Ecological Damage Behind Ski Resorts and Feasible Governance Measures

Chongchao Bao *

Beijing National Day School, Beijing, China

* Corresponding Author Email: 15060140236@xs.hnit.edu.cn

Abstract. Construction of ski resorts involves machine-grading slopes, which alters the soil's physical, chemical, and biological qualities and has a substantial long-term ecological influence on the environment. To improve slope stability and reduce the risk of natural hazards and restore the biotic and abiotic conditions of the soil, it is important to establish and develop plant communities. This study assesses changes in plant-soil characteristics and the long-term consequences of machine-grading and concurrent ski-run restoration to help create the best procedures for future ski-run development. Ski trails were surveyed for soil, vegetation and root characteristics and unaltered control sites away from the ski trails were evaluated. Plant cover on ski trails remained constant over time, but plant richness and variety significantly increased, reaching levels comparable to undisturbed vegetation. The plant mix transitioned to more semi-natural stages, exhibiting decreased planted plants and a corresponding rise in the cover of native species populating the area. Compared to unaffected locations, the root trait data showed significant differences between machine grading and vegetation's short- and long-term effects. As a result of long-term management, the aggregate stability in the ski slopes remained lower as well as the organic content remained higher than in the undisturbed locations. Even though the soil still has a lower chemical and physical fertility than the quiet sites, the plant species composition indicates a satisfactory degree of renaturalization. The standard actions used allowed the ecosystem to recover in three decades partially.

Keywords: Ecological damage, environmental impact, sustainability.

1. Introduction

The cruelest season of the year can be a great time to go skiing or snowboarding in the mountains. Ski resorts depend on complex, energy-intensive infrastructure, a large workforce, and extensive water use to provide this. Both the environmental costs and the potential solutions for resort skiing are multifaceted. Millions of tourists visit mountain communities each year thanks to the ski industry, which also contributes significantly to their economies by constructing new ski runs worldwide. The building of ski resorts and related infrastructures alters the environment over time, affecting many vital ecosystem services and properties. The techniques used to build the ski runs and the land restoration work significantly impact the ecological effects and recovery after ski run construction.

Machine grading is the most popular method for making ski resorts with even ground for skiers. This method entails shifting boulders and removing the entire vegetation cover, the soil surface, the soil biota, and the seed bank [1-2]. The soil's physical, chemical, and biological characteristics change significantly after construction. Previous research discovered higher levels of phosphorus, base cations, and pH in the ground and increased soil compaction. Areas with graded ski resorts compared to new sites. Found lower levels of nitrogen, organic carbon, and cation transfer capacity and a radical break - down of natural soil stability. Especially on slopes above the timberline, these altered soil properties cause erosion and impact plant communities' natural recolonization and growth. Although feedback mechanisms during the transition are rarely distinct, vegetation cover is critical in enhancing slope stability, lowering the risk of natural hazards, and impacting the biotic and abiotic soil environment. Roots raise their resistance by improving the soil's mechanical and hydrological qualities. Roots still support soil reinforcement when aboveground plants are absent (such as during winter hibernation or after grazing). Terrestrial vegetation brings down raindrop energy or runoff velocity by an increase in surface roughness.

Due to cost and availability, hydroseeding with hybrid seed combinations rather than local, site-specific seed mixtures is frequently used to restore tree cover to these graded sites. Commercial seed mixtures, on the other hand, call for additional fertilization can prevent the growth of native vegetation, and their leaf litter can change the soil's composition. As a result, choosing the right plant combination can delay slope stabilization and recovery while accelerating ecological restoration. Ski resorts must be thoroughly maintained and managed following construction and when no snow occurs. The chosen management strategies would further affect the time and degree of ecosystem recovery. Snow grooming, which involves moving, flattening, compacting, or rototilling snow with specialized equipment, and using artificial snow, which both hinder site recovery, may further stress the ecosystem during the winter. Snow grooming makes the soil and site more vulnerable to erosion by compacting the soil, drastically reducing infiltration, and increasing soil compaction. Compacted snow can significantly impact the pedoclimate, resulting in less effective insulation. Due to long periods of snow cover and, conversely, a shorter growing season for plants, lower soil temperatures cause more significant physical stress on vegetation. Early melting sites exhibit higher levels of biodiversity, degradation rate, humus content, and microbial activity.

