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Environmental modifications induced by the practice of "Artificial snow-making" in the Obereggen/Val D'Ega Area (Italy)

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Abstract

In this present paper, for studying the phenomenon of artificial snowmaking and its effects on the environment, the skiing area of Obereggen - Val d'Ega (Alto Adige/ Sudtirol - Italy) was chosen, in correspondence with the hydrographic basin of the San Floriano stream, where some artificially snowed ski runs are to be found. So as to produce a multiscalar study of the environmental effects of artificial snowmaking, the analyses have been carried out on three different levels. The upper level to ascertain a general picture on a large scale (climate, vegetation, geology, fauna and human settlements); on the middle level the territorial transformations have been studied through the application of indexes of Landscape Ecology; at the lower level snowed runs and the near-by meadows have been compared, applying abiotic and biotic indicators (earth-worm populations). The evolutive study of the landscape seems to show that the Obereggen area has diversified its structure and while abiotic parameters measured on samples of meadows and on samples of ski runs agree about results, a relative difference in biotic indicators has been recorded.

Introduction

At the beginning of the seventies the use of artificial snowmaking technology became very widespread in the European Alps because of the variable winter snowfalls. It was introduced into Italy during the eighties. Its environmental effects are still unknown.

Artificial snow is usually made with snow guns. These break up the water into fine droplets which, thanks to the low temperature of the atmosphere, freeze before they land, producing the effect of a layer of artificial snow. Snow falls from sky in delicate yet infinitely diverse form, but mostly as snowflakes, a general term that can mean an individual hexagonal snow crystal, which results from the intrinsic molecular structure of water-ice. However the temperature seen by the snow crystal is not constant, and the crystal growth rates and shape are contingent on temperature at which the crystal was formed (table 1). A few snow crystals stick together, all they way up to the large "puff-balls" of agglomerated snow crystals, which are in turn made up of 2 to 200 separate snow crystals.

Table 1. The crystal growth rate, shape and temperature (Chan & Poon, 2001)

Formation Temperature	Shape
0°C To - 3°C	Thin Plate
-3°C To - 6°C	Needle
-6°C To - 10°C	Hollow Column
-10°C To - 12 °C	Sector Plate
-12°C To - 16°C	Dendrite
Down to -34 °C	Column

Theoretically, snow will accumulate if both the wet bulb temperature on the air and the ground temperature are less 0 °C, in this case the snow will not melt, while it falls nor after it has settled. Three of most important variables involved are wet bulb temperature, nucleation temperature and droplet size, therefore the results will be very depending on contingencies. (Chan & Poon, 2001).

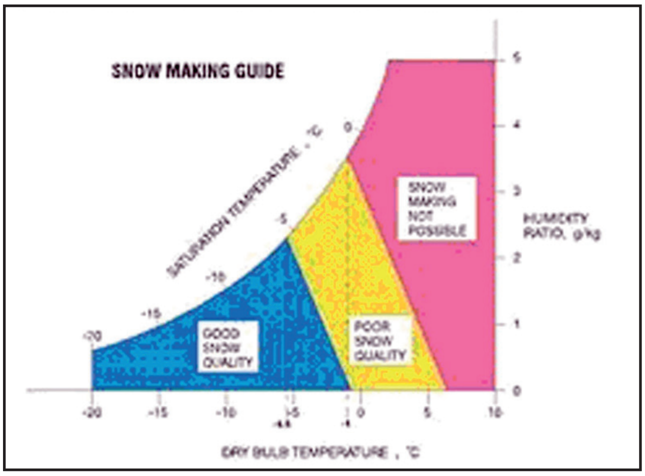


Figure. 1. Variables in snowmaking (Chan & Poon, 2001)

So, even when the ski-resort operators resort to making snow artificially, if the natural snowfall is insufficient, theoretically, they made snow like natural snow from the sky. They take in account only one variable (bulb temperature), but there are many variables that affect snowmaking (Fig. 1). Indeed, operators simply require that the air temperature is below freezing, so snowmaking machines are usually operated only at night, when the ground is colder than the air.

