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Authors: Job, Hubert, Willi, Gero, Mayer, Marius, and Pütz, Marco

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Open Spaces in Alpine Countries: Analytical Concepts and Preservation Strategies in Spatial Planning

Hubert Job^{1*}, Gero Willi², Marius Mayer³, and Marco Pütz²

* Corresponding author: hubert.job@uni-wuerzburg.de

¹ Julius-Maximilians-Universität Würzburg, Institute of Geography and Geology, Am Hubland, D-97074, Würzburg, Germany

² Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Zürcherstrasse 111, CH-8903, Birmensdorf, Switzerland

³ Universität Innsbruck, Department of Strategic Management, Marketing and Tourism (Team SME and Tourism), Faculty of Business and Management, Karl-Schönherr-Straße 3, A-6020, Innsbruck, Austria

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Open spaces in the Alps are becoming noticeably scarcer, and the long-term consequences for humans and the environment are often overlooked. Open spaces preserve ecosystem services but are under

pressure in many Alpine valleys due to demographic and economic development as well as corresponding technical and tourism infrastructure. This article conceptualizes and measures open spaces in Alpine environments. In addition to analyzing existing spatial planning instruments and the open spaces resulting from 2 of them—the Bavarian Alpenplan in Germany and the Tyrolean Ruhegebiete in Austria—we identify open spaces in Switzerland using a geographic information system. More generally, we discuss how spatial planning deals with open spaces. Results show that both the Alpenplan and the Ruhegebiete have contributed significantly to the protection of open spaces in the Bavarian and Tyrolean Alps since the 1970s. Indeed, both approaches prevented

several development projects. In the Swiss Alps, open spaces cover 41.9% of the Alpine Convention area. A share of 40.3% vegetation-free open spaces shows that they are concentrated in high alpine areas. Of the open spaces identified, 64.6% are covered by protected areas. Hence, about one third of the open spaces still existing in the Swiss Alps need preservation, not only for ecological connectivity reasons but also to preserve them for generations to come. We conclude that different sectoral approaches for the conservation of open spaces for people and natural heritage in the Alps and other high mountain ranges should be better coordinated. In addition, much more intensive cross-border cooperation in spatial development and planning is needed to preserve open spaces throughout the Alpine arc.

Keywords: Alps; ecological connectivity; open spaces; sectoral planning; spatial planning; sustainable development; cross-border coordination.

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Introduction

Open spaces in the Alps are becoming noticeably scarcer, and the long-term consequences for humans and the environment are often overlooked (Job 2005; HaBlacher 2006; Mayer et al 2011; Rupf et al 2011; Bätzing 2015a, 2015b; Siegrist et al 2015; HaBlacher et al 2018). Populations and their associated infrastructure are growing in many valleys. In addition, open spaces situated at altitudes above permanent settlements are also being successively impaired by technical infrastructure (eg cable cars).

This article conceptualizes and measures open spaces in Alpine environments. First, we identify open spaces in Austria, Germany, and Switzerland. Second, we analyze how spatial and sectoral planning are dealing with open spaces. The goal is to bring together approaches for preserving open spaces outside protected areas with the aim of enabling better cross-border coordination.

Open spaces provide ecosystem services and ecological connectivity for people, both locals and tourists, and

preserve our natural heritage by reducing landscape fragmentation and the loss of biodiversity. As such, a considerable amount of open space is required at the landscape level (Ritter 2005). Increasing land consumption and the associated loss of open spaces can have negative consequences, for example, soil sealing, fragmentation of landscapes and habitats (ecological consequences), increase in traffic volume or rising infrastructure costs (economic consequences), and infrastructurally transformed cultural landscapes that erode regional identity (social consequences) as well as accelerating climate change (Job and Vogt 2004; Schiller and Siedentop 2005; Lama and Job 2014; Bayerle 2016; BMI 2020; BMUB 2016). Thus, we explicitly deal with extra-urban open spaces that currently appear particularly endangered and that are most crucial for the protection of biodiversity, fertile soil, and ecological connectivity (Gottfried et al 2012; Vranješ et al 2013; Tolusso 2018; ALPARC 2019). A specific feature of settlements in the Alps is their location in the so-called area of permanent settlement. This is because the mountainous conditions set

TABLE 1 Overview of essential open-space concepts as used in Alpine countries.

Concept	Definition	Author(s)
Wilderness areas	Minimum size of 10,000 km ² , a low population density (<5 persons/km ²) and an intact ecosystem.	Mittermeier et al (2003)
	Minimum continuous area of 500 ha for fens, bogs, coastal areas, and riparian zones; a minimum size of 1000 ha is recommended for high-elevation mountains, woodland and forests, and former military and mining areas.	Schumacher et al (2018)
	1. Naturalness: Areas as unspoiled as possible 2. Human influence: Areas free as possible from human influence 3. Remoteness: Difficult to reach and access 4. Roughness of the topography: integrates relief energy and habitat diversity.	Moos et al (2019)
Landscape fragmentation and effective mesh size, m_{eff}	Probability is that 2 points lying arbitrarily in a delimited space are not separated by infrastructure (eg road) or can still be located in the same sub-area after the fragmentation. The more dissected the landscape, the higher the probability that 2 points will be separated and the smaller the resulting mesh size.	Jaeger (1999) Jaeger et al (2001)
Remote areas	<i>“All contiguous parts of valleys [...] which are larger than 3 km² [300 hectares] and can only be reached and crossed by muscle power and are therefore not accessible by road or cable car.”</i>	Boller (2007: 48) Boller et al (2010)
Ecological connectivity	Based on the idea of ecological stepping-stone biotopes. Ecological networks combine habitats with human land use and improve the connection between near-natural (cultural) landscapes (eg existing protected areas).	Scheurer (2016)

relatively rigid limits on the possibility of permanent settlement. Preservation of open space, including in the area of permanent settlement, is necessary to maintain flexibility for future developments.

