

SUSTAINABILITY OF SMALL SKI RESORTS AND SKI SLOPE MANAGEMENT UNDER CLIMATE CHANGE IN SOUTH TYROL

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ABSTRACT: Tourism is one of the leading economic sectors in South Tyrol, N Italy. Due to climate change in the European Alpine environment where a lack of snow during winter is becoming more frequent, ski pistes are increasingly created with artificial snow. Besides the 4 large regional ski resorts in South Tyrol, 38 small local ski resorts are present. These small ski areas rely on natural snow availability, and their ski season is usually concentrated between two and three months. Our research addressed two main questions: 1) What is the impact of different management practices (i.e. artificial snow vs. natural snow) on the vegetation of ski slopes? 2) How do small ski resorts in South Tyrol contribute to eco-social sustainability? To assess the impact of different ski-management practices and of different snow cover durations on soil properties and on grassland vegetation, snow and soil samples as well as vegetation sampling were taken from 10 ski slopes on a medium-large ski resort (M) and from three small ski resorts (S) in South Tyrol, Italy. To assess our second question, data from all small ski resorts were collected and operators of these local ski resorts were interviewed to understand the role of local ski resorts in contributing to the sociocultural activity of the local community.

KEYWORDS: artificial snow, technical snow, snow cover, plant functional groups.

1. INTRODUCTION

In South Tyrol, the winter tourism, especially skiing activity, is a leading sector of the local economy. The increasing air temperatures observed during the last decades, alterations in the precipitation regime (IPCC, 2014), and the resulting high variability in the snow cover duration are already impacting the winter tourism. The number of naturally snow-reliable ski areas is dropping (Abegg et al., 2007), and is forcing ski area operators to an intensive use of artificial snow. Artificial snow may have chemical and physical characteristics that differ from those of the natural snow (Kammer, 2002). As natural snow cover is decreasing, this may also affect soil and vegetation. In fact, snow plays a crucial role in the alpine-subalpine and mountain environment in generating adequate conditions for plant development, controlling soil temperature and moisture (Walker et al., 2001). Data from 2006 (Teich et al., 2007) show that in South Tyrol 59% of the ski slopes are covered

with artificial snow. The snow on the ski piste needs to be compacted, it becomes denser and less deep, and this reduces its insulation capacity (Rixen et al., 2004; Sturm et al., 1997). When the snow cover is scarce, however, the ground can freeze also outside the ski slope (Venäläinen et al., 2001). In addition, the duration of the snow cover can affect vegetation. Wipf et al. (2005) found differences in species composition on ski slopes respect to reference plots, and a lower abundance of early flowering species because of the late snow melt of the compacted artificial snow. Given that snow can regulate the species distribution, with some species preferring specific ranges of snow depth (Walker et al., 1993), it is no wonder that "If the snowpack changes, the vegetation responds", (Walker et al., 2001). Our study was carried out in the winter 2016-2017, where no precipitation occurred before February, whereas artificial snow was applied on the ski slopes starting from the first half of November. This difference allowed us to establish a study that well fits the projections of the global warming

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models predicting a great variability of snow cover regimes between different years. Besides the 4 large regional ski resorts in South Tyrol, 38 small local ski resorts are present. These small ski areas rely on natural snow availability and their ski season is usually concentrated between two to three months. Furthermore, they are thought to play an essential role in preventing the depopulation of the valleys. Our study wants to examine the impact of different management practices and of the artificial snow on the vegetation of ski slopes. In particular, we focused on the properties of the snowpack and its effects on the vegetation on ski pistes in medium-large sized and small ski resorts. In addition to the impact on the ecosystem, the role of small ski resorts for the South Tyrolean community was investigated. Here we present the methodology and some preliminary results.

2. METHODS

The study was performed on 10 pistes of the Ski Center Latemar (Trentino-Alto Adige region, Site 1, Figure 1), a medium-large sized ski resort where the preliminary data were collected starting from June 2016. The experimental approach follows a pairwise design of plots on ski pistes and adjacent control plots outside the pistes of 16 m². In every plot, Hobo data loggers were placed at 3 cm below the soil surface to monitor the soil temperature every hour. Snow samplings were done after the first snowfall (04.02.17) and replicated in March and April of the same year. We measured snow density, snow pH, snow electrical conductivity (EC), and the main cations' content. In summer 2017, the study was expanded in three small ski resorts nearby (sites 2, 3, 4, Figure 1). All the plots were located between 1360 and 2100 m a.s.l. On all sites, soil and vegetation records were collected: we measured the soil bulk density, soil pH and EC, the biomass production, vegetation cover, plant species richness and the Shannon's Index of plant diversity. For all the four ski resorts, the snow duration was monitored visually with the help of webcams (Figure 2). The pistes were considered snow-free as soon as all snow disappeared from 80% of the ski-slope surface (Vonlanthen et al. 2006).

