Forest Watch

15 years of school-university partnership

Forest Watch (http://www.forestwatch.sr.unh.edu) is a project in which data on tree characteristics are collected by teachers and students in grades K-12 as an integral and important component of research on forest ecosystems in New England. Each participating classroom is given study plot. Currently under study are White Pine and Sugar Maple. The project originated in 1986, when Concord High School science teacher Phil Browne appealed to NASA scientists to help his students regain their trust in science and in NASA. UNH scientist Barry Rock, answered Browned and together, they brainstormed Forest Watch. The project conducts teacher training workshops for teachers joining Forest Watch.

Barry Rock, co-founder of Forest Watch, does field work with two students.

The stated educational objectives of Forest Watch are to:

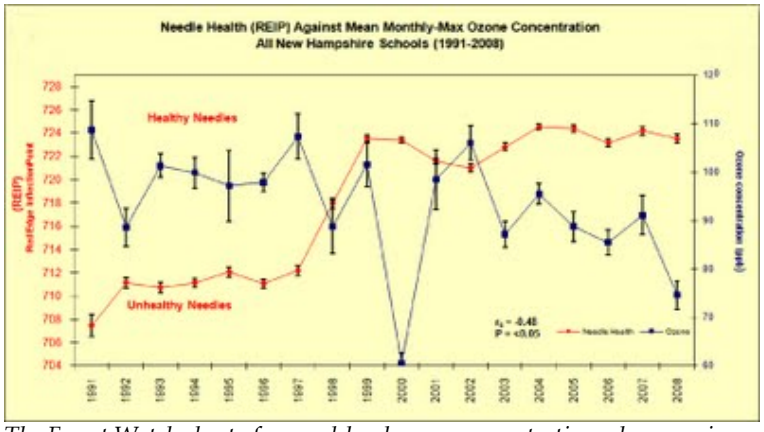
- Engage K-12 students in authentic science.
- Engage students in using 21st century scientific and technological tools.
- Enhance students' critical thinking about science.
- Develop students' data analysis and communication skills.
- Encourage team-work and inquiry-based learning.
- Meet state and national standards in science, technology and mathematics.
- Build students' interest in and aptitudes for science, technology and mathematics.

The science objectives are to:

- Assess white pine health at both the local and regional level.
- Correlate student biometric measurements with spectral measurements of needles.
- Compare biometric and spectral measurements with tropospheric ozone data.
- Document the use of white pine as a bio-indicator of the health of New England forests.
- Develop a long-term database.
- Assess white pine health using a site index.

In White Pine (Pinus strobus) Research, the Forest Watch program has studied the effects of ground-level ozone on the health of New England's forests since

1991. The Forest Watch chart of ground-level ozone concentrations shows that when needles were unhealthy in the 1990s, ozone levels were high. When ozone levels began to drop, white pine health soared. White pine is a bio-indicator tree, being sensitive to air pollution and ground-level ozone exposure. Many other species of trees in the New England forest are able to close their stomates against ozone when levels climb, but while White Pine may close stomates at very high levels of ozone, they maintain open stomates at levels of 60 to 80 ppbv. Forest Watch has confirmed the connection between ozone levels and white pine health. Over the past two decades, in all but a few drought years, white pine health has declined when ozone levels were high. White pine health has improved when ozone levels dropped.



The Forest Watch chart of ground-level ozone concentrations shows an inverse relationship with white pine health. When needles were unhealthy in the 1990s, ozone levels were high. When ozone levels began to drop, white pine health soared. Research by scientists and students has helped to improve air quality standards set by the Environmental Protection Agency.

Maple Watch grew out of a 2008 a master's degree thesis study of thirty trees near the Bearcamp Valley, New Hampshire, that found water stress in 100% of trees; reduced chlorophyll content in 60%; early abscission of leaves in 80%; reduced growing season in 70%; and poor fall foliage color in 80%. Maple Watch continued in 2009 and 2010 and had least two schools piloting the program in 2011. Maple Watch aims at addressing projections by the U.S. Forest Service that climate change--warming temperatures--over the next century may eradicate most of the sugar maples in the United States. This study involves five components:

- Historical records and climate change measures
- Anatomical measures of maple health
- Spectral measures and remote sensing
- Chemical measures of maple health
- Outreach partnership with citizen scientists

As an example, analysis of leaves from sugar maples in a classroom plot on Bald Mountain in Campton, NH, showed damage of a smog event which occurred on May 26, 2010. Forest Watch research concluded this was caused by peroxyacetyl nitrate, a powerful oxidant.

