



Harvard Forest LTER

Schoolyard Ecology Program

Scientist-Created Documents that integrate Harvard Forest Schoolyard Ecology themes into the curriculum

- Lesson Title: Drivers of Landscape Change
- Author: Amanda Suzzi, University of Massachusetts—Amherst
- Level: High School
- Date: September 2021

NEW ENGLAND LANDSCAPE FUTURES (NELF) EXPLORER

Drivers of Landscape Change

Lessons for Grades 9-12

Instructors' notes

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Adapted from Meghan Graham MacLean's Teaching materials for NRC 597LE: Landscape Ecology & Conservation, (2020). NELF Explorer: Drivers of Landscape Change. QUBES Educational Resources. doi:10.25334/SAXJ-XC69

Overview

In this module, students will explore the New England Landscape Futures (NELF) scenarios-based interactive land-use mapping tool created with the input of more than 100 New Englanders. This tool visualizes four scenarios that represent possible future land use and land cover 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 the NELF project and connects it to Mass. teaching standards.

Objectives

At the end of the lesson, students should be able to:

- Have a background understanding of human land-use change in New England
- Recognize the difference between land use and land cover
- Understand the benefits and challenges of future scenarios and modeling of land use/land cover
- Examine citizens' role in making informed land use decisions in a way that balances need for sustainable ecosystem services and other societal needs

Length of lesson

Approximately 45 minutes – though you may find allowing students to complete some at home can lead to more in-depth answers.

Instructions

First, instructors may want to introduce land use and land cover change in New England using the **included presentation (pgs 4- 12)** 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). During the presentation, students will take guided notes. 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.**

Slideshow Speaker Notes

1. (*Give students Guided Notes Worksheet*) Title Slide: The New England Landscape Futures Project tries to better understand possible trends and how they will affect changes to the landscape in New England.
2. The New England Landscape: The New England region encompasses 44 million acres covering six states in the northeastern United States. Historically, the region experienced an expansion of farming and agriculture in the colonial era, followed by nearly 200 years of forest regrowth. Now, however, the New England states are rapidly losing forest cover due to low-density residential development.
3. Experiencing Change: The incremental loss of open space is almost imperceptible daily, yet land use is altering forests and other natural lands in the northeastern United States faster than the effects of climate change. Think about these questions: What does the current landscape look like compared to the past? How can we see this change? What if recent trends continue? What will the landscape look like in the year 2060? What would the land look like if different futures came to pass? The goal of the New England Landscape Futures Project is to address those questions.
4. The New England Landscape Futures (NELF) project brought together nearly 200 stakeholders from all six New England states to design scenarios of how land use in New England might be different in the year 2060. Steps employed in the NELF stakeholder scenario development protocol were:
 - a. open-ended visioning about the future of the region,
 - b. identification of driving forces using a “STEEP” framework (i.e., Social, Technological, Economic, Ecological, and Political trends),
 - c. ranking and selection of two drivers with high perceived uncertainty and impact that are also viewed as divergent and independent,
 - d. definition of the opposite poles of the two drivers and creation of the scenario matrix by crossing the resulting axes,
 - e. inhabiting and fleshing out of the scenario narratives to integrate remaining drivers,
 - f. listening to a presentation on recent trends, and
 - g. translating the scenario storylines into initial quantitative land use change estimates.
 - h. After the workshops, the research team convened two interactive webinars to iterate with stakeholders and agree on the final quantification of the amount, intensity, and location of LULC change in each of the scenarios to produce model inputs.
5. Future Scenarios: Scientists and stakeholders in New England built four scenarios that represent alternatives to recent trends, dubbed Connected Communities, Yankee Cosmopolitan, Growing Global, and Go it Alone. Each of these scenarios is based on two intersecting concepts: socio-economic connectedness and natural resource planning and innovation.
 - a. Socio-economic connectedness refers to the extent to which population migration, culture, economic markets, goods and services, and trade and climate policy are globally or locally oriented.
 - b. Natural resource planning and innovation refers to the extent to which governments engage in proactive land use planning and invest in technological advances for land, energy, and water use.

6. These scenarios are:
 - a. Connected Communities - This is the story of how a shift toward living “local” and valuing regional self-sufficiency and local resource use increases the urgency to protect local resources.
 - b. Yankee Cosmopolitan - This is the story of how we embrace change through experimentation and upfront investments. While environmental changes break records and urbanization continues to pressure natural systems, society responds with greater flexibility, ingenuity, and integration.
 - c. Growing Global - This is the story of an influx of climate change migrants seeking refuge in New England and taking the region by surprise. Regional to national policies have promoted global trade but global agreements to address climate change have failed.
 - d. Go It Alone - This is the story of a region challenged by shrinking economic opportunities paired with increasing costs to meet basic needs. With local self-reliance and survival as the primary objectives, natural resource protections are rolled-back, and communities turn heavily to extractive industries.
7. The NELF Explorer helps us understand long-term consequences of land-use decisions we make today, via maps, graphs, and scenario narratives. This tool can be used by land-users and landowners, including conservationists, planners, developers, government leaders, and citizens who want to explore possible futures of our land.
8. (*Have students go to <https://newenglandlandscapes.org/>*) So, let’s take a look. When you first visit New England Landscapes dot org, you see this page. Where you can click three buttons:
 - a. Start the activity - launches a complete a “choose your own adventure” style activity that will take you to a specific scenario based on a few quick selections of what type of feature you would like to explore.
 - b. Tell me a story – brings you to a story map that walks you through the details of the new england landscape futures project including each of the scenarios. This is a great place to start if you want more information on the scenarios.
 - c. Skip to maps – which is where we’ll go. (Have students click around).
9. (*Give students compare and contrast Worksheet*) Let’s walk through a sample application of the NELF Explorer, contrasting the **Go It Alone** and **Growing Global** scenarios in the Merrimack River Watershed in 2060.
 - a. First, click **Skip to maps**. It starts with recent trends which is just a continuation of current trends where approx. 4% of our forests are lost to development by 2060.
 - b. Then, choose the scenarios on the top toolbar:
 - i. Select **Go It Alone** for the left scenario
 - ii. Select **Growing Global** for the right scenario
 - c. Explore areas on the top toolbar and click Watershed. Click on the Merrimack River Watershed (runs through Lowell, MA and Manchester, NH).
 - d. Now, you can compare the scenarios in that location. Use the slider to compare both scenarios for the year 2060.
 - e. Finally, answer the questions on your worksheet.

