Analysis of the drivers of urban growth and second home development in the Northern Forest Region of Vermont

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1) We developed a tool that facilitates regional evaluation of the impacts of residential development on the Northern Forest Region.
2) The effects of alternative policy scenarios on future land use patterns were evaluated, including changes to the regional road network to increase regional accessibility and the effectiveness of the Current Use program for preserving Vermont's working landscape.
3) Predicted future residential development patterns were used to estimate future changes in forest cover and fragmentation.

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http://www.nsrcforest.org

Project Summary

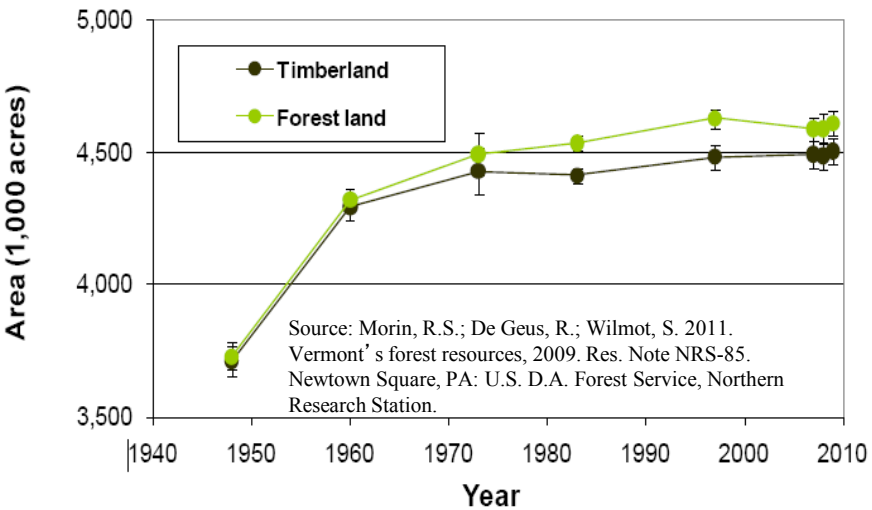
Vermont's Northern Forest is increasingly subject to fragmentation pressures due to the encroachment of urbanized areas and the scattered development of residential properties. New development in already built-up areas leads to a marginal decrease in forest cover, while development in rural locations leads to increased forest loss because they require the construction of access roads, driveways and, in general, feature a larger development footprint. However, guessing where development is most likely to occur poses a challenge for planners. The combination of land use change modeling and Geographic Information Systems (GIS) offers an excellent way to assess where development is likely to occur, how that development will affect forest habitat, and how the resultant land use pattern might change under alternative policy and investment scenarios.

We applied the land use change model UrbanSim to Vermont's Northern Forest region to assess future patterns of urban, suburban, exurban and rural residential development under baseline conditions and alternative infrastructure investment and land use policy scenarios. We partitioned the landscape into 150 x 150 m cells, and populated each of the nearly 650,000 cells with an array of social, ecological and policy relevant attributes. Residential development over the next 25 years was modeled as a factor of proximity to retail establishments, ski resorts, and protected areas, soil type, slope, and housing density, using a set of pre-determined population forecasts. Forest cover change was determined based on the results of the urban growth model. The alternative scenarios run included construction of new Interstate highway exits and more stringent implementation of the Current Use property tax program.

The results of the analysis indicate that new development will lead to increased fragmentation regardless of the proposed policy or infrastructure investment decisions. Placing limits on growth (e.g. enhanced Current Use) may steer new development away from forested lands. Constructing new Interstate interchanges in areas where access to the Interstate is limited leads to new development surrounding the interchange and improved accessibility to land that may otherwise not be considered for development. Model results show that close coordination between infrastructure development and policy implementation is necessary to maintain the overall integrity of Vermont's working landscape.

Background: Land Cover Trends in Vermont

- Vermont was 78% forested in 1998: up 2% from 1983 and 24% from 1948
- Since then, the amount of forested land has remained constant or been slightly reduced by low density (primarily residential) development
- The rate of low density development in Vermont is increasing
  - between 1982 and 1992, the amount of developed land grew by more than 25%, while the population grew by approximately 10%
- We are interested in determining whether the rate of development on forested lands is starting to outpace forest re-growth from agricultural abandonment?



