NELF Explorer

Drivers of Landscape Change

Instructors notes

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# Overview

In this module, we’ll explore the New England Landscape Futures (NELF) project where stakeholders from around New England created four scenarios that represent possible land use and land cover futures of New England. The NELF project uses concepts from Landscape Ecology and Land Systems Science to describe and then model potential future landscapes to show how land use decisions can impact our future landscape. This module introduces both the NELF project, as well as some of the modeling theories and practices used to create projections of future land cover for policy and scientific analysis.

## Objectives

At the end of the lesson, students should:

* Have a background understanding of land use change in New England
* Recognize the difference between land use and land cover
* Be able to identify what a neutral model is
* Understand the benefits and challenges of future scenarios and modeling of land use/land cover

## Length of lesson

Approximately 1.25 hours – though you may find allowing students to complete some at home can lead to more in-depth answers.

## Materials

First, instructors may want to introduce land use and land cover change in New England using much of the front matter from the *Voices from the Land* report (Lambert et al., 2018) to add some context to why scenarios of future land use and land cover matter (*optional,* some is already summarized for the students in the Overview section of their worksheet). Then, students will form groups of 2-3 and complete the attached worksheet. The worksheet includes a bit of background on the NELF project and land use change in New England, followed by directions for exploring the scenario maps, as well as questions to guide their exploration and encourage deeper understanding. Students will need access to computers and the internet to view the NELF explorer tool. Note: you may want to warn the students not to look at the last page until the module tells them to, or optionally remove that page and provide it at the end of the class period.

This module was supported in part by the National Science Foundation under NSF-DEB grant #1713307.

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Drivers of Landscape Change

Student worksheet

# Overview

Land usehas dramatically altered the New England landscape for centuries and continues to drive the patterns and processes we see across the landscape. During the 18th and 19th centuries, New England went from being nearly 90% forested to close to 50% forested in the mid-1800s, with much more dramatic forest losses in southern New England and less in the north. Most of the forest loss was due to the conversion of the land to farms. However, in the mid-1800s, moving food and goods around the country became easier, so most of the farms in New England were abandoned for better soil in the Midwest. Much of the abandoned farmland reverted to forest and, for nearly a century, forest cover expanded in New England. New England’s now extensive forest lands provide regionally and globally important ecosystem services, such clean water, habitat, and carbon sequestration and storage.

However, in the last 50 years we have seen another landscape change: many individual forest parcels being converted to low density residential or other developed land use types, again particularly in southern New England. If rates of forest conversion continue as they have from 1990-2010 through 2050, an additional 1.2 million acres of forest land could be lost to development (Lambert et al., 2018). Most of New England’s forest is owned by small family forest owners, each making their own individual decisions on how to manage their land, including if it might be converted to housing or other development. These decisions are often influenced by many things, including: land value, policy, culture and community ties, family needs, and even climate change driven landscape changes. Therefore, it can be incredibly difficult to predict what the New England landscape might look like in the future, but in order to try to make progressive policies that address issues like climate change and housing demand, we need to understand how different land use decisions may impact our landscape – this is where landscape modeling can be very impactful!

# New England Landscape Futures background

The New England Landscape Futures (NELF) project brought together nearly 200 stakeholders from all six New England states to co-design scenarios of how land use in New England might be different in the year 2060 (Lambert et al., 2018). Through this co-design process, where citizens and scientists sat together to think through possible future scenarios of the landscape, the stakeholders identified what they felt will be the most uncertain and most impactful drivers of land use change for the 50 year period from 2010 to 2050 (McBride et al., 2017). These drivers became the axis upon which four divergent future landscape scenarios were articulated. Through an iterative process, these stakeholders then qualitatively described, in a detailed narrative, how each scenario differed from each other, as well as how each scenario compared to what the landscape would look like if we continued to conserve, develop, and manage as we had in the previous 20 years (i.e., using the 1990-2010 trends in land use).

The major benefit to using this co-design scenario matrix method for modeling future landscapes is that it allows for the inclusion of multiple viewpoints on how **land use** (how we use the land – or the process) might change in response to various stressors (like climate change) and how those changes in land use will result in changes in **land cover** (what is on the land – or the pattern). This type of scenario development is particularly useful in a landscape where hundreds of thousands of landowners will make individual land management decisions that will impact the future land cover of New England. The co-design method also pushes people to think beyond recent trends in land use to try to incorporate new and different land use decisions in these scenarios, since previous land use is often not a good predictor of future land use.