Introducing a new land-use planning tool:
New England Landscape Futures (NELF) Explorer

The New England Landscape

The New England region encompasses 44 million acres covering six states in the northeastern United States.

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Historically, the region experienced an expansion of farming and agriculture in the colonial era, followed by nearly 200 years of forest regrowth.

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Now, however, the New England states are rapidly losing forest cover due to low-density residential development.



Experiencing Change

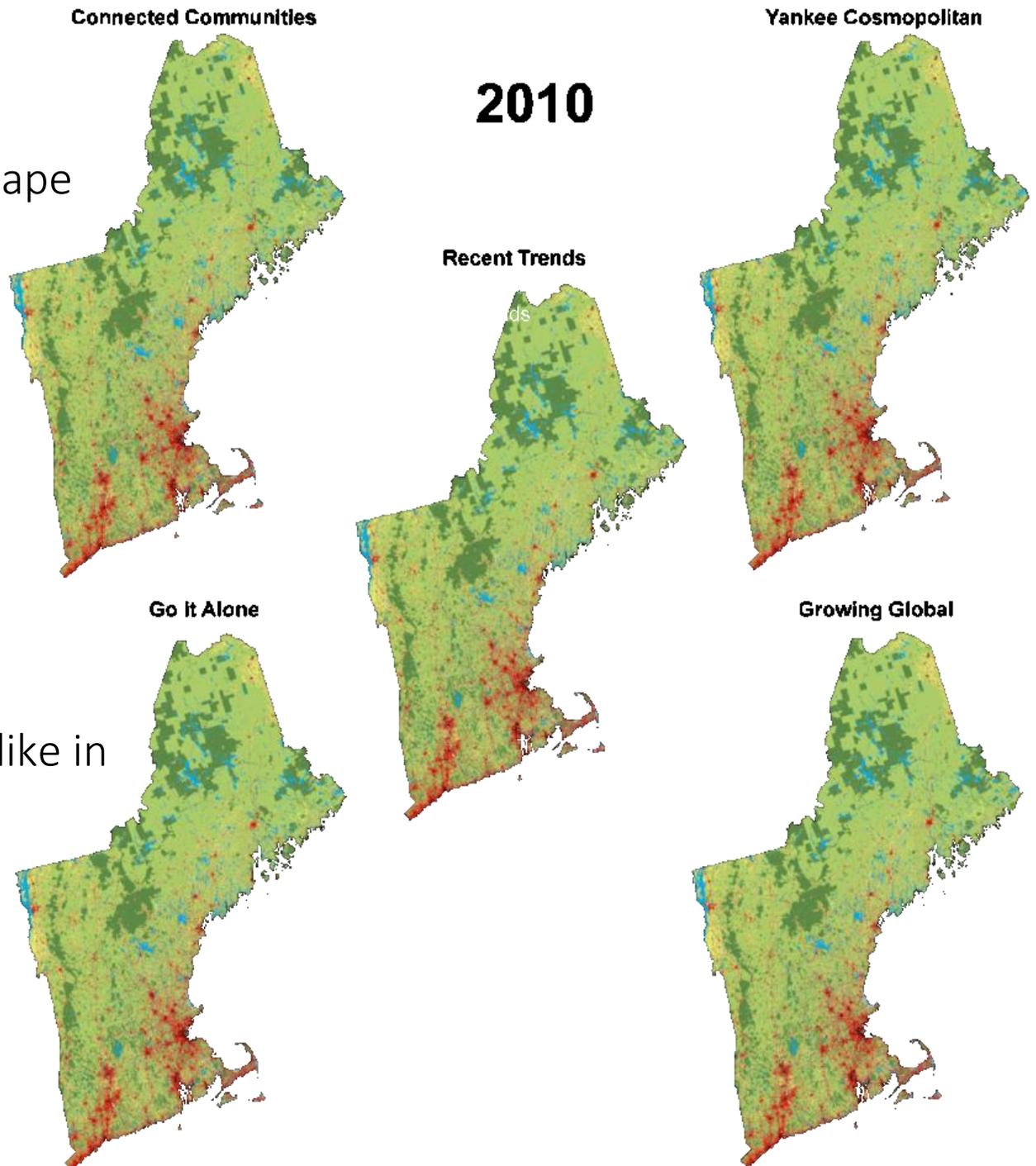
What does the current landscape look like compared to the past?

How can we see this change?

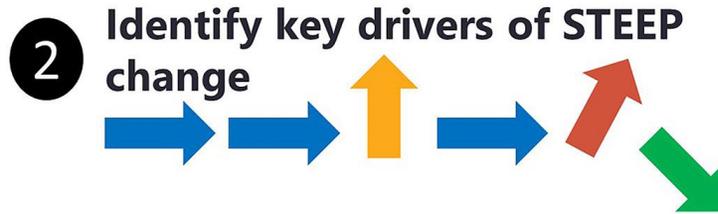
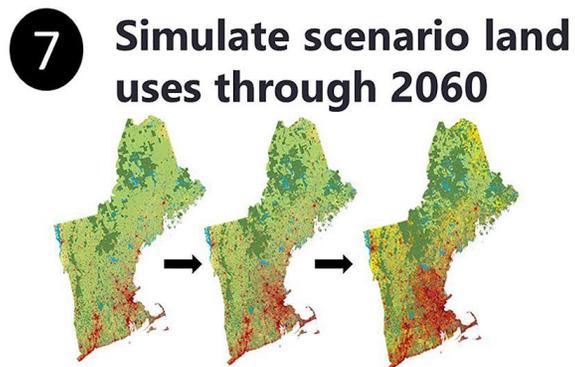
What if recent trends continue?

