NORTHEASTERN FOREST REGENERATION DATA NETWORK

Version 1.0

FEMC
Forest Ecosystem Monitoring Cooperative

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Northeastern Forest Regeneration Data Network

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Cover image: AM Kosiba, 2019

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Executive Summary

The ability of trees to create a successful new generation is imperative to maintaining forests in the future. However, there are many threats affecting tree regeneration in the northeastern US such as animal herbivory, competition from invasive species, and climate change. One step to better understand the patterns and trends in forest regeneration is to use research and monitoring efforts to answer specific questions. With easier sharing of data that has already been collected, researchers can employ cost-effective means to answer questions across space and time. For example, which tree species show low regeneration rates and what site factors are associated? Has intense browse pressure changed the composition of forests in the region? How have invasive species affected the success of the regeneration layer?

As a result of these needs, the Forest Ecosystem Monitoring Cooperative (FEMC) created the Northeast Forest Regeneration Data Network (www.uvm.edu/femc/forest_regen) for users to access and compare projects related to tree regeneration, including studies on browse impacts, seed production, and forest management. We have created a structured framework to capture project metadata that allows for easy comparison and discovery of appropriate datasets to ask pertinent questions about the status and nature of the region's seedling and saplings. Additionally, for each project, we have assessed how easily comparable it is to the USDA Forest Service's Forest Inventory and Analysis program (a nationwide forest inventory program where plots are sampled every 5-7 years) as well as the project's utility for a range of analyses at the seedling and sapling level (e.g. browse impacts, mortality rates, or biomass).

Northeastern Forest Regeneration Data Network

Version 1.0 of the Northeast Forest Regeneration Data Network, first released in July, 2020, contains 65 projects, and more can be added using the established framework. Through the interactive website, projects can be filtered by selecting which metrics a user is most interested in (like seedling species data), along with other project parameters, like location, timeframe, and number of repeat inventories. Users can then browse and explore individual projects, access structured metadata, download methods, view or download data (when available) and view the relative suitability of each project for a range of analyses. Provided in this format, we hope that the Northeast Forest Regeneration Data Network will allow researchers an easier way to locate appropriate datasets to answer pertinent questions about the status and future of our forests.
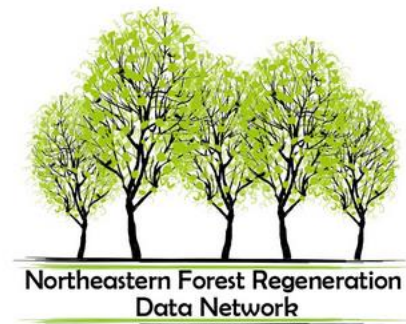
Introduction

A growing concern for forests in the northeastern US is the success and patterns of tree regeneration, which is key to understanding the region's forests in the future. It is necessary to understand the patterns and drivers of change in regeneration—which touch on future forest sector viability, wildlife habitat conservation and other important ecosystem functions—in order to successfully manage forests for the impacts of climate change. However, many questions related to tree regeneration remain unresolved.

Across the forests of the Northeast, species-specific responses to environmental conditions, as well as the interaction between species and site conditions, are still not well understood at the seedling and sapling level. Where are certain species showing successful regeneration and where is regeneration lacking? What are the main causes of low regeneration and what can we do to mitigate these impacts? Environmental conditions, like water availability and temperature, will continue to change, and may change to such a degree that the site is no longer within the species 'climate envelope'. Coupled with these changes in climate are other factors that affect regeneration, such as loss of forestland to development, impacts of pollution, competition from invasive species, and damage from animal herbivory.

Regeneration is measured by examining the emergent understory of the forest, usually through the measurement of saplings and/or tallying seedlings of tree species. However, there are many different methodologies used across research and monitoring efforts that complicate comparisons across projects. While many inventories, monitoring efforts, and research studies have collected data on regeneration, these data have not been compiled in a standard, easy to use format, and are not discoverable in a centralized location.

In 2018, the Forest Ecosystem Monitoring Cooperative (FEMC) Steering and State Partnership Committees identified forest regeneration as a critical information gap in the region. Specifically, collaborators cited a need to bring together information and data on forest regeneration from across the region in order to identify location- and species-specific changes that may impact future forest composition and structure.

The FEMC responded to these concerns by creating The Northeastern Forest Regeneration Data Network, a collection of datasets, projects, and methodologies aimed at assessing the status of tree regeneration, browse pressure, and seed production in the Northeast. FEMC staff have systematically described each project's metadata, methodology, and variables in a common framework to allow for easy discovery and use of these available sources, and assessed their utility for a range of analyses at the seedling and sapling level, such as browse impacts, mortality rates, or biomass.

The main goals of this project were to:

- Identify sources of regeneration data in the Northeast, including datasets that directly impact regeneration, like animal browse and seed or flower production.
- Document and assess regeneration measurement protocols across the region.

- Assess the utility of each dataset or project for comparison with USFS Forest Inventory and Analysis (FIA) and for specific analyses.
- Develop an online, searchable resource providing integrated access to all sources of potential information on forest regeneration, with customizable filters, targeted downloads and access to key metadata and methodological information for each data point.
- Document priority management and research questions related to regeneration trends.

As a result of this project, the forest ecology and management community will have improved access to regeneration data across the Northeast, and with this, will have improved potential for data integration through methods documentation and analytical assessments for comparing datasets across programs. As such, larger scale synthesis of these datasets can be used to evaluate pertinent questions about forest regeneration in the region.

Methodology

Resource Identification

We began by conducting an inventory of what datasets and/or programs exist in the region. The initial inventory of projects related to tree regeneration, browse, and/or tree seed production were collated based on cooperator suggestions, professional contacts, known datasets, and search engine queries. Any project or dataset was considered for inclusion if it had a component that measured tree seedlings, tree saplings, browse presence/absence or intensity on the regeneration layer, or mature tree seed or flower production. We erred on the side of including as many resources as possible so that users will have a larger pool to draw on for adapting methodologies to other projects. This work is a first round of dataset gathering, leaving many other appropriate projects to be added in a second version.

Project Methods Assessment

We developed a methods assessment framework to systematically evaluate each project included in this effort. In this framework, we catalogued the metadata, methods, and metrics collected. The assessment table was designed so it can be applied easily to additional programs and can accommodate a range of project types, but at the same time allow for easy comparison of projects and data analysis. We used this assessment to compare the potential utility of each program for addressing specific questions or analyses.