The production of artificial snow is at its most efficient when the atmospheric temperatures are between -5° C and -10° C and the relative humidity level is less than 40%. In these atmospheric conditions it is possible to obtain 3 m^3 of snow with 1 m^3 of water, while the average efficient transformation is about 2.4 m^3. Snow guns come in a variety of types, but they all make snow in basically the same way. A pipe supplies a large amount of water to the gun, where the water is broken up into very fine droplets through a nozzle or fan. These droplets are then distributed into the air where they freeze into a bead or pellet as they descend. Making snow involves releasing the compressed air into the atmosphere in combination with a spray of cold water. A large supply of compressed air is needed, commonly from a noisy compressor, and compression causes an increase in temperature. It is then cooled by conduction, for instance by funneling the compressed air through tubes in a nearby pond, river, or aqueduct. Sudden expansion of air to ambient air pressure then cools the air well below 0° C, possibly as low as - 40 °C. When ice nuclei are plentiful, freezing of the supercooled droplets occurs at much higher temperatures, and this allows lower compression and flow rates of air. Sometimes ice nuclei are released into the compressed air, to make sure that all droplets freeze even when the expanding air does not cool below - 40 °C. The expanding air freezes the water, producing "snow" at nozzles and a single gun typically has a large number of spray nozzles. The higher the compression ratio, the colder the expanding air and the less rimed the snow crystals will be, so the finer the spray droplets, the more crystalline the resulting snow. Typically, machines on top of towers, perhaps 10 m high, make the artificial snow to create snowdrifts that are then smoothed out by bulldozer (Linacre & Geerts , 1998). All of this makes for snow with a fairly high moisture content that resembles a transformed natural snow crystal. Combine this with manipulation by a grooming device and you immediately get snow that is wetter and effectively older than its age would indicate. The point to keep in mind here is that artificial snow is more abrasive than natural snow and also wetter. Artificial snow, like natural snow, can become transformed by the local weather. In other words, if the relative humidity is low and there is, say, a wind from the north, artificial snow will dry out a little just like natural snow, although it would not dry out as much as natural snow would. Finally, because artificial snow is mechanically manipulated so much, it can get very "dirty" (Coogan & Stepchuk, 2002).

People practicing snow sport should be able to distinguish among the three main type of snow:

1. **New snow**, is kind of snow has pointed and sharp edges of new crystal and has a high friction on ski, but these pointed structure disintegrates after about two days and became simpler and rounder crystal shape.

2. **Old snow**, this sort of snow has its crystal structure, by time or mechanical ski run preparation, and became finely grained or coarsely grained, because the snow grains have frozen together.

3. **Artificial snow**, this type of snow has the crystal composed of frozen droplets of water and is like "sleet". Sleet particles do not have any of the elaborate patterns found in natural snow crystals. Over time they became sharp-edged, pointed structures, so there friction is more with artificial than natural snow. (Anonymous 2003).

This information is important for skiers. It is also important in the management of slopes using artificial snow and prediction of environmental interactions of the entire snow field (Newesely, 1989; Cernusca, Angerer, Newesely & Tappeiner, 1990; Giacometti, 2001-02; Keller et al., in Press):

- The spherical form of the ice nuclei forming the snow flakes prevents the natural metamorphosis on the snow cover so that they must be groomed to make them more compact;
- The elevated density exercises greater pressure per superficial unit on the ground and more easily forms ice sheets;
- The low porosity and the high level of water saturation reduce gaseous exchange between the atmosphere and the soil.

The object of this present paper is to study the phenomenon of artificial snowing and its repercussions on the environment. Besides having conducted an accurate international bibliographic research on the theme, we have also set up a non-traditional methodological approach for an integrated and multi-scalar study of the landscape.

Materials and Methods

San Floriano d'Ega / Obereggen is a locality in the municipality of Nova Ponente / Deutschnofen, in Val d'Ega /Eggental, at about 22 km from Bolzano/ Bozen, the chief town of the autonomous province of the same name (fig. 2). The Ega/Eggentaler stream, and some of its effluents, runs through the valley, to the northeast of Bolzano/Bozen. Here it opens into a rocky ravine and extends between villages, pastures and woods in a southeasterly direction, until it reaches the province of Trento, passing through the Pampeago/Reiter Pass to the southeast and the Lavazè Pass to the west.

The skiing resort of Obereggen extends beyond to the above described basin as far as the village of Pampeago in the Trentino province. This study is limited to the older ski runs in the area, which were the first to be treated with artificial snow (fig. 3).