Source: J. Campoli et al. *Above and Beyond*

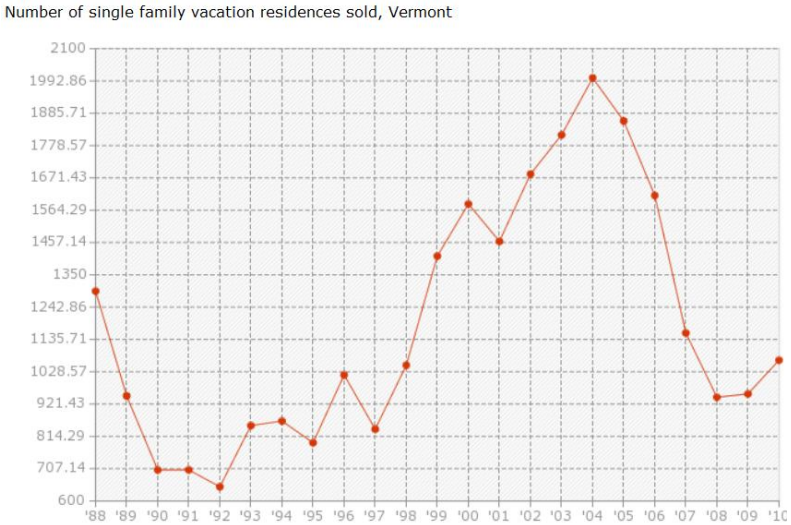
Background: Land Cover Trends in Vermont

- Residential densities are declining and per capita land consumption is increasing
- Rate of land development outpacing population growth by nearly 260%.
- About 40% of new development is occurring on farmland, and much of the remaining development is in forestlands

Source: J. Campoli et al. *Above and Beyond*

Background: Sources of Land Use Change

- Urbanization driven by employment centers
- Resort-, second- and vacation-home development
- Single family vacation home sales peak in 2005, then drop sharply with economic downturn
- Uptick?



Source: housingdata.org

Background: Effects of Fragmentation

- Compromise biodiversity (Cam et al. 2000; Fernandez-Juricic 2004) by reducing the size and quality of terrestrial habitat (Pardini et al. 2005; Trzcinski et al. 1999),
- Increases in impervious surface area and non-point pollution sources impact water quality and aquatic habitats (Lathrop et al. 2007; Wang et al. 2001).
- Low density development increases the extent of the natural-human interface zone which leads to:
  - the introduction of exotic plants (Borgmann & Rodewald 2004);
  - herbivore overpopulation; and
  - nest predation, (Chapa-Vargas & Robinson 2006) or exposure to domestic animals (May & Norton 1996).
- Deleterious to the forest products industry
  - wood from fragmented forest lots yields lower stumpage price, and long-term forestland investors are primarily interested in larger (i.e. > 5,000 acres) patches of contiguous forest land (Thorne 2000).

Source: Bing maps/Pictometry

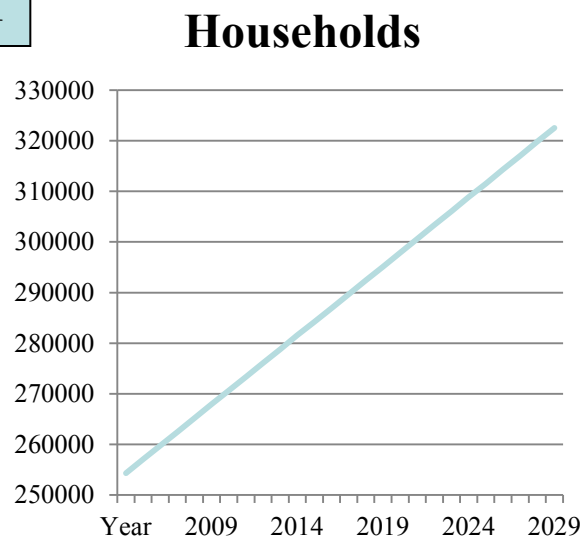
Research Objectives

1. Characterize and quantify the drivers of several types of residential development in Vermont;
2. Simulate future development patterns due to those drivers;
3. Simulate future forest fragmentation resulting from those predicted future development patterns, and
4. Assess how the outcomes of 2 and 3 differ based on alternative policy scenarios.

Source: Bing maps/Pictometry

Methods: Modeling Residential Development

1



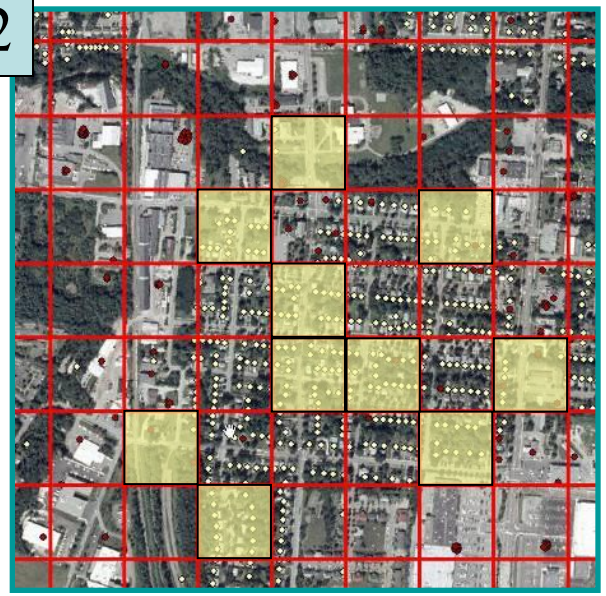
1. Statewide housing projections define the total number of anticipated housing units from 2005 – 2030.

