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Green alder decline in the Italian Alps

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ABSTRACT

Decline of green alder (*Alnus viridis* spp. *viridis* [Chaix] D.C.) has been reported since the 1990s in the Alps. In recent years, this disease has spread all over the Alps and it is now recorded over all Italian alpine regions, with several secondary green alder stands heavily affected. Old damaged stands show dramatic changes both in tree species composition and coverage. Investigations were carried out in Trentino province (northern Italy) to describe the pathological and ecological aspects of this phenomenon.

Various fungi and insects were detected on declining trees, but no single agent appeared to be a primary cause; the most common coloniser of declining stems, *Cryptodiaporthe oxystoma* (Rehm) Urb., had an endophytic behaviour in green healthy tissues but failed to produce symptoms in artificial inoculations. There was a negative relation between altitude and alder decline. Furthermore, reduction in snow cover and trends of increase in winter temperature are possible influencing factors.

The spread of the syndrome may be related to climate change, reducing green alder vigour and allowing opportunistic parasites to cause host decline. The disappearance of green alder stands will likely affect soil protection, biodiversity and stand evolution in treeline forests of the Alps. More research is needed to define future management options.

1. Introduction

The impact of forest decline on the landscape, forest composition and forest structure as well as on management choices is strong (Innes, 1993). Sometimes the decline can correspond to a particular stage in a natural successional trend (Manion and Lachance, 1992); in other cases, external factors, such as pathogens, air pollution or meteorological stresses, can be involved in a dramatic change in forest composition (Oliver and Larson, 1996). Moreover, as observed with "Waldsterben" in recent decades (Kandler, 1992), forest health conditions can have profound social and economic impacts. Therefore, throughout the years, forest health has assumed a fundamental role as an effective bioindicator of terrestrial ecosystem quality (Manion, 2003). In this context, the alpine treeline seems to be a sensible indicator of the ecological limit that is strictly related to climate perturbations.

In recent years, decline of *Alnus viridis* spp. *viridis* ([Chaix] D.C.) has been reported in the Italian and Swiss Alps, where it was observed for the first time in the 1990s (Maresi and Tagliaferri, 1997; Meyer et al., 1998; Maresi and Ambrosi, 1999). As the damage progressed, a broad decline affecting the majority of alder stands has been observed, often causing the death of whole stands. In Italy, diseases recorded in other alder species (Moriondo, 1958; Surico et al., 1996; Moricca, 2002) do not seem to fit with the observed symptoms in mountain alder. Although records on similar alder decline have been assessed in the last century and before (Von Tubeuf, 1892; Appel, 1904; Münch, 1936), little information is available about this phenomenon.

In the genus *Alnus*, green alder is the most common species to be found in the mountain environment. In Europe, the green alder natural range includes the Alps, the Carpathian Massifs, the Balkans, the Norwegian Alps and the Dinaric chains (Richard, 1967). This shrub grows on slopes covered with snow during several months of the year, in the avalanche chutes at medium altitudes (1600–1800 m) and in the former alpine pastures on moist soils (Richard, 1968). Its altitudinal range varies between 1600 m and 2300 m a.s.l., although scattered individuals can be observed up to 2500 m a.s.l. (Gellini and Grossoni, 1997). Green alder requires particular climate conditions, with winter temperatures optimal between −1 °C and −10 °C, along with conspicuous and constant winter snow cover. Summer temperatures have to remain mild (average of 15 °C in July) to balance the massive evapotranspiration of 200 mm water/month (Richard, 1968).

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In alpine regions differences in morphological and ecological characteristics determine two different coenoses with green alder dominance. The first is a late successional community located on humid sites with persistent snow cover, generally located in avalanche chutes and on soils at high altitudes. The latter is transitory and grows at lower altitudes, invading abandoned pastures. For its ability to improve soil nitrogen content by means of *Frankia* symbiosis on its roots, green alder may be considered an excellent pioneer species (Wiedmer and Senn-Irlet, 2006), but where alder thickets are more dense, the cover may prevent the return of woody plants (Anthelme et al., 2003). Green alder occurs throughout the Italian Alps (Gellini and Grossoni, 1997). Widespread in western regions, it reaches its eastern maximum in the Carniche Alps. In Trentino, *A. viridis* is located mainly in the continental valleys, such as Fassa, Fiemme, Non, and Sole, both as primary coenosis on rocky slopes and secondary stands on alpine pastures. The economic importance of this species is very low, even if sporadic utilisation as fuel wood occurred in the past. However, its ecological value is fundamental both for soil conservation and erosion control on mountain slopes and as a pioneer species in successional processes from pastures to forests.

The aim of this work is to investigate the magnitude and the possible causes of the *A. viridis* decline, and to estimate the ecological trend that green alder will experience in the coming years and its consequences for the alpine forest.

