A Spatial Model for Foliar Life Expectancy in Douglas Fir Affected by Swiss Needle Cast

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Background

- Swiss Needle Cast (SNC), caused by *Phaeocryptopus gaeumannii* (Rohde) Petrak, produces chlorosis, defoliation, and growth loss in Douglas-fir tree plantations growing in OR and WA coastal areas
- Aerial surveys have recorded moderate and severe areas of SNC symptoms during the spring of each year since 1996. These surveys and derived models are available for use in indicating where Douglas fir should be planted versus other species, such as Western hemlock and Sitka spruce, which may perform much better with the upswing in SNC impact
- Previous modeling studies (Rosso and Hansen 2003, Manter et al. 2005) have indicated the potential relationship between SNC severity and climate factors including winter temperatures and summer moisture

Project Objectives

1. **Examine site and aerial survey data of SNC for trends and patterns related to potential environmental factors**
2. **Determine what factors contribute to SNC disease development and symptom expression**
3. **Develop models for short and long term prediction of SNC severity in the form of expected needle retention in years**
4. **Convert results into a format needed for forest management decision models**

Approach / Methods

- Accumulate SNC aerial survey data (Kanaskie et al. 2006) to indicate cumulative long term severity scores using the GIS GRASS (Neteler and Mitasova 2004)
- Use multi-year site monitoring data to model the relationship between cumulative survey scores and needle retention values (linear model, R^2 =0.88, log model, R^2=0.95)
- Compare cumulative SNC severity to coastal weather patterns (conducted by Fox Weather, LLC)
- Develop a spatial climate database over the 12 years of aerial surveys for relevant parameters from the Oregon State University PRISM group (Daly et al. 1994). These included GIS raster data layers: monthly average daily max and min temperatures, dewpoint, and precipitation. Geographically weighted regression (GWR) in GRASS GIS was used to downscale PRISM derived layers (summer relative humidity, winter average temperatures and degree-days) from 2.4 km to 200 m using elevation as the independent variable
- Sample 164 points from spatial raster data (cumulative survey severity scores, climate data, aspect) to conduct model building using multiple linear and robust regression in R (RDCT 2006)
- Use GRASS GIS with resulting models to develop a spatial model of expected needle retention using PRISM climate layers and aspect
- Convert aerial survey data to needle retention and overlay onto spatial model of needle retention for a combined model
- Place resulting data and models on a website for use by foresters, plantation managers, and other end users

