

Use of Satellite Image Data to Identify Changes in Hemlock Health Over Space and Time

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Abstract

Eastern hemlock (*Tsuga canadensis* (L.) Carrière), is an important component of ecosystems in the northeastern United States and is the primary coniferous species in southern Connecticut. Hemlocks play a unique role in the region by providing spatial and structural habitat diversity that supports many wildlife and fish populations. Widespread damage to this species would have significant impact on water quality, wildlife, and recreational opportunities in the region. Widespread infestations of hemlock woolly adelgid (*Adelges tsugae* Annand) together with occurrences of hemlock looper (*Lambdina fiscellaria* (Guenée) and *L. athasaria* (Walker)), hemlock scale (*Fiorinia externa* Ferris), and shortneedle evergreen scale (*Nuculaspis tsugae* (Marlatt)) have led to a significant decline in hemlock stands in the area. There is a critical need to measure, monitor, and predict the effects that these pests will have on hemlock health. Remote sensing technologies and satellite images can provide a landscape view of the forest. Numerous studies have used satellite-based remotely sensed data to identify and map forests. The purpose of this study was to develop a technique to classify health of eastern hemlock stands using historical satellite images.

The study area included more than 110,000 ha of the lower portion of the Connecticut River watershed, ranging from approximately Middletown, CT, to just north of the river mouth at Long Island Sound. Hemlock covers 2,257 ha (about 2%) of this area. Specific Landsat Thematic Mapper (TM) images of the area were selected based on the least amount of cloud cover present on dates prior to leaf-out of deciduous trees. Images recorded in 1983, 1985, 1988, and 1995 were used in this study. The image dated April 1985 served as a baseline image to locate hemlock stands prior to the time of significant hemlock decline due to hemlock

woolly adelgid. Using a Global Information System (GIS), a contiguity analysis was done on the hemlock category to remove all groups of hemlocks less than 1 ha in area, and the hemlock mask file was then used to locate hemlock areas in all TM images. The Modified Soil Adjusted Vegetation Index₂ (MSAVI₂) transform was then performed on the most current TM image (1995) to provide a hemlock health classification. Techniques described in the U.S. Forest Service Crown Condition Rating Guide were used in Spring, 1996, to evaluate the health of 600 trees in the study area, and a Global Positioning System was used to locate each test site accurately. The overall accuracy of 1996 field data compared to 1995 satellite data was 82.11%. Based on this information, the hemlock mask file and MSAVI₂ transform were applied to the images recorded in 1985, 1988, and 1993.

Hemlock decline was monitored by comparing the health classification of each hemlock pixel in images captured at different times. A comparison of the images from the 4 different years showed a general decline in hemlock health over time. Using the baseline image taken in 1985, 60% of hemlock trees in the study area were classified *Average*, 19% *Good*, 17% *Poor*, and 4% *Very Poor*. In 1988, the largest change in the study area was a reduction in the *Average* health class to 45% and an increase in the *Good* and *Very Poor* health classes to 26% and 11%, respectively. There was a substantial decline in hemlock by 1993. The *Good* and *Average* classes fell to their lowest values of the study, 15% and 32%, respectively. Conversely, the *Poor* and *Very Poor* classes reached a peak, 26% and 27%, respectively. By 1995 there was overall improvement in health of hemlock in the study area; *Good* and *Average* classes improved to 64%. The *Poor* and *Very Poor* classes declined to 23% and 13%, respectively.

We conclude that remote sensing and GIS can be used to classify the health of eastern hemlock stands using the MSAVI₂ transform and this technique can be used to classify historical images when coexisting field data are not available. This technique may be somewhat subjective, but it does agree favorably with reports of past health conditions in the study area and can serve as an effective tool for future research on forest health.

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