What will the landscape look like in the year 2060?

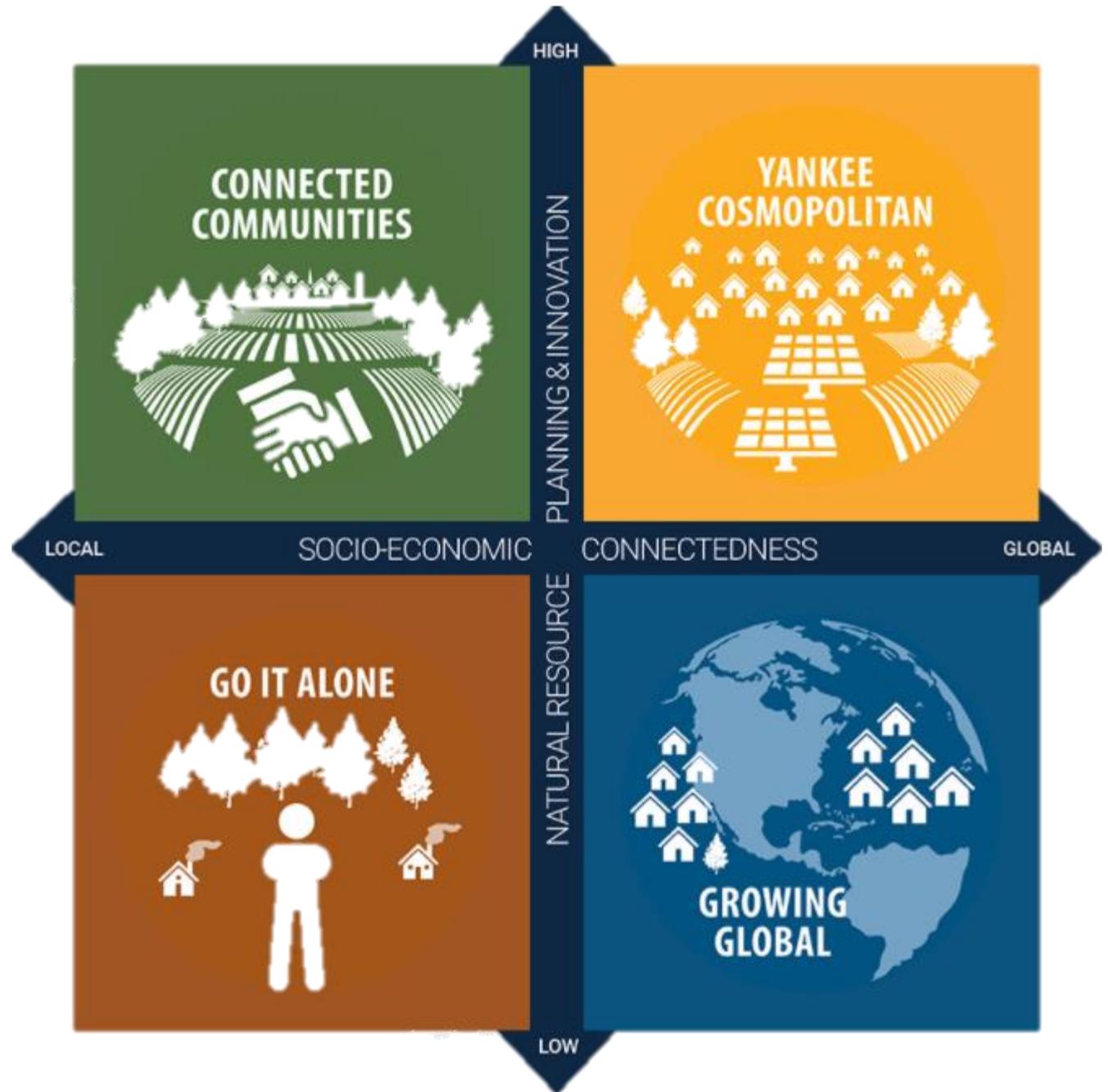
What would the land look like if different futures came to pass?



The Scenarios-Building and Mapping Process



Future Scenarios





Connected Communities - This is the story of how a shift toward living “local” and valuing regional self-sufficiency and local resource use increases the urgency to protect local resources.



Yankee Cosmopolitan - This is the story of how we embrace change through experimentation and upfront investments. While environmental changes break records and urbanization continues to pressure natural systems, society responds with greater flexibility, ingenuity, and integration.



Growing Global - This is the story of an influx of climate change migrants seeking refuge in New England and taking the region by surprise. Regional to national policies have promoted global trade but global agreements to address climate change have failed.