Aerial Survey Results and Insights

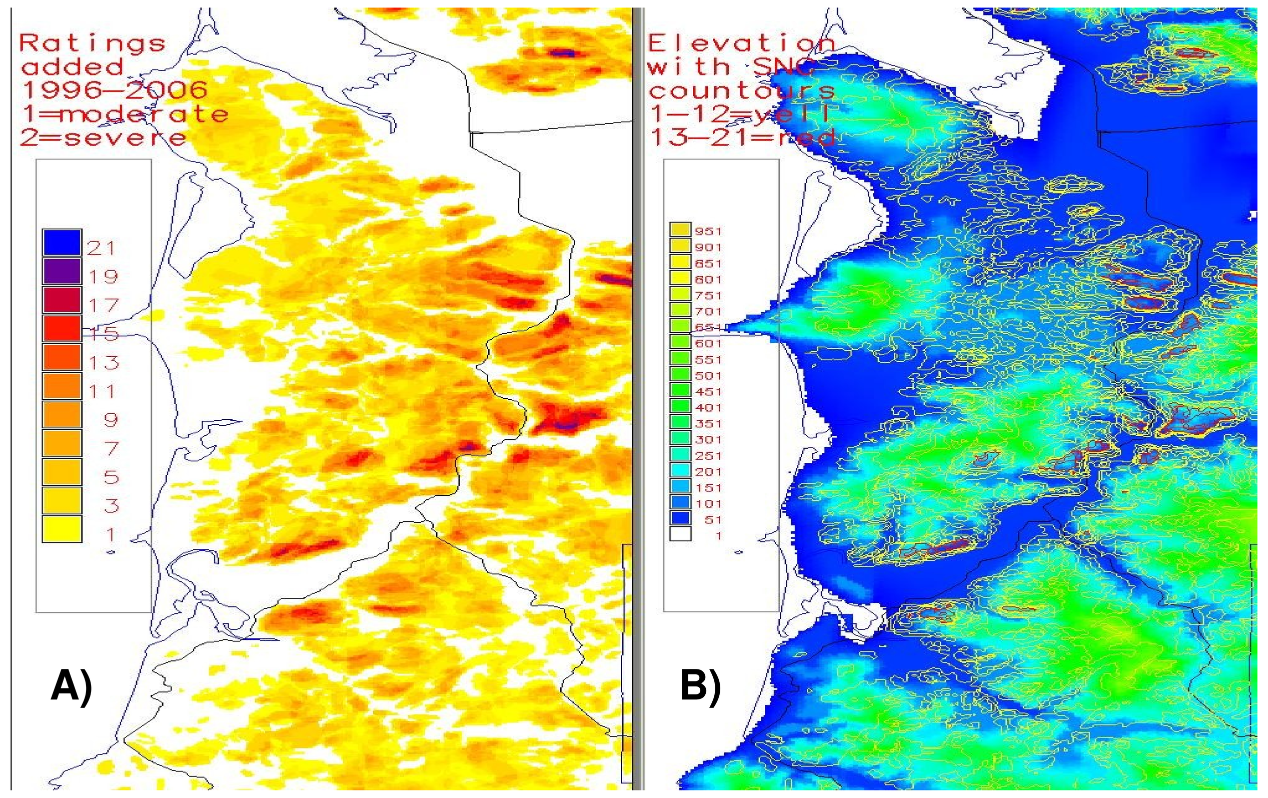

Fig. 1. A) Close up of aerial survey (cumulative survey scores) in Tillamook, OR area and B) Survey areas outlined over elevation background; showing greater accumulation of severity scores in areas especially a) for southern slopes of low to moderate elevation, and b) adjacent to coastal valley plains. See Fig. 2 for meteorological interpretation, Fig. 3E for full extent of cumulative survey data.

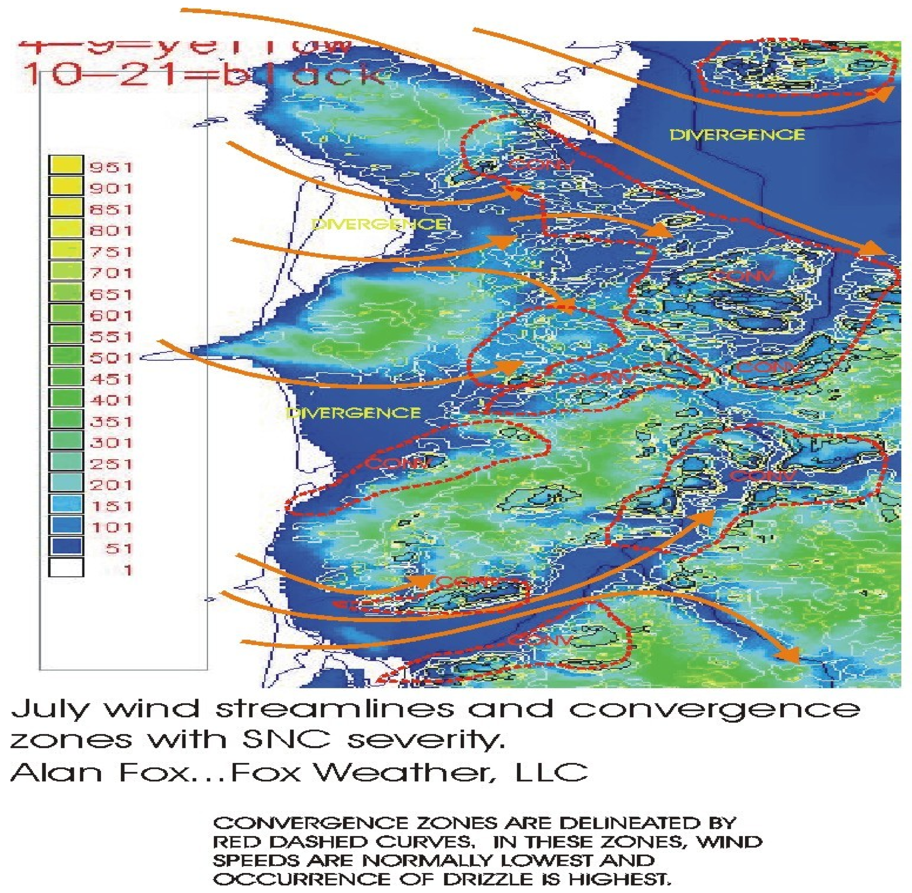

Fig. 2. Further close up and meteorological interpretation of Tillamook chronic SNC impact areas from cumulative survey data corresponding with coastal convergence areas, typically 200-400m elevation in the near-surface wind field below the marine inversion layer and where orographic forcing increases summer drizzle, fog, and RH (arrows and red dashed regions), as compared to lesser SNC impact in divergence zone areas, where greater wind speeds, air mixing, and lower moisture conditions occur.

Modeling Results

The final spatial model obtained for predicting survey scores converted to expected needle retention in years (Table 1) partially reflect findings of both Rosso and Hansen (2003) and Manter et al. (2005) in that winter temperatures (average winter degree-days >3° C. Dec-Jan) prior to spring surveys, average July RH in the summer prior to spring surveys, and aspect (coded as 2=SW, 1=SE and NW, and 0=NE) were significant in estimating converted survey scores for sites sampled randomly within the survey region (Fig. 3E) and augmented with sites for regions to the east of survey where SNC has had little impact thus far.