After the land use scenario development, the scenarios were then translated into quantitative inputs to a land cover change modeling process and the resulting land cover maps were used to assess how ecosystem services might be impacted through different future land use choices. Most conventional planning methods tend to focus on the land use choices that have happened in the past and projecting those choices forward (a.k.a., “recent trends”, or sometimes with slight deviations to the recent trends), but this method is usually not a great predictor of what could happen in the future, since peoples’ behavior changes, new technologies appear, and needs change; and these changes can be hard to predict, especially in a rapidly changing environment (McBride et al., 2017).

## Recent Trends

The ‘Recent Trends’ scenario took the rates and characteristics of development, conservation, and agricultural conversion observed from 1990-2010 for individual core-based statistical areas (CBSAs) and projected them through 2060 at 10 year time steps using the land use change program Dinamica EGO (Soares-Filho et al., 2002). CBSAs are U.S. Census Bureau defined areas that combine counties and towns based on population; some of the more rural areas in New England were not assigned CBSAs and were instead combined into their own regions for this analysis (Figure 1, see asterisks). The projection of these recent trends resulted in land cover maps for every 10 years from 2010-2060 where land use decisions mimicked those from 1990-2010. The projection of these recent trends in land use resulted in a 4% increase in development (from 8% to 12% of the total land area), a 4% decrease in total forested area (80% to 76%), and a 1% increase in agricultural area (6% to 7%). Within the forested area, there was a 30% increase in conserved forest (from 24% to 54% of the total forested area).

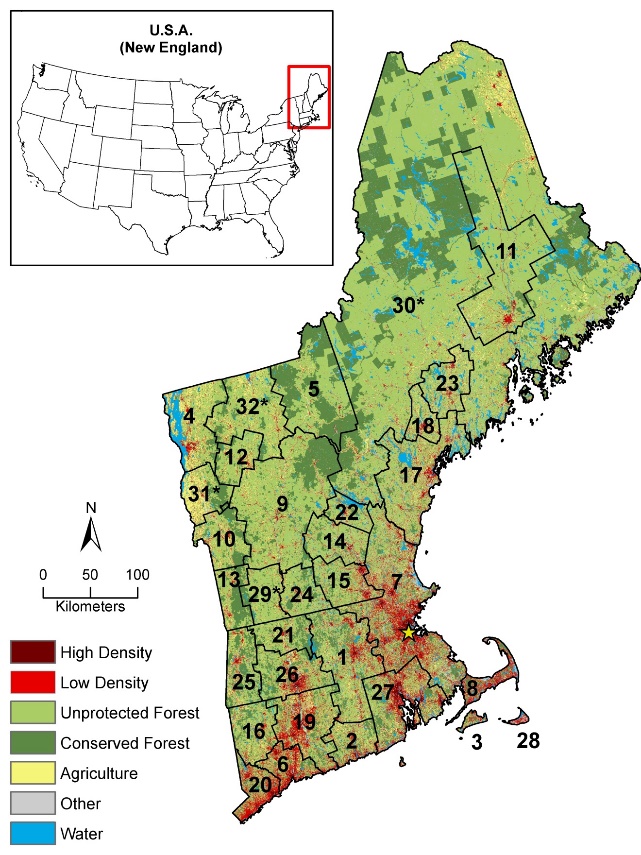


Figure 1. New England CBSAs, where an asterisk indicates a non-CBSA defined region that was created so that all areas were covered by a region. (from Thompson)

## Other Scenarios

Since previous land use is rarely a good predictor of future land use, as there are many drivers at play when people decide how to manage their land, through the co-design scenario matrix method and using the ‘Recent Trends’ scenario as the **neutral model** (the model from which the others can be compared), stakeholders were asked to determine what they felt were going to be the two most uncertain and most impactful drivers of land use change through 2060. The stakeholders defined the two major drivers of change in future land use as:

* Natural resource planning and innovation – or how much we plan and innovate in natural resource use in the future; and
* Socio-economic connectedness – how global or local our economy is in the future.

Using these two drivers of change, four divergent future scenarios were created with narratives describing how population, conservation, economies, infrastructure, and natural resource use might be different in 2060 (Figure 2). The stakeholders were purposefully challenged to think beyond the status quo for land use change (i.e., the recent trends), so that these four scenarios represent the envelope of possible futures as identified by the stakeholders. These four new scenarios: Connected Communities, Go It Alone, Growing Global, and Yankee Cosmopolitan, show how choices along each axis can result in different future landscapes. Once these qualitative narratives were explicitly described by the stakeholders, the narratives were translated into quantitative land transition values and implemented in Dinamica EGO using the same methods as in the Recent Trends scenario. The final 2060 simulated land cover maps for each scenario were checked by both citizen stakeholders and scientists to ensure they matched the scenario narrative.

