Predicting Forest Dieback in Maine USA: a simple model based on soil frost and drought

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A test model is described that uses routinely updated snow-depth, minimum and maximum air temperature, and total precipitation to predict dieback on *Acer saccharum*, *Betula* spp., *Fraxinus* spp., and *Picea rubens* in Maine USA. Dieback levels on these species, reconstructed historically from field insect and disease surveys 1920-1995, are used to verify and refine our model.

Our model, based on the simple average of soil frost in the most extreme winter month (DJF) and drought (Palmer Drought Severity Index) in the most extreme month of the growing season (MJJAS), accurately predicted the timing of major episodes of observed dieback. The magnitude of dieback predicted showed good agreement overall but with one exception -- that of *Betula* spp. 1939-1951-- marked by extraordinary levels of mortality in a population that was even-aged and 'over-mature'. In the subsequent episode (1955-1969), few vulnerable *Betula* spp. remained, and dieback of *Betula* was minimal despite high climate stress (Fig. 1). A response-lagged model based on the simple average of current-year soil frost and drought, and prior year actual dieback showed improved agreement with actual dieback (Fig. 2).

Statistical properties of the model were examined using stepwise linear regression. Whereas the composite model of all four species did not meet the Durbin-h test for 5% probability of no significant auto-correlation of residuals, models of individual species *Acer saccharum*, *Betula* spp., and *Picea rubens* (but not that of *Fraxinus* spp.) did meet this criteria.

Applications of these findings are discussed including corroboration of dieback being tracked annually by the US Forest Health Monitoring Program, and use of our model as a decision tool to assist forest managers in making timely decisions on intervention and treatment.

Figure 1. Predicted dieback (DRI, red line) based on climate *vs* actual dieback (blue line, average of four species, 1920 through 1995 period): (a) 7-year average, showing four historic episodes and species affected, (b) general trend (Double Averaging Method). Note recent episode predicted over 1998 through 2004 period.