The area concerned is the hydrographic basin of the San Floriano/Obereggen stream, a sub-basin of the Ega/Eggertaler stream, which is delimited by the confluence with the della Pala/Zaggen stream at the level of the village Novale d'Ega/Rauth. To the southeast it is delimited by Mt. Colfrion/Golfrion (1872 m.), to the east by the Latemar range, with the peaks of Corno d'Ega/Eggentalerhorn (2799 m.) and to northeast by Mt. Corona (1907 m.). No particular relief defines the southern limits of the basin, but only the ground valley (ca.1500 m.).

The landscape is characterized by a varied distribution of vegetation including meadows, poor in species, which are mowed once a year and kept as grazing land; woods of fir trees (*Abies alba*) giving way higher up to spruce (*Picea alba*), pine (*Pinus sylvestris*), larch (*Larix decidua*) then to highland pastures (fig. 4) (Provincia Autonoma di Bolzano, 2001). There is a rich fauna in this area, among which there are mammals such as red deer (*Cervus elaphus*), roe-buck (*Capreulus capreulus*) and stone marten (*Martes foina*) and birds such as nutcrackers (*Nucifraga caryocatactes*), jays (*Garrulus glandarus*) and buzzards (*Buteo buteo*) (Pasquali-Gasca-Queirazza Studio Associato 1992; Provincia Autonoma di Bolzano 2001a).

The territory is connected to the southeast with the "Regione Dolomitica", at the crossing point between the three different ethnic groups who live together here: Italian, German and Ladin, the language dating back to Roman time, but widely spoken here. The region was "discovered" by the first alpinists and the English tourists towards 1860, following in the wake of the scientific interest aroused by the geologists and mineralogists at the end of the 18th century. But in particular from 1820 onwards, when scientists from all over the word began to arrive to dispute there various reports between the igneous rocks (*granite*) and sedimentary rocks (*secondary calcareous*) (Borsellini, 1989). The XIX century was a

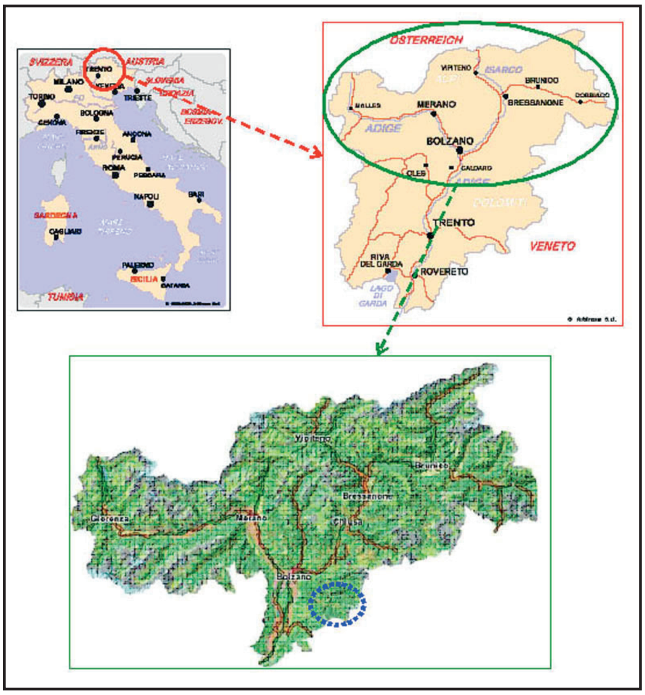


Figure 2. Location of the area of study, Obereggen, near Bolzano in the North of Italy (Anonymous a, 2000 - 2006; www.provinz.bz.it).

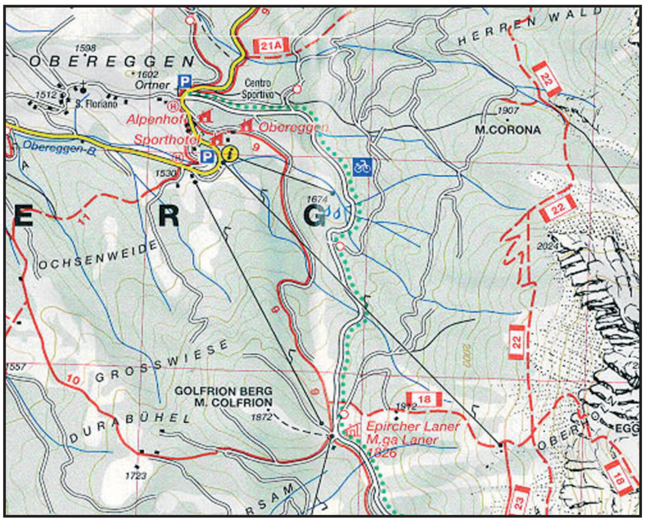


Figure 3. The Obereggen ski resort (Anonymous b, 2003).