Figure 2. Axis of drivers of land use change with four possible scenarios.

SOCIO-ECONOMIC CONNECTEDNESS

Natural Resource planning & Innovation

High

LOW

Global

LOCAL

# Scenario 1

# Scenario 2

# Scenario 3

# Scenario 4

Through this module you will try to identify where on the axis each of the simulated scenarios fits!

# Exploring land cover change using NELF

Let’s explore how these narratives got translated into landscape future models through the NELF Explorer tool – a web-based explorer for each of the scenarios, including Recent Trends. We will first explore the ‘Recent Trends’ scenario to see how the trends in land cover change from 1990-2010 projected through 2060 change the landscape.

* Visit [newenglandlandscapes.org](http://newenglandlandscapes.org/) (you can click the links in blue throughout)
  + Click 🡪 Skip to maps
  + Click the ‘Change Scenarios’ drop down and ensure both the left and right screens are on ‘Recent Trends’ (the middle scenario)
  + Use the zoom function and the slider window (the blue circle with three lines in the middle, it moves back and forth) to look at the differences in land cover from 2010 (left window) to 2060 (right window)

**Question 1:** What is the most noticeable change in New England as a whole in the Recent Trends scenario from 2010 (the start of the simulation) to 2060?



* Next, let’s look at specific differences from 2010 to 2060 in specific towns
  + First, look up using the ‘Explore Areas’ dropdown either the town/municipality you are in, or a town you know well
    - Discuss: what do you notice changing in the maps from 2010 to 2060?
    - Note: you can also use the ‘Land Uses Over Time’ graphs below to look at how different categories change through time for the town in the Recent Trends scenario.
  + Next, navigate to these two towns/municipalities (use the links):
    - [Deerfield, NH](https://newenglandlandscapes.org/?map=1&lat=43.1131&lon=-71.1892&zoom=10&leftScenario=rt&rightScenario=rt&leftYear=2010&rightYear=2060&impactsBy=subcounty&subcounty=3301517460&subcountyName=Deerfield)
    - [Rindge, NH](https://newenglandlandscapes.org/?map=1&lat=42.6766&lon=-72.2109&zoom=10&leftScenario=rt&rightScenario=rt&leftYear=2010&rightYear=2060&impactsBy=subcounty&subcounty=3300564580&subcountyName=Rindge)

**Question 2**: In what ways are these two NH towns different by 2060? What do you think is happening differently in each of these New Hampshire towns as far as land use decisions?



## Compare Recent Trends with Connected Communities

Now let’s look at how land use change is different for the four divergent scenarios, starting with Connected Communities.

* Using the ‘Change Scenarios’ dropdown menu, change the right screen to ‘Connected Communities’
* Use the sliding bar under ‘Recent Trends’ and ‘Connected Communities’ so that both scenarios are showing the predicted land cover at 2060 (rather than Starting Condition)
* Next, explore two counties to try to determine how land use choices are different in ‘Connected Communities’ as opposed to ‘Recent Trends’ (use the links)
  + [Worcester County, MA](https://newenglandlandscapes.org/?map=1&lat=42.3766&lon=-71.9031&zoom=8&leftScenario=rt&rightScenario=cc&leftYear=2060&rightYear=2060&impactsBy=county&county=25027&countyName=Worcester+County%2C+MA)
  + [Franklin County, MA](https://newenglandlandscapes.org/?map=1&lat=42.5620&lon=-71.7795&zoom=8&leftScenario=rt&rightScenario=cc&leftYear=2060&rightYear=2060&impactsBy=county&county=25011&countyName=Franklin+County%2C+MA)

**Question 3**: Since Recent Trends is our neutral model, we’ll compare everything to Recent Trends. Fill in the blanks in the table below comparing Connected Communities to Recent Trends.

|  |  |
| --- | --- |
| **Connected Communities** | |
| **Compared to Recent Trends, …** | **Choose the modifier** |
| total development \_\_\_\_\_\_. |  |
| development is \_\_\_\_\_\_ concentrated. |  |
| total forest cover \_\_\_\_\_\_. |  |
| forests are \_\_\_\_\_\_ conserved. |  |
| agricultural land \_\_\_\_\_\_. |  |

## Explore the other scenarios

Using the ‘Change Scenarios’ dropdown menu at the top of the maps, explore each of the other scenarios. Choose a towns or counties that have seen a lot of change in that scenario to explore how each scenario is different from Recent Trends.

