NON-STATIONARY SIMILARITY IN TRENDS OF MONTHLY RAINFALL IN THE TUSCAN APENNINE ALPS

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Purpose of Study

In 2010 Monash University (Australia) began a research program in collaboration with the “Corpo Forestale dello Stato, Ufficio Territoriale per la Biodiversità di Pratovecchio” (Forestale in the Tuscan Apennine Alps). Abetone is A, Camaldoli is C, La Verna is L, and Val di Piazza is V. The study was to investigate the relationships between recent and historical variability of climate, soil and site factors on the distribution and severity of the ‘but rot’ disease in silver fir (Abies alba Mill.) in the Tuscan Apennine Alps. Silver fir is susceptible to damage caused by drought or insufficient moisture availability. Studying silver fir forests in the study area (Fig. 1), and how climate alterations may impact on intensity and frequency of the complex disease is very important for the conservation and management of the species, and biodiversity. Therefore, one of our primary objectives was to assess if trends in rainfall show alteration during the 20th century in the Tuscan Apennine Alps, and that kind of variability in rainfall occurs in the study area, and if alterations in trends of rainfall follow a similar pattern at all sites in the study area.

Research Question

Do alterations in trends of rainfall follow a similar pattern during the 20th century across all sites in the Tuscan Apennine Alps (Middle Italy)?

Methods

- **Data**: annual, seasonal, and monthly rainfall
- **Enhanced visualization of medium-term variability smoothing by 7-years moving averages**
- **Variations in rainfall above and below the long-term mean: peaks and troughs in trend, upper and lower standard deviation**
- **Testing the presence of trends: Mann-Kendall trend tests**
- **Level of association in rainfall series amongst sites: matrix correlation (Pearson and Kendall)**
- **Matrix correlation and ANC could not show if similarity in trends among sites is stationary over time; then**
- **Pearson’s r correlation of 7-years moving averages to test whether similarity in rainfall series is non-stationary in the 20th century in the Tuscan Apennine Alps**

Results

Trends in annual rainfall in the study area

- **Annual rainfall trend**
  - Pearson’s r of 7-years moving averages
  - Time period: 1872-2002

Fig. 2 - A complex disease in a complex environment: 3 factors affect silver fir (“but rot”)

Trends in seasonal rainfall in the study area

- **Winter rainfall**
- **Summer rainfall**
- **Autumn rainfall**
- **Spring rainfall**

Fig. 1 - Location of the four hydrogeological subunits of the Tuscan Apennine Alps: Abetone A, Camaldoli C, La Verna L, and Val di Piazza V.

Table 1 - Pearson’s r of 7-years moving averages

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<th>ABE</th>
<th>CAM</th>
<th>LAV</th>
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</table>

Agglomerative hierarchical clustering

Dendrograms of similarity in the winter (left) and summer (right) rainfall series at the study sites as shown by agglomerative hierarchical clustering based on the Pearson’s correlation coefficient, method ‘complete linkage’. Results differ little when the ‘unweighted pair-group average method’ is applied. ‘Distance’ between sites changes with season and month.

Fig. 3 - Pearson’s r of 7-years moving averages

Non-stationary association of monthly rainfall series amongst sites in the Tuscan Apennine Alps

- **Results of this research show that the trends in seasonal rainfall in the study area (Tuscan Apennine Alps) vary amongst sites and with season during the 20th century**
- **Master series of seasonal rainfall are unlikely to show differences in rainfall that occur within the monthly level and are important to forest growth**
- **Similarity in trends of monthly rainfall from site to site varies irregularly with month and elevation in the study area**

Conclusions

- **The influence of seasonal and monthly rainfall on forest growth can be inhomogeneous over time and amongst sites and even at short-distance and similar elevation**
- **The analysis of effects of changes in precipitation on silver fir growth needs to verify climate/freeze growth relationships at the local level in relation to the specific trends in precipitation.**
- **The scope of this study is to verify whether**
- **Variability in rainfall is likely to influence the real response of silver fir at the local level, none of the statistics used nor regression analyses provide insights into the variability of association in monthly rainfall series over time**
- **However, marked variability in similarity of seasonal and monthly rainfall amongst sites produces the likelihood of different effects on silver fir growth.**