FOREST WATCH DATA BOOK 2012-2013

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Research with 2011 Needles

Chapter One - Introduction

The *Forest Watch* program studies the effects of ground-level ozone on the health of New England's forests. K-12 students, teachers and University of New Hampshire researchers have been working together each year since 1991 collecting large amounts of data annually from white pine (*Pinus strobus*) trees all across New England. National Acid Precipitation Assessment Program (NAPAP) research in the 1980s demonstrated that the white pine is a bio-indicator, sensitive to air pollution and ground-level or tropospheric ozone exposure. Many other species of trees in the New England forest are able to close their stomata against tropospheric ozone when levels climb. White pine, research finds, may close stomata at very high levels of ozone but maintain open stomata at levels of 60 to 80 parts per billion (ppb).

Forest Watch has confirmed the connection between variations in tropospheric ozone levels and white pine health. Over the past two decades, in all but a few drought years, white pine needle health during summers has declined when ozone levels were high (between 60- 80 ppb). White pine needle health has improved during summers when ozone levels were low (generally below 60 ppb). When white pine needles are damaged, they exhibit distinct and measureable tip necrosis and chlorotic mottle. Ozone damages needle mesophyll cells internally, reducing chlorophyll and cellular water concentrations. With reduced photosynthesis and less water, the needles make less sugar. The pines show reduced growth in needle length and reduced needle retention (fewer years of needles are retained). Internal damage is visible in yellow chlorotic mottling along the length of needles and in brown tip necrosis (See Chapter 2). These biometric measures of plant health correlate with spectral measures of light reflected from needle surfaces (See Chapter 5).

In addition to student measurements of tree and needle biometric data, each participating school sends a duplicate set of branch and needle samples from their trees to UNH for spectral analysis. Freshly-collected samples from each of five tagged trees are placed in Ziplock bags along with a wet paper towel, placed in a small picnic cooler (supplied by the program), and sent to the Forest Watch Program Coordinator by next-day mail. Once received at UNH, the first-year needles are scanned with the Visible Infrared Intelligent Spectrometer (VIRIS) to collect high-resolution reflectance spectra for each of the five trees. These spectral reflectance data are then analyzed to determine a range of needle characteristics, including chlorophyll concentrations, state of cellular health, and water content (See Chapter 5). The student biometric data are then compared with the reflectance data, resulting in an overview of the state of health of each of the five trees for the summer of 2011.

K-12 students, teachers and UNH scientists have collaborated to build a 22-year-long data base of white pine measurements, tracking the impact of tropospheric ozone on the white pines of New England's forests. Forest Watch Data Books provide a remarkable history of our measurements and findings and evidence of changing needle health over the past two decades.

2011 Needles

Current data presented in this report was collected by participating schools in either the fall of 2011 or the spring of 2012. These data are based on first-year needles which matured during the summer of 2011. The information in this booklet represents the work of students who have collected forestry data from63 white pines near 12 schools. Long term spectral and biometric analysis represents the work of thousands of students and hundreds of teachers who have contributed time and effort to the Forest Watch program over the last 22 years.

This year's report begins with an explanation of what ozone is, how it is formed, the differences between "good" ozone in the stratosphere and the "bad" ozone in the troposphere. The chapter explains how tropospheric ozone causes problems for humans and for plants. The chapter also includes a history of how ozone is monitored by the U.S. Environmental Protection Agency (EPA).

Chapters Three and Four examine troubling new findings about the white pines. As we discovered in 2010, the pines continue to show a drop in needle retention. And, as we will explore in Chapter Five, spectral measures show numerous first year needles exhibited water stress and early senescence, a first since 1993. In Chapter Three, we are honored to reprint here an article produced by Dr. Isabel Munck, a U.S. Forest Service plant pathologist, Barbara Burns of the Vermont Department of Forests, Parks and Recreation, William Ostrofsky, of the Maine Forest Service, and Kyle Lombard and Jennifer Weimer of the New Hampshire Division of Forests and Lands. The essay by Munck *et al*, 2011, explores several species of fungi which they have linked to the widespread needle cast reported by timberland owners across the region.

In Chapter Four, Forest Watch explores a bit further. Why are the pines suddenly so vulnerable to fungal attacks by species which have probably lived with the pine for centuries? Is something else stressing the pines? We consider atmospheric pollutants, both oxidants such as ozone and acid rain or fog as well as other possible contaminants carried in wildfire smoke. In opening this possible cause of stress, Forest Watch examines needles from four of our schools both in 2011 and 2012. In addition, we introduce a new web resource for interpreting atmospheric conditions and remote sensing information, The Smog Blog, produced by U.S. Air Quality, a daily diary and analysis provided by the University of Maryland, Baltimore County Atmospheric Lidar Group.

As always, the Data Book presents our analysis of spectral measures, including comparison of Red Edge Inflection Point (REIP) data with ozone reports, Chapter Five. Spectral measurements and the indices by which we "read" light reflectance are explained. We examine

what spectral measurements tell about the health of pine needles in 2010 and compare these new data with long term data.