The framework captured project information and grouped it in eight broad categories of methods metadata (Table 1). Each category contains many specific fields used to characterize that category. The description of each field in the framework is included in Appendix 1 of this report. This framework was used as the architecture for the resulting online resource portal, and we used some information from this table to populate project pages created for each project on the FEMC data archive.

Table 1. Regeneration project framework metadata categories and descriptions. For a full list of individual fields in each category, see Appendix 1.

Category	Description
Project Metadata	Details about the project overall (people, citations, number of inventories and plots, plot selection details).
Overstory Plot Metadata	Details about the plot in which trees are measured (number, size, shape).
Sapling Plot Metadata	Details about the plot in which saplings are measured (number, size, shape).
Seedling Plot Metadata	Details about the plot in which saplings are measured (number, size, shape).
Overstory Metadata	Details about the metrics collected in the overstory plot.
Sapling Metadata	Details about the metrics collected in the sapling plot.
Seedling Metadata	Details about the metrics collected in the seedling plot.
Other Metrics	Details about other metrics collected at any scale (e.g., deadwood, disturbance, treatments, insects/disease, soils, etc.).

Assessment of Comparability to Forest Inventory and Analysis

For each project, we assessed how easily it could be compared or integrated with FIA data. For each project, we ranked compatibility as 'low', 'medium', or 'high'. High compatibility was assigned if there were permeant plots that were assessed over multiple inventories and if there were similar metrics to those in the FIA program. Medium compatibility was assigned if there was some similarity in metrics assessed or if the project could be compared with one aspect of FIA data – for example, if the project only assessed eastern hemlock regeneration, the project would only be compatible with FIA data for that one species. Low compatibility was assigned if the data collected was not comparable to specific FIA data and might be more valuable for a specific location or metric.

Analysis Suitability Assessment

For each project, after all fields in the metadata assessment framework were completed to the best of our ability with the information we had, we assessed whether there was sufficient information to analyze the following seedling or sapling characteristics:

- density
- species composition
- mortality
- biomass
- browse impacts
- effects of treatment or management
- relationship with overstory trees

For each one of these analyses, we evaluated if the project had sufficient information based on the required data needed for that analysis (Table 2). If there was sufficient information for the specified

analysis, the project was assigned 'suitable'. If the project contained some of the information required for the specified analysis, it was assigned 'partially suitable'. This may mean that to complete the specified analysis, modeling, extrapolations or assumptions may be needed. If the project did not contain the information needed for the specified analysis, it was assigned 'unsuitable'. These assessments are intended to help guide researchers, analysts, and others in quickly locating projects that meet analysis requirements.

Table 2. Seedling and sapling analyses and the data or information that is required for that analysis.

Analysis	Required data
Density	Species, count, plot size
Species composition	Tallies by species
Mortality	Status (i.e., live and dead stems) or tracking of individuals over time
Biomass	Diameter, height
Browse impacts	Browse assessments
Change over time	Data collected over two or more time steps
Effects of treatment or management	Data per treatment or management type
Relationship with overstory trees	Overstory tree data collected in the same locations as regeneration data

Technical Implementation

The Northeastern Forest Regeneration Data Network is hosted within the FEMC website, building on top of the data archive and discovery infrastructure developed by the FEMC. Each project in the portal is available from the FEMC archive and partner organizations. The additional metadata and method information from the framework discussed above is hosted as a collection in the FEMC database. The portal is implemented using open source software and technology. The network is built using entirely open source software and technology. The tables are created using DataTables (https://datatables.net/) available under the MIT license. The metadata pdfs are built using FPDF (http://www.fpdf.org/), a free open source PHP software and FPDI (https://www.setasign.com/products/fpdi/about/) also available under the MIT license. The map uses OpenLayers (https://openlayers.org/) a dynamic web mapping API that is provided as a free open source JavaScript software under a FreeBSD license. These components were combined in a custom web front-end framework using Bootstrap 3 (https://getbootstrap.com/docs/3.4/ available under MIT license) to create a portal that provides seamless interaction across devices. All projects are available to view on the FEMC archive or partner site. If data is hosted by FEMC and publicly available, it can be downloaded directly. If the data is hosted by a partner organization, their link to the data is provided.

Outcomes and Findings

Northeast Forest Regeneration Data Network

From our structured metadata framework describing 65 regeneration related projects from the Northeast, we created the Northeast Forest Regeneration Data Network (www.uvm.edu/femc/forest_regen) to allow users to explore, search for, and locate projects related to forest regeneration. Using the detailed metadata assessment framework, users can compare project methods and metadata, download a methods document, and access data via the FEMC data archive. In addition, the full assessment of all the programs is available for download at https://www.uvm.edu/femc/file/info/10913.

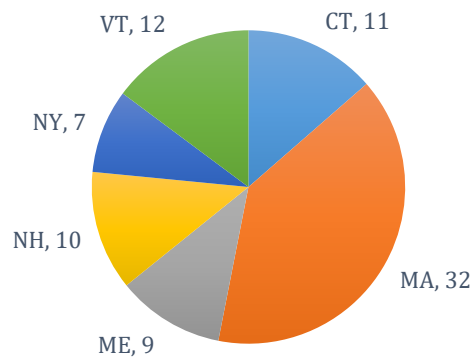See Appendix 2 for a full list of the projects used in Version 1.0 of this project.

Figure 1. Count of resources included in the Northeast Forest Regeneration Data Network, shown per US state. Note that many projects sample in multiple states so the counts per state exceed the total number of resources.