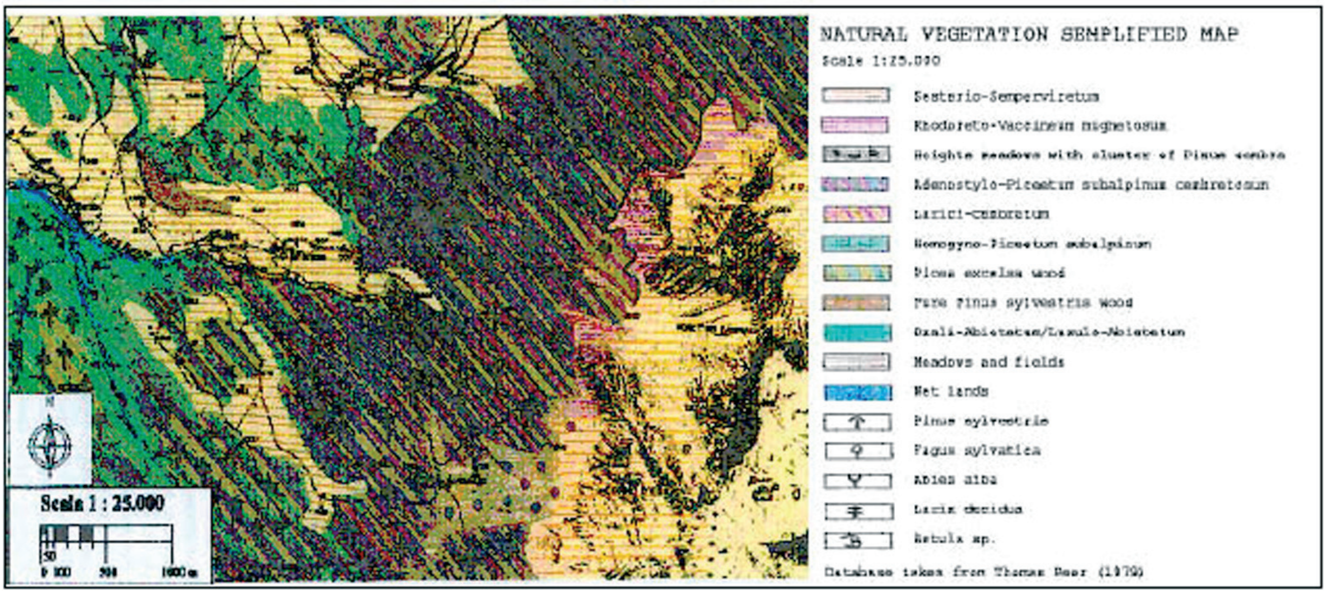


Figure 4. The distribution of vegetation in the area of study (Peer, 1979).

period of great transformation and profound upheavals, the technological conquests and new rational methods of production did not fail to have a profound effect on the economic and social structure also on this, previously remote, region of the Alps. At the end of the century this lead to the progressive migration of the people from the villages and hamlets towards the larger centers and the consequent abandonment of agriculture and livestock farming. At the same time the new railway lines and roads encouraged the arrival of mass tourism even to this isolated region, opening the doors of the region to the rest of the world. With the development of winter sports, towards the end of the century, came the creation of a second tourist season (Fontana, 1986). This however brought with it ever more frequent manipulation of the alpine environment with the construction of ski runs and the associated infrastructure.

The anthropic component of the landscape in this study has been marked by a strong increase in winter tourism, which, during the 1980s, brought with it the building of the first artificial snowmaking plant.