The analysis presented here is structured as follows: First, we describe different concepts of open spaces. Then, we outline the terminological history of open space and provide our own definition of this term, followed by explanations of the methodology applied. Next, we present the results. Finally, in a critical discussion and conclusion, we advocate for better Alpine-wide cross-border cooperation to preserve open spaces and suggest the transferability of insights to other high mountain areas.

Background

The debate about open spaces refers to related concepts, such as wilderness areas, landscape fragmentation, remote areas, and ecological connectivity. The selection presented in Table 1 is not exhaustive (Maruani and Amit-Cohen 2007).

Wilderness is a fairly old concept, but it is relatively new in the context of protected areas (IUCN 2016). The US Wilderness Act represents the first national legal anchoring of wilderness areas (IUCN 2016) and provides the standard definition of a wilderness area

... as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain, ... and which is protected and managed so as to preserve its natural conditions ... with the imprint of man's work substantially unnoticeable.

(US Wilderness Act 1964, Section 2c)

In a recent application of the concept, Moos et al (2019) estimated current and future potential wilderness areas in Switzerland—although their approach differed somewhat from the earlier US Wilderness Act definition. They used the

following criteria to quantify Swiss wilderness areas (Moos et al 2019: 66ff):

1. Naturalness, calculated by land cover statistics.
2. Human influence, calculated by the degree of landscape fragmentation.
3. Remoteness, reflected by the accessibility by foot or public transport.
4. Roughness of the topography, represented by calculating the standard deviation of the curvature of the terrain within a radius of 250 m.

Landscape fragmentation is an indicator of biodiversity conditions and can be measured using the concept of effective mesh size developed by Jaeger et al (2001). This is a method to quantify landscape fragmentation based on the probability that 2 randomly chosen points in a region will be connected, rather than separated by infrastructure. Alternatively, the degree of landscape fragmentation can also be represented by mesh density (ie the effective number of meshes per 100 km²) (Jaeger et al 2006; EEA 2011).

The remote areas approach uses 15 indicators (eg travel time to the starting point of the hike) to map the temporal, visual, and socioeconomic dimensions of remote areas. By rating each indicator on a scale of 1–5, the degree of remoteness of an area can be analyzed (Boller et al 2010).

The ecological connectivity approach tries to interconnect existing protected areas. A prime example is the European Union's Natura 2000 system (Symanek et al 1998). The establishment of ecological networks both supports human activities in open spaces (accessibility for recreation) and allows exchange of flora and fauna between individual habitats (securing the gene pool via large populations). Nature conservation and spatial planning play the most important role in the realization of ecological networks (Kohler 2016). Studies have shown that at least 40% of the total area must be protected in order to preserve biodiversity in the Alps. As existing protected areas cover

about 25% of the Alpine Convention area (Bender et al 2017), at least another 15% require protection (Scheurer 2016). In this context, spatial planning should focus on specific functions of natural or near-natural, extensively used, but always unsealed soils (Ritter 2005; Job et al 2017) to better safeguard open spaces.

Definition and methods

Open spaces and their protection originally appeared in the context of the environmental reorientation of spatial planning in Europe in the 1970s, driven by the increasing consumption of land to develop settlements. Open spaces represent a counter-concept to settlement space, parallel to previously used terms, such as green space. Initially, this was a negative definition, but we argue that the term is better described positively.

During the past few years, the deliberately broad term “open space” has gained importance as a planning category. In this context, open spaces are characterized by multiple overlapping spatial functions. This multifunctionality includes significant (climate-)ecological functions and historical-cultural, economic, social, spatial-structural, and aesthetic functions (Hartz 2018).

However, the term “open space” has not yet been clearly defined (Häpke 2012). In general, open spaces are all areas free from buildings. From a landscape ecology perspective, open space is the part of the landscape “not affected by buildings and line-like infrastructure facilities similar to buildings” (Baier et al 2000). However, these spaces are not necessarily completely unused and, thus, are not wilderness areas—which, strictly speaking, hardly exist anymore in the Alps.

Extensively used, near-natural areas (eg alpine pastures, mountain forests, moors, rivers and lakes, dirt tracks, hiking trails and paths), which are subject to a combination of natural and human factors (in the cultural landscape), are also of interest. These areas are composed of natural landscape in the broader sense and cultural landscapes with little human influence only.

In summary, our normative definition of “open spaces” is as follows:

Open spaces comprise areas outside housing/settlement areas, commercial/industrial areas, and other specially designated areas (eg leisure parks) that are kept free from building developments of any kind, are not predominantly developed (with punctual, linear, or planar infrastructure), and are widely free of soil sealing and ideally free of traffic or largely reserved for nonmotorized traffic and thus “noise-free.” Technical infrastructure not belonging to the landscape structure is either nonexistent or hardly present.

(Job et al 2017: 9)

Our research design was divided into 2 parts. First, we evaluated 2 long-established planning instruments for open spaces in the Alps: The Bavarian *Alpenplan* (AP) in Germany and the Tyrolean *Ruhegebiete* (RG) in Austria. Both have similar objectives but differ in their origins in spatial and sectoral planning (nature conservation), respectively. The instruments were analyzed through extensive desk research evaluating the planning objectives, identifying positive or negative issues, and discussing the coordination of these

instruments across national borders (Job et al 2013, 2014, 2017).

Second, as there is no overarching spatial planning instrument in Switzerland that explicitly protects open spaces, we calculated a status quo open-space analysis for the Swiss Alps using a geographic information system. The analysis was based on all available infrastructure data records of the Swiss Topographic Landscape Model. To record the elevations and inclinations, the swissALTI3D digital elevation model (without land cover and construction sites) was used with a mesh size of 2 m. In addition to the Swiss Topographic Landscape Model, we used Swiss area statistics (Nischik and Pütz 2018).