**Question 4**: Fill in the blanks in the tables below comparing the other scenarios to Recent Trends.

|  |  |
| --- | --- |
| **Go it Alone** | |
| **Compared to Recent Trends, …** | **Choose the modifier** |
| total development \_\_\_\_\_\_. |  |
| development is \_\_\_\_\_\_ concentrated. |  |
| total forest cover \_\_\_\_\_\_. |  |
| forests are \_\_\_\_\_\_ conserved. |  |
| agricultural land \_\_\_\_\_\_. |  |

|  |  |
| --- | --- |
| **Growing Global** | |
| **Compared to Recent Trends, …** | **Choose the modifier** |
| total development \_\_\_\_\_\_. |  |
| development is \_\_\_\_\_\_ concentrated. |  |
| total forest cover \_\_\_\_\_\_. |  |
| forests are \_\_\_\_\_\_ conserved. |  |
| agricultural land \_\_\_\_\_\_. |  |

|  |  |
| --- | --- |
| **Yankee Cosmopolitan** | |
| **Compared to Recent Trends, …** | **Choose the modifier** |
| total development \_\_\_\_\_\_. |  |
| development is \_\_\_\_\_\_ concentrated. |  |
| total forest cover \_\_\_\_\_\_. |  |
| forests are \_\_\_\_\_\_ conserved. |  |
| agricultural land \_\_\_\_\_\_. |  |

# Summary Questions

**Question 5**: Given your observations about each scenario, which scenario do you think belongs in each quadrant?

SOCIO-ECONOMIC CONNECTEDNESS

Natural Resource planning & Innovation

High

LOW

Global

LOCAL

# Quadrant 1

# Quadrant 2

# Quadrant 3

# Quadrant 4

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenario** | **Quadrant** | **Scenario** | **Quadrant** |
|  |  |  |  |
|  |  |  |  |

**Question 6**: Check your answers for the locations of the scenarios in the quadrants, did you get them all correct? Why or why not? Please comment on why you chose to place each scenario in each quadrant.



**Question 7**: Do you think the scenarios capture the variability along the chosen axes well? Why or why not?



**Question 8**: Do you agree with the stakeholders that socio-economic connectedness and natural resource planning and innovation are the two most uncertain and influential drivers of change in land use? Can you think of anything else that might not be encompassed in these axes?



**Question 9**: Given the envelope these scenarios present for possible future landscapes, how might these scenarios be useful in assessing how our land use choices impact our natural resources and way of life (e.g., drinking water, food or timber production, carbon sequestration, biodiversity, recreation opportunities)?



**Question 10**: What do you think worked well in this module? What do you think could be improved?



# Other resources and citations

Lambert, K. F., M. F. McBride, M. Weiss, J. R. Thompson, K. A. Theoharides, and P. Field. 2018. [Voices from the Land: Listening to New Englanders’ Views of the Future](https://view.publitas.com/p222-2239/voices-from-the-land/page/1). Harvard Forest, Harvard University and the Science Policy Exchange. 24 pp.

McBride, M. F., K. F. Lambert, E. S. Huff, K. A. Theoharides, P. Field, and J. R. Thompson. 2017. Increasing the effectiveness of participatory scenario development through codesign. Ecology and Society 22(3):16. https://doi.org/10.5751/ES-09386-220316.

Soares-Filho, B. S., G. Coutinho Cerqueira, and C. Lopes Pennachin. 2002. DINAMICA - A stochastic cellular automata model designed to simulate the landscape dynamics in an Amazonian colonization frontier. Ecological Modelling 154:217–235.

Thompson, J. R., J. Plisinski, K. F. Lambert, M. J. Duveneck, L. Morreale, M. McBride, M. G. MacLean, M. Weiss, and L. Lee. *In review*. Spatial simulation of co-designed land-cover change scenarios in New England: Alternative futures and their consequences for conservation priorities. Earth’s Future.

[NELF Explorer Help](https://help.newenglandlandscapes.org/)

**Answer to Question 5**:



Figure 3. The Scenario Matrix (Lambert et al., 2018)