The territory was studied using Landscape Ecology methods (Naveh & Lieberman, 1984;

Forman & Godron, 1986; Ingegnoli, 1997; Farina, 1998), at three different spatial and temporal levels, to analyze the different environmental aspects that could be affected by artificial snowmaking:

- Level of synthesis: contextualizing the general picture of the analyzed aspects of the territory under study (climate, geology, vegetation, fauna and anthropization) by means of literature gathered on a wider scale (> 1: 25 000);
- Level of interest: study of the territorial transformations through the application of indexes of Landscape Ecology at an intermediate scale (1:100 000);
- Level of detail: comparison with an artificially snowed runs and the nearby meadows, through the use of abiotic indicators (chemical analysis of the soil) and of biotic indicators (study of a population of lumbricids / earthworms) at a minor scale (1:5000).

Level of synthesis

Materials

The necessary materials have been traced with accurate bibliographic research to obtain an image of the sectorial environmental problems deriving from the practice of artificial snowmaking and skiing in general.

Methods

The resulting bibliography was divided according to the four fields of potential impact on the ecosystems: vegetation, soil, fauna and water resources.

Level of interest

Materials

A scale of 1:10.000 is capable of giving evidence to the phenomenon of structural and functional evolutions of the landscape; this was carried out on three temporal levels:

1) XIX century, a reconstruction based on cadastral maps of the municipality of Nova Ponente dated 1858;
2) 1960 for data relative of the period preceding the opening of the ski runs, based on Province of Bolzano's technical maps;
3) For present day data using the technical maps compiled in 1986 brought up to date 1997.

Methods

The analysis of the landscape implied the application of indexes used in Landscape Ecology, these permit the description of the functional evolution of the territory, in its ability of self-maintenance, and the structural evolution, in its composition and spatial configuration. Functional analysis was effected by means of Territorial Biopotentiality (Btc) (Ingegnoli & Giglio, 2005).

The structural analysis of the landscape focused on heterogeneity, calculated by means of the Indexes of connectivity (γ) and circuitation (α) (Cantwell & Forman, 1983; Risser, Karr & Forman, 1984; Gibelli & Palmeri, 1996).

Level of detail

Materials

Research made on the detailed level helped to give evidence of eventual ecological differences between the ski runs and the meadows, which could have repercussions on the level of the landscape. Analysis of the soil, as an abiotic indicator of the quality of the environment, of the worm population, as biological indicators, were then carried out to compare the ecological conditions of the artificial snow runs with meadows.

The Obereggen-Oberholz ski run, which opened in 1972-73, has been artificially snowed since 1982. At a height between 2090 m, at the foot of Mt. Corno d'Ega/Eggentalerhorn, and 1530 m, in parking start in Obereggen. The 1480 m long run has an average slope of 25%. As vegetation covers about 90% of the surface it is mown for hay and used for grazing from mid June to mid September. The alpine meadow, classified as arrehenateretum elatioris (Peer, 1979) is between 1650 and 1570 m , it is mowed every year and then used as pasture. Both of these ecosystems lie on a calcareous-marly substrata, exposed to the northeast and are surrounded by woods of mainly Picea spp.

The materials gathered for the ecological analysis consist of:

- Soil samples taken from the meadows and from the ski runs, taken from holes dug at a constant volume (30x30x10 cm) and at 10 different altitudes;
- Worm samples taken from holes of constant dimensions (30x30x15cm) following an altitudinal gradient.

Methods

The samples gathered were studied through the application of methods for chemical-physical and biological analysis by means of statistic check tests to verify the validity of the data collected.

For the abiotic analysis, the samples taken form the soil were treated with the standardized methods (Ministry of Agricultural, Food and Forest Resources, National Pedological Observatory for the Quality of the Soil, 1994):

- Measurement of the hydrogenionic activity (pH) that conditions the physical proprieties of the ground;
- The organic carbon and organic substance contents, according to the Walkley and Black method insert reference;

- Identification of the capacity of cationic exchange with barium and triethanolamine;
- Identification of the basis of exchange (calcium, magnesium, potassium) with barium chloride.

The analysis of the populations of earthworms took advantage of the hand-sorting method of sampling (Lee. 1985) and the captured earthworms were:

- Counted;
- Weighed;

Identified by means of the dichotomic keys (Graff, 1953; Sims & Gerard, 1985).

The statistic analysis of the data obtained from the abiotic and biotic analysis, was carried out by the application of statistic tests of significance (Bailey, 1995; Scossiroli, Clementel & Scossiroli, 1974),

- Control of the normal distribution of abiotic data;
- Application of Students t test of the data;
- Linear regression, with the Minimum Quadrants methods.