We found that the state with the most resources was MA (Figure 1), which is likely because of the inclusion of projects housed on the Harvard Forest data archive site. The other states had fairly equal representation in the projects, except for RI which was not represented. When we looked at patterns by the year each project was initiated (Figure 2), we found good representation back to 1935. Many of these projects are ongoing at regular or irregular periods, and thus provide a good temporal resource for investigating patterns back in time.
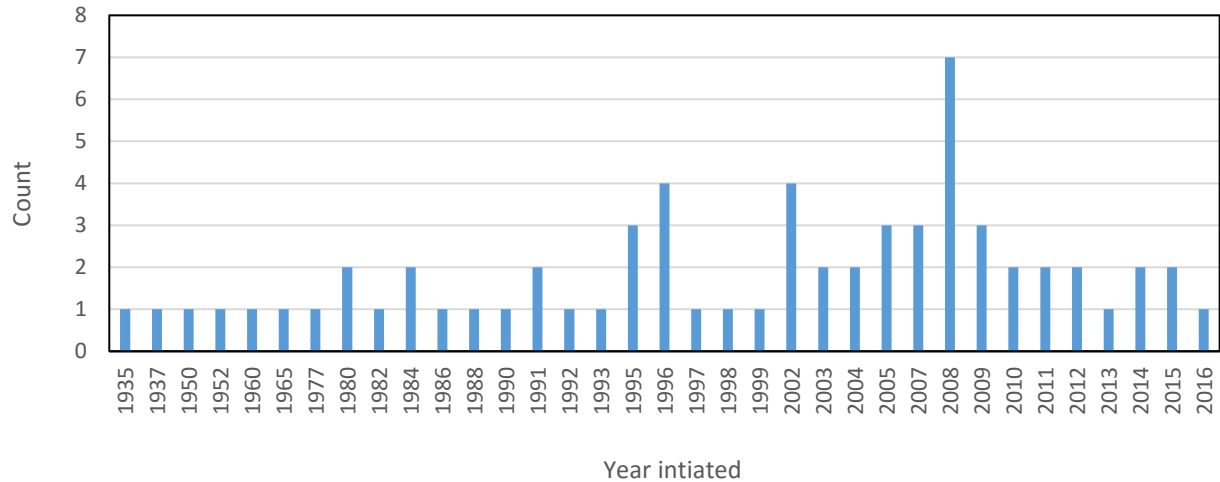
Figure 2. Count of resources included in the Northeast Forest Regeneration Data Network by the year the project was initiated. Note that the 'Year initiated' scale is not continuous.
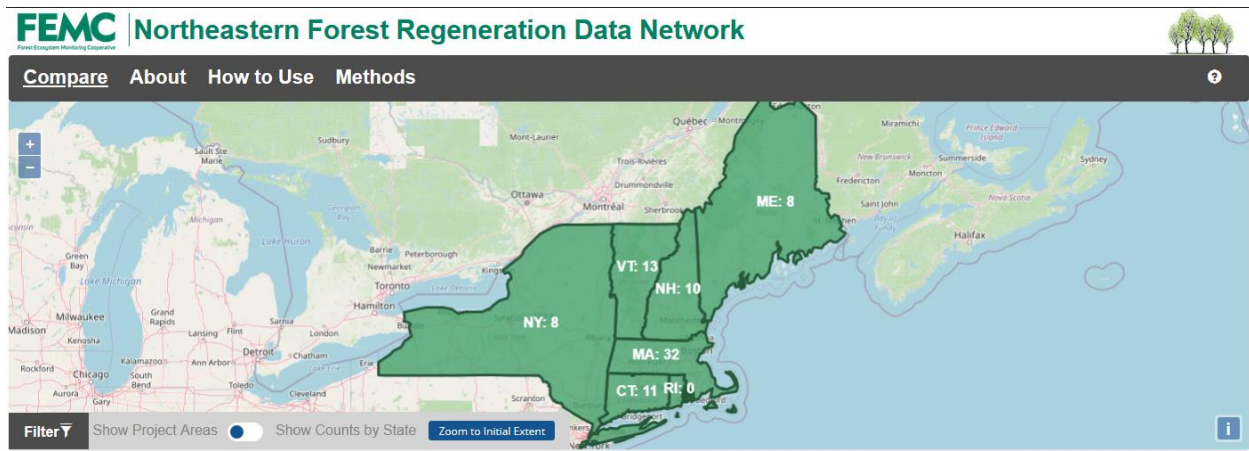

Figure 3. Landing page of the Northeast Forest Regeneration Data Network, available at www.uvm.edu/femc/forest_regen.

The main landing page allows users to see counts of projects per state (Figure 3), as well as access a filter screen for more specific queries (Figure 4). On the filter screen, users can select specific locations, time frames, elevation ranges, as well as select specific metrics that the project collects. Examples of these metrics include overstory tree height data, sapling species information, or seedling status.
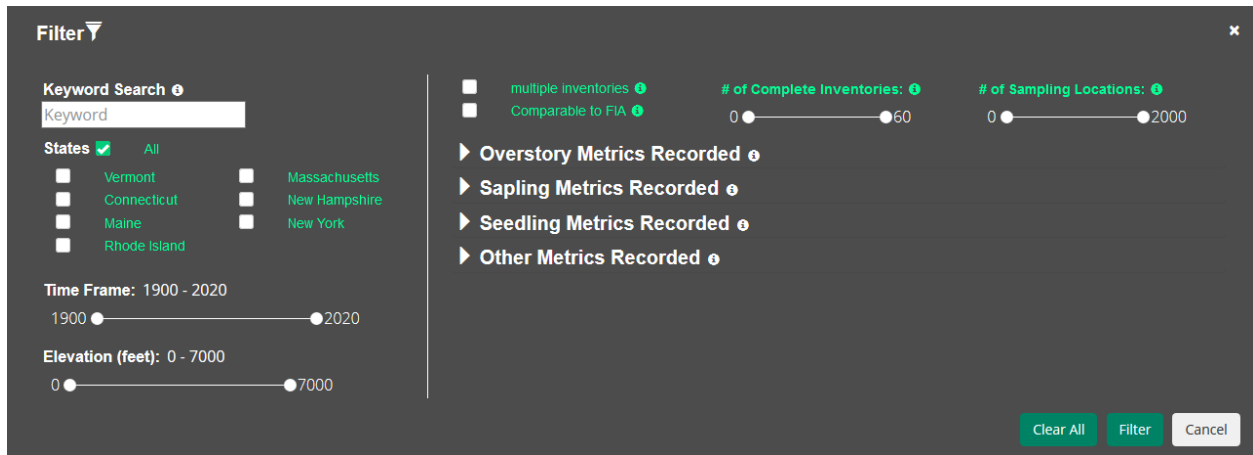
Figure 4. The filter window in the Northeast Forest Regeneration Data Network allows users to select specific criteria for the resulting list of projects. These filters include the specific metrics collected.