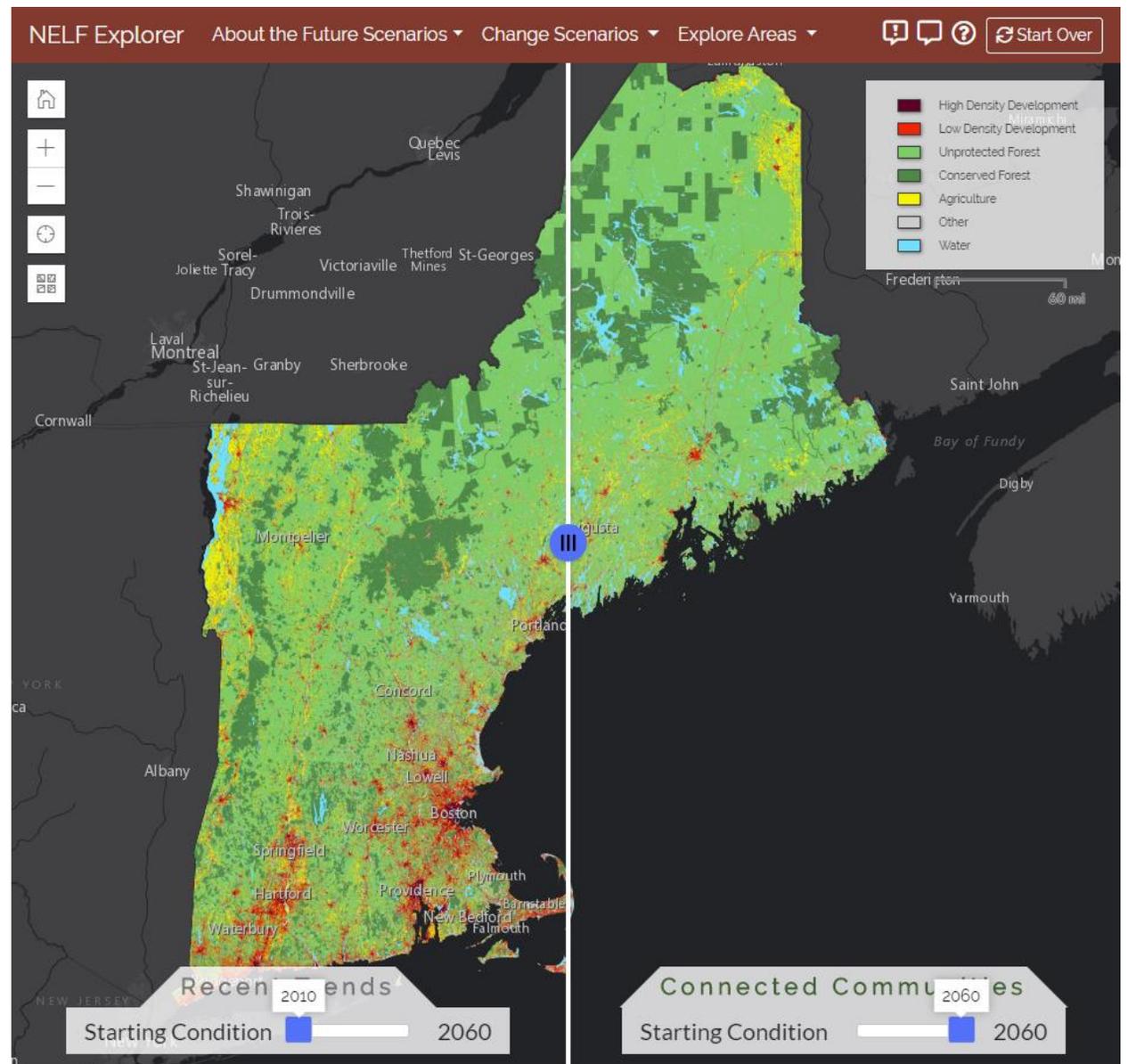


Go It Alone - This is the story of a region challenged by shrinking economic opportunities paired with increasing costs to meet basic needs. With local self-reliance and survival as the primary objectives, natural resource protections are rolled-back and communities turn heavily to extractive industries.

The NELF Explorer

The NELF Explorer helps us understand long-term consequences of land-use decisions we make today, via maps, graphs, and scenario narratives.

This tool can be used by land-users and landowners, including conservationists, planners, developers, government leaders, and citizens who want to explore possible futures of our land.



New England Landscape Futures Explorer

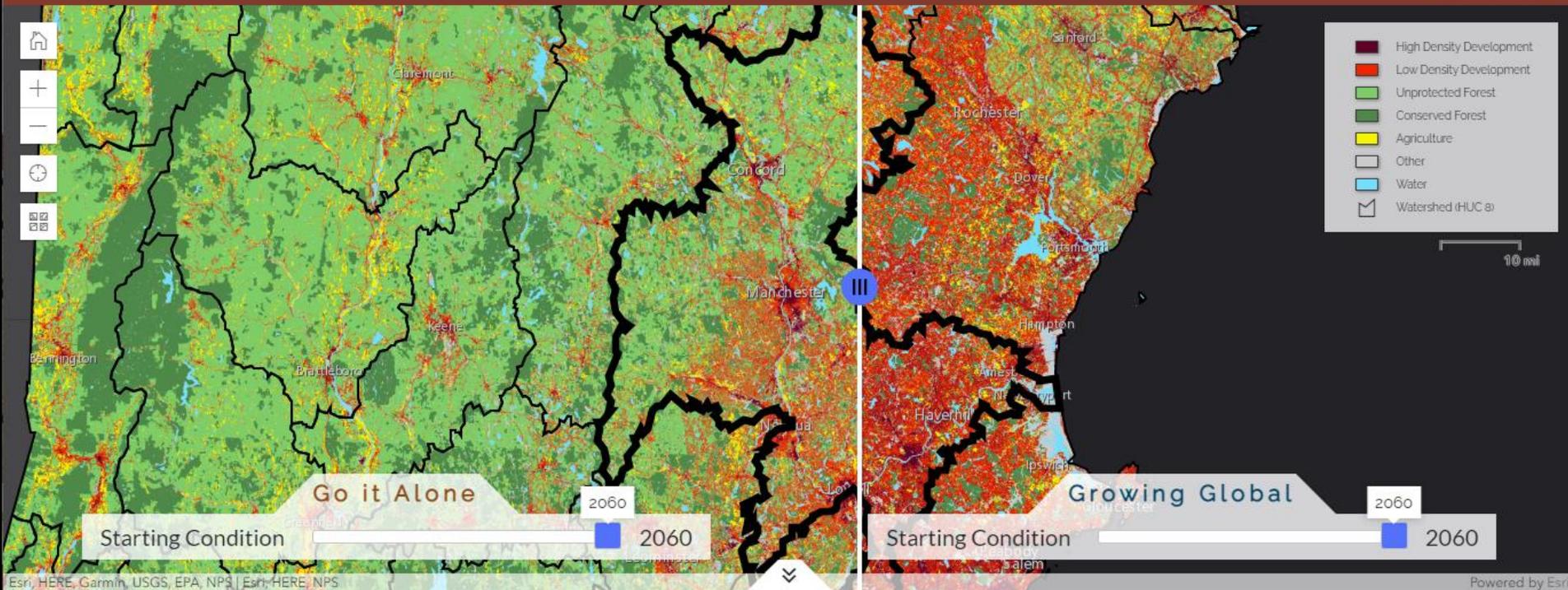
Hi, I'm the NELF Explorer. I'm here because wondering about the future can help us make decisions about our communities, land, forests, farms, and water resources. What will the future of your community look like? How would you change it if you could? I will help you explore different possible outcomes based on global trends and local decisions.