2. The Real Estate Development Location Choice Model (RDLCM) identifies potential locations for new residential development.

3. The RDLCM ranks the potential sites based on the their suitability for development, surrounding household density, **accessibility** (see next slide) to employment and retail services. The darker the shade, the more suitable a location for receiving new residential development.

4. Once a site is selected, the grid cell attributes are updated, and the model continues to iterate until enough new residential development is sited.

2



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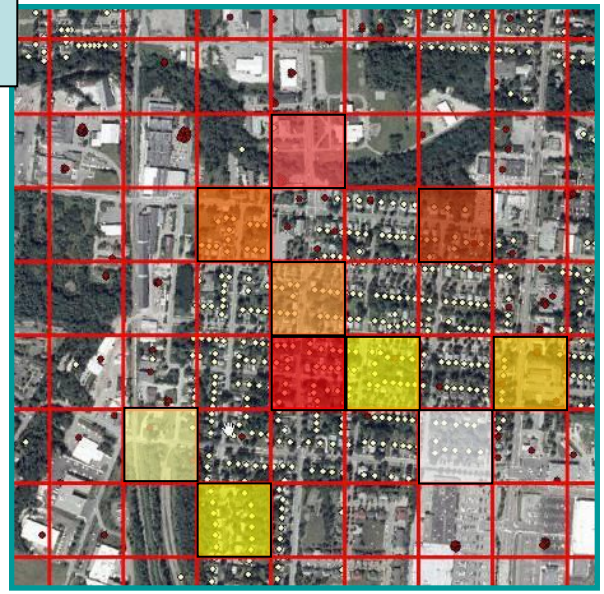

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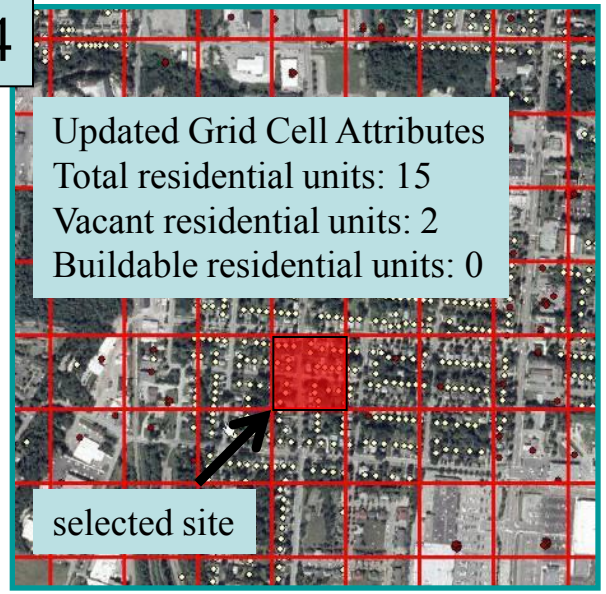
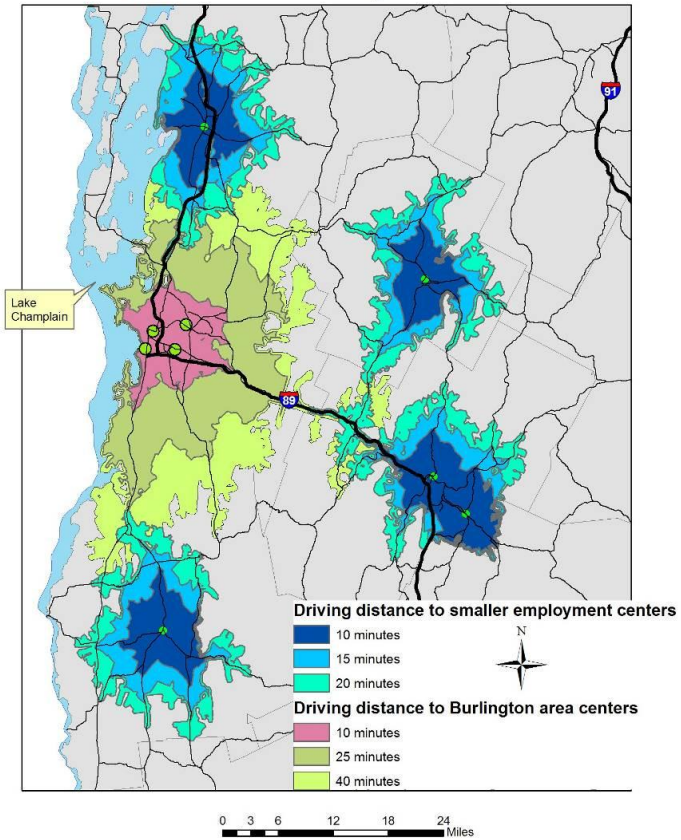
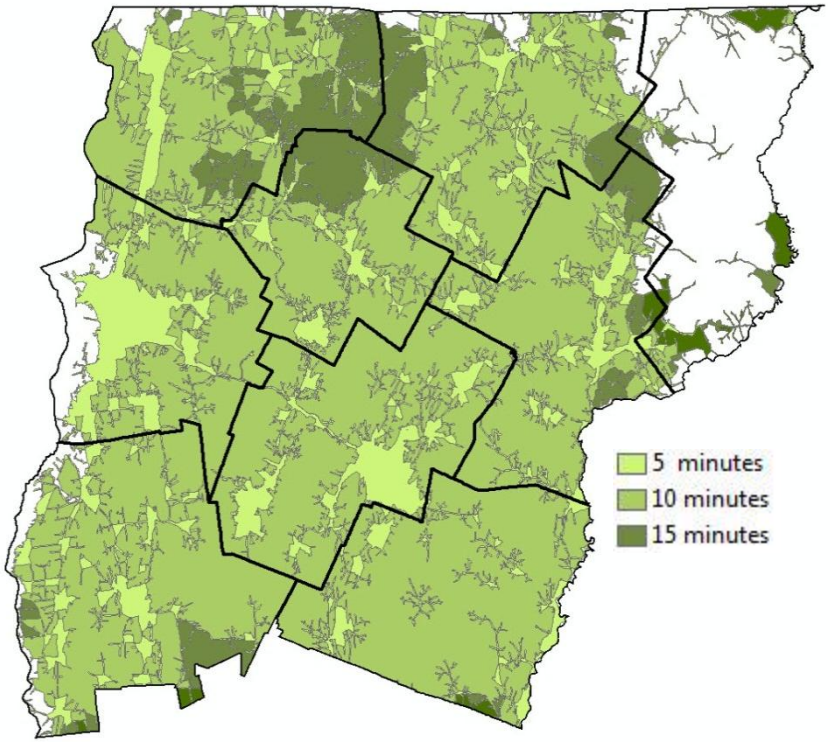