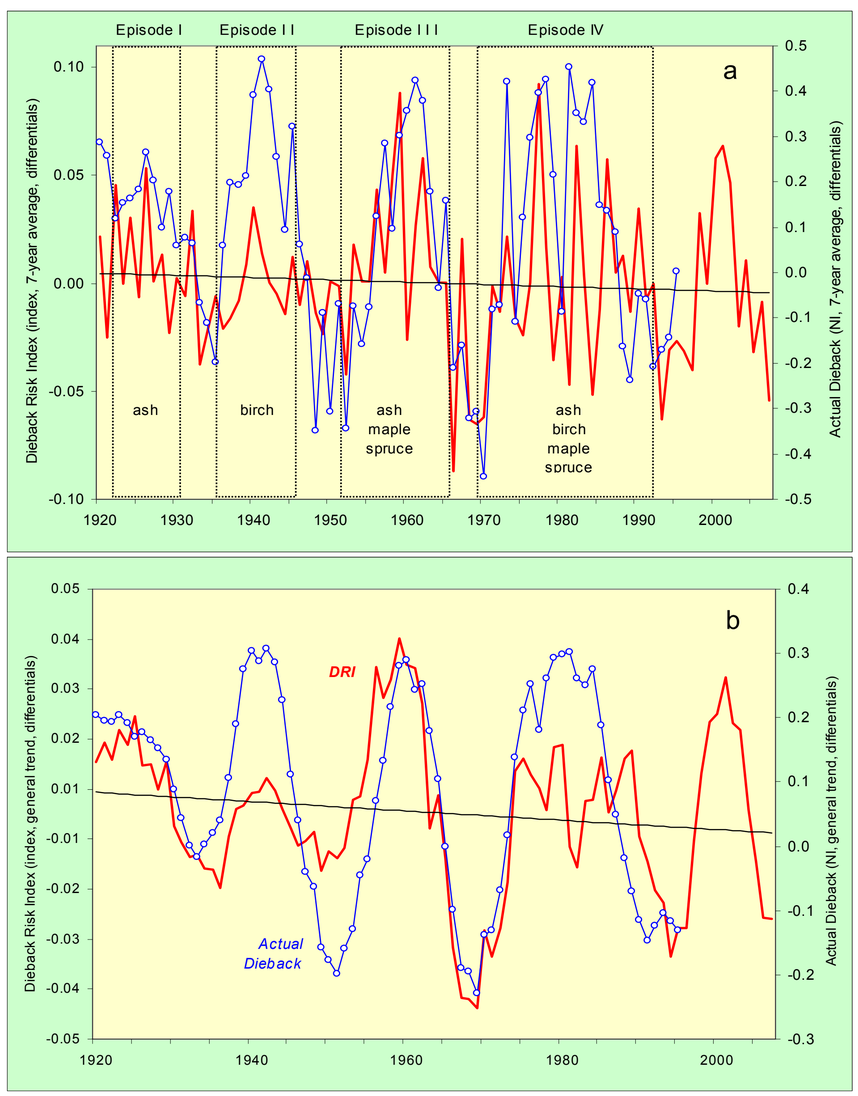
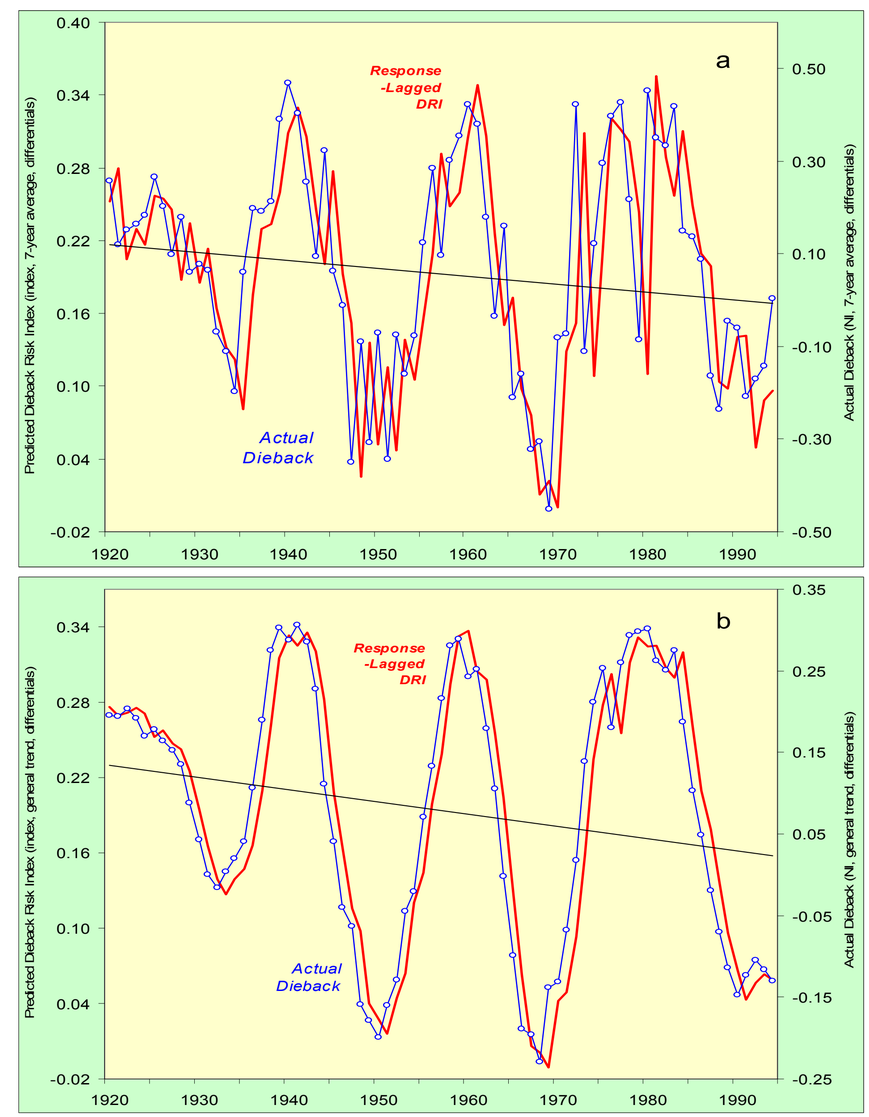
Figure 2. Predicted dieback (Response-Lagged DRI, red line) based on response-lagged model *vs* actual dieback (blue line, average of four species) over 1920 through 1995 period: (a) 7-year averages, (b) general trend (Double Averaging Method).