The Data Book also presents biometric data gathered by schools, with our analyses of tree heights, live crown, diameter at breast height (dbh), foliar water content, needle retention, needle length and needle damage symptomology, Chapter Six.

Each school's spectral and biometric data are presented in Chapter Seven.

The stress which Forest Watch finds among the pines is distressing. *Pinus strobus* is a key species in the New England forest and a critical part of the timber industry. Our research may assist plant pathologists such as Dr. Munck in detailing the causes of recent needle cast and declining health. In using new access to remote sensing through The Smog Blog, we may develop pioneer ground truthing evidence of the impacts of atmospheric conditions. Like so many things in our trees' environment, atmospheric chemistry appears to be changing. Forest Watch, teachers, students and your partners at the University of New Hampshire are in the forefront of understanding these changes.

Highlights of Forest Watch in 2011-2012

Forest Watch held a second Forest Watch Student Convention in May 2012. Students from Gilmanton School and Josiah Bartlett School came to UNH to display projects and to talk about their research. These young scientists visited labs and scientists in the Institute for the Study of Earth, Oceans and Space. They also toured the Chase Ocean Engineering Laboratory to learn how robotic submarines are built and tested at UNH and how ocean floor mapping can be directed and monitored from a computer control center right in Durham. We will hold another convention this year on May 31.

Forest Watch teachers joined EOS scientists for a day of scientific fun early in June. Dr. Michael Palace and Dr. Crystal McMichael explained their latest research in the Amazon, finding and mapping terra preta, ancient soils made by farmers, still identifiable with remote sensing tools. The visiting teachers toured Dr. Ruth Varner's laboratory, meeting graduate and undergraduate students who were busy building and packing gear for their trip to Norway to measure how much methane is escaping from melting Arctic peat bogs. Lastly, the teachers trimmed their fingernails with Dr. Erik Hobbie and graduate student Andrew Quimette to learn about isotopes, chemical markers that could discern who is a vegetarian and who is eating corn-fed beef. This first treat for Forest Watch teachers was so successful we will repeat it in June 2013.

In August, 12 new teachers joined Forest Watch for a three-day workshop. Two more helped us pilot the workshop in June. We are delighted to welcome these 14 environmental science educators to the program. In the coming year, we hope all of them as well as many Forest Watch teachers who have not participated lately will help us to rebuild our research network.

Lastly, Forest Watch celebrated the formal retirement of Dr. Barrett Rock, founder of Forest Watch. Many founding Forest Watch teachers, staff members and graduate students honored him with gifts and reminiscences at a party in October 2012. With approval from the UNH Foundation, we have established a permanent Forest Watch Fund to support the annual work we do and, if the Fund grows, to endow its research and outreach in the future.

The New Hampshire Space Grant Consortium continues to support Forest Watch. We greatly appreciate their help and encouragement. Thanks to the website which Space Grant funds, we were able to share our protocols with two young researchers in Greenwich, CT. We scanned spruce needles for these students and helped them to interpret the data for their forest health research project.

Lastly, Forest Watch continues to provide stout roots for our emerging Maple Watch Program. Eight schools now plan to participate as pilot schools with Maple Watch. We also had interest in partnerships from the Rocks Estate in Bethlehem, NH, and Monticello, Charlottesville, VA. A grant proposal is now pending with the National Science Foundation. Maple Watch work with our pilot teachers and New Hampshire sugar producers was presented at the American Geophysical Union's 2012 annual meeting in San Francisco. The sprout is growing.

Thank you, Forest Watch teachers and students. You have helped Dr. Rock, now Professor Emeritus, to build a unique school to university partnership. Together we are doing important research with vibrant new horizons. Thanks, Forest Watchers!

The UNH Forest Watch Team

A small crew of personnel at UNH runs Forest Watch and produces the Data Book:

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Schools Participating in 2011 Studies

Connecticut	Town	In Forest Watch since…	# Trees Reporting
RHAM High School – Frank Schmidt	Hebron, Andover, Marlborough	1997	10
Tolland High School – Fred Szezciul	Tolland		5
Maine			
Morse High School – Carolyn Nichols	Bath	2008	5
Massachusetts			
Hanson Middle School – Wes Blauss & Russ Young	Hanson	1996	5
Springfield Central School – Naomi Volain	Springfield	2007	8
New Hampshire			
Community School – Kathy Flaccus	Tamworth	1993	5
Gilmanton Middle School – Mary Fougere	Gilmanton	1993	5
Lyme School – Skip Pendleton	Lyme	1994	5
Monadnock Regional High School- Gerry Babonis	Swanzey		
Salem High School – Norma Bursaw	Salem	1994	5
Sant Bani School – Robert Schongalla	Sanbornton	1992	5
Vermont			
St. Johnsbury School – Otto Wurzburg	St. Johnsbury	1997	5
Number of Trees			**63**

Chapter 4 also includes data from Prospect Mountain High School, Barnstead, NH, where Sarah Thorne and her students sampled 10 new Forest Watch trees in November 2012. These 2012 needles provide evidence of new damage to young white pine needles.