We examined whether infrastructure was disrupting the character of the open space. We based our classification on the results of a quantitative survey on the interference effects of infrastructure. This representative survey of the Swiss population, known as LABES, was conducted in 2011 to study the landscape with all its aspects, qualities, and services in order to monitor landscape change (Kienast et al 2015). Further, we assigned different buffer classes (25–1000 m) to infrastructure classified as disrupting the open space, based on values and assumptions of existing approaches. In addition, the interference effect of roads and railroad tracks was calculated based on the noise spread (>50 dB). Switzerland’s landscape perception units were delimited according to the hydrological sub-basins defined by the Swiss Federal Office for the Environment. Only landscape units (ie catchments) larger than 2 km² were considered. We determined the degree of spatial development of a catchment by overlaying the area of the space-effective interference effect of all infrastructure (including the buffered area) with the total area of the hydrographically delimited unit. Open spaces are defined here as having a degree of spatial development of up to 20% (Nischik and Pütz 2018).

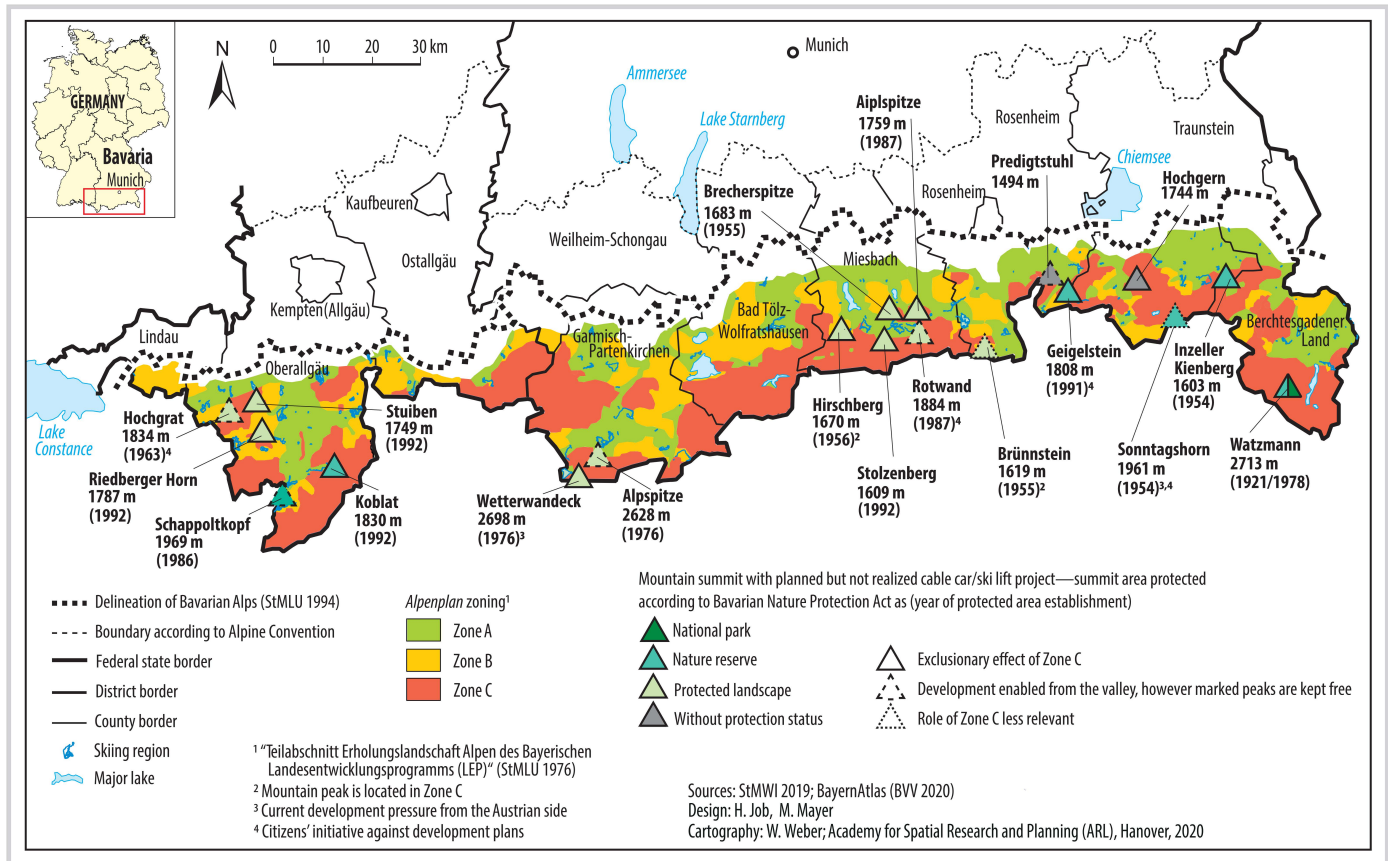
Results

Alpenplan

In the 1960s and early 1970s, the number of ski areas in the Bavarian Alps rose quickly. Recognizing that individual case assessments could not protect the Bavarian Alps from mass tourism infrastructure, the basic idea of the AP was to govern transport infrastructure as a key function for spatial development and usage of different areas (Karl 1969, Job et al 2013, 2014). The Bavarian State government decreed the AP in 1972. As part of the first Bavarian State Development Program, the AP regulates the construction of airports, roads, cable cars, ski lifts, and ski slopes, balancing the spatial needs of tourism while preventing an overuse of mountain landscapes (Barker 1982).

The main instrument for implementing the AP is the zoning of the Bavarian Alps (4393.3 km², without lakes) as a whole, based on how land is already used, how sensitive the Alpine environment is, and what development might be suitable in the future (StMWI 2019). The Bavarian Alps are thus differentiated into 3 zones (see Figure 1) (Barker 1982, Job et al 2013, 2014). **Zone A** (35%) comprises all settlements and most areas with substantial preexisting land uses (eg valley floors). Zone A is regarded as generally available for further infrastructure development. **Zone B** (22%) is a buffer

FIGURE 1 The Bavarian Alpenplan as a spatial planning mechanism.



zone where development is permitted only if it is not at odds with more rigorous regional planning goals. Infrastructure projects must be individually reviewed and their eventual environmental consequences assessed. **Zone C** (43%) is a strictly protected zone where infrastructure development is generally not permitted and only mountain farming and forestry and nonintensive, nature-based recreation activities, such as hiking, are acceptable. Forest tracks and dirt roads for the management of traditional cultural landscapes (eg to reach alpine pastures) are the only infrastructure allowed.