Results

The integration of the results obtained through bibliographic research, the ecological analysis of the landscape and the study by means of abiotic and biotic indicators have permitted us to arrive at the following considerations at the various levels studied.

Level of synthesis

At this level the study has shown that:

a) Vegetation

The literature suggest that the vegetation can suffer due to the practice of skiing in general rather then programmed snow making in itself. Although the thicker layer of artificial snow gives greater protection to the soil and regulates thermal excursion, the prolonged period of permanence of the artificial snow on the ground postpones the regrowth of vegetation. This reduces the plant biomass especially for the more sensitive species. These are substituted at the moment of the snowmelt, by cryophilous species that are better adapted to water-logged ground. Also it has become evident that there is a lower gaseous exchange between the atmosphere and the pedosphere because of the greater compactness of the snow on the ski runs and consequently less gas-permeability of both the natural and artificial snow, that can then lead to phenomenon of anoxia in the pedosphere (Newesely, 1989; Cernusca et al., 1990; Cernusca, 1986; Cernusca, 1987; Cernusca, 1987a; Newesely, Cernusca & Bodner, 1994; Hünerwadel & Rüsch, 1982; Kammer & Hegg, 1990; Holaus & Partl, 1994; Serafin, Chiesura & Buffa, 1997-1998; Rixen, Stoeckli & Amman, 2002; Kammer, 2002).

b) Soil

Various authors have shown that on the ski runs the soil structure is completely lacking. This results from the activity of breaking down and re-mixing necessary for their creation, which destroys the profile, and compaction. The phenomena of erosion is only present on very steep runs and ones that present a reduced degree of plant coverage (70 to 80%), because of the increased phenomena of streams and the consequent hydro-geologic risk (Keller et al., in press; Rixen, Stoeckli & Amman, 2002; Meisterhans, 1982; Schwarzenbach, 1982; Weiss, 1982; Hünerwadel & Rüsch, 1982a; Coslop, 1989; Löhmannsröben & Cernusca, 1990; Eidgenössisches Departement Des Inneren Eds. 1991; Trockner & Kopeszki, 1994).

c) Fauna

The fauna is disturbed especially in the winter period by the noise coming from the snow guns (operated during the night time), but above all by the presence of the skiers. When the skiing activities finish, some of the animal species use the ski run areas for reproduction (avifauna), for hunting (birds of prey and reptiles) and for grazing (ungulates) (Provincia Autonoma di Bolzano, 2001; Tecnovia S.r.l., 1997).

d) Water resources

There is a very high demand for water for the production of artificial snow and this corresponds to 33.3 Ls-1 to produce snow from 18.00 to 6.00 hr. for 10 consecutive days for a 3 km long run 40 m wide with a depth of 30 cm. An average sized run (ca. 20 ha) requires 20x106 L of water and about 5x105 KWh. To reduce the amount of water taken from the mountain stream and torrents, come countries and the Provincia Autonoma di Bolzano have regulated the quantity of water that each society can take. As far as the quality of the water used for snowmaking a European directive and a Provincial Resolution of Bolzano (D. R. 216/95), in contrast to other countries, forbids the use of additives to water that is destined for snow-making (Keller et al., in Press; Bundesamt fur Industrie , Gewerbe und Arbeit - Bundesamt fur Raumplanung, 1991 (Ed.); Provincia Autonoma di Bolzano - Alto Adige, Ufficio Gestione Risorse Idriche, 1995).

Level of interest

The application of ecological indexes have shown that:

a) Territorial bio-potentiality (Btc)

The comparison of the bio-potentiality of different historical moments shows how this has undergone an increase since the last century and today (from 2.39 to 3.92 Mcal m-2 yr), even if between 1960 and 1997 there was a slight fall, from 3.94 to 3.92 Mcal m-2 yr. This increase in the Btc is to be ascribed to the increase of surface used for woodland, an element of high bio-potentiality. During the XX century this became the most extensive element of the landscape. The slight fall that was noticed in 1997, was due to the fact that although the extension of woodland remained constant, the pastures diminished giving place to housing, roads and new ski runs, all of low bio-potentiality. The substantial increase in the Btc values in the natural habitat suggests that the "landscape" system has increased its capacity of self-balance and "resistance" to disturbances. This indicates a tendency to the naturalization of the habitat, proving that the opening of ski runs (1972) have not cause marked modifications in the landscape system (table 2).