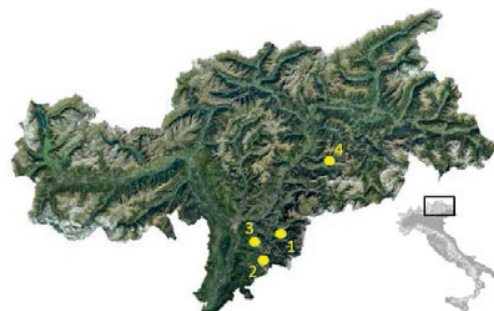


Figure 1: Studied ski resorts: 1-Ski Center Latemar, 2-Oclini, 3-Petersberg, 4-Skigebiet Villnöss. Source: Geobrowser.

The differences between the ski pistes and the control plots were tested with a paired t-test, and a PCA was run to assess which of the variables contributed more to the differences observed. The pistes of the site 1 were analyzed as a medium-large sized ski resort (M), whereas the pistes of the sites 2, 3, and 4 were analyzed jointly as a small ski resort (S). In order to investigate the role of the small ski resorts for the local community, economic, social, and ecological information was collected through a questionnaire from all small ski resorts of South Tyrol during the winter seasons 2016/17 and 2017/18.

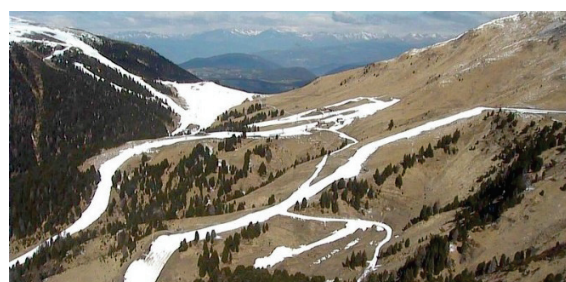


Figure 2: Ski Center Latemar, 07.04.17. Source: vittrentino.info/it/webcams/

3. PRELIMINARY RESULTS

The data collected in 2016 show a different proportion of the plant functional groups (Figure 3) inside and outside the piste. Whilst more grasses and woody plants were present on the control plots, more legumes were found on the pistes (t-paired test, $p < 0.01$). No differences in the total species number and on the Shannon's index of diversity were recorded. Biomass

production was significantly higher on the ski slopes only in the medium ski resort; in the small resorts it did not change. The questionnaires showed the importance of the small ski resorts for serving primarily the local inhabitants, who also can work within these local realities. All local ski resorts and ropeways have a relatively short season, which is concentrated in the central winter months and positively influences their cost management.

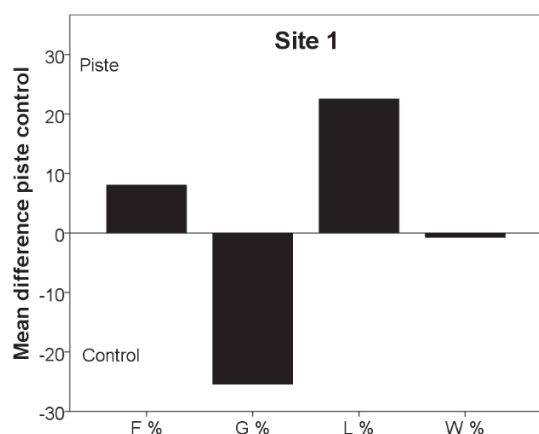


Figure 3: Mean differences in the percentage covered by the different functional groups (F: forbs; G: grasses; L: legumes; W: woody plants) between the ski piste plots and the control plots, $n = 14$, data of the year 2016.

4. FUTURE WORK

We are processing the snow and soil data to test if there are correlations with the vegetation analysis. We will test if and how the snow properties measured influence the soil characteristics and affect the vegetation cover and the distribution of the species. We are testing if the impact on the ecosystem of the small ski resorts and that of the medium ski resort differ, in terms of effects on vegetation.

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