The system of protected areas overlaps with the AP. Although the latter is not a protection instrument, it has considerable influence on the open-space situation in the Bavarian Alps. In fact, Zone C covers approximately 10% more area than all strict protection categories (1694.5 km²) combined. Moreover, it provides an additional area share of 15.2% in open spaces that are only protected by their Zone C status (Job et al 2014).

Figure 1 shows that none of the 19 proposed cable cars or ski lifts have been realized since 1972. A comparison with 46 currently operating ski areas in the Bavarian Alps (Mayer and Steiger 2013) quantifies the development measures prevented. Without the AP, the Bavarian Alps would have been developed much more intensively (Job et al 2017).

Among the 19 proposed projects, only 6 peaks have the same level of protection as a nature reserve. The remaining 13 cases have been designated as much less strict landscape protection areas or have not yet been protected at all. The fact that many ski areas in the Bavarian Alps are located in landscape protection areas underlines the weak effect of this

protection status (Job et al 2017; Nischik et al 2019). This in turn highlights the stringent control, compared with most protected area categories, and far stronger protection afforded by the Zone C designation of the AP.

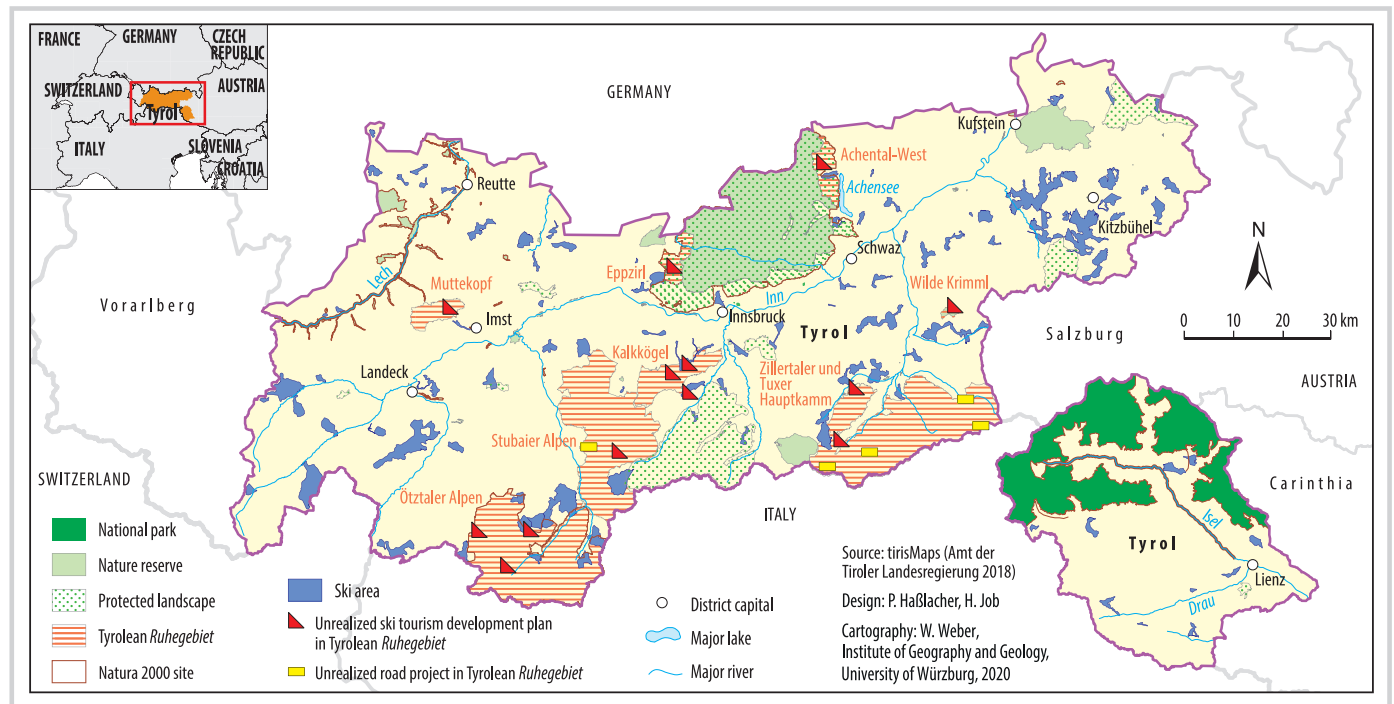
Ruhegebiete

The Tyrolean RG, or "Quiet Areas," were first proposed in 1972–1973 in the landscape plan of the Tyrolean Forestry Authority. However, in contrast to the AP, this landscape plan was not legally binding. The juridical anchoring of RG through ordinances only occurred on their incorporation into the Tyrolean Nature Conservation Act in 1975. The technical foundation of the spatial planning mechanism of the RG is guaranteed in the Tyrolean recreational areas concept developed by the Tyrolean state planning agency (Haßbacher et al 2018).

The RG lie outside built-up areas and are particularly suitable for sedate recreation. They have very clear prohibitions: (1) no establishment of noisy businesses, (2) no installation of ski lifts or cable cars for public transport, (3) no new construction of public roads, (4) no significant noise emission, and (5) no landings or takeoffs of powered aircraft for tourism purposes (Haßbacher 2007). Due to their clear regulations and by drawing limits directly on the external borders of ski areas and roads, the establishment of RG is often preferred to the designation of protected areas when it comes to setting final limits on ski areas (see Figure 2) (Job et al 2017; Nischik et al 2019).

In Tyrol, 8 RG were designated between 1981 and 2000 (Haßbacher et al 2018). With a total area of 1370.94 km², they

FIGURE 2 Ruhegebiete as a mechanism countering spatial development pressures in Tyrol.



currently cover nearly 11% of Tyrol's territory (see Figure 2). Despite considerable development pressures, the RG have not been substantially impaired by ski tourism since their designation. Efforts by ski area operators and local communities to implement various projects have failed so far (Essl 2017).