Start the activity

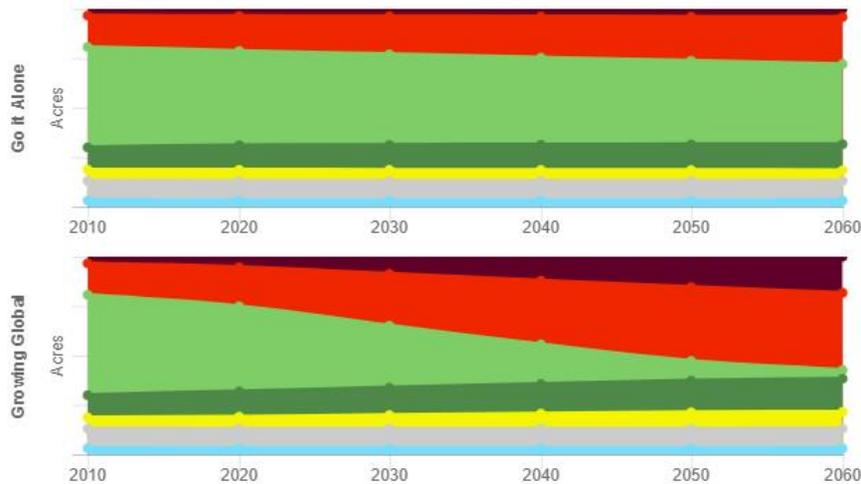
Tell me a story

Skip to maps

The New England Landscape Futures Explorer is brought to you by Harvard Forest and the 100+ citizens who helped define this project. Funding for this project comes from the National Science Foundation and from Highstead. See full acknowledgements [here](#).



Land uses over time for Merrimack River



Impacts on within Merrimack River

Conserved forest land increases

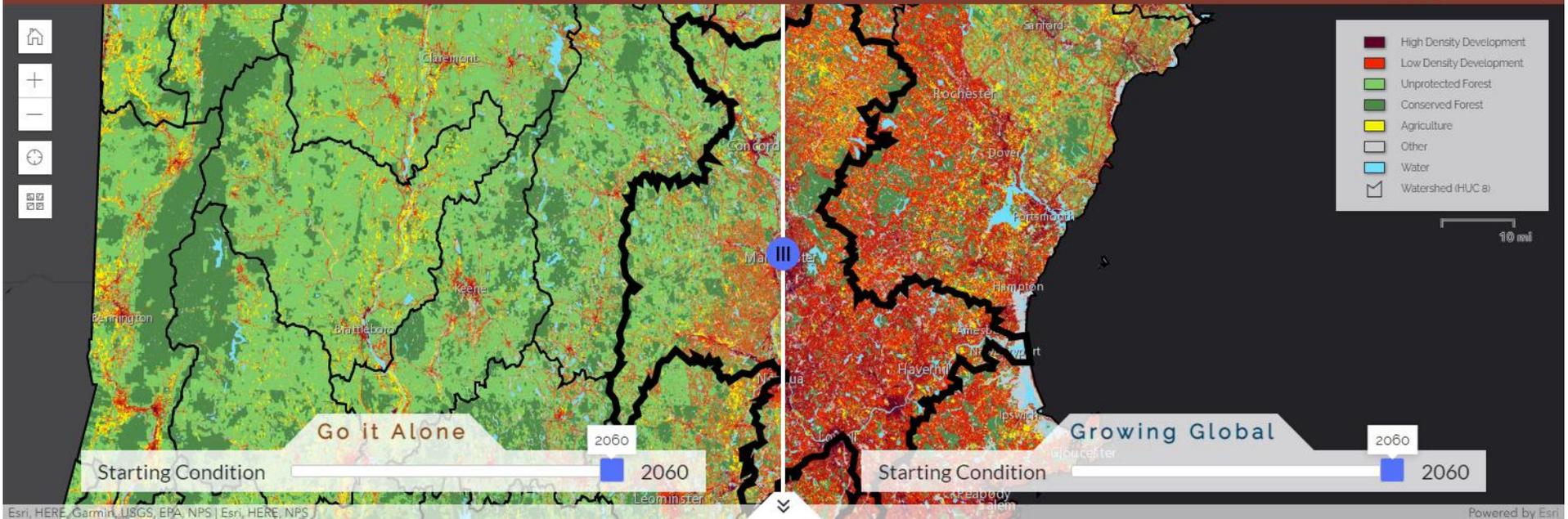
Go it Alone: 23,504 acres | Growing Global: 65,101 acres
 By 2060 in Merrimack River, conserved forest land in subwatersheds important for surface drinking water **increases** in the Growing Global scenario compared to the Go it Alone scenario.

Developed land increases

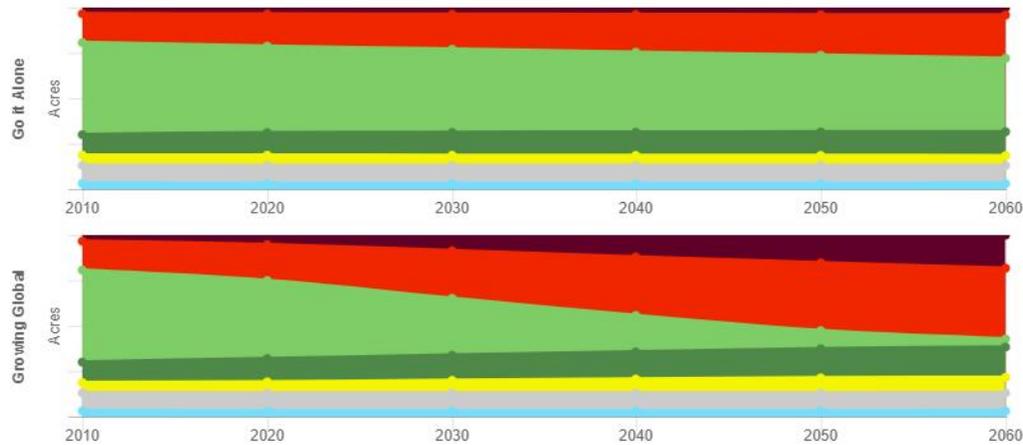
Go it Alone: 95,849 acres | Growing Global: 413,894 acres
 By 2060 in Merrimack River, developed land in subwatersheds important for surface drinking water **increases** in the Growing Global scenario compared to the Go it Alone scenario.