Once the filter has been applied, the resulting table below the map displays only those projects that meet the criteria selected (

Figure 5). Here users can explore specific projects for information related to the contact or agency responsible for the project, view a project description, access data (if available), and download a document of the metadata. Users can also select up to three projects to compare and download the associated metadata in PDF format.

In the table, color-coded circles denote the utility of the project for certain specified analyses. For example, as seen in Figure 5, a project may be suitable for analyzing seedling density, but not the impacts of browse on seedlings because animal browse on seedlings is not assessed. Clicking on an individual circle provides the user with the criteria needed for each analysis. Also displayed in the table is an assessment of the comparability of the project to the Forest Inventory and Analysis program.

Figure 5. The Northeast Forest Regeneration Data Network contains a table of projects related to regeneration where users can compare each project to USDA Forest Service Forest Inventory and Analysis program data as well as each project's utility for a range of specified analyses at the seedling and sapling level. Each project can be expanded for more information, including links to the data and detailed metadata.

Comparability of Projects for Key Regional Issues

Methodology differences were abundant across the 65 projects currently included in the Northeast Forest Regeneration Data Network, which makes analysis with more than one project difficult. We provided structured metadata to allow users to compare projects and perform analyses more easily (Figure 6). As we also included 'other metrics' that projects collected – such as information on the herbaceous layer or soil – the projects included can be used for many more analyses than provided in the assessment table. For a full list of fields documented for each project, see Appendix 1.

Figure 6 Metadata comparison between three different regeneration projects

Potential Research Questions

There is a wealth of questions related to tree regeneration that could be answered or investigated using the Northeast Forest Regeneration Data Network. With the release of Version 1.0 of this tool, FEMC staff and cooperators will engage in ongoing discussion about how to document these questions and needs in our region. Questions that have been documented already as part of the development of this tool include:

- How have regeneration rates and success varied by location and site characteristics?
- How has regeneration varied by forest type and species?
- Are there certain forest types, species, or locations where low regeneration is cause for concern?
- Do we see the same species diversity in the understory as we do in the overstory?
- How does silviculture influence regeneration across a range for sites?

- How does animal browse effect regeneration rates?
- What impact do invasive species have on regeneration success?

Gaps and Future Steps

There ae likely many other datasets that include tree regeneration, browse impacts, or reproduction that if added to this network, would increase the power of possible analyses. Inclusion of projects that encompass locations not well represented in Version 1.0 (see Figure 1) would improve the analytical utility of the Network.

Additionally, we have not been able to obtain data for all projects currently included on the website. Having access to data in a standardized format would allow for easier discovery and analysis. The Northeast Forest Regeneration Data Network is the first attempt to make tree regeneration projects discoverable and comparable in one location. If the forest ecology community wants to better understand and forecast tree regeneration patterns and trends across a wide range of site conditions, we require more data across more areas. One way to do this is to aggregate research and monitoring data in standardized platforms to enrich and fill in gaps present in coarser spatial networks such as Forest Inventory and Analysis. FEMC cooperators are currently working on an analogous system for forest inventory data (see https://www.uvm.edu/forest_inventory_data_network/ for more information).

As FEMC cooperators continue to work on the drivers and consequences of change in forest regeneration, FEMC will continue to track opportunities for providing more access to regeneration data, making it easier to synthesize and aggregate data, and improve understanding about the role this critical process will play in our forests' future.

Appendix 1 – Definitions of Metadata Fields by Category

For each category of metadata, we assessed a number of fields. The definition and data type are given below for each category.

Project Metadata

Field	Description	Data Type
Project Name	Name of the project.	Text
Agency name	Name of the primary agency for the project.	Text
Agency URL	Primary agency URL.	URL
Other URLs	Other websites associated with the project.	URL
Primary contact	Name of primary project contact for the project.	Text
Primary contact email	Email address of the primary contact for the project.	Email address
Principal investigators	List of people involved with this project.	Text
Project state	State(s) where project data was collected.	CT, MA, ME, NH, NY, RI, VT
Specific location	Specific location of project, if applicable.	Text
Land type	Designation if project occurred on public or private land.	Public, Private
Project status	Indication if the project is active, inactive, proposed, or completed.	Active, Inactive, Proposed, Completed
Project type	Designation of the project type.	Monitoring, Research, Outreach/Extension, Other
Project start year	Year the project began.	Date
Project end year	If project is not active, the year the project was complete.	Date
Project description	Description of the project.	Text
Project objectives	The main purpose or expected outcomes of the project.	Text
Project citation	Recommended citation for the project.	Text
Collection period	Duration of the project.	Year range
Collection period details	Details about the duration of the project.	Text
Repeat inventory	Designation if the program includes multiple inventories.	Yes, No
Repeat Inventory details	Details about the inventory rotation.	Text
Number inventories	Number of complete inventory cycles, if applicable.	Number
Number inventories details	Details about the number of complete inventories.	Text
Number plots	Count of plots or study locations.	Number
Number plots details	Details about the count of plots or study locations.	Text
Coordinates	Indication if project coordinates are available.	Yes, No
Coordinates details	Details about the coordinates, or if not available, extent of study area.	Text or coordinates
Min elevation feet	Minimum elevation sampled, in feet (a.s.l).	Number
Max elevation feet	Maximum elevation sampled, in feet (a.s.l).	Number

Field	Description	Data Type
Plot density	Approximate plot density (N plots relative to total area).	Fraction
Plot density details	Details about the plot density.	Text
Plot selection	Type of plot selection method used.	Stratified random sample, Simple random sample, Stratified systematic, Systematic, Non-probability sampling, or Other method
Plot selection details	Details about the plot selection process.	Text
Plot establishment	Indication if the plots were permanently marked for repeat visits.	Yes, No
Plot establishment details	Details about the plot establishment.	Text
Plot layout	Designation on how the plots were laid out (e.g., nested, clustered, or single).	Nested, Clustered, Single
Plot layout details	Details about the plot layout.	Text
Plot size consistency	Indication if the plots were designed to be the same size (i.e., fixed area or variable area).	Fixed, Variable
Plot size consistency details	Details about the size consistency of the plots.	Text
Comparable to FIA	Assessment if the project design is comparable to the USFS Forest Inventory and Analysis program (FIA).	Low, Medium, High
Comparable to FIA details	Details about project comparability to Forest Inventory and Analysis (FIA).	Text