Methods: Quantifying Accessibility

Driving distance to central Burlington metro area and four smaller emploment subcenters





Alternative Scenarios

- Road Network Improvements
  - locate three new Interstate interchanges (2 on I89, 1 on I91)
  - recalculate travel times, service areas, distance to destinations (downtown Burlington, ski areas)
- Current Use
  - Baseline: current use parameter included in the model estimation
  - Moderate scenario: increase parameter value to render current use land more difficult to develop
  - No Build scenario: land designated as current use is not available for new construction

Methods: Common fragmentation metrics

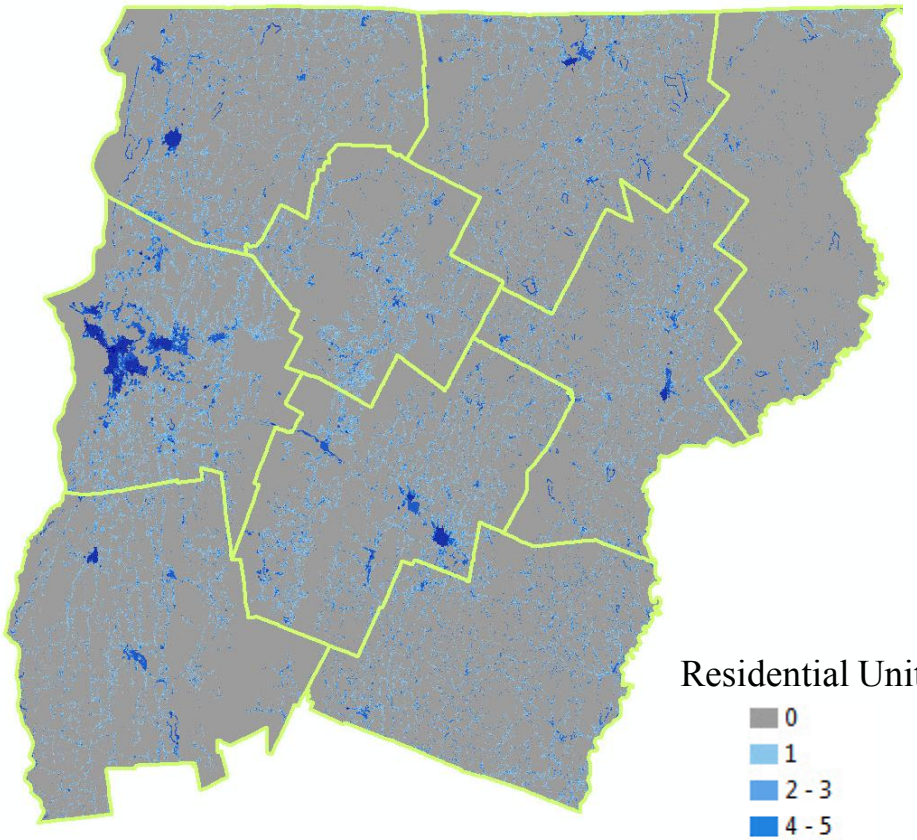
- Landscape level:
  - Proportion/area of landscape in habitat type
  - Number of patches
  - Mean patch size/ patch density
  - Dominance/ Shannon Evenness
  - Patch density
  - Total edge/edge density
  - Landscape shape index (ratio of edge to minimum edge)/ perimeter-area ratio
  - Largest patch index (% area of largest patch)
  - Perimeter-area Fractal Dimension (measure of shape complexity)
- Patch level
  - Patch area/perimeter
  - Perimeter-area ratio/shape index
  - Fractal Dimension
  - Contiguity index (connectedness of cells in moving window)