RG also extend the range of established protected areas, especially those that are less strictly protected. However, only 3 RG are part of the Natura 2000 regime. Some RG were also awarded the title of nature park, for tourism marketing reasons, among others. However, the legal basis for their protection remains with the RG regulation. RG designation has protected open spaces by preventing 18 ski tourism and road projects (see Table 2). After extensive political and public discussion, these projects did not even reach the procedural stage due to the clear formulation of the RG ordinance (Job et al 2017; Nischik et al 2019). However, an exception was recently introduced to the Tyrolean Nature Conservation Act in the context of the energy transition, to enable a large hydropower plant extension project in the Kühtai valley in the Ruhegebiet Stubai Alpen:

In any case, the construction noise associated with the implementation of energy system transformations ... is not considered to be significant noise within the meaning of this provision.

(Tiroler Landesregierung 2015: 3, own translation)

Swiss Alps

In the analysis of the Swiss Alps, 2331 out of 4772 landscape units were found to have a degree of spatial development of no more than 20% and hence to qualify as open spaces. These cover 41.9% of the Swiss Alpine Convention area (12,334.6 km² including water bodies; see Figure 3). They are mainly located along the main and northern Alpine ridges and are more frequent at higher elevations and in more

peripheral locations. Examples include the Bernese Alps, the Pennine/Valais Alps, the Urner/Uri Alps, Northern Ticino, the Adula group, the Glarus Alps, and large parts of the Engadine (see Figure 3).

It stands out that 40.3% of the open-space area is vegetation free. This reflects the concentration of open spaces in high alpine areas (see Figure 4). The main Alpine ridge can be recognized from both the lack of vegetation and the glaciation (8.3%). These open spaces are difficult to access due to their relief and are not suitable for settlement or infrastructural development (except for ski tourism or hydroelectric infrastructure). Forests cover 17.7% of the open spaces, grass and herb vegetation 9.4%, and bushes 5.4%. The ground cover correlates with the elevation, and so do the open spaces, of which 63.3% are located above 2000 m, and 82% have a slope gradient of more than 30°. This makes them largely unsuitable for any productive land use.

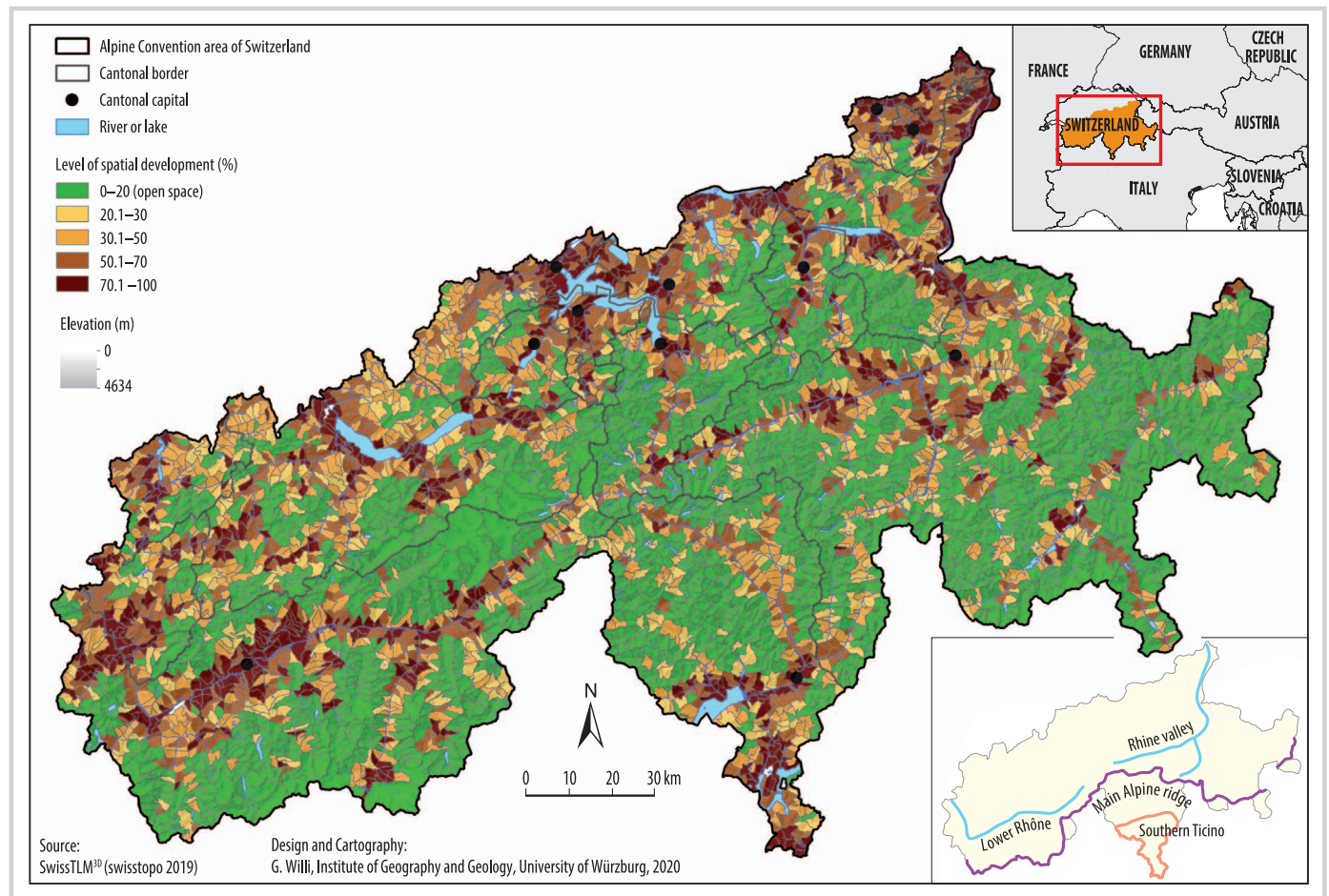
Overall, 64.6% of the open spaces identified are designated protected areas (see Figure 5). These include both strict categories (Federal Inventory of Landscapes and Natural Monuments, Federal Inventory of Swiss Game Reserves, Federal Inventory of Mire Landscapes of Particular Beauty and National Significance, Swiss National Park) and less strictly protected areas (regional nature parks, biosphere reserves, United Nations Educational, Scientific and Cultural Organization [UNESCO] World Natural Heritage sites). Nearly half (46.6%) of the open spaces are under national protection. A further 18% are currently protected by the cantons; however, these areas' protection status can easily be changed in the cantonal structure plans (Pütz et al 2017; Nischik and Pütz 2018). Accordingly, about one third of the open spaces still existing in the Swiss Alps need preservation, not only for ecological connectivity reasons but also to preserve them for generations to come.