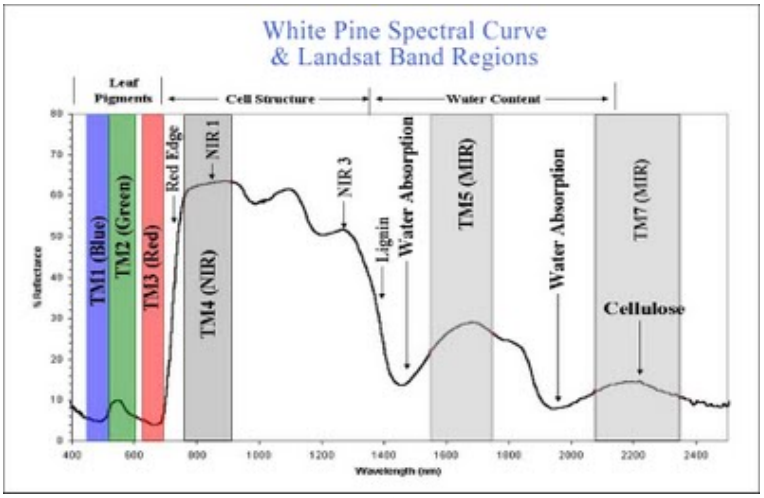
Forest Watch data all the way back to 1993 are posted on the Internet - http://www.forestwatch.sr.unh.edu/data.shtml

Forest Watch also uses satellite imagery from remote sensing instruments that capture light reflected from Earth three bands of visible light (blue, green and red that our eyes can see) as infrared light (in Band 4), near infrared (in Band 5), and very long wavelengths in Bands 6 and 7. Forest Watch uses

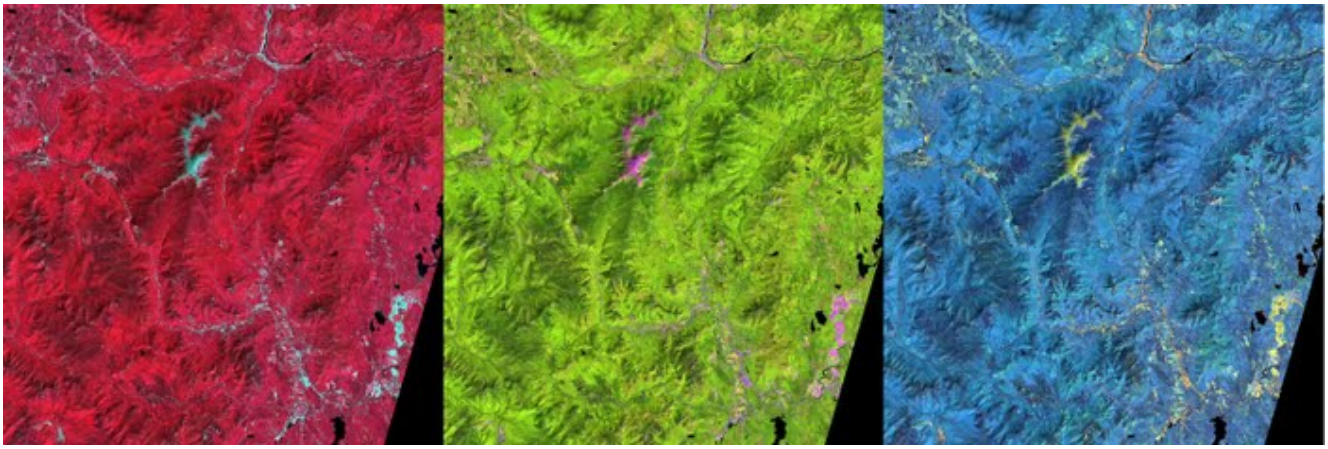
Multispec software to mix and match any of the 7 Landsat bands of information. Each different combination allows us to see different Earth features more clearly.

To illustrate how various wavelength bands can be displayed as 3-color visible light images, below are three views of Mt. Washington, the tallest mountain in New Hampshire. Forest Watch schools in North Conway and Bartlett lie just south of the mountain.

Each view is different. Each gives us different information about the mountain, the forests, lakes and towns around Mt. Washington. What can you see?



A spectral curve shows the location of each Thematic Mapper Landsat Image band, 1, 2, 3, 4, 5 and 7. Each band and comparisons of bands give scientists information about the health of plants as well as the identity of other features on Earth. The same light which a satellite sees reflected from Earth is what we see in the laboratory reflected from leaves or needles. This image shows the spectral curve of light reflected from some Forest Watch white pine needles.



The red image is a 4,3,2 selection. That means Band 4, the near infrared, a highly reflective band of light, is shown in the red color channel. Band 3, the reflected red light which is very low in trees which absorb red light, is shown in the green color channel. Band 2, the green light which plants reflect, is displayed in the blue color gun. The combination gives us a bright red picture. This combination often tells us about the difference between the near infrared high reflectance and the deep absorbance of light in the red band, an indication of lots of chlorophyll in forest tree tops.

The green image is a 5,4,3 selection. The mid-infrared band, Band 5, is displayed in the red color channel. The near infrared Band 4 is shown in the green color channel. And the red visible Band 3 is displayed in the blue channel. Which of the three bands do you think is more reflective? Did you guess "Green!" This combination allows us to compare water in plants. Can you decipher where the conifers are and where the deciduous or mixed forests are?

The blue image is a 2,5,4 selection. Green light reflected from forest canopies, captured as Band 2 by Landsat, is displayed in red! Mid-infrared light is shown in green. And near infrared is shown in blue. Again, which band is most reflective? Healthy plants generally reflect 60 to 80% of all the near infrared light which falls on them. Which are more reflective —deciduous trees or conifer trees?