Source: J. Campoli et al. *Above and Beyond*

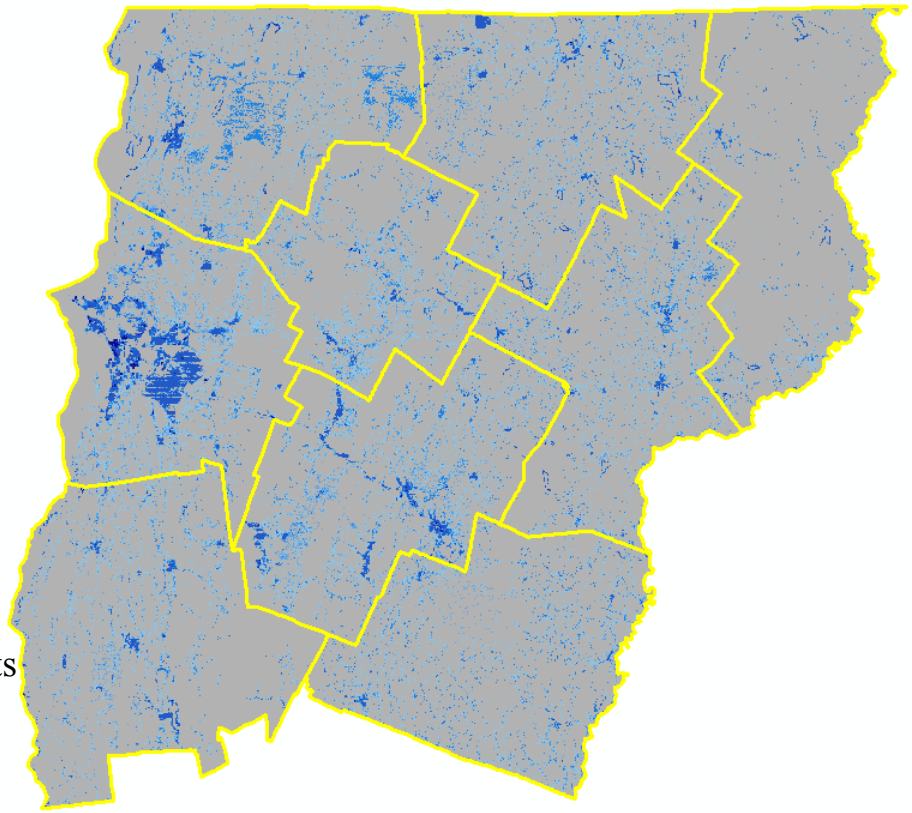
Source: McGarigal and Marks, 1995

Results: Residential Development

Baseline Total Residential Units: 2030



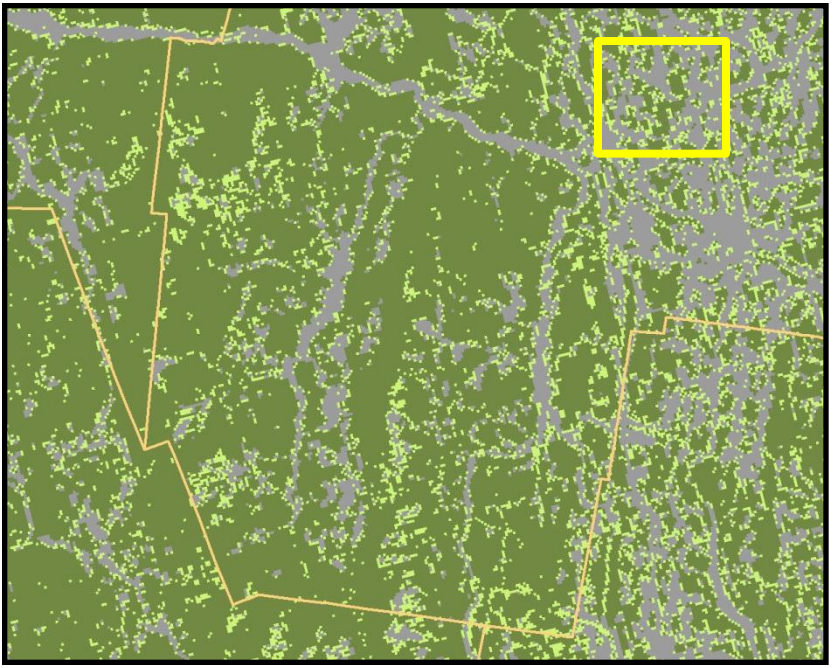
Current Use Total Residential Units: 2030