In addition to the protected areas mentioned earlier, Switzerland has many other spatial planning instruments

TABLE 2 Tyrolean *Ruhegebiete* and unrealized ski tourism and road projects.

Name of Ruhegebiet (from west to east)	Date of first designation or reduction or extension	Area (km ²)	Municipalities	Planned development projects (from west to east)	Project known before first designation Yes/no	Current project Yes/no
“Muttekopf”	09 Jul 1991	38.00	Imst, Pfafflar	Extension of the winter sport area Hochimst in direction of Seebrig	Yes	No
“Ötztaler Alpen”	27 Oct 1981 10 Jun 1997 02 May 2006	396.00 394.70 405.53	Kauertal, St Leonhard im Pitztal, Sölden	Connection of ski areas Schnalstaler glacier (Italy) and Vent	Yes	No
				Connection of ski areas Vent and Pitztaler glacier via Rofenkar	No	No
				Ski run on the Gepatschferner after extension of the Kauertaler glacier ski area	Yes	No
“Stubai Alpen”	26 Jul 1983 02 May 2006	348.90 352.20	Längenfeld, Neustift im Stubaital, St Sigmund, Sölden, Umhausen	Mountain road connection Stubaital-Ötztal (via Sulztal)	Yes	No
				Extension of the glacier ski area Hochstubai into Glamergrube	Yes	Yes
“Kalkkögel”	26 Jul 1983	77.70	Axams, Götzens, Grinzens, Mutters, Neustift in Stubaital, Sellrain, Telfes	Connection of ski areas Schlick and Axamer Lizum	Yes	Yes
				Feeder lift Neustift in Stubaital/ Neder-Kaserstattalm-Sennjoch	Yes	Yes
				Next steps: Niederer Burgstall, Schlicker-Schartl-Seejochl; Oberbergtal-Milderaun (long-term perspective: connection to Stubai glacier ski area)	No	Yes
“Eppzirl”	20 Dec 1988	33.40	Scharnitz, Seefeld, Zirl	Extension of Seefeld’s ski area to the Eppzirl Alm	Yes	No
“Achenal-West”	20 Dec 1988	38.10	Achenkirch, Eben am Achensee	Extension of the Christlum ski area in direction of Hochplatte, Kleinzemm, and Gröbner Hals	Yes	No
“Zillertaler and Tuxer Hauptkamm”	02 Jul 1991 03 Feb 1998 02 May 2006 07 Oct 2016	372.00 371.78 379.00 421.71	Brandberg, Finkenberg, Mayrhofen, Tux	Extension of the B 169 Zillertaler national road to Pfitscher Joch (road connection “Zillertal-Sterzing”)	Yes	No
				Feeder lift from Schlegeisspeicher to the glacier ski area Hintertux	Yes	No
				Crossing of the main ridge of the Zillertaler Alps for “Alemagna”-motorway	Yes	No (only in Italy)
				Road connection Zillertal-Ahrntal over Hundskehljoch (“Freundschaftsstraße”)	Yes	No
				Opening of the street on the dam crest “Speicher Zillergründl” to motorized private vehicles	Yes	No
				New development of ski area “Kreuzjoch”	Yes	No
“Wilde Krimml”	20 Jun 2000	4.30	Gerlos, Stummerberg	Limitation of development possibilities of the ski area Zillertalarena in direction of Torhelm, Katzenkopf, Rifflerkogel	Yes	No

FIGURE 3 Open spaces and spatial development in the Swiss Alps.



with which open spaces can be protected. At the federal level, these include the sectoral plan for crop rotation areas and the forest protection laws. At the cantonal level, for example, both the cantonal structure plan (*Kantonaler Richtplan*) and the building permit procedures for buildings outside the building zones can have major impacts on land protection. The local planning of the municipalities makes the plans binding. Furthermore, various instruments are independent of the planning level, including landscape development concepts and the right of conservation organizations to lodge appeals. All these instruments can be used to protect open spaces, strictly or less strictly (Nischik and Pütz 2018). However, they all depend on the decision and the legal intention to implement them. Implementation practices differ among cantons, depending on the level of coordination of planning and on political influence (Kiessling and Pütz 2020). Hence, the normative force of the instruments available in Switzerland to protect open spaces can vary greatly.