Overstory Plot Metadata

Field	Description	Data Type
Overstory Plot number	Number of overstory plots per sampling location.	Number
Overstory Plot number details	Details about the number of overstory plots.	Text
Overstory Plot radius ft	Radius of overstory plot if circular (feet).	Number
Overstory Plot radius ft details	Details about the overstory plot radius.	Text
Overstory Plot area sqft	Area of the overstory plot (square feet).	Number
Overstory Plot area sqft details	Details about the overstory plot area.	Text
Overstory Plot expansion factor	Approximate overstory plot expansion factor for an acre.	Number
Overstory Plot expansion factor details	Approximate faction of acre per overstory plot.	Fraction
Overstory Plot shape	Shape of the overstory plot.	Circular, Square, Rectangular
Overstory Plot shape details	Details about the shape of the overstory plot.	Text

Sapling Plot Metadata

Field	Description	Data Type
Sapling Plot number	Number of sapling plots per overstory plot (or if no overstory plots, per sampling location).	Number

Field	Description	Data Type
Sapling Plot number details	Details about the number of sapling plots.	Text
Sapling Plot radius ft	Radius of the sapling plot if circular (in feet).	Number
Sapling Plot radius ft details	Details about the sapling plot radius.	Text
Sapling Plot area sqft	Area of the sapling plot (square feet).	Number
Sapling Plot area sqft details	Details about the sapling plot area.	Text
Sapling Plot expansion factor	Approximate sapling plot expansion factor for an acre.	Number
Sapling Plot expansion factor details	Details about the sapling plot expansion factor.	Fraction
Sapling Plot shape	Shape of the sapling plot.	Circular, Square, Rectangular
Sapling Plot shape details	Details about the shape of the sapling plot.	Text

Seedling Plot Metadata

Field	Description	Data Type
Seedling Plot number	Number of seedling plots per overstory plot (or if no overstory plots, per sampling location).	Number
Seedling Plot number details	Details about the number of seedling plots.	Text
Seedling Plot radius ft	Radius of the seedling plot if circular (in feet).	Number
Seedling Plot radius ft details	Details about the seedling plot radius.	Text
Seedling Plot area sqft	Area of the seedling plot (square feet).	Number
Seedling Plot area sqft details	Details about the seedling plot area.	Text
Seedling Plot expansion factor	Approximate seedling plot expansion factor for an acre.	Number
Seedling Plot expansion factor details	Details about the seedling plot expansion factor.	Fraction
Seedling Plot shape	Shape of the seedling plot.	Circular, Square, Rectangular
Seedling Plot shape details	Details about the shape of the seedling plot.	Text

Overstory Metadata

Field	Description	Data Type
Overstory recorded	Indication if data on overstory trees was recorded.	Yes, No
Overstory recorded details	Details about the overstory data.	Text
Overstory definition	Indication if the project provides a definition for overstory trees.	Yes, No

Field	Description	Data Type
Overstory definition details	Details about the definition of overstory trees, including thresholds.	Text
Overstory location	Indication if overstory trees were marked or mapped for repeated inventories.	Yes, No
Overstory location details	Details about overstory tree location or markings.	Text
Overstory species	Indication if the species of overstory trees was recorded.	Yes, No
Overstory species details	Details about the overstory species data, including codes or nomenclature used.	Text
Overstory status	Indication if the status of overstory trees was recorded.	Yes, No
Overstory status details	Details about the overstory status, including codes if used.	Text
Overstory crown class	Indication if the crown class of overstory trees was recorded.	Yes, No
Overstory crown class details	Details on overstory crown class, including codes if used.	Text
Overstory dia	Indication if the diameter of overstory trees was recorded.	Yes, No
Overstory dia details	Details about the overstory diameter measurements.	Text
Overstory height	Indication if overstory height was recorded.	Yes, No
Overstory height details	Details on overstory height measurements.	Text
Overstory crown condition	Indication if data on overstory tree crown health or condition was collected.	Yes, No
Overstory crown details	Details about the overstory crown assessment.	Text
Overstory reproduction	Indication if seeds or flowers of overstory trees were assessed.	Yes, No
Overstory reproduction details	Details about overstory seed, flowers, or other reproductive assessments.	Text
Overstory damage	Indication if damages to overstory trees were assessed.	Yes, No
Overstory damage details	Details about overstory damage assessments.	Text
Overstory other metrics	Indication if any other metrics on overstory trees were collected.	Yes, No
Overstory other metrics details	Details about other metrics collected on overstory trees.	Text

Sapling Metadata

Field	Description	Data Type
Sapling recorded	Indication if saplings were assessed.	Yes, No
Sapling recorded details	Details about the sapling data.	Text
Sapling definition	Indication if the project provides a definition for a sapling.	Yes, No
Sapling definition details	Details about the definition of a sapling, including thresholds.	Text

Field	Description	Data Type
Sapling dia	Indication if the diameter of saplings was recorded.	Yes, No
Sapling dia details	Details about the sapling diameter measurements.	Text
Sapling height	Indication if sapling height was recorded.	Yes, No
Sapling height details	Details on sapling height measurements.	Text
Sapling location	Indication if saplings were marked or mapped for repeated inventories.	Yes, No
Sapling location details	Details about sapling location or markings.	Text
Sapling species	Indication if the species of saplings was recorded.	Yes, No
Sapling species details	Details about sapling species data, including codes or nomenclature used.	Text
Sapling status	Indication if the status of saplings was recorded.	Yes, No
Sapling status details	Details about the sapling status, including codes if used.	Text
Sapling browse	Indication if saplings were assessed for browse impacts.	Yes, No
Sapling browse details	Details about sapling browse assessments.	Text
Sapling damage	Indication if damages to saplings were recorded.	Yes, No
Sapling damage details	Details about sapling damage assessments.	Text
Sapling other	Indication if any other sapling metrics were recorded.	Yes, No
Sapling other details	Details about other metrics collected on saplings.	Text

Seedling Metadata

Field	Description	Data Type
Seedling recorded	Indication if seedlings were assessed.	Yes, No
Seedling recorded details	Details about the seedling data.	Text
Seedling definition	Indication if the project provides a definition for a seedling.	Yes, No
Seedling definition details	Details about the definition of a seedling, including thresholds.	Text
Seedling dia	Indication if the diameter of seedlings was recorded.	Yes, No
Seedling dia details	Details about the seedling diameter measurements.	Text