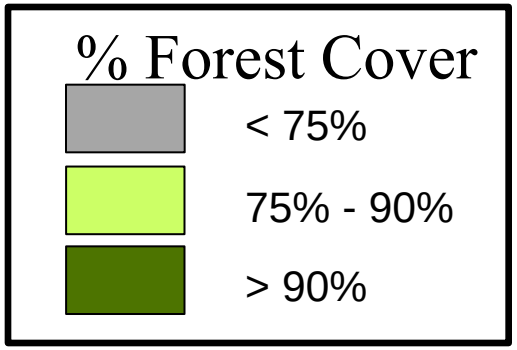


Residential Units

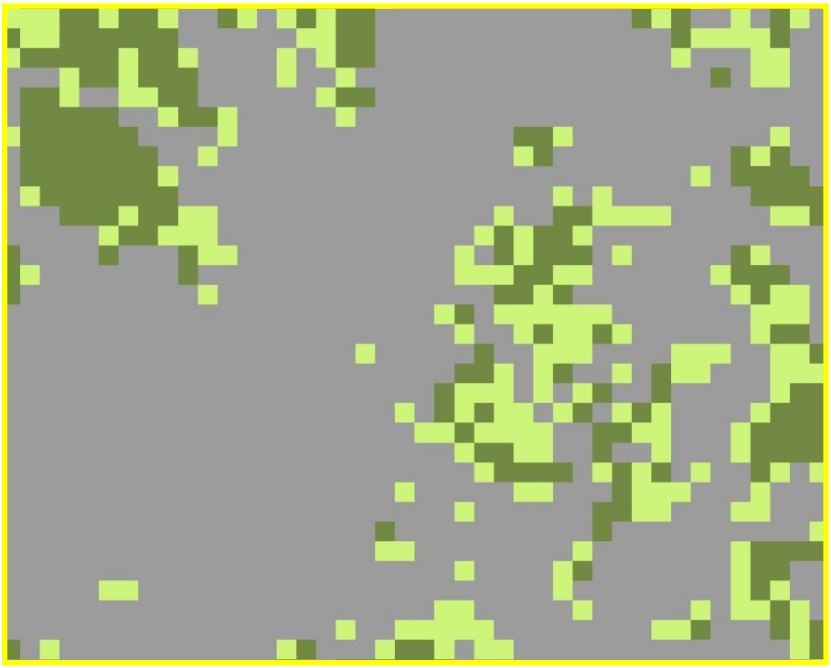
- 0
- 1
- 2 - 3
- 4 - 5
- 6 - 25
- 26 - 50
- 51 - 143

Results: Forest Fragmentation

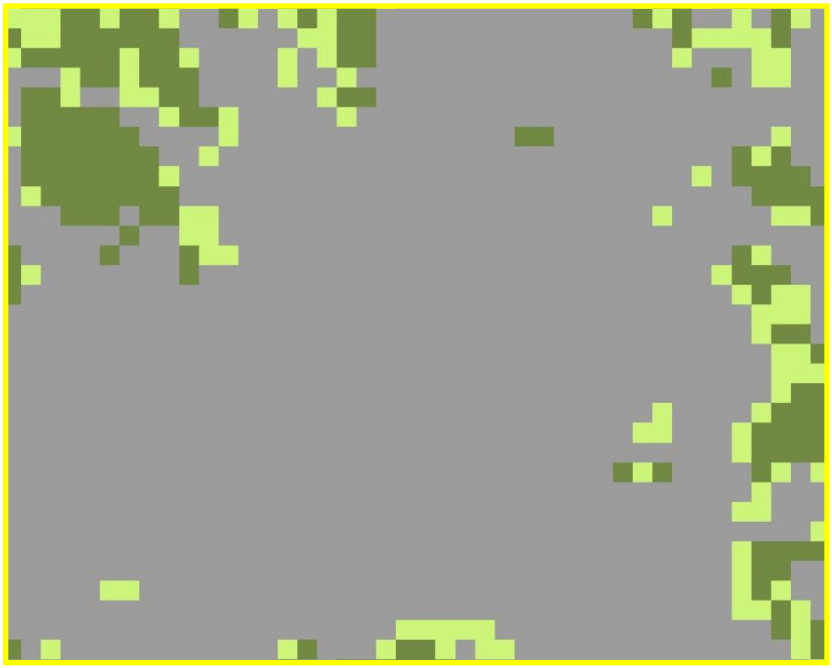




Baseline Scenario - 2025



Baseline+25% Population Scenario - 2025



Forest Fragmentation Metrics: Regular Control Totals for All Scenarios

Metrics for grid cells with 75% < Canopy Cover < 90%

	2005	Baseline Scenario	Alternative Network Scenario	Current Use Scenario
Class Area	512,714	491,614	491,285	495,826
Number of Patches	11,785	12,843	12,822	12,425
Largest Patch Index	3.03	2.92	2.95	2.98
Mean Patch Size	43.51	38.28	38.32	39.91
Total Edge	50,389,050	50,761,500	50,756,700	50,355,000
Edge Density	32.30	32.54	32.54	32.34
Mean Nearest Neighbor	346.91	346.45	347.19	347.21