Discussion and conclusion

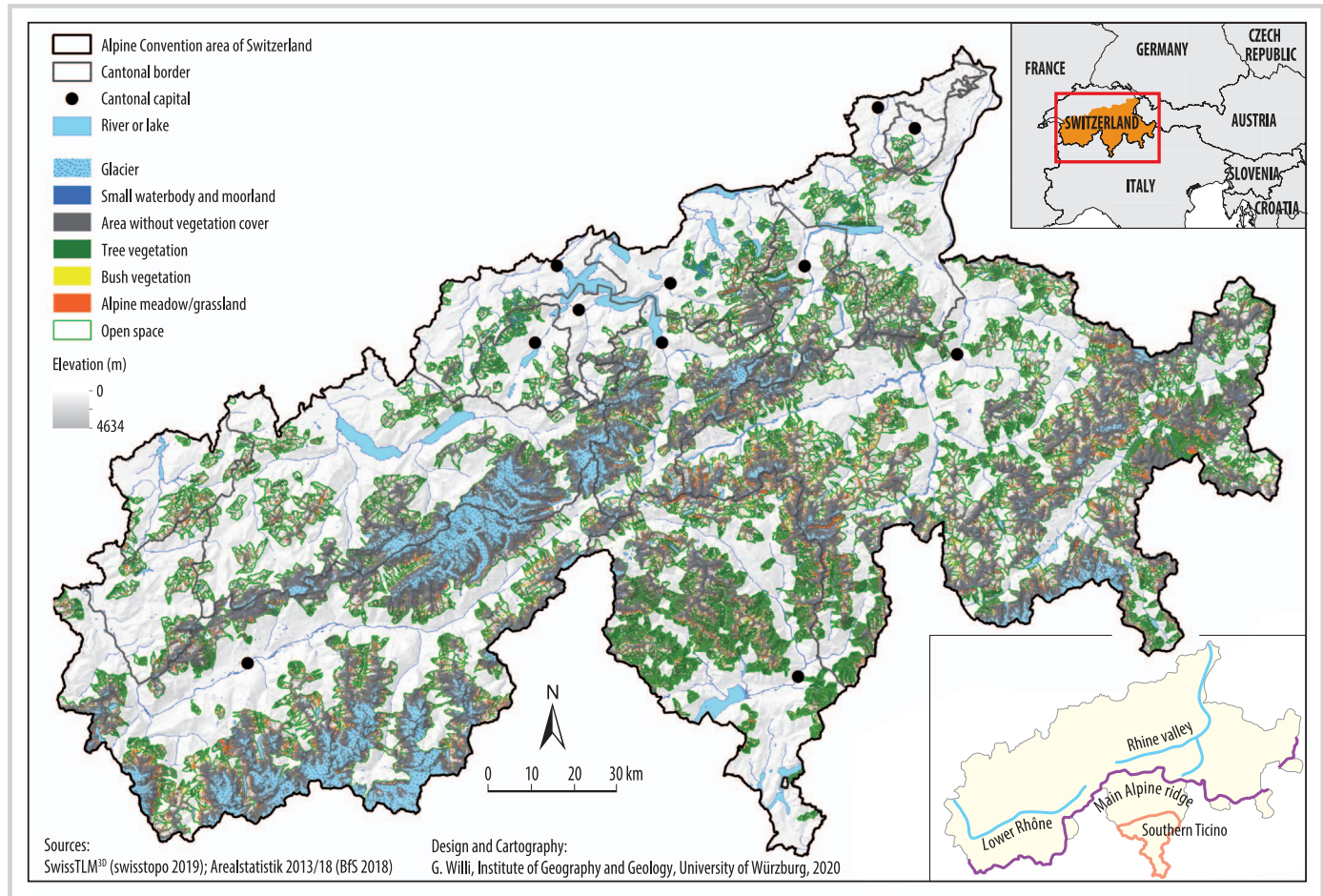
With Zone C, the AP fulfills the legal framework of the Alpine Convention (Article 2 i), which has been in force in Germany since 1995. It also fulfills several implementation protocols on the mandatory definition of so-called quiet zones (Job et al 2017). Thus, the AP has prevented the

Bavarian Alps from becoming overdeveloped with tourism infrastructure and has provided important improvements for protecting open spaces—without restricting tourism, its economic impact, or recreational function. The AP is unique as a strict instrument of comprehensive spatial planning in the Alps; most notably, it achieved the implementation of sustainability principles 2 decades ahead of the 1992 Rio Declaration (Job et al 2014).

Although the main aim of the AP is to regulate ski tourism, it has not affected tourism performance in general (Mayer et al 2016). Since 1972, not a single exception for development projects in Zone C has been granted. This has helped to avoid time-consuming debates on individual cases and prevented numerous development projects. Nonetheless, the AP is not suitable for managing today's post-Fordist recreational demand, which has led to increased differentiation and individualization of outdoor recreation activities. These aspects need to be included in future research and planning initiatives. Moreover, new technologies—for example, e-mountain-bikes—tend to enable tourists to travel longer distances and promote the expansion of tourism into hardly developed areas (Job et al 2014).

The RG are a successful planning initiative, too. They expand the Tyrolean protected area portfolio considerably and have much greater planning controls than landscape protection areas or even nature parks. Despite the limiting

FIGURE 4 Open spaces and land cover in the Swiss Alps.



of ski tourism through the RG (and the Tyrolean cable car and ski resort program; see Schindelegger 2017), Tyrol is one of the most successful winter tourism destinations in the world. Since the designation of the RG in 1975, the number of overnight stays in the winter season has risen by more than 120% (1974–1975: 11.8 million; 2016–2017: 26.5 million) (Amt der Tiroler Landesregierung 2017).

In still-growing ski tourism markets in other high mountain ranges in Europe and elsewhere, an easily understandable, transferable, and applicable planning tool like the AP or RG could guide infrastructure development, for example, by limiting it to suitable areas for ski tourism, while at the same time protecting sensitive open spaces.

However, both instruments also have limitations:

- The RG and the AP's Zone C areas are mostly situated in high alpine locations; open spaces are rare in valleys. Processes of sub-urbanization and peri-urbanization in the valleys are hardly affected. Accordingly, so far only a few natural open spaces are providing ecological connectivity, and those that do are therefore of great importance (ALPARC 2020). These ecological bridges are not sufficiently covered by instruments such as the RG and the AP in their current outline.
- Furthermore, cross-border coordination of these planning instruments is lacking. In the Alpine border area of Germany and Austria, the AP's Zone C and the RG have not yet been harmonized. There are serious gaps in the

