Title: **Linking *Dothistroma septospora* to Climate Variability through Establishment of Regional Paleoclimate Baseline: Skeena Stikine Climate Network**

FSP No.: Y08-1269

Project Description: The recent effects of *Dothistroma septospora* on forest health and tree mortality has underscored the need to establish a causal relationship between forest health impacts (*Dothistroma*) and climate forcing events (El Nino/ La Nina, PDO). Woods et al. (2005) has shown *Dothistroma* to be related to climate change and further work by the University of Northern BC agrees with Woods et al., suggesting that *Dothistroma* responds sensitively to temperature and precipitation patterns. However, before we can establish strategies to reduce future risks we first need to develop a cause and effect relationship.

Understanding paleoclimate is a necessary process in reconstructing ecosystem responses to current climate forcing events; and eventually predicting ecosystem structure. Therefore in order to improve our understanding of inter-decadal to inter-annual-scale climate variability we need to extend our observation beyond the instrument record (Jacoby and D'Arrigo 1999).

Annually resolved tree-ring analysis is a widely accepted proxyindicator of climate variability. Providing baseline information on the spatial extend and natural variability of regional climate (Wiles et al. 1998). Instrumental records of paleoclimate offer significant evidence that the Northeast Pacific experiences distinct modes of climate variability (Ware 1995; Mantua et al. 1997; Zhang et al. 1997), with decadal-scale variability dominated by the Northern Oscillation Index (NOI) (Schwing et al. 2002) and the Pacific Decadal Oscillation (PDO) (Hare and Mantua 2000; Gedalof and Smith 2001, Gedalof et al. 2002;). Inter-decadal and inter-annual variability also tend to be strongly influenced by El Niño / Southern Oscillation (ENSO), which exhibits a spatial organization similar to that of the PDO (Gedalof 2002). Climate of the Northeast Pacific is further influenced by the Aleutian Low pressure cell during winter and spring months (Wiles et al. 1998). Recent multiproxy research suggests the frequency and magnitude of these processes are increasingly variable due to climate forcing processes such as PDO, ENSO, NOI, Pacific North American Pattern (PNA) and the Aleutian Low Pressure Index (APLI) (Gedalof 2002). Attendant to these processes are an increase in local climatic anomalies and extreme weather patterns emanating distinct ecosystem responses in the Pacific Northwest (Cayan et al. 1998, Mantua and Hare 2002).

This proposal describes an approach to reconstruct paleoclimate, using tree ring analysis, in the Skeena Stikine Forest District to relate climate forcing events to *Dothistroma* outbreaks. This work is aimed at deepening our understanding as to the effects of climate variability in this region. This project will use tree ring analysis to further build on recent work by Woods et al. (2005) and UNBC.

Dendroclimatology has two distinct advantages over other proxy indicators of paleoclimate. First, a living tree-ring chronology provides exact annual resolution. Second, the technique refines confidence by defining variability of measurement separately from the climate signal. Developing such paleoproxy indicators in the Skeena Stikine Forest District will aid to interpret recent forest health impacts (temperature and precipitation anomalies) and subsequent ecosystem responses (*Dothistroma*), while placing these changes in the context of longer-term climate (Davi et al. 2003).

Three high-elevation sites will be established to compliment work done by the UVic Tree Ring Laboratory. The sub-alpine Mountain Hemlock Zone has been chosen as Mountain Hemlock (*Tsuga mertensiana)* and White Spruce (*Picea glauca*) trees respond sensitively to climate and store coherent signals of low-frequency climate forcing processes within their radial growth (Smith and Laroque 1998). One hundred and twenty cores from 60 *T.mertensiana* and *P. glauca* will be collected, processed and analyzed to create a ring-width index from which a climate signal will be extracted. Spatial autocorrelations between the sites will address the extent of heterogeneity among climate variability within the region. Final output will include an annually resolved ring width index, a response function analysis of growing conditions in conjunction with statistically derived climate forcing relationships. Once established *Dothistroma* outbreaks will then be investigated.

Recent work at UNBC has identified *Dothistroma* outbreaks in Pinus species through host- non host tree-ring analysis. Through a data-sharing partnership this project will use these findings combined with co-located climate chronologies to link *Dothistroma* and climate forcing events, hopefully establishing a direct causal relationship.

Therefore this research will link climate forcing processes to *Dothistroma* outbreaks. Further enabling landscape level management of climate change impacts, such as further *Dothistroma* & MPB outbreaks and other timber losses related to environmental factors. This research also provides the platform for modeling and/ or predicting ecosystem responses such as insects, disease & growth and yield attributes of tree, stand and landscape scale systems. The findings will be presented in a paper suitable for formal publication followed by a stakeholder presentation.