Metrics for grid cells with Canopy Cover >= 90%

	2005	Baseline Scenario	Alternative Network Scenario	Current Use Scenario
Class Area	297,113	283,887	283,997	286,556
Number of Patches	7,739	7,990	8,047	7,876
Largest Patch Index	5.69	5.46	4.65	5.27
Mean Patch Size	38.39	35.53	35.29	36.38
Total Edge	24,269,100	24,618,900	24,631,350	24,357,300
Edge Density	15.56	15.78	15.79	15.65
Mean Nearest Neighbor	453.97	451.88	449.48	451.90

Forest Fragmentation Metrics: +25% Control Totals for All Scenarios

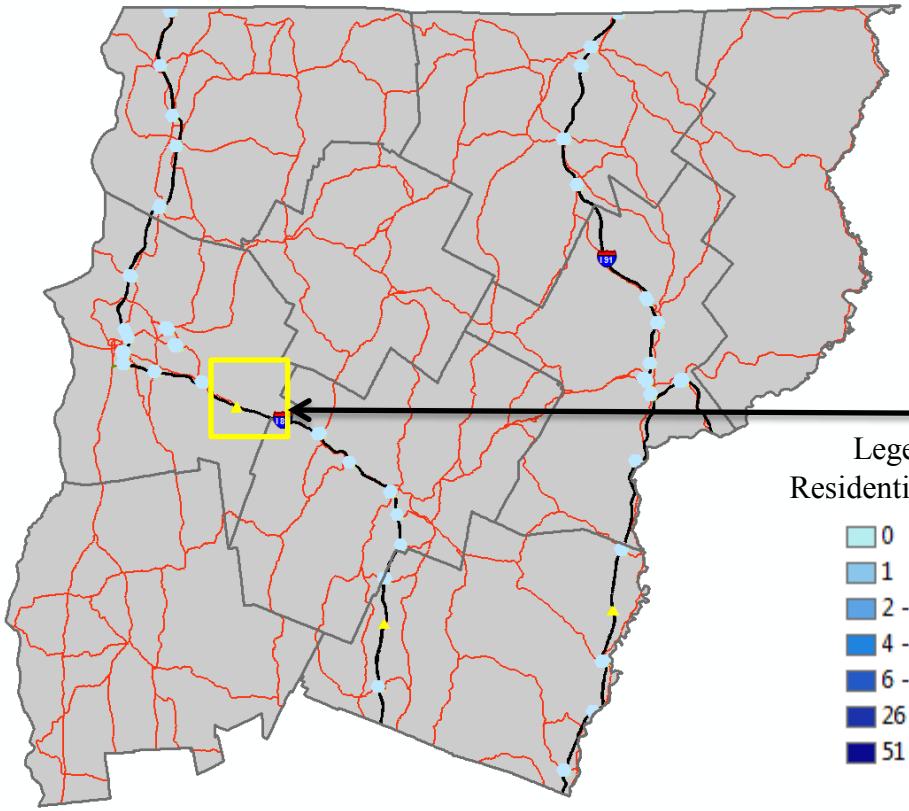
Metrics for grid cells with 75% < Canopy Cover < 90%

	2005	Baseline Scenario	Alternative Network Scenario	Current Use Scenario
Class Area	512,714	491,505	491,384	492,165
Number of Patches	11,785	12,822	12,793	12,759
Largest Patch Index	3.03	2.96	2.95	2.96
Mean Patch Size	43.51	38.33	38.41	38.57
Total Edge	50,389,050	50,735,700	50,821,800	50,671,500
Edge Density	32.30	32.52	32.58	32.48
Mean Nearest Neighbor	346.91	347.38	347.02	346.49

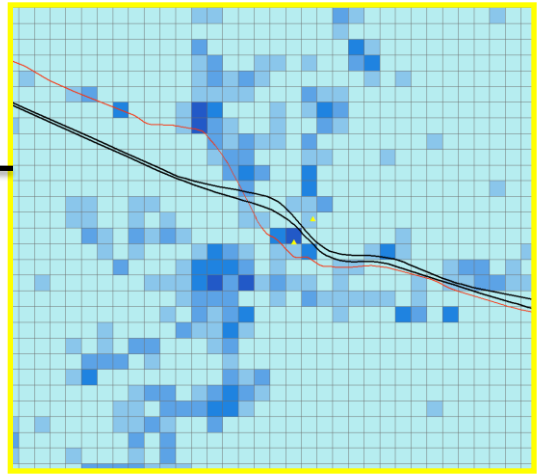
Metrics for grid cells with Canopy Cover >= 90%