The most frequently advised management method during the snow-free season is cutting or grazing vegetation, except for the highest altitudes where farming could hasten erosion and slow the recovery rate. The amount of initial disturbance, restoration methods, and the ski run management strategy can significantly impact how long it takes for disturbed alpine slopes to recover and maintain themselves. The ultimate objective of this research is to help develop the best practices for building ski runs. This study's specific goal is to assess how ski resorts affect the biodiversity in the area by tracking changes in soil and vegetation over time. To do that, survey sites were identified and resurveyed on ski resorts built and reclaimed in the 1990s in 2017. Variations measured in study plots on the resorts were compared to nearby reference sites of the ski run to see if the plant and soil dynamics were heading toward self-sustainable and semi-natural conditions. The study's primary reference would be the Nanshan Ski Resort in China.

2. Example of The Nanshan Ski Resort

2.1. Basic information and overviews of Nanshan Ski Resort

The Nanshan Ski Resort, which has a vertical drop of over 247 meters, is situated at the base of a mountain range in Beijing, China's Miyun District. It is a popular ski region in northern China because of the topography, which offers skiers a variety of alternatives to suit their expertise level and includes mild slopes, wide lines, and some steeper areas. The snow resort offers a range of slopes and terrain for skiers and snowboarders of all skill levels. The resort has invested in cutting-edge snowmaking and grooming machinery to guarantee good winter conditions. The resorts offer a combined total of 25 ski tracks ranging in difficulty from beginner to expert, covering an area of around 6 square kilometres. Visitors can also enjoy a tubing area and many snow parks. The resort offers ice skating, sledding, snowmobiling, other winter sports, and skiing and snowboarding [3].

2.2. The impact of the construction and operation of a ski resort on the natural ecological environment

2.2.1 Effects on water sources

Ski resorts are typically built in places with good water quality and relatively high subterranean water content. Therefore, contamination of nearby water sources, such as streams, lakes, and reservoirs, would result from the development of ski resorts. Using the Nanshan ski resort as an example, this article has shown that during the construction phase, a lot of effluents were released from machine operation, concrete mixing, and employees' housing quarters, which originally damaged the nearby water bodies.

Moreover, Beijing is in a moderate continental temperature zone, which experiences less winter snowfall than frigid or sub-arctic climate zones. To meet demand and make up for the drawbacks of its location, Nanshan Ski Resort must continuously generate artificial snow due to the rising number of tourists. Chemical disposal in artificial snow is challenging. Due to the difference in altitude between mountains and plains, the melting snow flows down the valley into the nearby streams and reservoirs as the weather warms up. Also, nearby hotels and restaurants released a lot of sanitary wastewater, full of bacteria, colloidal particles, and greasy dirt, particularly when many tourists visited China for the Spring festival. As a result, the pressure for water purification would also rise to preserve the water's purity.

Ski resorts must also use a melting-snow agent to clean the accumulated snow on roads and parking lots to guarantee transportation safety. The primary snow-melting substance on the market today is chlorine salt, which includes sodium chloride, calcium chloride or magnesium chloride. This snow-melting agent is difficult to replenish quickly due to its lower cost and great efficiency. The density of the water would change due to the increase in salt content as the snow-melting agent diffuses with runoff water and soil to water areas such as streams and lakes, disrupting the distribution of ion concentrations that releases mercury, phosphate, as well as other metallic elements from the soil in the bottom of water bodies. Also, the chlorine salt snow-melting agent's diffusion encourages the nutrient levels to rise, which promotes the formation of algae in lakes or reservoirs that would take a lot of time and effort to eradicate. People frequently disregard another issue; the amount of water needed to create artificial snow. To make snow at Nanshan Ski Resort throughout the winter, Miyun Reservoir provides abundant water resources. The growing demand for snow in ski resorts progressively consumes a significant portion of the reservoir's water production. It would harm the city's overall sustainable growth [4].

