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# Project Summary

# The Role of Climate in Forest Monitoring and Assessment: A New England Example

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**The development of climatological information products to support ecological data collection and analysis is described. The scope of research is narrowed to issues of direct interest to the joint U.S. Environmental Protection Agency Environmental Monitoring and Assessment Program (EMAP) and U.S. Department of Agriculture Forest Service New England Forest Health Monitoring program (NDFHM).**

**Characteristics of climatological persistence and recurrence that are especially critical to New England forest health and productivity are identified. These include physical disturbance events (tornadoes, high winds, and wet snowfall), drought, growing degree days, and late spring freezes. Climatological data are assembled and presentations developed based on the analysis issue to be addressed: background (status and persistence), most recent decade (short-term trends), and most recent sampling year (near-term impacts). A Geographic Information System is used for presentation, data management, and analysis.**

**Major research findings focus on the application of climate data and products to operational ecological monitoring and analysis situations. Possible future activities are identified in the areas of new climatologies, program design, database acquisition, or development and applied research. All these efforts would result in significant contributions to the development of a more coherent theory of natural disturbance and ecosystem response.**

***This Project Summary was developed by EPA's Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

## Project Overview

The primary goal of this report is to define a working hypothesis of climate/ecosystem interactions suitable for operational environmental monitoring programs. Such an exercise is necessary before climate research and analysis can become an integral part of these programs. Although the research has focused on a specific cooperative EPA and USDA sampling project initiated during 1990, insights are provided pertinent to the general topic of climate/biosphere interactions.

The approach adopted is to establish a common ground of concepts and terminology to facilitate exchanges between the climatological and ecological communities. This is accomplished through the careful definition of key terms and a discussion of the role of climate in current ecological theory. The discussion provides an avenue for identifying major environmental policy issues, establishing which of these are significantly climate related, and initiating the development of the necessary data and analysis products.

The hypothesis developed is that the relationship of climate (the synthesis of weather) to ecosystems depends on the

time and space scale of the biological system to be monitored and the analyses to be performed. Climatological averages and ranges reflect one set of physical bounds on the number of possible ecosystem states represented within a landscape. Inter-annual disturbances affect ecosystem health and productivity as measured by changes in growth, system energetics, plant populations, and species characteristics. Disturbance events affect the persistence and recurrence of ecological states. Disturbance events vary with geographic location and can be described by their frequency, size, and magnitude. Many forest status, health, and trend indicators, particularly those based on directly monitored observations, may be incorrectly interpreted and inappropriate associations between observations construed unless mitigating or compounding climatological factors are considered as well.

## Data and Methodology

The vast array of possible climate/ecosystem interactions that could be examined is substantially narrowed by "targeting" the analysis to a particular geographic setting. In this case, the cooperative U.S. EPA EMAP-Forests pilot and USDA Forest Service New England Forest Health Monitoring (NEFHM) project has been selected (Figure 1).

Data bearing on several major categories of ecosystem disturbances facilitate the assessment of forest response to severe weather and tornadoes, hurricanes, drought, late spring freeze, late spring snowfall, and growing degree days. Summaries of climatological means and disturbance characteristics such as event frequency, magnitude, and size are developed with particular attention to their relevance to forest status and health assessment. Given the events listed above, Table 1 summarizes all climate disturbance summaries pertinent to the New England region. An "X" indicates that the characteristic has been summarized within this report. A blank entry indicates disturbance attributes that were not characterized. The entire set of products are stratified into three groups defined by the analysis issue to be addressed: background (status and persistence), most recent decade (short-term trends), and most recent data year (near-term impacts).

Products that describe the long-term, or background climate of the New England region are the first of the three groups discussed. Using the earlier analogy of ecological persistence and recurrence, the background climate defines, in part, the "bounds" for the recurring ecosystem states.