About Surface Drinking Water:

Watersheds important for surface drinking water are defined as the top 25% most important watersheds as classified by the U.S. Forest Service in its Forest to Faucet report. To meet this criteria, watersheds must have populations which rely on surface water and forests which act as natural infrastructure to clean surface water without requiring the use of filtration facilities.



Land uses over time for Merrimack River



Impacts on within Merrimack River

Conserved forest land increases

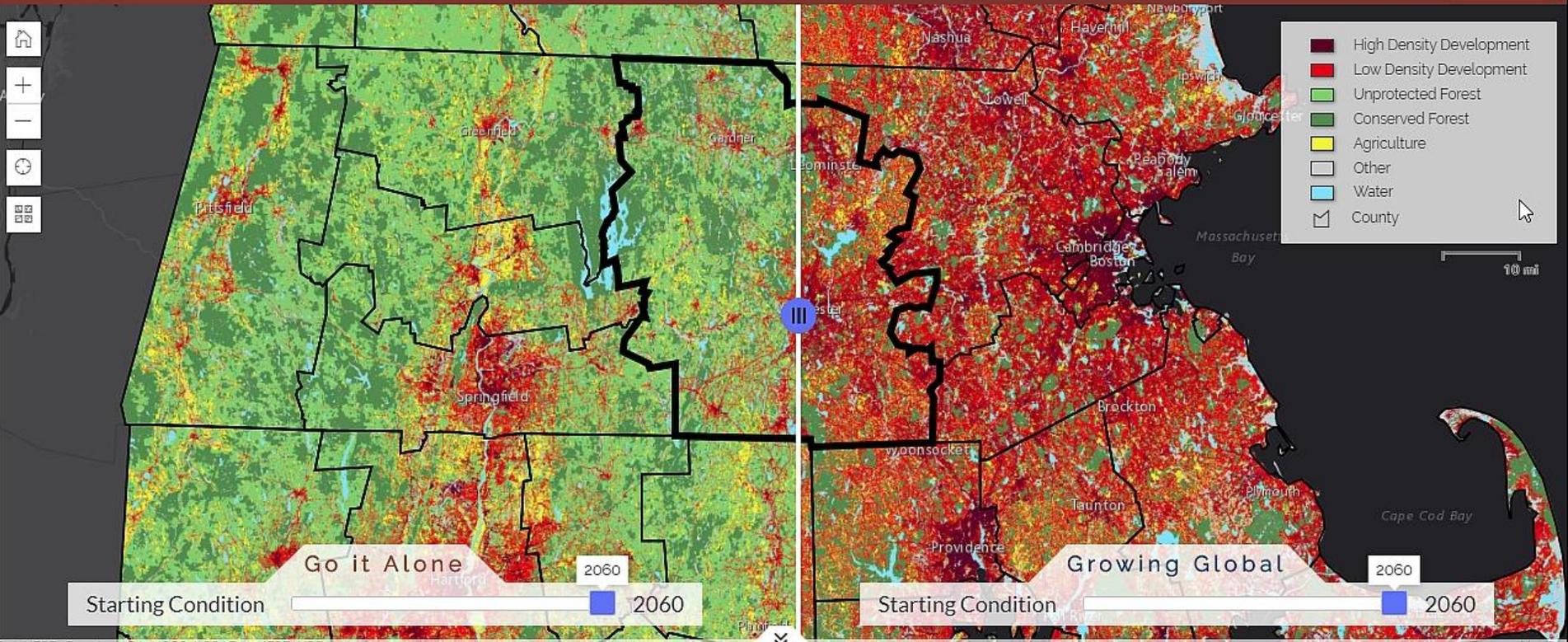
Go it Alone: 23,504 acres | Growing Global: 65,101 acres
 By 2060 in Merrimack River, conserved forest land in subwatersheds important for surface drinking water **increases** in the Growing Global scenario compared to the Go it Alone scenario.

Developed land increases

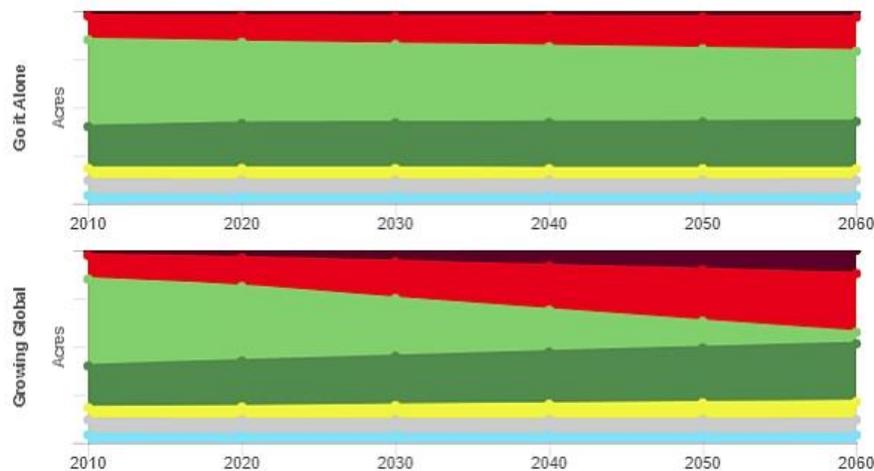
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Land uses over time for Worcester County, MA



Impacts on within Worcester County, MA

Conserved forest land increases

Go it Alone: 1,462 acres | Growing Global: 7,179 acres
 Conserved forest land in current wetlands within Worcester County, MA **increases** by 2060 in the Growing Global scenario compared to the Go it Alone scenario.