Table 1. Climate-based model of SNC needle retention (yrs) using augmented converted survey data as dependent variable. This is the final model to generate the GIS map layer in Fig.s 3D and 4.

Coeffic.	Estimate	Std.Error	t value	Pr(>|t|)	
(Intercept)	10.65510	0.21349	49.91	< 2e-16	***
July RH	-0.08918	0.00303	-29.39	< 2e-16	***
Winter DDs	-0.00836	0.00060	-13.87	< 2e-16	***
aspect	-0.15914	0.03452	-4.61	8.16e-06	***

Signif. codes: 0 `***' 0.001 `**' 0.01 `*' 0.05

Multiple R-Squared: 0.8982, Adjusted R-squared: 0.8963

F-statistic: 473.4 on 3 and 161 DF, p-value: < 2.2e-16

Model verification (spatial covariance analysis in GRASS) and validation studies (independent site measurements taken in 2005) indicated that these spatial models echo earlier site-based studies but that available spatial data resolution could be improved, especially in regard to estimating the effects of coastal fog and drizzle. Also there has been a lack of multi-year site data comparable to aerial survey years and extent needed to further improve model analysis.

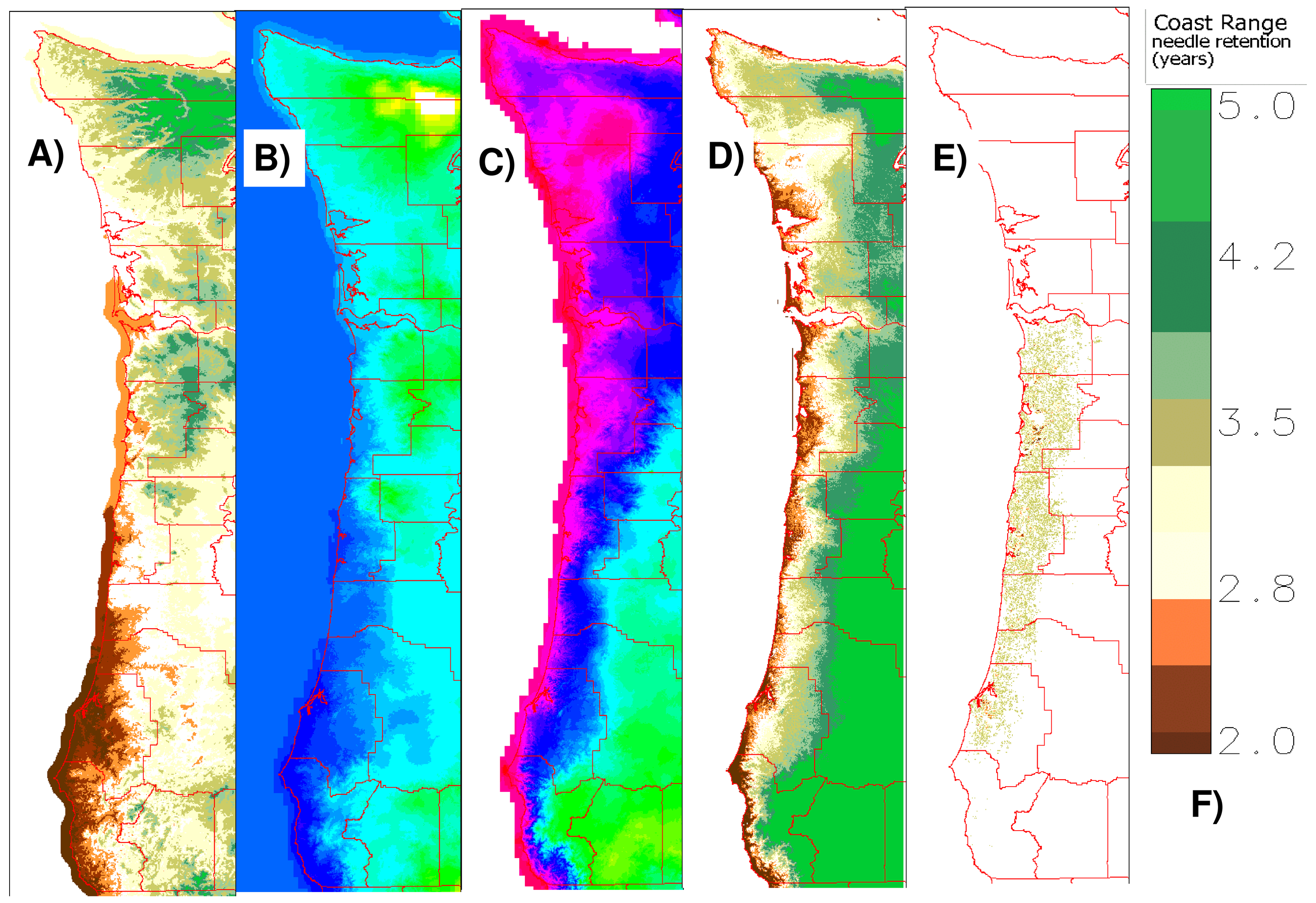