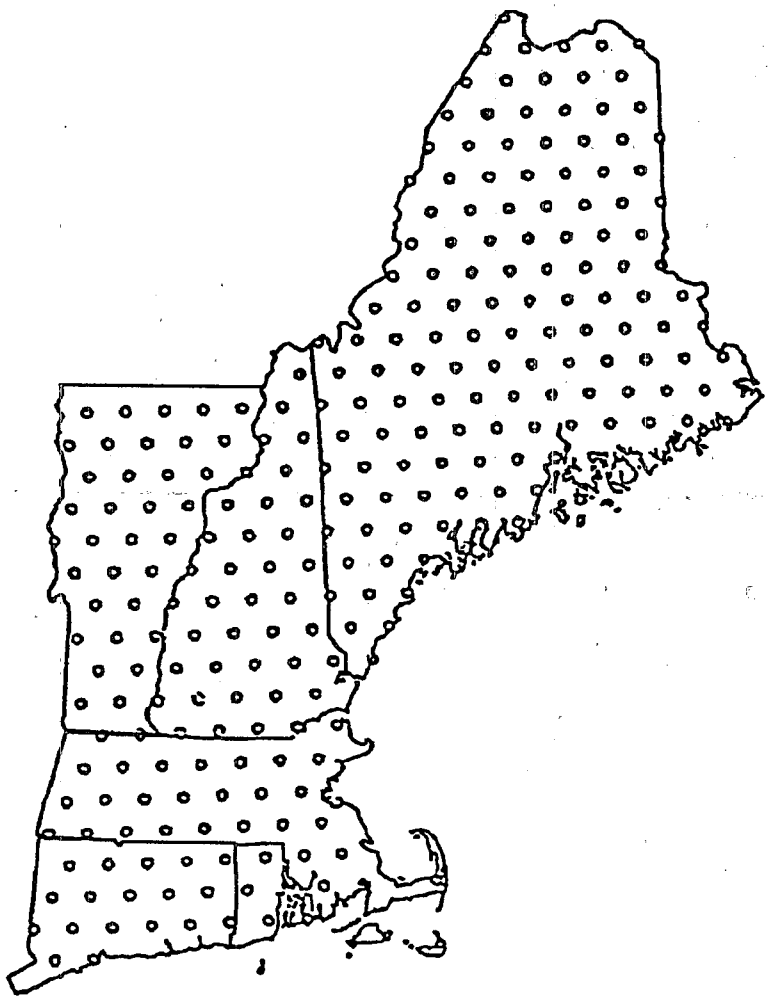

***Figure 1.*** *The New England Forest Health Monitoring Program network of potential sampling sites.*

The second product group, a 10-year analysis, emphasizes short-term variability of climate stress. This also represents more closely the regional response time of forest ecosystems to chronic climatological stress.

Figure 2, developed as part of the decadal summary, contains a summary of drought, growing degree day (GDD) sums, spring freezes, and warm spring snowfall events in terms of the percent of the study area affected. Drought, small GDD totals, late spring freeze, and late snowfall dates are included if, based on the entire climate record for a station, the current value is expected to occur fewer than once in 20 years. A one-in-100-year return period would be more appropriate, but statistical approximations will be needed before values for most variables and locations can be determined.

The purposes of Figure 2 are 1) to facilitate visual identification of short-term trends in forest-related climate variables, 2) to identify the frequency and size of regional-scale climate events, and 3) to identify associations of stressful climate conditions. This figure does not quantify the amount of forest damage or forest response to these stresses. The impact of

**Table 1.** *Examples of Climate Disturbance (Stress) Products Developed for New England*

| Climate Variable | Frequency | Magnitude | Size |
|---|---|---|---|
| Tornadoes | intra-annual | intensity only | X |
| Wind | intra-annual | | |
| Tropical cyclone | X | intensity only | X |
| Drought | X | intensity duration | X |
| Temperature | X | intensity only | X |
| Precipitation | X | intensity only | X |
| Growing degree days | X | intensity only | X |
| Late spring freeze | X | intensity only | X |
| Late spring snowfall | X | intensity only | X |

environmental stress will vary with ecological system (although all of these measures reflect local conditions) and combinations of stresses may result in threshold behavior (discontinuities) or nonlinear increases in damage. The figure represents a consistent intensity of stress across stressors and permits, for this decade, some generalizations of size/frequency relationships which could be associated with monitored forest status, health, and trend indicators.

Next, this 10-year summary is related to the NEFHM sampling network. A distribution of event/sampling area intersections is constructed. Geographic locations that are classified as being located in the upper tail of the distribution represent areas experiencing a large number of relatively unusual climate events. Monitored data from these areas might be expected to contain stress characteristics that could be associated with natural climate stress. Geographic locations classified as belonging in the lower tail of the intersection distribution indicate relatively few climate-related disturbance events. Stress-related ecosystem characteristics in these areas could be associated with non-climate stressors.

