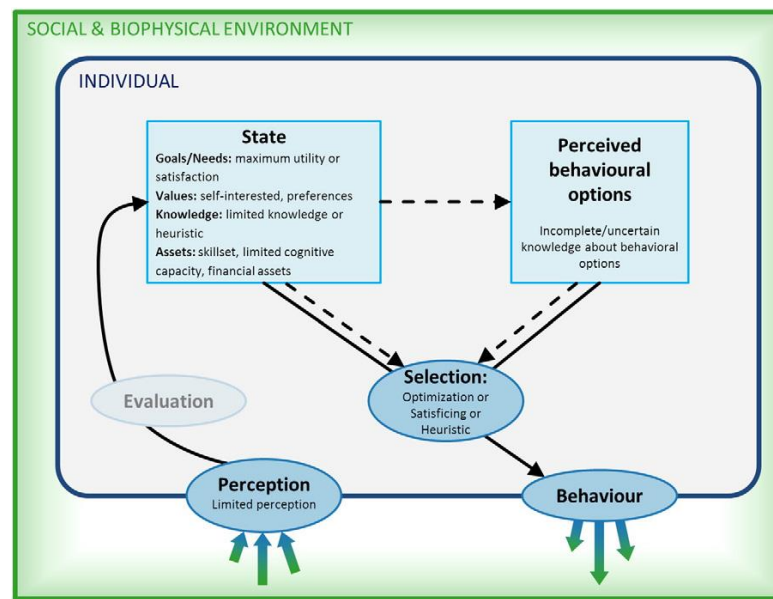
Parcel Size (acres)	Change in Parcels with Dwellings	2004 Parcels	2016 Parcels	Percent Change
0-2	+9,334	152,330	161,664	+ 6.1%
2-5	+4,633	30,240	34,873	+ 15.3%
5-10	+3,195	13,990	17,185	+ 22.8%
10-25	+2,421	30,488	32,909	+ 7.9%
25-50	+1,164	8,517	9,681	+ 13.7%
50-100	+635	6,386	7,021	+ 9.9%
100-200	+181	4,417	4,598	+ 4.1%
>200	+65	2,352	2,417	+ 2.8%

