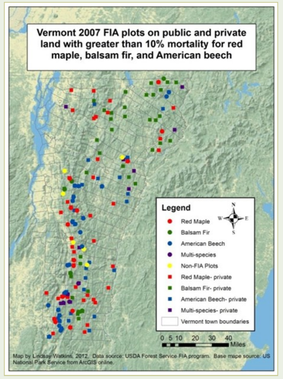
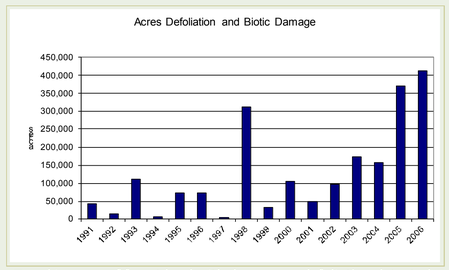
# Investigating causes for tree mortality in Vermont

## Background

A spike in the number of dead trees at sites visited from 1998-2007 as part of the Forest Inventory and Assessment (FIA) program triggered a more thorough investigation. Determining causes for mortality after the fact is challenging and can be difficult to assign a cause with certainty. Fortunately, annual monitoring of forest health from ground plots and from aerial detection surveys have provided substance for our investigation. Additional visits to damaged or declining stands complemented existing information. Our findings identified inciting (initiating) and contributing factors for species and locations involved in this mortality study.




*Trend in acres of forest land with damage or defoliation detected during annual aerial surveys. Principal causes for damage were: 1998- ice storm, 1999-2002– drought, 2002-2006– forest tent caterpillar.*

*Forest damage (brown areas) as seen from the air during annual aerial detection surveys.*

*The 1998 ice storm caused significant damage across Vermont (above). Some forests recovered by regrowing tree crowns so that the initial damage wasn't obvious after a few years (below).*


## Information Used

Long term damage to forests often involves several factors, one that causes initial stress, and others that compound tree stress and result in mortality.

In this study we used compiled information on known trigger events as well as possible compounding stress factors.

The trigger events included: 1998 ice storm, balsam woolly adelgid injury, ash yellows disease, beech bark disease, forest tent caterpillar defoliation, tree wounds from past logging, and windstorms.

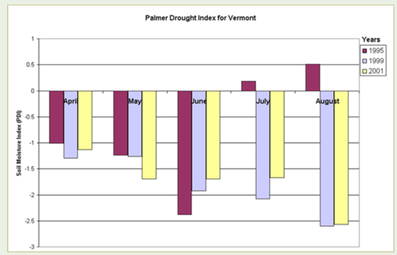
Additional factors that may have contributed to declines included: 1999-2002 droughts, site factors such as soil moisture, air pollution effects such as ozone injury or soil nutrient deficits.

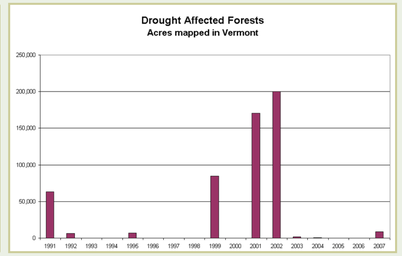
Since each tree species involved in the mortality event could have been affected by different combinations of factors they were considered separately and the conclusions are slightly different for each species.

## Beech mortality

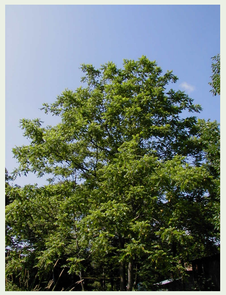
Beech mortality was likely initiated by beech bark disease. Beech trees showed reduced growth and poor crown condition due to beech bark disease, with stand age, elevation and lack of precipitation contributing factors in increased mortality.

Beech bark disease and drought

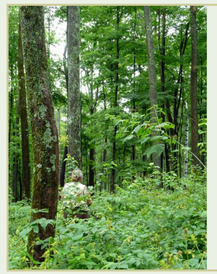



*Palmer drought index (left graph) shows below normal soil moisture over the growing season for 3 dry years: 1995, when there was sufficient rain in July and August; 1999 and 2001, when dry conditions that lasted all summer affected tree health in a variety of ways. Aerial surveys mapped drought symptoms during the drought period (right graph) and in many cases the drought compounded other stress factors to cause tree decline and mortality.*



*Healthy (left photo) and declining (right photo) white ash trees.*



## White Ash Decline

White ash declines were likely initiated by water fluctuations at well-drained sites. Ash yellows disease was confirmed at only one location in southeastern Vermont.

Ash yellows is the common name for a disease that can cause ash mortality. One indicator of the disease's presence is witches brooms (right photo) on tree trunks or branches. Current locations of the disease in the state include scattered areas of southern and central Vermont.

## Balsam fir mortality

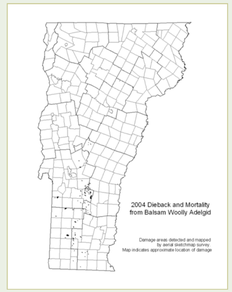
Balsam fir trees in southern Vermont experienced mortality from balsam woolly adelgid damage and lack of precipitation contributed to mortality.

In northern Vermont, we initially concluded that balsam fir trees likely experienced water fluctuations during drought years resulting in decline and mortality. However, more recent mortality has been found to also involve balsam woolly adelgid.

Balsam woolly adelgid and drought

*Balsam woolly adelgid (left photo) is an introduced pest that periodically causes waves of balsam fir mortality. Moderate populations of the white woolly insects appear on tree trunks.*

*Southern Vermont mortality from balsam woolly adelgid was mapped during aerial detection surveys in 2004 (right map).*




## Red Maple Mortality

Red maple mortality was likely related to internal decay from past logging wounds that reduced vigor but didn't cause mortality until other compounding factors reached a critical level. Tree age and multiple drought years may have been contributing factors.

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