Field	Description	Data Type
Seedling height	Indication if seedling height was recorded.	Yes, No
Seedling height details	Details on seedling height measurements.	Text
Seedling location	Indication if seedlings were marked or mapped for repeated inventories.	Yes, No
Seedling location details	Details about seedling location or markings.	Text
Seedling species	Indication if the species of seedlings was recorded.	Yes, No
Seedling species details	Details about seedling species data, including codes or nomenclature used.	Text
Seedling status	Indication if the status of seedlings was recorded.	Yes, No
Seedling status details	Details about the seedling status, including codes if used.	Text
Seedling browse	Indication if seedlings were assessed for browse impacts.	Yes, No
Seedling browse details	Details about seedling browse assessments.	Text
Seedling damage	Indication if damages to seedlings were recorded.	Yes, No
Seedling damage details	Details about seedling damage assessments.	Text
Seedling other	Indication if any other seedling metrics were recorded.	Yes, No
Seedling other details	Details about other metrics collected on seedlings.	Text

Other Metrics

Field	Description	Data Type
Other vegetation	Indication if metrics on other vegetation components were collected.	Yes, No
Other vegetation details	Details about the other vegetation metrics collected.	Text
Other deadwood	Indication if data on downed woody debris or standing dead trees were collected.	Yes, No
Other deadwood details	Details about the dead wood assessments.	Text
Other forest type	Indication if forest type was defined by the project.	Yes, No
Other forest type details	Details about the forest type designation.	Text
Other crown cover	Indication if data on crown closure or cover was recorded.	Yes, No
Other crown cover details	Details about the crown cover assessment.	Text

Field	Description	Data Type
Other management treatment	Indication if there is a management or treatment component.	Yes, No
Other management treatment details	Details on the management or treatment component.	Text
Other disturbance history	Indication if past management or natural disturbance history was noted.	Yes, No
Other disturbance history details	Details on the disturbance history information.	Text
Other soil	Indication if information on soils was recorded.	Yes, No
Other soil details	Details on the soil information.	Text
Other stand age	Indication if stand age was estimated.	Yes, No
Other stand age details	Details on stand age assessments.	Text
Other site index	Indication if site index was computed.	Yes, No
Other site index details	Details on site index information.	Text
Other terrain position	Indication if the slope, aspect, or other terrain position metrics were recorded.	Yes, No
Other terrain position details	Details on the terrain position information.	Text
Other invasive plants	Indication if invasive plants were assessed.	Yes, No
Other invasive plants details	Details about invasive plant information.	Text
Other browse	indication if animal browse was assessed.	Yes, No
Other browse details	Details on browse assessments.	Text
Other insects diseases	Indication if tree insect or diseases were recorded.	Yes, No
Other insects diseases details	Details about insect and disease assessments.	Text

Sapling Analysis

Field	Description	Data Type
Sapling density	Indication if there is sufficient information to calculate sapling density.	Complete, Partial, Incomplete
Sapling density details	Requires: sapling species, sapling count, plot size.	Text
Sapling species composition	Indication if there is sufficient information to compute sapling species composition.	Complete, Partial, Incomplete
Sapling species composition details	Requires: sapling tallies by species.	Text
Sapling mortality	Indication if there is sufficient information to analyze mortality of saplings.	Complete, Partial, Incomplete
Sapling mortality details	Requires: sapling status (i.e., inclusion of both live and dead), sapling location data ideal (i.e., tracking of individual stems).	Text

Field	Description	Data Type
Sapling biomass	Indication if there is sufficient information to compute sapling biomass.	Complete, Partial, Incomplete
Sapling biomass details	Requires: sapling diameter and height.	Text
Sapling browse	Indication if there is sufficient information to examine sapling browse.	Complete, Partial, Incomplete
Sapling browse details	Requires: browse data on saplings.	Text
Sapling change	Indication if there is sufficient information to examine sapling change over time.	Complete, Partial, Incomplete
Sapling change details	Requires: sapling data over more than two timesteps.	Text
Sapling treatment management	Indication if there is sufficient information to assess the relationship of saplings with treatment or management.	Complete, Partial, Incomplete
Sapling treatment management details	Requires: sapling tallies per treatment or management type.	Text
Sapling overstory	Indication if there is sufficient information to relate saplings to overstory trees.	Complete, Partial, Incomplete
Sapling overstory details	Requires: overstory data at same locations as sapling data.	Text

Seedling Analysis

Field	Description	Data Type
Seedling density	Indication if there is sufficient information to calculate seedling density.	Complete, Partial, Incomplete
Seedling density details	Requires: seedling species, seedling count, plot size.	Text
Seedling species composition	Indication if there is sufficient information to compute seedling species composition.	Complete, Partial, Incomplete
Seedling species composition details	Requires: seedling tallies by species.	Text
Seedling mortality	Indication if there is sufficient information to analyze mortality of seedlings.	Complete, Partial, Incomplete
Seedling mortality details	Requires: seedling status (i.e., inclusion of both live and dead), seedling location data ideal (i.e., tracking of individual stems).	Text
Seedling biomass	Indication if there is sufficient information to compute seedling biomass.	Complete, Partial, Incomplete
Seedling biomass details	Requires: seedling diameter and height.	Text
Seedling browse	Indication if there is sufficient information to examine seedling browse.	Complete, Partial, Incomplete
Seedling browse details	Requires: browse data on seedlings.	Text
Seedling change	Indication if there is sufficient information to examine seedling change over time.	Complete, Partial, Incomplete
Seedling change details	Requires: seedling data over more than two timesteps.	Text
Seedling treatment management	Indication if there is sufficient information to assess the relationship of seedlings with treatment or management.	Complete, Partial, Incomplete
Seedling treatment management details	Requires: seedling tallies per treatment or management type.	Text
Seedling overstory	Indication if there is sufficient information to relate seedlings to overstory trees.	Complete, Partial, Incomplete

Field	Description	Data Type
Seedling overstory details	Requires: overstory data at same locations as seedling data.	Text