	2005	Baseline Scenario	Alternative Network Scenario	Current Use Scenario
Class Area	297,113	283,655	284,155	284,999
Number of Patches	7,739	7,994	7,945	7,930
Largest Patch Index	5.69	5.44	5.08	5.28
Mean Patch Size	38.39	35.48	35.77	35.94
Total Edge	24,269,100	24,655,950	24,645,600	24,523,050
Edge Density	15.56	15.81	15.8	15.72
Mean Nearest Neighbor	453.97	449.8	452.18	452.48

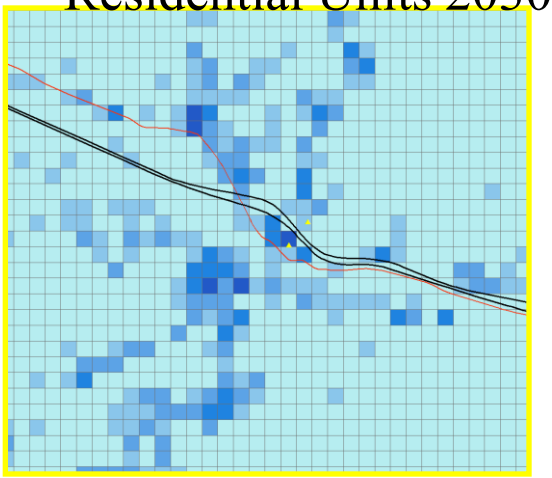
Graphical scenario comparisons



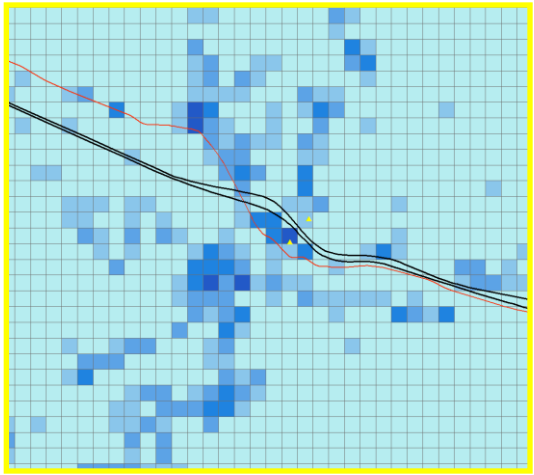
Baseline Residential Units 2030



Network scenario + 25% Population Residential Units 2030



Network Scenario Residential Units 2030



Implications and applications in the Northern Forest region

- Residential development in the Northern Forest region has the potential to fragment Vermont's working landscape, particularly in rural and exurban areas where new residential construction is not contiguous with existing development. Isolated developments, often for vacation homes, result in the greatest fragmentation per housing unit.
- If this Current Use program were made more stringent (through much higher financial penalties for development of properties enrolled in the program) it could influence residential development location choices
  - the Current Use program may be effective for protecting large forest parcels, but not multiple adjacent small parcels with predominant forest cover
  - the model developed here could be used to test alternative formulations of the Current Use program, including changing the minimum parcel size or the approach to implementing the policy as it relates to real estate development and transactions
- Construction of new interchanges on the Interstate system has the potential to make large areas much more accessible, thereby increasing development and fragmentation
  - Many areas currently near the Interstate are far from an exit, and so are effectively shielded from development pressure. New exits could have sweeping impacts on these less accessible areas.
  - The model developed here could be used to identify outcomes from a coupled infrastructure development / policy implementation approach that aims to increase accessibility to rural regions while protecting critical landscapes and ecological functions

Future directions

- Continue developing policy relevant scenarios for studying future land use patterns, such as changes to Act 250, or additional transportation scenarios
- Explore better ways of translating housing units per grid cell to land cover change
- Better understand the determinants of second home development and how they differ from other development
- Explore new fragmentation metrics, including patch isolation and connectivity
- Collaborate with NGOs and local towns to apply the model and integrate results with long range planning objectives (e.g. Town Plan)

List of Products

- Peer-reviewed publications
  - Voigt, B. and A. Troy. *In prep.* Analysis of the drivers of residential development in the Northern Forest Region of Vermont, expected completion August 2012.
- Presentations
  - Troy, A. and B. Voigt. April 2011. Analysis of the drivers of urban growth and second home development in the Northern Forest Region of Vermont, A presentation to the Northeastern States Research Cooperative.
  - Troy, A. and B. Voigt. March 2012. Analysis of the drivers of urban growth and second home development in the Northern Forest Region of Vermont, A presentation to the Forest Guild, https://forestguild.mitel-nhwc.com/join/cjzpxzp
- Honors Thesis
  - Hall, N. Assessing Current and Future Development Pressure on Drinking Water Supplied by Forested Land in Vermont, Honors Thesis, Department of Geography, University of Vermont, expected graduation May 2012.