Developed land increases

Go it Alone: 522 acres | Growing Global: 11,608 acres
 Developed land in current wetlands within Worcester County, MA **increases** by 2060 in the Growing Global scenario compared to the Go it Alone scenario.

About Wetlands:

Wetlands are defined as all areas in the U.S. Fish & Wildlife Service's National Wetlands Inventory. These include forested swamps, freshwater herbaceous marshes, and saltwater marshes.

NELF Explorer

Drivers of Landscape Change

Student Guided Notes

The New England Landscape Futures Project seeks to understand _____
and _____ of landscape change in New England.

The New England Landscape: The New England region encompasses _____
_____ covering six states in the northeastern United States. Historically, the region
experienced an expansion of farming and agriculture in the colonial era, followed by
_____ years of forest regrowth. Now, however, the New England states are rapidly
losing forest cover due to _____.

Experiencing Change: The incremental loss of _____ is almost imperceptible
daily, yet _____ is altering forests and other natural lands in the
northeastern United States faster than the effects of _____.

Steps employed in the NELF stakeholder scenario development protocol:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

8. _____

Future Scenarios: Scientists and stakeholders in New England built four scenarios that represent alternatives to recent trends. Each of these scenarios is based on two intersecting concepts: _____

_____ and _____

_____.

Future Scenarios: The 4 scenarios that show how land-use choices and climate change could shape the landscape over the next 50 years:

1. _____

2. _____

3. _____

4. _____

The NELF Explorer helps us understand long-term consequences of land-use decisions we make today, via _____, _____, and

_____.

This tool can be used by land-

users and landowners, including _____, _____,

_____ and _____ who want to explore possible futures of our land.

NELF Explorer

Drivers of Landscape Change

Student Compare and Contrast

Using the NELF Explorer, compare the Go It Alone and Growing Global scenarios. Look at how conserved forests and developed land are manifested in various "impact areas," such as floodways and watersheds, wildlife habitat, farmlands, and the like. The resulting text indicates how your selected scenario will compare to the recent trends forecast for 2060.

What do you notice about the maps?

How do the maps relate to the graphs showing land use over time?

Based on the maps and graphs, can you think of how your life might be different in the Growing Global scenario compared to the Go It Alone scenario?

NELF Explorer

Drivers of Landscape Change

Student worksheet

Overview

Land use has seriously altered the New England landscape for centuries. During the 18th and 19th centuries, New England went from being 90% forested to 50% forested. More dramatic forest losses happened in southern New England. Most of the forest loss was due to agriculture. However, in the mid-1800s, New Englanders abandoned most of their farms 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**, the benefits provided by ecosystems that contribute to making human life both possible and worth living, such as clean water, habitat, and carbon storage.

However, in the last 50 years we have seen another landscape change: many individual forest parcels being converted to low density residential, aka suburban sprawl, or other developed land use types, especially 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 forests are 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. In order to try to make 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 scientists, business owners, government officials, landowners, and non-profit representatives, from all six New England states to design scenarios of how land use in New England might be different in the year 2060 (Lambert et al., 2018). Scenario planning is a rigorous way of asking "what if?" and it can be a powerful tool for natural resource professionals preparing for the future of socioecological systems.

After the land use scenario development, the scenarios were then translated into 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

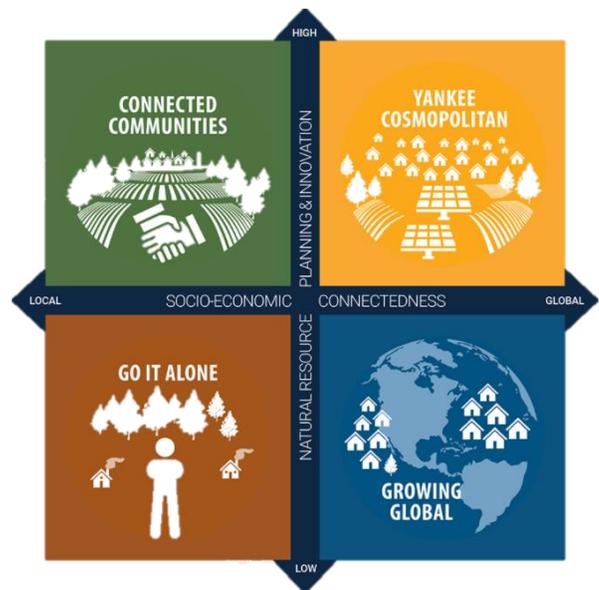
This is a future of continuing along the current path where forest cover is declining in all New England states. Based on recent trends, New England will lose 1.2 million acres of forest by 2060, reducing forest cover by 4% from about 75% of the total land area today to 71% by 2060. Recent trends of land use indicate a future New England landscape with less forest overall and increasing fragmentation of our remaining forests with sprawling development.

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, 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 future scenarios were created with narratives describing how population, conservation, economies, infrastructure, and natural resource use might be different in 2060. 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.



Connected Communities is a future where a shift towards living 'local' and valuing regional self-sufficiency increases public interest in protecting local resources. **Yankee Cosmopolitan** is a future where we embrace change through experimentation and proactive investments. While environmental changes break records and urbanization continues to pressure natural systems, society responds with greater flexibility and ingenuity. **Go It Alone** is a future where the region is challenged by shrinking economic opportunities paired with increasing costs to meet basic needs, yet innovation is stagnant and new technologies are not rising to increase efficiency or create new opportunities. With local self-reliance and survival as the primary objectives, natural resource protections are rolled-back and communities turn heavily to extractive industries. **Growing Global** is a future where a large influx of climate change migrants seek refuge in New England and existing residents move inland, taking the region by surprise. New pressures on municipal services drive a trend toward privatization. Regional to national policies have promoted global trade but global agreements to address climate change have failed.