Table 2. The degree of incidence of the Territorial bio-potntiality (Btc) of the natural habitat in respect to the average Btc for the whole territory expressed in percentages. (Btc Hn=Natural habitat Btc)

YEAR	1858	1960	1997
BtcHn/Btc mean %	77.8	92.9	92.5

b) Heterogeneity

Although a limited heterogeneity is registered at all three temporal levels, that is 70% of those of a landscape system such as the one under study, the significant increase of the heterogeneity between 1958 (1.08) and 1960 (1.33), suggests that the structure of the landscape has become diversified. This contributes to and consolidates the landscape's capacity of auto-maintenance, even though it must be born in mind that the data for 1985 are incomplete and may give an imprecise picture of the situation then. In that period the matrix mainly consisted of pasture, and from 1960 became woodland, in which case it has only been possible to give a coherent comparison for the last two temporal levels.

c) Connectivity and circuitation

For an analysis of the degree of connectivity and of circuitation of the landscape matrix, the nodes were placed in correspondence with the points where there is a marked modification of the directives of possible movements. The values taken from both of the indexes result as being "good" on the threshold of 1858 (table 3), in that 85% of the meadow matrix results as being connected to 77% circuitation, while they noticeably diminish in reference to the woodland matrix of the XX century. The increase in the complexity of the landscape therefore brings about a fragmentation of it that is accentuated, if only slightly, by the opening of ski runs. In this way, even though shifting within the matrix is possible (γ of the average value), it could result in difficulties (α low) for the animal species.

Table 3. Values of connectivity (γ) and circuitation (α) at the three historic thresholds.

	Knot	Connection	Connectivity	Circuitation
1858 (meadow)	132	330	0.85	0.77
1960 (woodland)	99	148	0.51	0.26
1997 (woodland)	151	232	0.52	0.28

Level of detail

The analysis at this level evidenced that:

a) Abiotic analysis of the soil

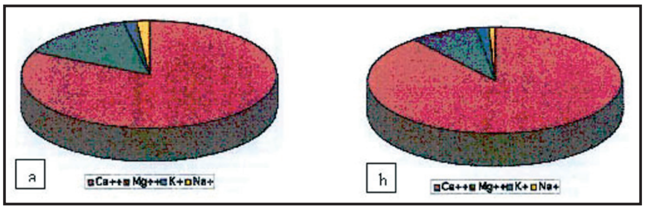
The data obtained from the analysis of the soil and the applied statistic analysis demonstrated that there is little difference between the ski runs and the meadows used as a control. Only in the values of hydrogenionic activity (ph) is there a difference between the two sites (pH 7.05 for the meadow and pH 7.44 for the ski runs) which however is not sufficient to induce an eventual modification in the presence of the fauna. It also shows that the soil of the runs has a higher content of organic matter than the meadow (table 4), but it is an unfertile soil without the typical structure of the terrain divided in horizons, as a result of the preparation of the ski run.

The statistical analysis of "the control of the normal distribution of the data" underlines the high variance of the data for the relative capacity of cationic exchange and the presence in organic carbon of the two soil samples (table 5). These variants could be due to the complexity of the methods of analysis.

Table 4. Comparison between analysis of the soil of the ski run and meadow

	Organic Matter mean (g kg^{-1})	Cation Exchange Capacity	Saturation Mean
Ski run	105	44.5	37.90%
Meadow	96	40.9	21.19%

Figure 5. Comparison between the elements contributing to the base exchange capacity of soils in the meadow (a) and ski runs (b).



b) Biological analysis of the earth- worms.

Lower populations of earthworms were registered in samples taken from ski runs, compared with the meadow, and there was a delayed build up of an active life of these organisms in the ski runs. But with the progressing of the season

Table 5. Statistical results of the abiotic indicators normal distribution in two soil samples taken from the meadows and the ski runs.