Appendix 2 - List of Programs Assessed

Project	Agency	FEMC Data Archive Link
Baseline Data for Long-term Forest Vegetation Monitoring at Bear Brook Watershed in Maine	University of Maine, Bear Brook Watershed	https://www.uvm.edu/femc/data/archive/project/bear-brook-watershed-maine
Baxter State Park Scientific Forest Management Area - Continuous Forest Inventory	Baxter State Park Authority	https://www.uvm.edu/femc/data/archive/project/baxter_park_sfma_cfi
Connecticut Cutting Method Study	Connecticut Agricultural Experiment Station	https://www.uvm.edu/femc/data/archive/project/Connecticut_Cutting_Method_Study
Connecticut Forest Habitat Study	Connecticut Agricultural Experiment Station	https://www.uvm.edu/femc/data/archive/project/connecticut_forest_habitat_study
Connecticut Highlands Study	Connecticut Agricultural Experiment Station	https://www.uvm.edu/femc/data/archive/project/Connecticut_Highlands_Study
Connecticut New-Series	Connecticut Agricultural Experiment Station	https://www.uvm.edu/femc/data/archive/project/Connecticut_New-series
Connecticut Oak Regeneration Survey	Connecticut Agricultural Experiment Station	https://www.uvm.edu/femc/data/archive/project/Connecticut_Oak_Regeneration_Survey
Connecticut Old-Series	Connecticut Agricultural Experiment Station	https://www.uvm.edu/femc/data/archive/project/Connecticut_old-series
Continuous Forest Inventory on the state forests in the Northeast Kingdom of Vermont	State of Vermont Agency of Natural Resources, Department of Forest, Parks and Recreation	https://www.uvm.edu/femc/data/archive/project/continuous-forest-inventory
Continuous Revegetation Survey Data, Watershed 5, Hubbard Brook Experimental Forest, 1984 - 1989	Hubbard Brook Ecosystem Study; Cornell University	https://www.uvm.edu/femc/data/archive/project/Hubbard_Brook_Ecosystem_Study/dataset/continuous-revegetation-survey-data-watershed-5
Deer and Moose Browsing in Hemlock Removal Experiment at Harvard Forest 2008	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/deer-moose-browsing-hemlock-removal-experiment
Ecosystem and Vegetation Response to Hemlock Logging in Southern New England 1999-2005	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/ecosystem-vegetation-response-to-hemlock-logging
Effects of Warming on Tree Species Recruitment at Harvard Forest and Duke Forest since 2009	Harvard Forest, Duke Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/effects-warming-tree-species-recruitment-harvard

Project	Agency	FEMC Data Archive Link
Fern Understory as an Ecological Filter at Harvard Forest 1993-1995	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/fern-understory-as-ecological-filter-Harvard
Forest Inventory of a Calcium Amended Northern Hardwood Forest 1996-2011: Watershed 1, Hubbard Brook Experimental Forest	Hubbard Brook Ecosystem Study; University of California Berkeley; Syracuse University	https://www.uvm.edu/femc/data/archive/project/Hubbard_Brook_Ecosystem_Study/dataset/forest-inventory-calcium-amended-northern-hardwood
Forest Inventory of a Northern Hardwood Forest 1965-2012: Watershed 6, Hubbard Brook Experimental Forest	Hubbard Brook Ecosystem Study; University of California Berkeley	https://www.uvm.edu/femc/data/archive/project/Hubbard_Brook_Ecosystem_Study/dataset/forest-inventory-northern-hardwood-forest-1965
Forest Inventory of a Whole Tree Harvest 1982-2009: Watershed 5, Hubbard Brook Experimental Forest	Hubbard Brook Ecosystem Study; University of California Berkeley	https://www.uvm.edu/femc/data/archive/project/Hubbard_Brook_Ecosystem_Study/dataset/forest-inventory-whole-tree-harvest-1982
Gap Partitioning Among Maples at Harvard Forest 1986-1989	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/gap-partitioning-among-maples-Harvard-forest
Global Change Fingerprints in Protected Montane Forests of Northeastern US	SUNY-Environmental Science and Forestry (ESF)	https://www.uvm.edu/femc/data/archive/project/global-change-Northeastern-montane-forests
GMNF - Long-term Ecosystem Monitoring Program (LEMP)	Green Mountain & Finger Lakes National Forest	https://www.uvm.edu/femc/data/archive/project/long-term-ecosystem-monitoring-program-gmfl
Hemlock History Plots at Harvard Forest since 1995	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/hemlock-history-plots-harvard-forest-since
Hemlock Understory Vegetation Plots at Harvard Forest since 2002	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/hemlock-understory-vegetation-plots-harvard-forest
Hopkins Memorial Forest Permanent Plot System	Williams College	https://www.uvm.edu/femc/data/archive/project/Hopkins_Memorial_Forest_Permanent_Plot_System
Hubbardton River Clayplain Natural Area Restoration Project	The Nature Conservancy	https://www.uvm.edu/femc/data/archive/project/Hubbardton_river_clayplain_Natural_Area_restoration_Project
Hurricane Recovery Plots at Harvard Forest since 1937	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/hurricane-recovery-plots-harvard-forest-since-1
Impact of Moose Browsing on Forest Regeneration in Northeast Vermont	University of New Hampshire	https://www.uvm.edu/femc/data/archive/project/impact_of_moose_browsing_on_forest_regeneration_in_northeast_vermont
Impacts of Hemlock Harvesting in Central Massachusetts 2003-2009	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/impacts-hemlock-harvesting-central-massachusetts-2003
Inventory of Hubbard Brook Valley Plots	Hubbard Brook Ecosystem Study; University of California Berkeley	https://www.uvm.edu/femc/data/archive/project/Hubbard_Brook_Ecosystem