Exploring land cover change using NELF

Let's explore how these narratives got translated into landscape future models through the NELF Explorer tool. 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.

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?

Follow the steps to answer the question:

- Visit 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 2: Next, let's look at specific differences from 2010 to 2060 in specific towns. 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?

Follow the steps to answer the question:

- 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](#)
 - [Rindge, NH](#)

Question 3: Now let's look at how land use change is different for the four scenarios. Since Recent Trends is most like today, we'll compare everything to Recent Trends. Fill in the blanks in the table on the next page comparing each scenario to Recent Trends.

Follow the steps to answer the question:

- Use the 'Change Scenarios' dropdown to change the right screen to a different scenario.
- Make sure both scenarios are showing the predicted land cover in 2060.
- Next, explore two counties to try to determine how land use choices are different in the new scenario as opposed to 'Recent Trends' (use the links)
 - [Worcester County, MA](#)
 - [Franklin County, MA](#)

CONNECTED COMMUNITIES

Compared to Recent Trends, ...	Choose the modifier
total development _____.	<input type="radio"/> <i>increases</i> <input type="radio"/> <i>decreases</i> <input type="radio"/> <i>remains the same</i>
development is _____ concentrated.	<input type="radio"/> <i>more</i> <input type="radio"/> <i>less</i> <input type="radio"/> <i>similarly</i>
total forest cover _____.	<input type="radio"/> <i>increases</i> <input type="radio"/> <i>decreases</i> <input type="radio"/> <i>remains the same</i>
forests are _____ conserved.	<input type="radio"/> <i>more</i> <input type="radio"/> <i>less</i> <input type="radio"/> <i>similarly</i>
agricultural land _____.	<input type="radio"/> <i>increases</i> <input type="radio"/> <i>decreases</i> <input type="radio"/> <i>remains the same</i>

GO IT ALONE

Compared to Recent Trends, ...	Choose the modifier
total development _____.	<input type="radio"/> <i>increases</i> <input type="radio"/> <i>decreases</i> <input type="radio"/> <i>remains the same</i>
development is _____ concentrated.	<input type="radio"/> <i>more</i> <input type="radio"/> <i>less</i> <input type="radio"/> <i>similarly</i>
total forest cover _____.	<input type="radio"/> <i>increases</i> <input type="radio"/> <i>decreases</i> <input type="radio"/> <i>remains the same</i>
forests are _____ conserved.	<input type="radio"/> <i>more</i> <input type="radio"/> <i>less</i> <input type="radio"/> <i>similarly</i>
agricultural land _____.	<input type="radio"/> <i>increases</i> <input type="radio"/> <i>decreases</i> <input type="radio"/> <i>remains the same</i>

GROWING GLOBAL

Compared to Recent Trends, ...	Choose the modifier
total development _____.	<input type="radio"/> <i>increases</i> <input type="radio"/> <i>decreases</i> <input type="radio"/> <i>remains the same</i>
development is _____ concentrated.	<input type="radio"/> <i>more</i> <input type="radio"/> <i>less</i> <input type="radio"/> <i>similarly</i>
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agricultural land _____.	<input type="radio"/> <i>increases</i> <input type="radio"/> <i>decreases</i> <input type="radio"/> <i>remains the same</i>

YANKEE COSMOPOLITAN

Compared to Recent Trends, ...	Choose the modifier
total development _____.	<input type="radio"/> <i>increases</i> <input type="radio"/> <i>decreases</i> <input type="radio"/> <i>remains the same</i>
development is _____ concentrated.	<input type="radio"/> <i>more</i> <input type="radio"/> <i>less</i> <input type="radio"/> <i>similarly</i>
total forest cover _____.	<input type="radio"/> <i>increases</i> <input type="radio"/> <i>decreases</i> <input type="radio"/> <i>remains the same</i>
forests are _____ conserved.	<input type="radio"/> <i>more</i> <input type="radio"/> <i>less</i> <input type="radio"/> <i>similarly</i>
agricultural land _____.	<input type="radio"/> <i>increases</i> <input type="radio"/> <i>decreases</i> <input type="radio"/> <i>remains the same</i>

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](#). 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>.
- MacLean, M. G. (2020). NELF Explorer: Drivers of Landscape Change. QUBES Educational Resources. doi:10.25334/SAXJ-XC69
- "NELF Explorer Tool Summary." YouTube, uploaded by RISCC Management, narrated by M.G.MacLean, 12 Jan 2021, <https://www.youtube.com/watch?v=5YWdJmQMUI>.
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- Thompson, J. R., Plisinski, J. S., Lambert, K. F., Duveneck, M. J., Morreale, L., McBride, M., Graham MacLean, M., Weiss, M. Lee L. (2020). Spatial Simulation of Codesigned Land Cover Change Scenarios in New England: Alternative Futures and Their Consequences for Conservation Priorities. *Earth's Future*, 8, e2019EF001348. <https://doi.org/10.1029/2019EF001348>
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Additional Videos

<https://www.youtube.com/channel/UC6l07r3KyjPE9og5Xgkp7Ww>

MA State Education Framework Standards

HSS.WHIII.T6.05 Evaluate the impact of international efforts to address global issues: environmental efforts to slow climate change, preserve wildlife habitat, and increase agricultural production

HS.ESS.3.1 Construct an explanation based on evidence for how the availability of key natural resources and changes due to variations in climate have influenced human activity.

HS.ESS.3.3 Illustrate relationships among management of natural resources, the sustainability of human populations, and biodiversity.

HS.LS.2.6 Analyze data to show ecosystems tend to maintain relatively consistent numbers and types of organisms even when small changes in conditions occur but that extreme fluctuations in conditions may result in a new ecosystem.

HS.LS.2.7 Analyze direct and indirect effects of human activities on biodiversity and ecosystem health, specifically habitat fragmentation, introduction of non-native or invasive species, overharvesting, pollution, and climate change.

VANR.VENVR.2.B.01 Explain concepts fundamental to Environmental Systems and Society.