Project Objective: The direct objectives of this project aim to reconstruct climate over the past 400 years to better understand climate impacts and ecosystem responses in this region. Specific objectives include:

1. Construct a climate chronology in the Skeena Stikine Forest District, using standard dendroclimatolgical techniques,
2. Link climate forcing processes such as El Nino, La Nina, Pacific Decadal Oscillation and Northern Oscillation to regional temperature and precipitation patterns and growth response,
3. Relate *Dothistroma* outbreaks years, and subsequent conditions, to climate forcing events (ENSO, PDO), as per temperature and precipitation patterns.

Experimental Design and Methods: Trees of the Pacific Northwest are long-lived, commonly reaching ages of 500 years (Peterson and Peterson 1994; Laroque and Smith 1999). Many of these species are sensitive to climatic variability, specifically mountain hemlock (*Pseudotsuga menziesii*) (Wiles et al. 1996; Gedalof and Smith 2001; Peterson and Peterson 2001) and White spruce *(Picea engelmannii*), (Luckman and Colenutt 1992; Peterson and Peterson 1994). Therefore, we propose to: (1) use climate sensitive trees to reconstruct temperature and precipitations patterns within the Skeena Stikine Forest District and (2) link climate variability to *Dothistroma* outbreaks through temperature and precipitation patterns. This brings forward our research question “Are *Dothistroma* outbreaks in the northwest linked to climate variability?”

The objectives of this project are: 1) to construct a climate chronology in the Skeena Stikine Forest District, using standard dendroclimatolgical technique; 2) Link climate forcing processes such as El Nino, La Nina, Pacific Decadal Oscillation and Northern Oscillation to regional temperature and precipitation patterns and growth response found in the tree rings; and (3) to relate *Dothistroma* outbreaks years, and subsequent conditions, to climate forcing events (ENSO, PDO), as per temperature and precipitation patterns.

To meet our first objective, three climate sites from around the Skeena Stikine Forest District will be used for paleoclimate reconstruction. Each site will be a high elevation Mountain Hemlock zone. Most important is that the site has shallow soils and a selection of long-lived, moisture deficient *Tsuga mertensiana* and *Picea glauca* trees. Two samples per tree and 20 trees per site -totaling 40 cores per site - will be the target sample size. Initial tree core processing and ring width measurement will be conducted with WinDendroTM. Samples will be collated and checked for signal homogeneity with COFECHA. A ring width chronology will be developed following standard techniques (Fritz, 1976). Gap dynamics along with growth related trends will be removed using ARSTAN, which will create a ring width index from the living chronology.

To resolve how the annual ring widths are correlated to temperature and precipitation we will use climatic data from close weather stations. Where possible, Environment Canada's meteorological stations will be utilized. Alternatively, Northwest Fire Control (Forest Protection) operates several stations in the region, some of which are year round stations. A common approach is to correlate between data sets. IN conjunction with this previously compiled climate data, from Forest Service Research Branch, will also be utilized where possible (proximity dependant). All data must be compiled, checked meticulously for errors and continuity, and transformed in preparation for lab analysis.

To meet our second objective a climate relationship will be extracted from the common signal held within the radial growth rings using PRECON. A principal component analysis will be calculated from existing climate data (temperature and precipitation) and regressed against the ring with index. Final output will include a response function analysis, which will be tested for significance using a bootstrap method to rule out residual autocorrelation problems from the chronology, and a ring width index for all three chronologies.

In order to compare the three chronologies we are proposing to use another principal components analysis (PCA) to extract common modes of variance between the three chronologies. The temporal period common to all three proxy records will define the data set. The resulting eigenvectors will be the common climate signal for that area. At this point inquiries into teleconnections between the PDO, ENSO, NPI, NOI, SOI and the CTI will be investigated. Correlation, regression and PC analysis will be the primary statistics used to identity common variance between ring width indices and climate forcing events. Once the strength of each teleconnection and the influence they have on temperature and precipitation is determined those relationships will be combined with Dothistroma outbreak data.

In order to meet our third objective, we will build on existing research and relate climate variability to *Dothistroma* outbreak conditions. In 2006 the University of Northern BC (UNBC) identified temperature and precipitation as driving factors in *Dothistroma* outbreaks, through host/ non-host tree ring analysis of Lodgepole Pine (*Pinus latifolia*) (per. Com Lewis 2006). A relationship also identified by Woods et al. (2005). Building on these, we are proposing to combine climate forcing information with a forest health data set to exploit the influence climate events may have on Dothistroma outbreaks.

UNBC will contribute an analog of Dothistroma outbreak years and supporting climatic conditions, derived from Pinus latifolia, through tree ring analysis. As Pinus latifolia was used in their work a longer term climate relationship was not able to be extracted. Thus this work will build on UNBC's efforts by offering the influence climate may have in creating outbreak conditions. Specifically we propose to combine ring width indices from the paleoproxy reconstructions with records of Dothistroma outbreak years (supplied through data sharing agreement with UNBC), and subsequent climate conditions, in a principle component analysis to identify which climate forcing processes, if any, contribute towards Dothistroma outbreaks. Thus, PCA will be used to meet our third objective of identify a relationship between climate variability and this forest health issue.