2.2.2 Effects on the atmosphere

During construction, a great deal of dirt is released into the air by the large machinery and the concrete. It is difficult to contain the rising dust in the air that contributes to air pollution during equipment installation, weed removal, and filling of abandoned soils. Many factors, including energy consumption, cause air pollution. When the ski resort was first being built, energy was needed to run the lifts, snowmaking machinery, lodge lighting systems, and other facilities' heating systems. The primary energy sources used to run the construction were fossil fuels. Fossil fuel combustion releases various greenhouse gases, such as carbon dioxide, sulfur dioxide, and water vapor. These substances play a part in the atmosphere's impact on climate change. After construction, ski resorts require enormous machinery to run continuously to maintain the necessary snow on the slopes daily. Energy is used extensively during the winter to maintain and repair all ski resort facilities. As a result, the release of greenhouse gases caused by energy consumption will raise sea levels and harm the ozone layer, undermining the stability of human progress in the future.

2.2.3 Effects on the surrounding community

Several residential communities are close to the ski resorts in Nanshan or elsewhere. The massive equipment used to create artificial snow and the power plants that provide ski resorts with electricity generates a lot of noise. Locals frequently raise complaints. Also, during the ski season, the entertainment from music and bands in the resort and the sounds of car horns can be loud. When a group of locals was interviewed, the complaints outweighed the approval of the outcome.

2.2.4 Effects on biodiversity

Clearing or burning off all mountain vegetation is a prerequisite for constructing ski resorts [5]. Building ski resorts causes indigenous wildlife, particularly birds, to lose their homes and sources of food. This is due to the decreased forest and tree cover after cutting to create room for construction. Bird numbers will decline due to increased susceptibility to natural predators, disturbing biodiversity in the area [6].

3. Reasons Analysis

3.1. Lack of technologies

There are a few alternatives for snow-melting products to choose from chlorine salt. In comparison to the cost of salt, calcium chlorides or magnesium chlorides are considerably more costly. This is because clean, renewable chemicals have a far longer half-life than snow melt. Another factor is that China needs to catch up to Europe in the development of snow sports. The country's government needs to focus more on developing chemicals for snow melt that are renewable and biodegradable. China started participating in snow sports later than most European nations. Public opinion has not agreed on the problems that ski resorts cause, as a result, neither governments nor commercial entities spend resources producing green chemical ingredients.

3.2. Developers focus on their profits from the project

After China's 2020 Winter Olympics hosting, skiing has significantly increased in popularity. Numerous developers and investors want to exploit this economic opportunity to make money. As a result, ski resorts were built on a vast scale, and nearby communities developed supporting infrastructure that attracted visitors from all over the nation. It neglected the harm caused by excessive development to the local ecological environment, especially in areas like Xinjiang with many endangered animals. However, objectively promoting the development of the skiing sector and bringing matching tourism income to the local area. The operators failed to quickly restore the vegetation cut down after the snowfall or clean up any water sources that might have been contaminated during the operating period. Their quality could improve the forest landscape even if they replace the plants. Moreover, the poor quality of the vegetation in the mountains prevents the biodiversity from recovering as well. Throughout the summer, people could observe multiple spots experiencing permanent forest degradation around the ski resorts. In addition, there are very few green spaces due to the development of hotels, restaurants, and cable cars—significantly few green areas to withstand natural disasters like mudslides and sandstorms, especially in northern China.