Units	Average		Standard Deviation		Varience	
	MEADOW	SKI RUN	MEADOW	SKI RUN	MEADOW	SKI RUN
pH	7.05	7.44	0.33	0.13	0.11	0.02
organic carbon	55.50	60.90	12.36	23.20	152.72	538.32
base exchange capacity	40.80	44.50	7.98	10.17	63.64	130.33
Ca^{2+}	1.02	1.06	0.17	0.27	0.027	0.070
Mg^{2+}	0.18	0.10	0.07	0.04	0.005	0.002
Na^{+}	0.02	0.02	0.02	0.01	0.000230	0.000050
K^{+}	0.02	0.03	0.01	0.01	0.000140	0.000003

the differences between the two sites diminished, to the point of becoming irrelevant (fig. 6).

The composition and the diversity of the species do not show particular differences between the runs and the meadows, in fact in both sites we find the dominant species to be: *Lumbricus rubellus, Octolasion tyrtaeum tyrtaeum*, and lesser number of *Aporrectodea rosea, Dendrodrillus rubidus, Eisenia hortensis*, this last species were represented by only one individual, found in a sample of the meadow soil.

The application of Student's t test has shown significant differences between the values of the biomass in the first and second samplings (table 6). These observations support the hypotheses that the distribution and the abundance of the earth worms is influenced by the work of leveling and clearing of the ski runs, hence also the structure of the soil, or by the use of artificial snow, with the resultant extension of low temperatures. Consequently the earthworms seem to be good bio-indicators in mountain areas. The linear regression of the data of the biomass, using the method of least squares, shows the correlation between the biomass of the earthworms and time. Only on the ski runs were there was verified a delay in the development of the earthworm biomass. On the contrary, in the meadows, the maximum development of the biomass probably comes in the summer at the beginning of the sampling.

Table 6. Average number of individuals sampled in four different times and in two sites.

	1st sampling (June 1996)	2nd sampling (July/August 1996)	3rd sampling (November 1996)	4th sampling (November 1996)
Meadow	51	206	60	21
Ski run	42	14	10	5

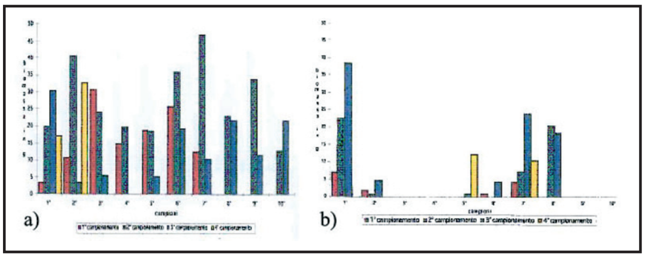


Figure 6. Earth-worms biomass (g m^{-3}) sampled in meadows (a) and in ski runs (b) in four different samplings: the red one in June, the green one in July-August, the blu one in November and another one yallow in November.

Discussion

The evolutive study of the landscape seems to show that from 1858 to 1997 the Obereggen area, despite the development of skiing facilities and artificial snowmaking, has diversified its structure. The indexes of territorial Biopotentiality and of Heterogeneity have shown an increase in the complexity and the capacity of auto maintenance of the ecological system under study, despite an increase fragmentation of the landscape matrixes (pasture in 1858 and woodland in 1960 onwards), the reduction in its Connectivity and Circulation resulting from the introduction of the ski runs.

While the analyses carried out at the soil level, have shown a substantial agreement with the abiotic parameters measured in samples of meadows and in samples of ski runs, while a relative difference in the abundance of the biomass of earthworms as biotic indicators has been recorded. The earthworms were much more abundant in all the samples taken from the meadows and registered their maximum increase in mid-summer. While the on the runs, besides registering less abundance in the biomass, this increased with the progress of summer, probably caused by the delay in development due to:

- The lengthened permanence of the snow on the ski runs, which prolongs the time of temperatures at winter levels;
- The protracted saturation of the terrain, at the moment of the snowmelt in spring, which causes phenomenon of anoxia.
- The upset nutrient dynamics for vegetation (Wipf et al.. 2002), consequently a possible unfavourable situation for edafic fauna.

Starting with bibliographic data and from the analyses carried out in the present study, it can be concluded that the practice of programmed artificial snow-making has brought to light three important problems that influence the structure and the ecological functionality of the landscape including the ski runs, which should become the object of attention for the ecological monitoring of these landscapes:

- The establishment of species of cryophilic flora, indicating a variation of the micro-climate of the ski runs towards colder temperatures;
- The delay of the snowmelt by 7-10 days on the ski runs compared to the nearby meadows.
- The temporal changing the renewal of the biotic activity within the ski run element.

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