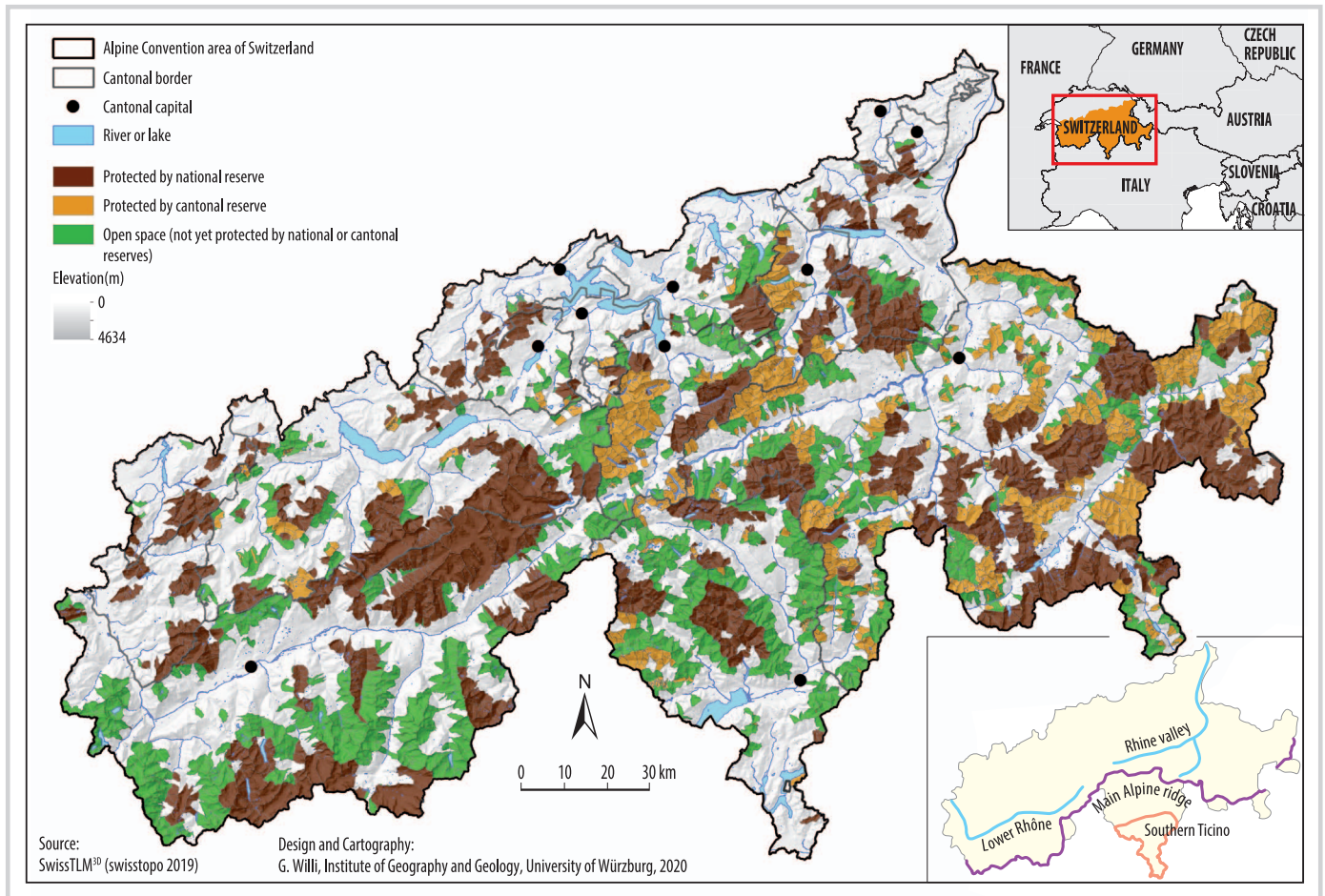
maintenance of Alpine open spaces (see Figures 1, 2).

Regular protected areas also only affect small portions of the Tyrolean state border. The preservation of open spaces is often not continued across borders, which prevents the coordinated protection of open spaces and potentially disrupts ecological connectivity. This also holds true for the Alpine border area of Switzerland and the Austrian federal state of Vorarlberg, where the absence of cross-border cooperation prevents coordinated preservation of open spaces in the intensively used Alpine Rhine valley.

In Switzerland, the remaining open areas are similarly concentrated at high elevations, in the so-called “worthless lands” (Runte 1977) where extensive development is not possible. In the Swiss Alps, 35.4% of the open spaces are not yet protected. A planning instrument at the federal level that protects the remaining open spaces needs to be set up soon. Particularly in the valleys and low mountain ranges that have very few protected areas, it is important to preserve open space through timely application of effective spatial planning instruments (Nischik and Pütz 2018).

Spatial planning must be in the public interest because space is a nonrenewable, finite resource. Supralocal regulations for spatial and sectoral planning are indispensable for spatial functional relationships, especially in the ecologically sensitive Alpine arc. After all, neither the sum of individual investment projects nor the sum of individual decisions at the municipal level leads to a

FIGURE 5 Open spaces and protected areas in the Swiss Alps.



resource-saving allocation corresponding to sustainable Alpine development (Schindegger 2019).

Spatial planning and protected areas should not be regarded as 2 separate approaches but rather constitute 2 sides of the same coin. Both their functioning and their effects overlap. The RG are an outcome of spatial planning procedures, but legally regulated by the law on nature protection. At the same time, the AP, which was designed as a spatial planning instrument, has a stronger protection effect compared with some protected area categories. Its core Zone C stretches out beyond existing strictly protected areas (Mayer et al 2016).

In the Swiss Alps, options for new federal planning approaches across cantonal borders should be discussed and implemented soon. In the future, more intense cross-border cooperation is necessary in spatial planning to protect open spaces over all of the Alps. This will also prevent a race to the bottom regarding planning standards for tourism projects, for example, projects to link existing large ski areas. Without cross-border cooperation, further fragmentation and the related loss of Alpine open spaces and ecological connectivity will be inevitable. The AP and the RG represent top-down approaches based on the rational, technocratic planning paradigm of the 1970s, in contrast to today's governance approaches, which are mostly bottom-up concepts (Pütz and Job 2016; Willi et al 2018). Nonetheless,

both could serve as best-practice models for other high mountain ranges around the globe.

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