



Indicators of climate change effects: Relationships between crown transparency and butt rot in silver fir (*Abies alba* Mill.) in Middle Italy

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Climatic analysis conducted on the trends and changes in temperature and rainfall during the 20th century in the Tuscan Apennine Alps (Middle Italy) have highlighted the possibility that these changes have a significant impact on the growth and/or health conditions or stress in silver fir (*Abies alba* Mill.). In this framework, identification of appropriate indicators to verify relationships between stress symptoms, which are frequently caused by climate adverse conditions, and pathological phenomena is a necessary step functional to the identification of climatic-environmental impacts on forests.

The presence of butt rot pathology - a complex disease that causes rotting of the trunk internally - in silver fir is known the time as well as its severity. Nonetheless, very little research on the potential effects of changing climate conditions on the diffusion and intensity of butt rot seems available; thus, effects of climate change seem to be not excluded nor verified. No research or studies that quantify distribution and incidence or, especially, relationships of butt rot with adverse climatic and/or environmental factors were found. However, climatic alterations can have an impact on the intensity and spread of serious disease complexes and therefore it is of great importance to investigate the relationships between climate changing conditions, diffusion and incidence of butt rot in silver fir forests for their conservation and the management of species and biodiversity associated. As butt rot unlikely could be directly related to climate variables, crown transparency has been used as a proxy for tree growth, where climate variability is assumed to be the main driver of silver fir growth and stress. Actually, crown transparency is considered to be a main factor associated to tree growth, and healthier trees are assumed to grow faster than less-healthy trees. Thus, theoretically denser crowns would correspond to faster growing and healthier trees and indicate better climatic-environmental conditions, and vice versa. If so, crown transparency may be expected to be an indicator of butt rot diffusion and incidence. Our research shows that it may not be necessarily so.