Project	Agency	FEMC Data Archive Link
		_Study/dataset/inventory-hubbard-brook-valley-plots
Landscape Response to Hemlock Woolly Adelgid in Southern New England 1997-2011	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/landscape-response-to-hemlock-woolly-adelgid
Long-Term Impacts of the Hemlock Woolly Adelgid on Forest Carbon at Harvard Forest 2008-2011	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/long-term-impacts-hemlock-woolly-adelgid
Long-term Soil Monitoring: Plot Regeneration Data	Natural Resources Conservation Service USDA	https://www.uvm.edu/femc/data/archive/project/long-term-soil-monitoring
Maine Natural Areas Program, Ecological Reserve System	Maine Department of Agriculture, Conservation and Forestry	https://www.uvm.edu/femc/data/archive/project/Maine_Natural_Areas_Program_Ecological_Reserve_System
Massachusetts' Continuous Forest Inventory	Massachusetts Department of Conservation and Recreation	https://www.uvm.edu/femc/data/archive/project/Mass-CFI
Moose Foraging in Temperate Forests of Central Massachusetts 2005	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/moose-foraging-temperate-forests-central-Massachusetts/overview
New York City Watershed Lands Forest Inventory	NYC Environmental Protection, Bureau of Water Supply	https://www.uvm.edu/femc/data/archive/project/Forest_inventory_nyc_dep
New York City Watershed Lands Forest Stand Delineation	NYC Environmental Protection	https://www.uvm.edu/femc/data/archive/project/NYC_DEP_forest_stand_delineation
North American Maple Project (NAMP)	Vermont Department of Forest, Parks and Recreation	https://www.uvm.edu/femc/data/archive/project/forest-health-monitoring-north-american-maple
Northeast Temperate Inventory and Monitoring Network	National Park Service	https://www.uvm.edu/femc/data/archive/project/NE_Temperate_inventory_monitoring_network
Overstory and Regeneration Data from the "Rehabilitation of Cutover Mixedwood Stands" Study at the Penobscot Experimental Forest	USDA Forest Service, Pennobscott Experimental Forest	https://www.uvm.edu/femc/data/archive/project/Forest_research_penobscot_Forest/dataset/overstory-regeneration-data-from-rehabilitation-cutover
Overstory Tree and Regeneration Data from the "Management Intensity Demonstration" Study at Penobscot Experimental Forest	USDA Forest Service, Penobscot Experimental Forest	https://www.uvm.edu/femc/data/archive/project/Forest_research_penobscot_Forest/dataset/overstory-tree-regeneration-data-from-management
Overstory Tree and Regeneration Data from the "Silvicultural Effects on Composition, Structure, and Growth" Study at Penobscot Experimental Forest	USDA Forest Service, Penobscot Experimental Forest	https://www.uvm.edu/femc/data/archive/project/Forest_research_penobscot_Forest/dataset/overstory-tree-regeneration-data-from-silvicultural
Permanent Plots at Pisgah State Forest in Winchester NH since 1984	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/permanent-plots-pisgah-state-forest-winchester
Phenology and Vegetation Growth in Prospect Hill Soil Warming Experiment at Harvard Forest 1992-1993	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/phenology-vegetation-growth-prospect-hill-soil

Project	Agency	FEMC Data Archive Link
Plantation Biodiversity Plots at Harvard Forest since 2007	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/plantation-biodiversity-plots-Harvard-forest-since
Plantation Biodiversity Plots at Harvard Forest since 2007	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/plantation-biodiversity-plots-harvard-forest-since-1
Red Maple Seedling Soil Warming Experiment in Harvard Forest Lath House 201	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/red-maple-seedling-soil-warming-experiment
Regeneration Following Clearcutting Study at Harvard Forest since 1991	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/regeneration-following-clearcutting-study-Harvard-forest
Role of Moose and Deer Browsing in Harvested Forests of Southern New England since 2008	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/role-moose-deer-browsing-harvested-forests
Role of Moose and Deer Browsing in Unharvested Forests of Southern New England since 2011	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/role-moose-deer-browsing-unharvested-forests
Seed Bank in Hemlock Removal Experiment at Harvard Forest 2004-2015	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/seed-bank-hemlock-removal-experiment-Harvard
Seedlings and Saplings in the Clear-cut Site at Harvard Forest since 2013	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/seedlings-saplings-clearcut-site-Harvard-forest
Shaw Mountain Ice Storm Study 1998-2002	Vermont Nature Conservancy	https://www.uvm.edu/femc/data/archive/project/shaw_mountain_ice_storm_study
The Impact of Deer Overabundance on Forest Regeneration	Cary Institute of Ecosystem Studies	https://www.uvm.edu/femc/data/archive/project/deer-exclosure-monitoring
Timber Harvesting Field Study in Western Massachusetts 2004-2005	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/timber-harvesting-field-study-western-massachusetts
Tree Growth and Coarse Woody Debris in Regenerating Forests at Harvard Forest since 2008	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/tree-growth-coarse-woody-debris-regenerating
Tree recruitment Data for the Hubbard Brook Valley Plots, Baseline Data Collected 1995 - 1998	Hubbard Brook Ecosystem Study; University of California Berkeley; Cornell University	https://www.uvm.edu/femc/data/archive/project/Hubbard_Brook_Ecosystem_Study/dataset/tree-recruitment-data-for-hubbard-brook
Tree Seed Dispersal in Hemlock Removal Experiment at Harvard Forest 2005	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/tree-seed-dispersal-hemlock-removal-experiment
Tree Seedlings in CRUI Land Use Project at Harvard Forest 1996	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/d

Project	Agency	FEMC Data Archive Link
		ataset/tree-seedlings-crui-land-use-project
Understory Vegetation in Hemlock Removal Experiment at Harvard Forest since 2003	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/understory-vegetation-hemlock-removal-experiment-harvard
Ungulate Browsing and Foundation Tree Regeneration in Central New England 2010	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/ungulate-browsing-foundation-tree-regeneration-central
Ungulate-Disturbance Interactions in Hemlock Ecosystems at Harvard Forest since 2012	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/ungulate-disturbance-interactions-hemlock-ecosystems-harvard
Ungulate-Forest Interactions in Partially Harvested Oak-Pine Stands in Central Massachusetts 2009	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/ungulate-forest-interactions-partially-harvested-oak
Vegetation Response in Simulated Hurricane Experiment at Harvard Forest since 1990	Harvard Forest	https://www.uvm.edu/femc/data/archive/project/Harvard_Forest_Research/dataset/vegetation-response-simulated-hurricane-experiment-harvard
Vermont Forest Health Monitoring Program	Forest Ecosystem Monitoring Cooperative	https://www.uvm.edu/femc/data/archive/project/forest-health-monitoring
Wind Disturbance in Temperate Forests	University of Vermont, Rubenstein School of Environment and Natural Resources	https://www.uvm.edu/femc/data/archive/project/cdlwinddisturbance

Providing the information needed to understand, manage, and protect the region's forested ecosystems in a changing global environment