2. Materials and methods

2.1. Study sites

Investigations were carried out in three plots that can be considered as typical for *A. viridis* in the Trentino mountains. The first one was located in Val Sadole (11°35′55″E, 46°15′07″N), a narrow lateral valley of Val di Fiemme (Eastern Trentino). Green alder grows monospecifically, following wet avalanche-prone gullies, but it can also be found below steep rock formations on upper slopes, mainly on silicate substrates.

The second plot, belonging to a secondary stand, was in Val Maleda (10°44′53″E 46°26′24″N), a lateral branch of the Val di Rabbi (Western Trentino), where the distribution of alder follows the same pattern as in Val Sadole but with a different aspect.

The third site was on Monte Bondone (11°03′51″E 46°02′20″N), a 2200-m-high mountain close to the city of Trento, where *A. viridis* forms a secondary stand characterised by a mixed population with other species (*Sorbus aucuparia*, *Salix* spp., *Picea abies*, *Larix decidua*) on calcareous substrate. In this area, green alder exhibits different behaviour from the previous plots, as its distribution lies entirely around 1650 m a.s.l., where it forms an island of its own. The main features of each site are reported in Table 1.

2.2. Spatial and temporal distribution of disease

The distribution of the disease in the province of Trento was recorded by means of the Forest Tree Damages Monitoring (FTDM), which has been recorded since 1990 by the Forest Services of the Autonomous Province of Trento in collaboration with FEM IASMA (Fondazione E. Mach Istituto Agrario S. Michele all'Adige). Using the WebGIS system adopted since 2005 (Valentinotti et al., 2004), affected areas were recorded in the IASMA FTDM database, and the general characteristics of the sites were analysed.

Seventy-five records of damaged areas were collected from 31 August 2005 to 10 September 2009. Since the same record was reported twice or more during the period, many polygons were overlapping. We performed a spatial aggregation reducing the observation to 37 polygons. On these polygons, morphometric characterisation was performed. Minimum, mean and maximum elevations were inferred using the Digital Elevation Model (DEM) at 40 m resolution. Slope and aspect maps were calculated from DTM following Horn algorithm (Horn, 1981). Aspect map was then reclassified in four classes (East, North, West South), while slope map was reclassified in five classes (0%–20%, 21%–40%, 41%–60%, 61%–80%, 81%–100%).) The class values were attributed to each polygon. Finally, polygons were cut using altitudinal belts of 50 metres.

In both Val Sadole and Val Maleda, permanent plots were selected along the altitudinal range of alder occurrence: clusters of 20 healthy trees were marked every 50 metres in altitude, following the distribution of plants. Each selected stem was inspected for symptoms. In Val Sadole, marked plots started from 1720 m and 1780 m culminating at 2100 m a.s.l., for a total of eight areas and 160 plants. In Val Maleda, 12 plots were created from 1650 to 2200 m. a.s.l., for a total of 240 labelled trees. A single plot of 20 healthy plants was also established on Monte Bondone, where alder occurs over a narrow range of elevation.

Plants were marked in spring 2004 (April). In Val Sadole and Monte Bondone, surveys were carried out in the growing season in 2004 and 2005; stems and branches were carefully inspected to record the diseased and symptomatic ones. A final survey to check the incidence of decline was carried out in August 2005 at all three experimental sites. During the last survey, three declining plants were randomly chosen from each plot for root system examination. Roots were excavated and roots and root collar were carefully examined.

2.3. Fungal and insect collection

To determine the fungal species composition, samples of *A. viridis* were collected at the different plots in all investigated areas during periodic surveys, twice in 2004 and in 2005 (July and August), except at Val Maleda, where samples were taken only during the final survey in August 2005. Three recent symptomatic branches from three different trees were collected randomly over the altitudinal range, and three samples of green branches where gathered from completely healthy and non-labelled alders in or near each established plot. Samples were placed in plastic bags and taken to the laboratory. Affected samples were kept separated from the healthy samples in each step of investigation.

To characterise the species composition of the green alder pests during the surveys, insects were collected from randomly chosen healthy and decaying plants (five of each at each site). Insects were collected with a 1×1 m entomological umbrella held horizontally below the vegetation; alders were vigorously hand-shaken. All collected arthropods were identified, and a list of the recorded species was arranged, focusing on the level of danger that the insects pose to trees. Furthermore, observations during the whole growing season were carried out.

2.4. Isolation and growth conditions of the fungal strains

Fungal isolations were performed from the margin between necrotic and healthy areas on the symptomatic samples. Isolations

Table 1
Main environmental characteristics of the investigated site.

	Site		
	Val Sadole	Val Maleda	Mt. Bondone
Altitude a.s.l. (m)	1700–2100	1650–2200	1650
Aspect	North-West	South-East	North
Substrate	Volcanic	Mica Schist	Calcareous
Average slope (%)	40	30	23