Table 13

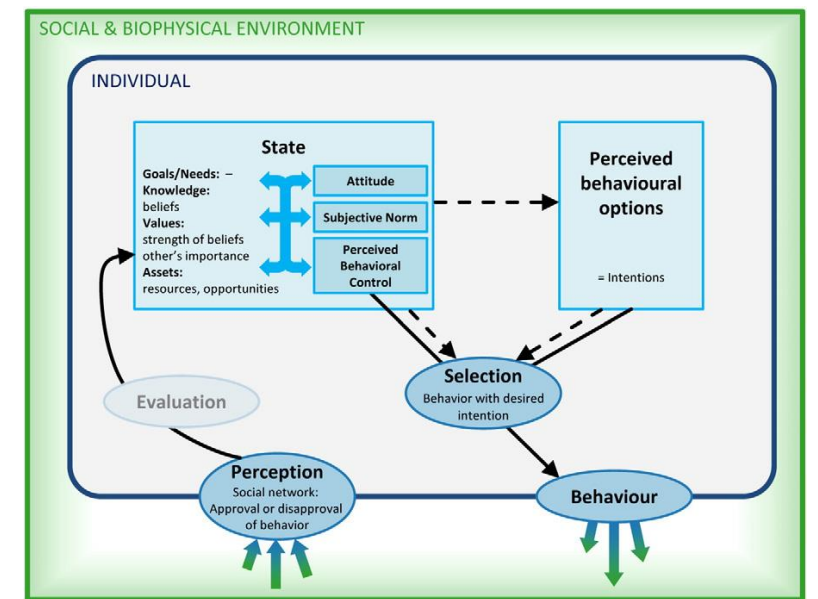
Rational Actor Model



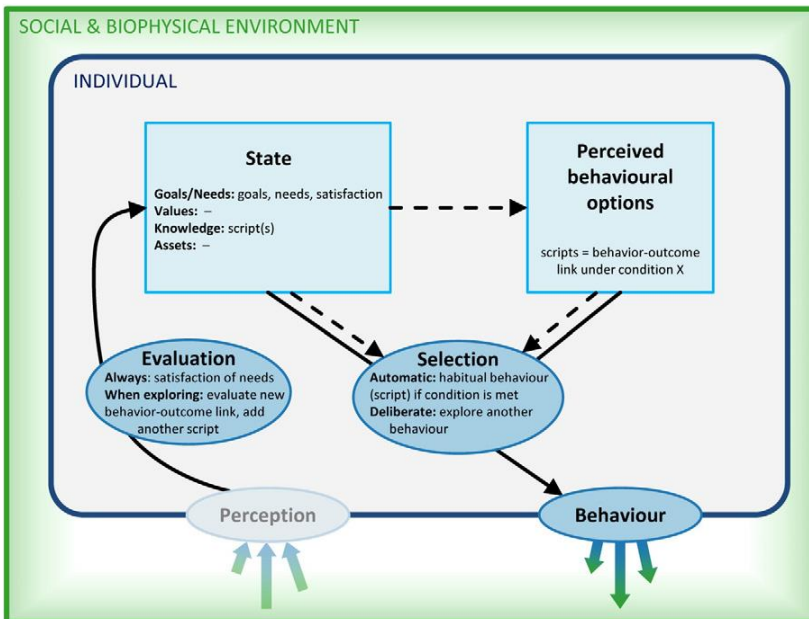
Bounded Rational Actor Model



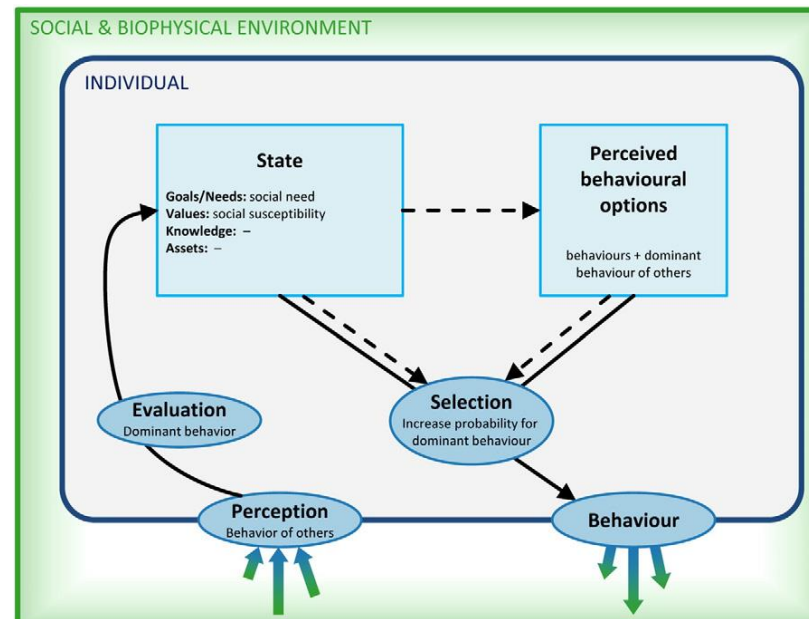
Theory of Planned Behavior Model



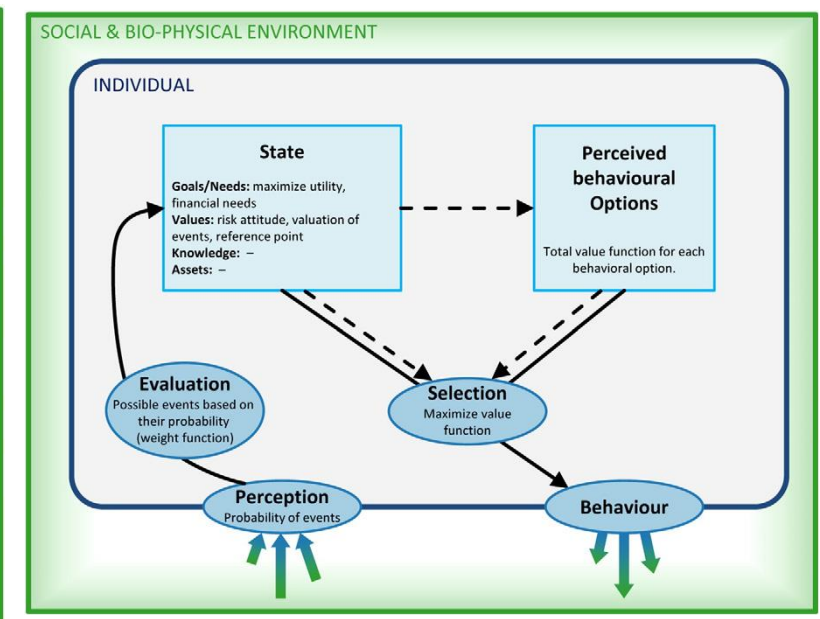
Habitual DM/Reinforcement Learning



Descriptive Norm model



Prospect theory model



BMPs By Agent Type

Best Management Practice Intervention	Type
Planned crop rotations	Agricultural
Soil test at least every 3 years	Agricultural
Strip Cropping	Agricultural
N, P, & K applications at rates recommended by soil tests	Agricultural
Buffers at field edges	Agricultural
Cover Cropping	Agricultural
Reduced tillage (strip, zone, and no)	Agricultural
Applying manure at recommended rates and times	Agricultural
Applying fertilizer at recommended rates	Agricultural
Incorporating manure and fertilizer as quickly as possible after application	Agricultural
Manure spreading setbacks (from water bodies and private/public wells)	Agricultural

Best Management Practice Intervention	Type
Rain barrels	Household
Rain garden	Household
Permeable pavement/pavers	Household
Infiltration trenches	Household
Tree box filters	Household
Green roofs	Household
Constructed wetlands	Household
Bioretention without underdrain, or raingarden	Municipal
Bioretention with an underdrain connecting to storm sewer	Municipal
Tree pit/cell/box	Municipal
Infiltration/storage trench	Municipal
Infiltration/storage basin	Municipal
Dry well	Municipal
Dry detention pond/basin (surface, non-infiltration)	Municipal
Vegetated or Grass swale	Municipal
Gravel-bed wetland	Municipal
Shallow surface wetland	Municipal
Wet detention/retention ponds	Municipal
Cistern (200+ gal.)	Municipal
Rain barrel (30-55 gal.)	Municipal
Green roof	Municipal
Pervious/porous pavement (asphalt, concrete, etc., designed for stormwater infiltration and storage)	Municipal
Pervious/porous pavers (blocks, bricks, designed for stormwater infiltration and storage)	Municipal
Gutter/downspout disconnection to vegetated area	Municipal
Road drainage such as culverts and ditches	Municipal
Road drainage with storm sewer/pipes	Municipal