The final climate summary example is developed for the most recent available year of data. Such summaries are primarily used to aid in the interpretation of the current year's sampling program. These products and analyses, in combination with supplemental field observations, can help to identify areas in need of special studies and to suggest previously unknown sources of stress or mortality.

## Report Summary and Future Work

Forest response research has established that climate plays an important role in forest ecosystems, influencing both persistence and recurrence characteristics of the landscape. Forests act as environmental integrators of both natural and anthropogenic disturbances. New monitoring programs such as EPA EMAP and the USDA FHM program hope to capture forest response to changes in these stresses, but their observations cannot be correctly interpreted without an ability to discern between natural climate variability and signals of permanent climatological change. Likewise, changes in ecosystem health and productivity cannot be accurately attributed to changes in societal behavior unless the ecosystem response to natural disturbance can be better understood and predictively modeled.

This research addresses several critical climate impact issues. First, while existing historical networks may be adequate for landscape or regional analyses, local geographic influences critical to the development of accurate predictive models (a stated goal of the FHM) may be lost or misinterpreted by using nonrepresentative climate observations.

Next, although there are usually far more climate data available for analysis than for ecosystem status and health, there are serious quality control and representation problems. Some of these issues are currently being addressed by the atmospheric science community, but true, uniform quality control of cooperatively observed weather conditions is a formidable task.

Finally, new data analysis technologies offer unique opportunities to integrate previously intractable multimedia research issues. With increased flexibility come new challenges to research problem definition. One issue illustrated in this research is the problem of graphically representing an inherently temporal process (climate/forest interactions and dynamics) in a spatial setting (regional analysis). Remotely sensed and new ground-based monitoring programs increase analysis opportunities, but to realize this potential, there is first the need to establish the new data in the assessment process. Even if remotely sensed data provide improved characterization of spatial and temporal variability of the climate, comparative relationships between historic data sources and new sources must be established before they are routinely incorporated into ecological assessment products.

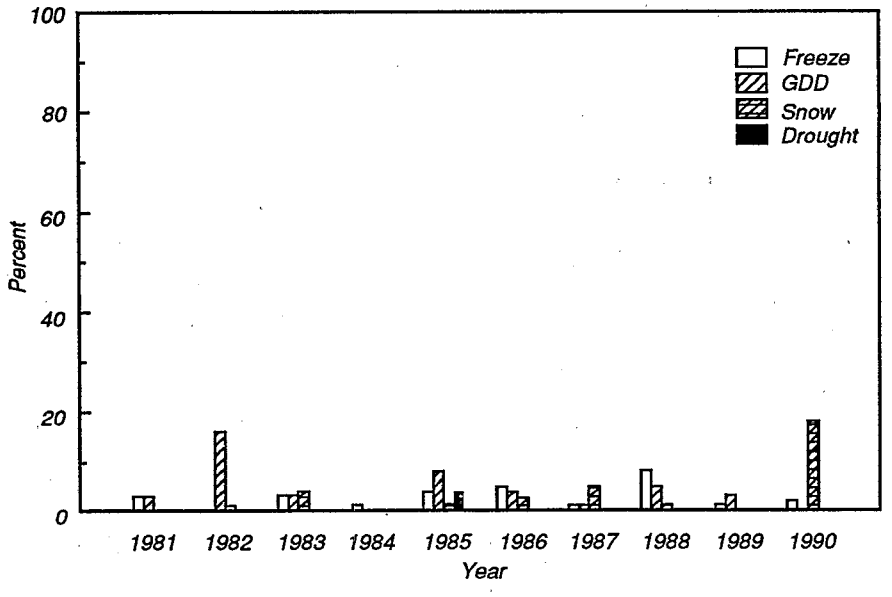


**Figure 2.** *Percent of New England region impacted by climate stress, 1981-1990.*



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*The complete report, entitled "The Role of Climate in Forest Monitoring and Assessment: A New England Example," (Order No. PB92-132869/AS; Cost: $26.00, subject to change) will be available only from:*

*National Technical Information Service*
*5285 Port Royal Road*
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