4. Ecological restoration measures

4.1. Improve corresponding policies

Governments should encourage chemical industrial enterprises to create snow-melting and snow-making chemicals mainly constituted of clean and biodegradable chemical elements to raise awareness of the need to safeguard the ecological systems around ski resort areas. Governments must enact strict legislation to penalize building firms that violate environmental protection principles and firms that exaggerate the cost of their energy usage to lessen the adverse effects caused by skiing resorts [2]. Setting a red line will stop developers from overusing the environment for personal gain.

4.2. Laying green dust-proof nets & using renewable energy to supply the power

Construction businesses must strictly set green nets to contain the dust rising into the air to comply with laws and stop it from spreading. Several possible strategies for reducing dust emissions are; They should consolidate the backfilling of vacant areas and waste soil disposal, By making the dust damp to prevent it from being airborne, water sprayed on the ground can aid in suppressing dust emissions, Setting up windbreaks all around the worksite can help to lessen wind speed and the spread of dust, To help limit dust emissions, chemical dust-suppressing agents can be sprayed on the ground surface. These substances, which can be either water- or soil-based, function by tying up dust particles to keep them from spreading [7]. To reduce the consumption of conventional fossil fuels and the emission of greenhouse gases, we might substitute them with wind, hydroelectric, and solar Power to run ski resorts and the infrastructure in the area[8].

4.3. Measures for protecting biodiversity

During construction, resist cutting all the trees around the ski resorts. Due to deforestation, wild animals would be confined to a small area, which further slows the growth of the animal population. Construction corporations should consider land reclamation and reforestation after the work is done. The use of local plant types that grow fast and do well in those areas should be adopted in the programs [9]. Economic crops can be produced in locations with mild slopes, enhancing the snowscape and raising farmers' income. In places with steep slopes, fixing the top soil layer and employing three-dimensional plant nets to reinforce the pitch should be used to prevent landslides or collapses. Increasing water infiltration by using topographical drainage on ski slopes, creating 'Z'-shaped buried trenches, filtering and channeling the water from the process for subsistence use. While snow-melt water carrying dangerous chemicals is diverted to a centralized treatment pool for subsequent purification, the cleaned water is then released into the environment to support the growth of flora[10].

5. Conclusion

Any disturbance related to winter recreation will most likely have more detrimental than beneficial effects on biodiversity: ski runs or winter tourism. While published studies are rare, inquiries on the impacts of resort infrastructures and winter tourism still require further focus. Determining the effects of specific disruptions associated with winter leisure is crucial since doing so will make ski resort management measures more effective. An appropriate management plan, for instance, would involve restricting tourist access to regions home to nests, dens, or hibernacula if direct human stimulation of animals during the winter harms the welfare of individuals or communities. Other tactics, such as changing grooming procedures or limiting the quantity of artificial snow, may not appreciably increase the fitness standards of target populations. Further empirical investigations are therefore urgently required to improve the conservation results of fauna using targeted management measures. Many ski areas have worked hard to reduce their environmental impact. Solar panels, wind turbines, and tiny hydro turbines have been installed to provide renewable energy. There are now better waste collection and composting programs, and green building techniques are being used. Plans for forest management include improving wildlife habitat. Skiers can now research a resort's sustainability initiatives and make knowledgeable purchasing selections. The Ski Associations even bestow annual prizes on resorts that exhibit exceptional environmental performance.

As an alternative, a growing percentage of outdoor enthusiasts search out snowy slopes by engaging in less strenuous skiing. These outdoor skiers and snowboarders utilize specialist equipment to ascend the mountain independently and ski down unlogged, ungroomed, natural terrain. These skiers must be independent and capable of reducing mountain-related safety threats. Remote skiing has a lower environmental effect than resort skiing, and the curve is considerable. Although highly delicate, alpine regions are nonetheless subject to the effects of all activities there: According to a study conducted in the snowy Mountains, outdoor skiers and snowboarders constantly disturb black grouse, resulting in heightened stress levels that affect reproduction and survival. Therefore, whatever type of winter leisure activity is going on, there indeed is an effect, and mitigation measures should be thoroughly researched and implemented.

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