Fig. 3. Coast of W. Oregon and Washington data and models from left to right: A) Model based on that of Manter et al. (2005) which uses winter temperatures, B) Average Dec-Jan DDs from PRISM data, C) Average July RH from PRISM data, D) Current Model described in Table 1, E) Cumulative aerial survey data model, F) Legend for A), D), and E). Note similarities between A) and B), and C), D) and E).

Project Website

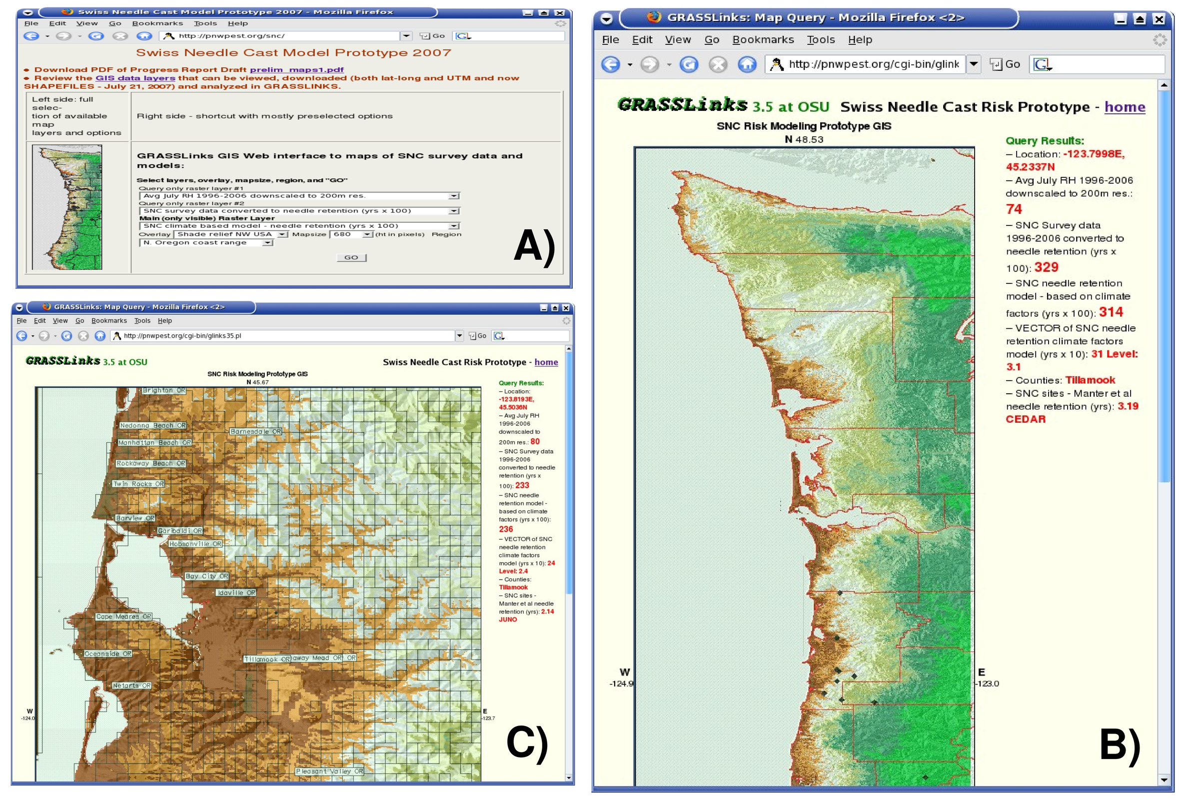

Fig. 4. Project web page examples A) *http://pnwpest.org/snc* homepage; B) GRASSLinks interface to all maps shown in Fig. 3 plus accessory GIS data; C) Zoom to Tillamook Oregon with query results of multiple GIS layers for local data cross-comparison.

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Conclusions and Ongoing Work

- **Regions of greatest SNC severity (expected needle retention 2.8 years or less, Fig 3D brown and orange areas) correspond with average July RH of 77% or higher and with traditional Western Hemlock/Sitka Spruce forest lands (OFRI 2002)**
- **Revise PRISM climate data analysis using new 800m data, revise models using additional survey, site sampling, and climate data layers. Possibly use satellite imagery/remote sensing (e. g. Landsat) analysis to a) better quantify yearly severity surveys, and b) find a better estimate of leaf wetness duration during early summer**
- **Link SNC impact models to more specific management models**